Evaluation of the state of the Business Intelligence among small Czech farms

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Abstract: Business Intelligence (BI) can assist in agricultural enterprises to strengthen their production potential and technical efficiency due to its effective support to the managerial, analytical, planning, and decision-making activities of managers and specialists. However, the state of the BI in the Czech Republic is not still completely understood. In this context, this paper aims at the evaluation of the current state of the art of the BI among small Czech farms. The focus of the research was put on the evaluation of both the state of the BI, and the relevant business information systems and software for agriculture. There was a survey among 135 agricultural entrepreneurs from various regions in the Czech Republic. The survey results are presented by the descriptive statistics and frequency tables. There is an examination of the relationship between the agricultural enterprise structure and the use of the BI. Dependencies among the examined characteristics were sought by the means of the analysis of qualitative variables. With 95% probability, it could be claimed that the type of production, the size of farmed land, the number of employees and the level of financial subsidies have no significant impact on using the BI, the expert and analytical systems in agricultural enterprises.

Key words: agriculture, information systems, multidimensional database, OLAP, precision agriculture

The latest economic results of Czech agricultural enterprises and the development of the main structural indicators of the farm's economy can be evaluated as positive. The annual report on the Czech agriculture in 2012 issued by the Czech Ministry of Agriculture says that the high economic standard set in 2011 (after the drop in 2009 and a moderate increase in 2010) brought the total turnover of 16.1 bln. Czech crowns, which represents historically the second best result achieved after 1990 (MoA 2013). An important trend is the reduction of the number of workers, when in 2011 the number of workers was equal to 70% of that in 2000, while the labour productivity is increasing annually by an average of 7% (Lososová and Zdeněk 2013). However, these facts and other similar surveys do not include the information about the economic efficiency of agricultural enterprises. Čechura (2010) estimates the technical efficiency at 90% level regarding their heterogeneity. The survey from Kroupová (2010) measures the efficiency of organic farming by 13.5% lower when compared to conventional farming methods. The study points out that the organic farms production amounts in average to 55.1% of the potential production level, and also that 50% of the researched organic farms achieves the technical efficiency measure lower than 50.1%. The fact that the agricultural enterprises do not reach full production potential and technical efficiency is the motivation for the study presented here. The aim is to get a better information availability for the agricultural enterprise management and to get closer to the concept of the precision agriculture.

In relation with the necessity of information for farm owners about their economic performance, there is also a need for new methods enabling, on one side, an interactive and flexible evaluation of the current

progress in the economic efficiency from various perspectives and in the time series, and, on the other side, providing future prospects of the economic and financial performance.

Business Intelligence (BI) methods can assist in agricultural enterprises to strengthen their production potential and technical efficiency due to its effective support to managerial, analytical, planning, and decision-making activities of managers and specialists. For example, some analytical problems in the context of the precision agriculture (Cabrera Garcia et al. 2013; Lips et al. 2013), econometrics (Čechura 2010; Kroupová 2010; Čechura and Taussigová 2013) and the information technology (Schulze et al. 2007; Rai et al. 2008) might be easily implemented by the means of the BI methods. Reports and dashboards (visualization of the most important parameters) enable the farm managers to interpret data that are relevant to the solved problem. Thus, the farm would have to collect data about its agricultural activities and also conduct the analysis of the summarized and aggregated data.

There has been no research attention devoted to the evaluation of the state of the BI in Czech agriculture so far. Neither there has been any assessment of the analytical and information systems in agriculture. There are 40–50% of enterprises in the Czech Republic that utilize and develop this type of applications and their level of equipment is still increasing (Pour et al. 2012).

The subject matter of the paper is the evaluation of the BI in agriculture. The BI is a set of processes, applications and technologies that aim to foster efficiently and effectively the decision processes in the organization. It assists the analytical and planning activities in the companies and organizations and they are built upon the principles of the multidimensional data views (Novotný et al. 2005; Pour et al. 2012). In the BI, there is much attention focused on the data storage layer with the accentuation of the users' needs for the analyses and planning. This includes not only the database components but also the components for the online analytical data processing. Multidimensional databases are implemented for this reason. *Multidimensional databases* are suitable for the storage of the large amount of (multidimensional) data that are mostly analysed and summarized due to the decision-making. The term *multidimensional data* represents the data of aggregated indicators that were created with various groups of the relational data aimed for the online

analytical processing (OLAP). OLAP is an approach to the decision support that serves for the data warehouse, the data mart retrieval (Abelló and Romero 2009). The solely way of the data organization in the multidimensional database is implemented as the data cube.

