# PRODUCTIVITY PARADOX IN SELECTED SECTORS OF AGRI-FOOD PRODUCTION BRANCH IN POLAND

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**Abstract:** Results of studies on IT solutions advancement, financial situation, logistic costs, market position, and IT support for logistics quality level in Polish agri-food production companies are presented in the paper. This sector is very dispersed (98.9% are small and medium companies, and 69.7% with employment under 10 persons). Research was based on survey conducted among 511 food processing companies in 2010-2011. Results showed no correlation between IT solutions advancement and financial situation of company except for dairy and meat industries. In all industries an association between IT advancement level, market position and quality of computer support for company logistics was detected.

**Keywords:** productivity paradox, IT advancement, food production, financial situation

**JEL classification:** D22, L20, O12

## INTRODUCTION

Both in modern society and economy information plays the role of a key economic resource. Company abilities to effective collection, processing, analysis and using of information most often determine the possibility to gain an competitive advantage. Therefore, information technologies (IT) play such a significant role in the modern economy, which is often referred to as the digital economy or electronic business. Without adequate access to IT and skills to use

them even on a basic level, it is not possible full participation in contemporary social life. A society in which information is both merchandise, the most valuable asset and the most precious good is called information society. Economic development further increases information importance and in consequence it increases the using and advancement of modern technologies. The best example of these processes is the role of Internet, which has become the primary global communication channel in present economy and society [Castells 2011].

In common perception, investments for implementation and upgrade of technology and IT systems have strongly positive influence on various functioning aspects of companies on present markets. The most frequently mentioned benefits are: quality of management information improvement, better relationships with business partners, better service and relations with customers, increasing of competence level, higher operational efficiency, cash flows acceleration. Much less frequently mentioned positive effects of modern IT technologies using are: operating costs reduction and reduction of inventory level [Khazanchi 2005]. Whereas for a long time no direct impact of IT expenditures on better financial results of companies. This lack of correlation is known as "Productivity Paradox", which was identified and indicated in the late 1980s and early 1990s [Strassmann 1990; Brynjolfsson 1993; Loveman 1994; Barua, Lee 1997]. Explanation of this contradiction were sought in direct impact of IT investments on better organizational efficiency, higher ability to redefine and define new business processes, better possibility of business cooperation extension, higher level of trust and willingness to cooperate with the company [Brynjolfsson, Hitt 2000; Croteau, Bergeron 2001; Melville et al. 2004; Ryssel et al. 2004]. As a consequence enhancing of IT solutions advancement increases the potential of innovation and competitiveness of the enterprise but not its financial results [Henderson et al. 2010; Lim et al. 2011; Masli et al. 2011; Khalaf 2012]. This problem is particularly apparent in the sector of Small and Medium Enterprises (SME). The main reasons are significant less financial abilities and often worse organizational readiness for new technologies [Kim 2004; Love, Irani 2004; Dozier, Chang 2006; Bohorquez, Estevez 2008].

The role of technology and IT systems to improve the competitiveness of enterprises in all sectors of the economy is beyond doubt. This also applies to those sectors that are not traditionally associated with a broad using of modern information technology, such as agriculture and food processing. It should be noted that in recent years, this general opinion is rapidly changing, the best example is the concept of digital agriculture implemented in many countries and using in a wide range technologies of wireless networks and GPS positioning [Buick 1997; Auernhammer 2001; Hagar, Haythornthwaite 2005; Koutsouris 2010] . In an even greater extent this applies to food production sector, which plays also in the Polish economy a very important role. Agri-food processing branch generates about 17% of sold industrial output in Poland and it is responsible for about 12% of the value of Polish industry export [Jałowiecki 2018]. Companies in this sector are

characterized by complex supply chains involving a large number of suppliers of agricultural products and consumers of food products [Jałowiecki, Jałowiecka 2013]. Among others therefore in this branch efficient management of supply chains and their associated flows of information plays such an important role. In addition, especially in large companies, it is not possible its practical implementation without broad application technology and IT systems.

