Economics and Organization of Logistics
5 (1), 2020, 41–54

DOI: 10.22630/EIOL.2020.5.1.4

Piotr Jałowiecki
Warsaw University of Life Sciences – SGGW

Advancement level of logistic information management systems in Polish food industry

Poziom zaawansowania systemów zarządzania informacją logistyczną w polskim przemyśle spożywczym

Abstract. The paper presents the results of research on differentiation of the advancement level of solutions and logistics management systems based on ICT (Information and Communication Technologies) used in the Polish food industry. The research was conducted in terms of industry, employment size and three market characteristics of the surveyed enterprises: investment level, financial situation and market position. The study used the IAI (Information Advancement Index) synthetic indicator and two methods for categorizing its values: uniform across the range of values and based on mean values and standard deviation. The paper also presents the reference of the obtained research results to the productivity paradox of Solow and the results of similar research previously carried out on the level of advancement of logistics solutions and systems in the Polish food industry.

Key words: food industry, information management systems, logistic information, advancement level, synthetic index

Synopsis. W pracy przedstawiono wyniki badań nad zróżnicowaniem poziomu zaawansowania rozwiązań i systemów zarządzania informacją logistyczną opartych na technologiach ICT (Information and Communication Technologies) wykorzystywanych w polskim przemyśle spożywczym. Badania przeprowadzono w ujęciu branżowym, wielkości zatrudnienia oraz trzech charakterystyk rynkowych badanych przedsiębiorstw: poziomu inwestycji, sytuacji finansowej i pozycji rynkowej. W badaniach wykorzystano wskaźnik syntetyczny IAI (Information Advancement Index) oraz dwie metody kategoryzacji jego wartości – równomierną w całym zakresie wartości oraz opartą na wartościach średniej i odchylenia standardowego. W pracy zaprezentowano również odniesienie uzyskanych wyników badań do paradoksu produktywności Solowa oraz wyników analogicznych badań przeprowadzonych wcześniej nad poziomem zaawansowania rozwiązań i systemów logistycznych w polskim przemyśle spożywczym.

Słowa kluczowe: przemysł spożywczy, systemy zarządzania informacja, informacja logistyczna, poziom zaawansowania, wskaźnik syntetyczny

Introduction

In modern society, information plays a key role. It is treated as a good, ware and one of economic resources equivalent or more often more important than other traditional goods such as land, real estate, capital or labor. In such a society, the economy is based on knowledge, which is treated as a strategic, albeit intangible resource of economic entities. That is why the possibilities of access, processing for own needs and using information determine the possibilities of effective conducting business activity and gaining competitive advantage. At the same time, the readiness, preparation and skills of using various ICT information and communication technologies enable full participation in social life, and their lack most often determines partial or total exclusion from it. Such society was initially referred to as the Postindustrial Society. This term was popularized in the early 1960's by the American economist Bell [1962, 1973]. Currently, the term Information Society by Japanese anthropologist Umesao [1963], which appeared in literature almost simultaneously, is used much more often.

Also in the modern economy, the ability to obtain information, their effective processing into usable information, as well as manage it are one of the most important factors determining the possibility of achieving market success by enterprises. The authorship of the concept of the knowledge-based economy, its use as a key factor in economic development and the condition for achieving commercial successes, as well as the concept of the information sector consisting of entities managing knowledge and providing information services is attributed to the American economist Machlup [1962]. Closely linking economic activity with the effective use of information resources is not possible today without extensive use of ICT. That is why the modern economy is often referred to as Electronic or Digital Economy. This term was popularized by the well-known Canadian economist Tapscott, although his authorship is often attributed to the American architect Negroponte [Negroponte 1996, Tapscott 1997, Tapscott et al. 1999]. One of the characteristics of such an economy is the rapidly growing number and increasing availability of transactions concluded exclusively via digital technologies. Economic activity based on ICT, primarily the Internet, is referred to as e-business or, more often, e-business.

The digital economy is embedded in the information society, and the most important binder and foundation without which it would not be possible for them to be created are ICT technologies and systems commonly used for storing, processing and transmitting information. Rational information management both within business entities and as part of cooperative cooperation is not only a factor contributing to better business efficiency, but above all a necessity in the modern global market with a high level of competitiveness. Digital information management concerns many areas of activity of individual enterprises, as well as various areas of the economy as a whole. In the modern digital economy, ICT technologies are widely used in virtually all sectors of the economy, including those that are not traditionally associated with them, e.g. in agriculture or the food industry.

Information solutions and systems based on modern ICT technologies are implemented primarily to improve the productivity of enterprises understood as both profitability, efficiency, as well as better financial liquidity and lower debt levels. However, in the 70s and 80s of the last century, the results of empirical research on the state of the economy in the US showed a decrease in productivity despite very significant and increasing invest-

ments in modern technologies of information processing and transmission. The results obtained have not confirmed in any way the existence of a positive relationship between the implementation of modern information and communication technologies and the increase in productivity. In addition, it turned out that the largest decrease in productivity occurred in sectors of the economy in which investments in ICT technologies were the largest and the share in employment of people serving them was the highest [Brynjolfsson 1993]. Therefore, as early as 1987, Solow formulated his famous productivity paradox, noting that investments in increasingly modern ICT solutions that are catalysts of change in almost all areas of life, do not translate into increased productivity both on a micro- and macroeconomic scale [Solow 1987].