The *Data cube* is a data structure for the storage and analysis of a huge amount of multidimensional data (Pedersen 2009b). In general, it is interpreted as a basic logical structure that describes the multidimensional databases same as a relation describes the relational databases. The data cube represents an abstract structure that, in contrary with the classical relational structure, has not the unique definition. There are plenty of formal definitions of the data cube operators, a compact overview is e.g. in (Vassiliadis and Sellis 1999). At large, the data cube consists of the dimensions and measures. *Dimension* is a hierarchically organized set of the dimensional values that provide the category information characterizing certain aspects of data (Pedersen 2009c). *Measures* (observed indicators) of cube are mainly quantitative figures that could be analysed.

For the physical storage of multidimensional data (and the implementation of OLAP applications), there can be used several technologies. The two main ways to store data include the so-called *multidimensional OLAP* (MOLAP), the *relational OLAP* (ROLAP) (Datta and Thomas 1999). MOLAP physically stores the data in an array like structures that are the similar data cube shown on Figure 1. In the approach ROLAP, the data is stored in a relational database using a special scheme instead of the traditional relational schema. There are also other approaches, the so-called *hybrid OLAP* (HOLAP) that combine the properties of the ROLAP and MOLAP (Khan 2005) and the so-called *desktop OLAP* (DOLAP). The DOLAP is capable to connect to a central data store and download the required subset of the cube on a local computer (Novotný et al. 2005).

For the design of the multidimensional databases it is used the multidimensional modelling. *Multidimensional modelling* nowadays is mostly based on the relational model, or on the multidimensional data cube (Zádová 2009). *Multidimensional models* categorize the data either as facts with the associated numerical measure, or as the dimensions that characterize the facts and are mostly text. Facts are the objects that represent the subject of the required analysis that has to be analysed for better understanding of its behaviour (Pedersen 2009a).

The multidimensional data model based on the relational model distinguishes two basic types of sessions that are called the dimension tables and tables of the facts. They can create a star structure (*star schema*) (Chaudhuri and Dayal 1997; Wu and Buchmann 1997; Ballard et al. 1998; McGuff 1998; Boehnlein and Ulbrich-vom Ende 1999), various forms of snowflakes (snowflake schema) (Chaudhuri and Dayal 1997; Ballard et al. 1998; Boehnlein and Ulbrich-vom Ende 1999) and constellations (constellation schema) (Abdelhédi and Zurfluh 2013). The issue of choosing an appropriate structure is solved in the paper Levene and Louizou (2003).

Within our research survey, we focused on the assessment of the state of the art of the enterprise information systems in farms (particularly on the ERP, CRM, the statistical software and database systems). ERP (Enterprise Resource Planning) is an industry notion for a wide set of management activities which support all essential business processes within the enterprise (Sørensen et al. 2010). The CRM (Customer Relationship Management) refers to building one-to-one relationships with the customers that can drive value for the firm (Kumar 2010). The EDI (Electronic Data Interchange) encourages a long-term commitment with the trading partners, makes the transmission of information more efficient, and allows the firms to be more responsive to the customer needs through shorter order cycles (Choudhary et al. 2011).

The above stated systems are able to support the decision-making and economic processes in an agricultural enterprise. Precision agriculture requires the research models such as the complex solutions and specialized software tools (Janová 2014). The ERP and CRM systems are the basic enterprise information systems for operational activities. The databases that create their foundation are important source for the construction of data warehouses (Gupta and Mazumdar 2013; Jarke et al. 2013) and multidimensional databases in the Business Intelligence.

The paper presents an analysis of the current state of the enterprise information systems and looks for barriers of the use of the BI in agriculture of the Czech Republic. The description of the sample data and the used scientific methods are described in the chapter Materials and Methods. Interpretations of the achieved results and explanations of their meaning are in the chapter Discussion and Results. There are also possible applications of the results, the potential problems and the further research of the Business Intelligence in agriculture.