Table 1. Structure of Polish food production sector according to enterprise employment size and branch

| Sector | Large | Middle | Small | Micro | Total |
|---|---|---|---|---|---|
| Meat | 89 | 439 | 1322 | 3767 | 5617 |
| Fishes | 17 | 60 | 141 | 399 | 617 |
| Fruits and Vegetables | 26 | 148 | 337 | 1277 | 1788 |
| Oil and Fats | 2 | 9 | 38 | 163 | 212 |
| Milk | 45 | 144 | 135 | 722 | 1046 |
| Cereal and Starch | 6 | 52 | 178 | 1386 | 1622 |
| Bakery | 28 | 362 | 3722 | 8207 | 12319 |
| Other Groceries | 46 | 119 | 335 | 1871 | 2371 |
| Feed | 8 | 31 | 181 | 590 | 810 |
| Beverages | 25 | 84 | 287 | 849 | 1245 |
| Tobacco | 8 | 4 | 5 | 10 | 27 |
| Total | 300 | 1464 | 6734 | 19541 | 28039 |

Source: own preparation

According to the REGON database, Polish agri-food industry consists of more than 28 thousand companies (see Table 1). 70% were microenterprises, which employed up to 9 employees, 24% are small enterprises with 10 to 49 employees, 5% are medium-sized companies with 50 to 249 employees, and only 1% are large enterprises with employment of 250 or more. Definitely the largest sector was 44.5% of bakeries. Significantly higher than other industries was also meat industry with 20.3% of companies. Other sectors include from 2 to 6% of the companies, except for the oil and fat, and tobacco industries, which had less than 1% of companies. Introduction of modern IT systems is connected with the necessity of fairly significant investments. Meanwhile 98.9% of agri-food companies are small or medium enterprises and they have generally significantly less financial opportunities than large enterprises. In this case, implementation of modern, highly integrated and expensive IT systems may be serious problem.

## MATERIAL AND METHODS

The results presented in the paper are the part of a much larger research to diagnose the state of logistics and information solutions in the Polish food production industry. Objective of this part of study was to verify the existence of

productivity paradox in selected sectors of food production branch. Correlations between used information solutions advancement, and its financial situation, logistic costs level, market position against the whole branch, and quality of IT support for logistics were examined. Data from survey research conducted in 2009-2011 in Polish food production companies were used as a main data source. There were obtained responses from 511 companies.

Examined companies was divided into subgroups due to its production sector. Six sectors in which the number of responses was sufficiently large were selected to the study. There were sectors of: meat, fruit and vegetable, milk, cereal and starch, bakery and other groceries production. In studies on individual questions obtained different numbers of responses. Only such companies were taken into account. For example, when determining the strength of correlation between the used IT solutions advancement, and the financial situation of the company, only 493 companies were taken into account. The reason was the fact that 9 companies did not provide its sector, and 10 companies did not provide its financial situation too, including 1 company, which did not specify both parameters.

To determine the advancement of used IT solutions level proposed in the paper Jałowiecki and Jałowiecka [2013] coefficient was used. It was constructed on the basis of six components:

- comprehensive IT system using (values: 0 points for negative answer, 1 point for affirmative answer);
- five areas of logistics supporting by IT systems: transport, stocks, packaging and reverse logistics, storage management, order management and forecasting (values: 0.2 points for each affirmative answer, number of points possible to obtain from 0 to 1);
- information transfer principal method in internal circuit (values: 0 – any declaration, 1 – verbally, 2 – by paper documents, 3 – by phone, 4 – by fax, 5 – via e-mail and/or Internet communicators, 6 – via software and/or IT systems);
- information transfer principal methods in external circuit (values: the same as in the case of internal information circuit);
- used IT system proficiency level (values: 0 – any system, 0.2 – Financial and Accounting (FA) system and/or popular utility software, e.g. MS Excel spreadsheet, 0.4 – Electronic Data Interchange (EDI) system, 0.6 – Materiel Requirements Planning (MRP) or Manufacturing Resource Planning (MRP II) system, 0.8 – Enterprise Resource Planning (ERP or ERP II), 1 – system functioning due to Business Intelligence (BI) philosophy);
- using business forecasts building method (values: 0 – any formal forecasts, 0.2 – production based on the raw material supply, 0.4 – production depending on orders received, 0.6 – forecasting based only on data from company, 0.8 – forecasting based only on the market data, 1 – forecasting based both on company and market data).