MATERIALS AND METHODS

The analysis of the current state of the Business Intelligence among Czech farms was based on the questionnaire survey conducted by the Department of Information Technologies and by the Department of Software Engineering at the Faculty of Economics and Management at the Czech University of Life Sciences in Prague in 2013. There were over 500 respondents asked to fill the survey by e-mail or via the online form at http://dotaznik.czu.cz. To evaluate the Business Intelligence, the methods of descriptive statistics and frequency tables were used. Partial results of the survey were already published in Kubata et al. (2014).

We obtained 135 correctly filled answers from agricultural producers, 89% out of them were maintaining land up to 500 hectares (Table 1). The highest relative frequency was in the category 100–499 hectares. Only 8% of subjects operate at more than 500 hectares of land. The main subject of this survey was the group of the privately run farms with the mid-sized land.

96% of the observed farms employed less than 9 workers (Table 2). The most frequent were the enterprises with less than 3 people (with frequency 90).

Other findings are that 90% of the subjects were in the plant production, 52% in the animal production a

Table 1. The structure of farms according to agricultural land

Category	Frequency	Cumulative frequency	Relative frequency	Cumulative (rel. frequency)
Less than 50 ha	24	24	17.77778	17.7778
50–99 ha	29	53	21.48148	39.2593
100–499 ha	67	120	49.62963	88.8889
More than 500 ha	12	132	8.88889	97.7778
ChD	3	135	2.22222	100.0000

Source: Kubata et al. (2014)

Table 2. The structure of farms according to the number of employed people

Category	Frequency	Cumulative frequency	Relative frequency	Cumulative (rel. frequency)
Less than 3 people	90	90	66.66667	66.6667
4–9 people	40	130	29.62963	96.2963
10–19 people	4	134	2.96296	99.2593
20–49 people	1	135	0.74074	100.0000
ChD	0	135	0.00000	100.0000

Source: own calculation

16% in other types of production (mostly agri-tourism and services) – see Table 3.

The basic exploratory analysis brought out that the sample set was mainly consisting of small and middle-sized agricultural enterprises focusing on the plant and animal production on land up to 500 hectares and with up to 10 workers.

To identify the relationships between the farm structure (the type of production, hectares of land, the number of workers, subsidies) and the use of the Business Intelligence and other types of the information system, we set following working hypotheses (Table 4).

Table 3. The structure of farms according to the type of production

The structure of farms by type of production	Count	Percent
Crop production	122	90.37
Animal production	70	51.85
Other	21	15.56

Source: Kubata et al. (2014)

The presence of dependency between the qualitative characteristics was verified by the means of the Pearson's and the M-V chi-square tests. The Pearson's χ^2 statistic is calculated based on the formula (Bolboacă et al. 2011; Canal and Micciolo 2012) presented in Equation (1).

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i} \qquad (1)$$

where:
χ^2 = Pearson's cumulative test statistic, which asymptotically approaches a χ^2 a distribution
O_i = observed frequency
E_i = expected (theoretical) frequency, asserted by the null hypothesis
n = the number of cells in the table

All associative tables must accomplish the condition that the size of the sample set is higher than 40 ($n > 40$). We tested the null hypothesis that assumes the statistical independence between the examined qualitative characteristics. To measure the strength of relationship, the Phi test (for 2 × 2 tables) and the Cramér V&C (for larger than 2 × 2 tables) were used.

Table 4. Working hypotheses about the dependencies between the BI and the selected factors

Factor	Hypothesis
Plant production	H1: There is a statistically significant dependency between the focus on plant production and the use of the Business Intelligence.
Animal production	H2: There is a statistically significant dependency between the focus on animal production and the use of the Business Intelligence.
Hectares of land	H3: There is a statistically significant dependency between the number of hectares of used agricultural land and the use of the Business Intelligence.
Number of workers	H4: There is a statistically significant dependency between the number of employed people in the enterprise and the use of the Business Intelligence.
Subsidies	H5: There is a statistically significant dependency between the enterprises that receive subsidies and those that do not regarding the use of the Business Intelligence.

Source: own calculation

In case of the 2 × 2 contingency table with cells a, b, c, d, the Phi coefficient is calculated according to the formula (Sheskin 2003):

$$\varphi = \frac{ad - bc}{\sqrt{(a+b)(c+d)(a+c)(b+d)}} \text{ or } \phi^2 = \frac{\chi^2}{n} \quad (2)$$

n = the total number of observations

The Statistica 12 software was used to produce the exact results of the statistical analysis of the associative tables.

RESULTS AND DISCUSSION

The next part describes the results of the basic exploratory analysis of the data and the analysis of the associative tables. Firstly, the results of the evaluation of business informatics (BInf) are described as an important factor for the development of the Business Intelligence (BI) in agricultural enterprises. Business informatics is the way of representing information, its processing, communication and use in the business (Heinrich and Riedl 2013; Maryska and Novotny 2013). Secondly, there is the analysis of the state of the Business Intelligence and the verification of the statistical hypothesis.

Business informatics evaluation

The current state of the BInf was evaluated in the terms of the hardware and software equipment of the farms and the overall impact of informatics on their activities was assessed. As to the investments into information technologies, we proved that there

are no obstacles for the farmers. Most of the expenditures on the hardware are now directed to mobile technologies (Figure 1). There is a positive rating of the level of information technologies in farms and the readiness to use the BI applications.

A further important finding of the analysis is that the business informatics is perceived as a necessary technology solution for the realization of the business goals in 59% of the cases (80 respondents), while 16% (22 respondents) find it as having a major impact on the realization of the business goals and merely 12% (16 respondents) think that business informatics has no effect on the realization of the business goals (see Figure 2). It is relevant to further examine and identify the barriers to the effective use of the BI concepts and applications.

The next part of the survey inspected the type of the used software equipment in the observed agricultural enterprises (Figure 3). The most frequently used software was the accounting and stock control (39%) and the software for crop production (25%). These findings adhere to the farms' production structure specified in Table 3. Interesting facts are that the farmers use even further specialized information systems and software such as the human resources and payroll management (16%), the electronic communication with suppliers (15%), the specialized software for animal production (15%) and the enterprise resource planning (13%). The exploratory analysis shows that the farm management systems and software for the precision agriculture are rare (5%), which is similar to the database management systems (4%) and the statistical software (2%). None of the respondents uses the computer-aided customer relationship management (CRM).
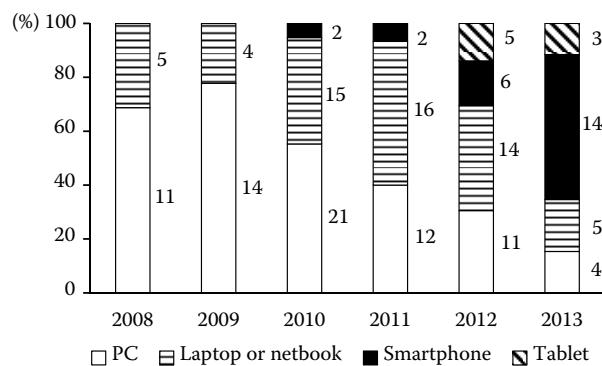

Figure 1. Structure of the hardware purchases in the period 2008–2013
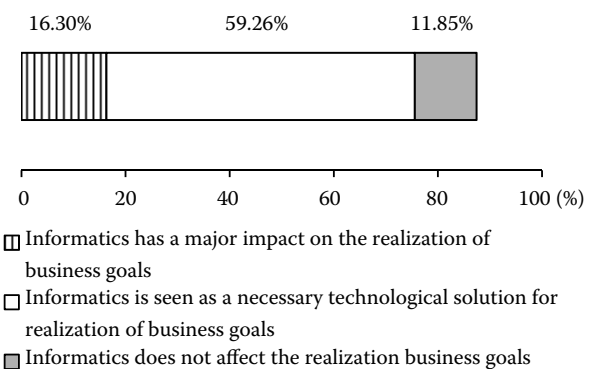
Source: own calculation