This coefficient was categorized into five categories: very low, low, average, high and very high, by the fact that the other variables included in the studies also take categorized into five values. Its values were ranged from 0 to 5. Categorization of coefficient was carried out by a balanced sharing the range of values for five classes of equal width.

To assess the strength of the correlation between studied variables and the advancement of used IT solutions, Spearman's rank correlation coefficient was used. The use of Spearman's rank correlation coefficient was related to the fact that among examined variables, there is a logical sequence of values. The financial situation of the company was defined by four categories: 1 – very bad, 2 – rather bad, 3 – mediocre, 4 – rather good, 5 – very good. The costs related to logistics were defined as a share of total costs incurred by the company and have taken four categories: 1 – very high, 2 – rather high, 3 – average, 4 – rather low, 5 – very high participation. The position of company in the market was categorized on four categories: 1 – very weak, 2 – rather weak, 3 – average, 4 – rather strong, and 5 – very strong. The logistics IT support quality has four possible values: 1 – very poor, 2 – rather poor, 3 – mediocre, 4 – rather good, and 5 – very good. Only in one case, instead of the Spearman rank correlation coefficient and t-Student distribution test, $\chi^2$ independence test and V-Cramer coefficient were used. $\chi^2$ test and V-Cramer were used to examine the existence of statistically significant dependence between the advancement level of used IT solutions and companies belonging to the sector. There were used, because there was no logical order of studied sectors as in the cases of other variables.

## RESULTS

At the beginning it was examined whether the company sector differentiates IT solutions advancement level statistically significant. According to the $\chi^2$ test of independence, it was found that these two variables are dependent on each other. The value 0.23 of the V-Cramer coefficient indicated weak relationship between them.

Among the surveyed companies the highest average level of applied IT solutions advancement were found in the milk sector (average was 3.33), and fruit and vegetables (2.97), whereas the lowest in the bakery sector (2.24). In this case, an average level for all surveyed enterprises was 2.51. The highest average level of declared financial condition was found in bakery companies (2.16), while the lowest was in the milk (1.92), and cereal and starch production companies (1.97). In this case, an average level for all surveyed enterprises was 2.10. The lowest average level of declared logistic costs was found in cereal and starch (2.03), meat (2.07), and bakery (2.10) companies, the highest in other groceries (2.33) sector. In this case, an average level for all surveyed enterprises was 2.13. The strongest position on the market against the whole sector, was found in meat (2.76), and milk (2.75) production companies, the weakest position in cereal and starch (2.54)

enterprises. The highest level of IT support for logistics was found in companies from milk sector (2.54), and the lowest level in cereal and starch (2.03), and bakery (2.05) enterprises. In this case, an average level for all surveyed enterprises was 2.12 (see Table 2).

Table 2. Average values and standard deviation of IT solutions advancement coefficient, and declared financial condition, logistic costs level, company's market position against the sector, and quality of IT support for logistics level indicators

| Sector | IT solutions adv. coefficient | Declared financial condition | Declared logistic costs level | Declared market position of company | Declared logistics IT support quality level |
|---|---|---|---|---|---|
| Meat | 2.59 ± 1.01 | 2.06 ± 0.48 | 2.07 ± 0.89 | 2.76 ± 0.53 | 2.10 ± 0.92 |
| Fruits and Vegetables | 2.97 ± 1.03 | 2.12 ± 0.65 | 2.16 ± 0.77 | 2.68 ± 0.52 | 2.27 ± 0.79 |
| Milk | 3.33 ± 0.91 | 1.92 ± 0.28 | 2.17 ± 0.82 | 2.75 ± 0.50 | 2.54 ± 0.68 |
| Cereal and Starch | 2.47 ± 1.16 | 1.97 ± 0.54 | 2.03 ± 0.97 | 2.54 ± 0.75 | 2.03 ± 0.97 |
| Bakery | 2.24 ± 0.82 | 2.16 ± 0.53 | 2.10 ± 0.97 | 2.69 ± 0.58 | 2.05 ± 0.97 |
| Other Grocery | 2.76 ± 0.99 | 2.11 ± 0.53 ± | 2.33 ± 0.84 | 2.66 ± 0.62 | 2.22 ± 0.94 |
| Total* | 2.51 ± 1.00 | 2.10 ± 0.54 | 2.13 ± 0.95 | 2.68 ± 0.61 | 2.12 ± 0.95 |