Figure 2. Business informatics perception among small Czech farms
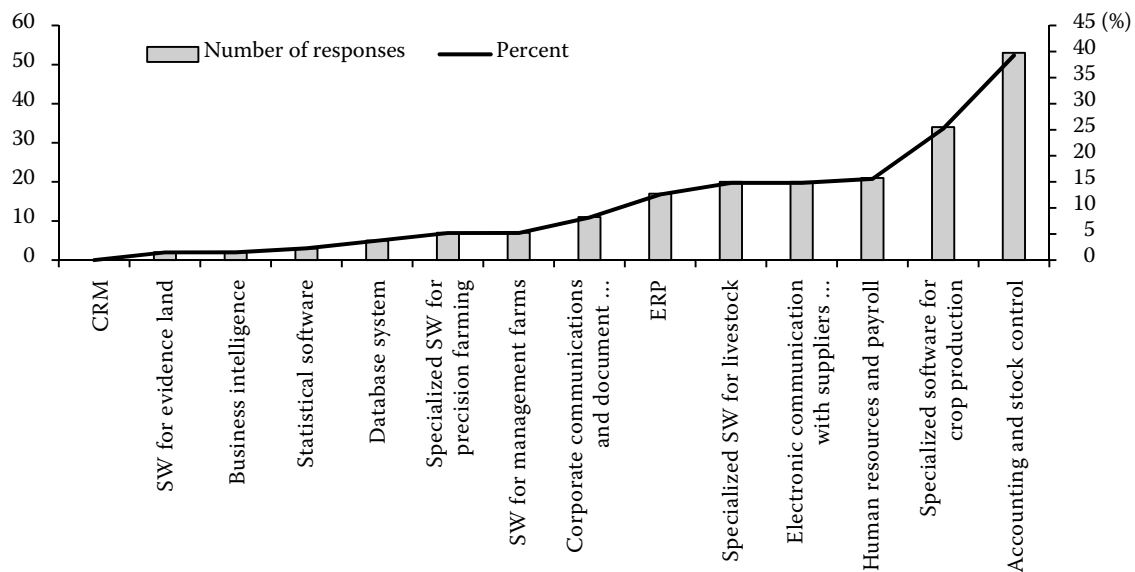
Source: own calculation

Figure 3. Types of software used for the activities among small Czech farmers

Source: own calculation

Based on the results provided above, the software equipment of Czech farmers is on the average level. The BI systems require a database provided by systems like the ERP. There was a satisfactory level of readiness for the BI implementation at 15% of the farms. The interval covers those farms where the BI can be applied to all main activities in the farm (i.e. accounting, economics, animal and plant production). Only 15% of farms can use data from their operational databases to implement the BI such as the multidimensional databases and the OLAP.

Business Intelligence current state analysis

Survey results showed that only 2 respondents (1%) used some type of the BI application (Table 5). The BI rate in Czech farms is negligible. If we generalize the results, we can see a significant difference between the agricultural and other sectors, where 40–50% of enterprises in the Czech Republic use and invest into the BI applications. Their level of the BI equipment is constantly increasing, which is in contrast with agricultural enterprises. Unfortunately, it is not possible to compare the results of this research with another research. The reason is that a similar research that was aimed at the evaluation of the state of the BI in agriculture has not received any attention in both the Czech and English scientific literature yet.

To test the working hypotheses (Table 4), the existence of dependencies between the agricultural enterprise structure (type of production, hectares of land, number of workers, subsidies) and the use of the BI and other types of information systems were examined. The types of information systems were taken from the survey results (Figure 3), namely the operational systems (ERP), the database systems (DBS), the electronic communication with suppliers (EDI) and the statistical software (SPSS).

The existence of the dependency among the qualitative variables is verified by the means of the chi-square test (sample size is higher than 40). The null

Table 5. Frequency of the use of Business Intelligence in farms

Category	Frequency	Cumulative frequency	Relative frequency	Cumulative (rel. frequency)
No	133	133	98.51852	98.5185
Yes	2	135	1.48148	100.0000
ChD	0	135	0.00000	100.0000

Source: own calculation

Table 6. Table of the statistics for the evaluation of dependency

	Number of employees(4) x BI(2)		
	chi-square	df	*p*
Pearson's chi-square	0.4440790	df = 3	*p* = 0.93099
M-V chi-square	0.4777186	df = 3	*p* = 0.92376
Phi	0.0573539		
Contingency coefficient	0.0572598		
Cramér. V	0.0573539		

Source: own calculation

hypothesis was that there is a statistical independency between the examined qualitative variables. As first, the dependency between the number of workers and the use of the BI was tested. The results with the chi-square test criteria and the correlation characteristics are summarized in Table 6. The calculated level of significance *p* is higher than α = 0.05 for both types of the chi-square test. The null hypothesis is accepted at the given level of significance. There is no significant dependency between the number of workers at farm and the use of the BI.