* Values for all surveyed companies belonging to all 10 sectors
Source: own preparation

The results of previous studies indicates no correlation between the used IT solutions advancement level, and the financial situation of the company (Spearman's correlation coefficient was 0.05). It was also found a weak but statistically significant, negative correlation between the used IT solutions advancement level and the level of logistics costs (0.17). Despite the absence of direct impact of modern IT technologies using on the financial results of companies, there was a significantly stronger correlations between the level of IT technologies advancement and market position the company (0.34) and the quality of IT support logistics (0.44). These correlations were growing stronger in increasing categories of company employment size [Jałowiecki, Jałowiecka 2013].

Analysis of the correlation between the level of used IT solutions advancement, and the financial situation of the company in different sectors,

indicates the division of the surveyed sectors on the two or three groups. The first group included companies from the meat and milk sector, which was a statistically significant, positive correlations. In the dairy industry correlation was almost twice as strong as in meat sector. The second group includes the other sectors in which there was no statistically significant correlation between studied variables. Third group may be determined for clearly visible, but statistical insignificant, negative correlation in fruits and vegetables sector.

It means that the growing of IT advancement level results the deterioration of the financial situation of the company (see Table 3).

Table 3. Spearman correlation between the level of used IT solutions advancement and the financial situation of company coefficient values depending on the branch (significance level $\alpha=0.05$)

| Sector | $r_S$ | t | p-value | $t_\alpha$ |
|---|---|---|---|---|
| Meat | 0.26 | 2.82 | 0.01 | 1.98 |
| Fruits and Vegetables | -0.22 | -1.26 | 0.22 | -2.04 |
| Milk | 0.42 | 2.19 | 0.04 | 2.07 |
| Cereal and Starch | 0.01 | 0.05 | 0.96 | -2.03 |
| Bakery | 0.10 | 1.39 | 0.17 | 1.97 |
| Other Groceries | 0.03 | 0.20 | 0.84 | 2.02 |

Source: own preparation

Taking into account the correlation between the advancement of used IT solutions, and the level of logistics costs, it was also the division of the surveyed industries into the 3 groups. The first group included only the meat sector, which a negative correlation was found.  No statistically significant correlations were found in the other five sectors. For baking and other groceries sectors there were positive correlations, negative in other sectors (see Table 4).

Table 4. Spearman correlation between the level of used IT solutions advancement and the share of logistics costs in the total cost of the company coefficient values depending on the branch (significance level $\alpha=0.05$)

| Sector | $r_S$ | t | p-value | $t_\alpha$ |
|---|---|---|---|---|
| Meat | -0.32 | -3.29 | <0.01 | -1.98 |
| Fruits and Vegetables | 0.14 | 0.75 | 0.46 | 2.04 |
| Milk | 0.07 | 0.31 | 0.76 | 2.07 |
| Cereal and Starch | 0.16 | 0.91 | 0.37 | 2.03 |
| Bakery | -0.14 | -1.92 | 0.06 | -1.97 |
| Other Groceries | -0.19 | -1.25 | 0.22 | -2.02 |

Source: own preparation

In all industries there was a statistically significant positive correlation between the level of advancement of used IT solutions and market position of the

company. The strongest dependence was observed in the fruit and vegetable and milk sectors, and the weakest in bakery sector (Table 5).