Further statistical calculations for the verification of all hypotheses are presented in Table 7. There are the lowest values of *p*-values according to the Pearson's chi-square or M-V chi-square test in the table. The correlation index *r* was omitted because none of tests reached *p*-value below α = 0.05. We accept the null hypothesis and reject the alternative hypothesis about the statistically significant dependency between the variables.

It was observed that with 95% probability, there is no significant dependency between the structure of the farm and the use of the BI. The same is valid for all other types of the information systems (ERP,

DBS, EDI and SPSS). We can conclude that the type of production, the size of the farm land, the number of workers and subsidies have no significant influence on the fact whether or not the farms use the BI and other expert and analytical systems.

CONCLUSION

The presented research was focused on the evaluation of the state of the Business Intelligence and the related enterprise information systems among small Czech farms. We used a sample of 135 farms from various regions of the Czech Republic. The cohort represented mostly small and middle-sized farms that worked in the plant and animal production, operated land up to 500 hectares and employed up to 10 people.

The results showed that there are no problems with investments to the information technologies among the farmers. Money is put in a larger extent to the mobile information technologies, which is a positive signal for the potential use of the BI applications. Business informatics is perceived among the farmers as a necessary technological solution for the realization of business goals (59% of respondents). These facts make a further examination and identification of barriers for implementation of the BI relevant. Among the most used software at the farms, there belong the accounting and stock control (39%), and the specialized software for the plant production (25%) and animal production (15%). The software for the farm management including the precision agriculture software (5%), the database systems (4%) and the statistical software (2%) are of a marginal interest. A remarkable finding was that none of the respondents used the CRM system. In the terms of the readiness for the BI implementation, 15% of the farms have enough software to apply the BI in all

Table 7. Statistically significant dependencies among factors and BI, *p*-value

Hypothesis/No. of service	ERP	DBS	EDI	SPSS	BI
H1: Plant production	0.0546	0.42311	0.4126	0.433	0.5229
H2: Animal production	0.6723	0.13493	0.1988	0.5995	0.9579
H3: Hectares of land	0.7571	0.25132	0.1978	0.2471	0.4331
H4: Number of employees	0.1121	0.8754	0.1007	0.4813	0.9238
H5: Subsidies	0.366	0.63223	0.3612	0.7119	0.7635

Source: own calculation

main activities of the farm (accounting, animal and plant production).

The current state of the BI among Czech farms is less favourable. The exploratory analysis of the survey showed that only 1% of respondents use any type of the BI application, which is a significant difference in comparison with other sectors in the Czech Republic, where 40–50% enterprises use the BI.

Based on the results presented above, the possible reasons of the unfavourable state were searched. To identify the relationship between the agricultural enterprise structure (type of production, hectares of land, number of employees, subsidies) and the use of the BI (and other important information systems), working hypotheses were formulated and verified. It was concluded that with 95% probability the type of production, the size of farmed land, the number of workers and the subsidies have no significant influence on the fact whether or not the farms use the BI and other expert and analytical systems.

To generalize the survey results, we can say that as to the hardware and software, the readiness for the BI use is at a very good level among small Czech farms. However, the motivation to use the ICT or the BI for a more effective farm management is worse. With the increase of the computer and information literacy of the farm managers, a higher acceptance of new technologies and information systems can be expected. This requires an analysis and reflection of new ways of work with the analytical data in the agrarian sector. It is obvious that the BI concepts and applications can serve for the optimization of the agricultural enterprise economics. If the calculations and multidimensional model are set correctly, they can help to build the economic balance sheets and to design various model situations for the online predictions and the farm managers' decision-making.

If the information barrier is reduced, the level of the BI use in agriculture will increase and it will become closer to the rate in other sectors of the national economy.

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