Table 5. Spearman correlation between the level of used IT solutions advancement and the company position on the market against the sector coefficient values depending on the branch (significance level α=0.05)

| Sector | $r_S$ | t | p-value | $t_\alpha$ |
|---|---|---|---|---|
| Meat | 0.37 | 4.29 | <0.01 | 1.98 |
| Fruits and Vegetables | 0.55 | 3.55 | <0.01 | 2.05 |
| Milk | 0.64 | 3.90 | <0.01 | 2.07 |
| Cereal and Starch | 0.36 | 2.21 | 0.03 | 2.03 |
| Bakery | 0.28 | 4.13 | <0.01 | 1.97 |
| Other Groceries | 0.43 | 3.06 | <0.01 | 2.02 |

Source: own preparation

The situation is similar in the case of the correlation between used IT solutions advancement level, and the quality of IT support of logistic operations. Definitely the strongest relationship was found in the case of enterprises in the cereal and starch production. The weakest dependences were found in the sectors of other groceries and meat production companies (Table 6).

Table 6. Spearman correlation between the level of used IT solutions advancement and the quality level of IT support for logistics coefficient values depending on the branch (significance level α=0.05)

| Sector | $r_S$ | t | p-value | $t_\alpha$ |
|---|---|---|---|---|
| Meat | 0.34 | 3.51 | <0.01 | 1.98 |
| Fruits and Vegetables | 0.49 | 2.94 | 0.01 | 2.05 |
| Milk | 0.53 | 2.95 | 0.01 | 2.07 |
| Cereal and Starch | 0.66 | 4.93 | <0.01 | 2.04 |
| Bakery | 0.36 | 5.13 | <0.01 | 1.97 |
| Other Groceries | 0.47 | 3.13 | <0.01 | 2.02 |

Source: own preparation

## CONCLUSION

Among the analyzed six sectors of food processing, diversification of enterprise employment structure was similar to the structure of the whole sector: 1.08% of large enterprises, 5.25% middle, 24.4% small, and 69.53% microcompanies. Only among dairy enterprises significantly more large and medium enterprises were functioned (respectively 4.30% and 13.77%). In turn, in cereal and starchy and bakery sectors a share of large enterprises was significantly lower than the nationwide (more appropriately 0.37% and 0.23%).

Stimulating effect of higher advancement level of used IT solutions for better financial situation of enterprises was only found in the dairy and meat

sectors. In the first industry it was almost twice strong as in the second (Table 3). For both sectors among suppliers of agricultural raw materials dominates definitely individual farmers, and among recipients of food retail shops. Simultaneously, in both cases these are the sectors with the highest average number of suppliers and customers [Jałowiecki, Gostkowski 2013] . Most likely, this means that the use of suitably effective IT solutions can significantly improve a number of cooperative relations. A large number of logistic connections coupled with the fact that both industries were provided biggest investments necessary to adapt production base and food quality control systems to obligatory requirements in European Union.

Significant reduction of logistics costs was accompanied by a more advanced IT solutions only in the meat production sector (Table 4). This is a sector in which structure of employment size of companies, and the average level of advancement of IT solutions is very similar to the national average (Tables 1 and 2). Part of the explanation for this is definitely an advantage for individual farmers of agricultural raw materials suppliers and retail shops among food products recipients [Jałowiecki, Gostkowski 2013]. In this situation, a higher level of advancement of used IT systems, implies not only to their better efficiency of the systems themselves, but also for better opportunities to optimize logistics. This means undoubtedly reducing logistics costs. However, in the case of the dairy sector with a very similar structure of suppliers and recipients, such a relationship is not found. It seems that in this case a greater share of large companies is not a sufficient explanation for this difference.

In all studied sectors a statistically significant relationship between higher advancement level of used IT solutions and better market position and better quality of IT support logistics was identified. Correlations were definitely strongest in the industries of dairy, fruit and vegetable production companies, and definitely weakest in meat and bakery. Only in the cereal and starch sector a little impact on the market position and at the same time the greatest impact on the quality of IT support for logistics were found.

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