The purpose of the work is to present the diversity of the level of advancement of solutions in the field of logistics information management using ICT exactly in the Polish food industry. It constitutes one of the most important sectors of the Polish economy, generating almost 17.5% of the value of sold production of Polish industry and 12.6% of Polish exports. In addition, it is a sector of industry characterized by a large diversity both in industry and in terms of employment. The selection as a food sector research area was dictated by two main premises. The first was the fact that the food sector is one of the most important branches of the Polish economy. The second is the fact that it is very diverse both in terms of industry and employment in enterprises. This premise led to the conclusion that also the occurrence of the Solow productivity paradox will be characterized by a large diversity both in individual industries and in employment size groups.

Characteristics of Polish food industry

Agriculture and food production have always played a significant role in the Polish economy. As a consequence, Poland has been and still is perceived as a large agricultural country as well as an important food producer [Borkowski et al. 2003]. Therefore, the agri-food processing sector plays a very important role in the Polish economy. Over the past 25 years, he has undergone significant changes that have completely changed his face. First, in the 90s of the last century they were associated with the social and political transformation, as a result of which the Polish economy transformed from centrally managed to free market. At that time, changes in the agri-food processing sector concerned mainly the ownership and organizational structure of enterprises as a result of privatization processes and foreign investments. Then, as a consequence of Poland's efforts to join the EU, both before and after accession, changes in the agri-food processing sector covered the organization and technology of food production. They were, in turn, a consequence of the need to adapt Polish food producers to EU legal regulations and quality standards [Krajewski and Borkowski 2002].

Despite significant transformations, the Polish food industry not only brilliantly coped with the problems resulting from the political transformation, but also quickly became a source of significant revenues for the state budget, as well as one of the sectors that strongly stimulated the development of the Polish economy. The most important factor driving the development of the agri-food processing sector was the opening of the Polish market to foreign entities. It resulted in almost a sudden increase in the level of competi-

tion on the market as a result of the emergence of foreign food concerns, characterized by a high organizational and technological level and large investment opportunities. Another negative stimulus for the development of the Polish food sector was undoubtedly the need to adapt enterprises to legal regulations and quality procedures in force in the EU, which was most often associated with the need for significant investments and implementation of modern technologies. Among the most important positive stimulators for the development of the food sector should be mentioned subsidies and subsidies, both before and after accession, which made it possible to carry out many modernization investments in Polish enterprises. In turn, integration with the EU market also enabled significant foreign investment in the processing industry. They not only ensured the inflow of funds, but also became a source of a number of important organizational and technological innovations [Jałowiecki 2018].

The Polish food industry generates 17.5% of total industrial production sold and 20.4% of the manufacturing industry. Exports of food products account for 12.6% of total Polish industry exports. The average employment in the food industry is 15.3% of employment in total industry and 18.0% of employment in the processing industry. Investment outlays in the food industry account for 11.3% of investment outlays in total industry and 21.4% of investment outlays in the processing industry.

In addition, the food sector is one of the most diverse in terms of industry (Figure 1) and in terms of employment (Figure 2). Bakeries constitute a very large overrepresentation in the Polish food sector (43.88% in 2015). In turn, enterprises producing tobacco products constitute only 0.22% of all entities operating within the sector. In addition, real and market-leading volume production (over 99% of cigarettes) is produced by four companies, which are currently owned by the largest international tobacco concerns: Philip

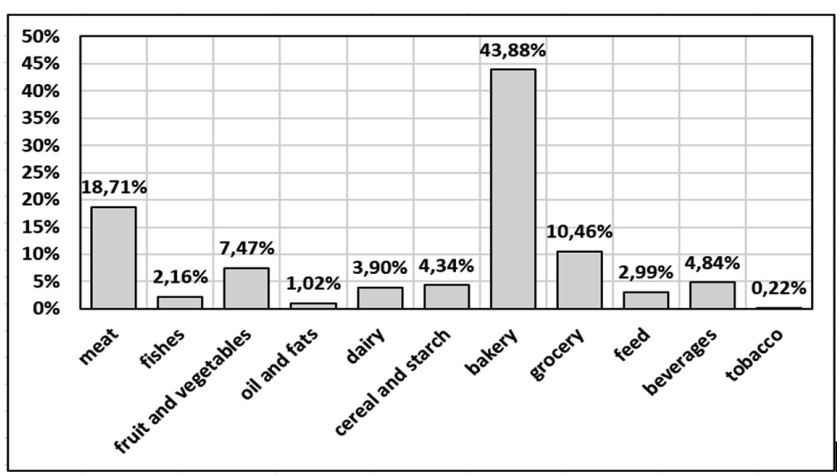

Figure 1. Sectorial diversity of the Polish food industry in 2015 (on the axis y number of studied enterprises)

Rysunek 1. Zróżnicowanie branżowe polskiego przemysłu spożywczego w 2015 roku (na osi y liczba badanych przedsiębiorstw)

Source: own study.

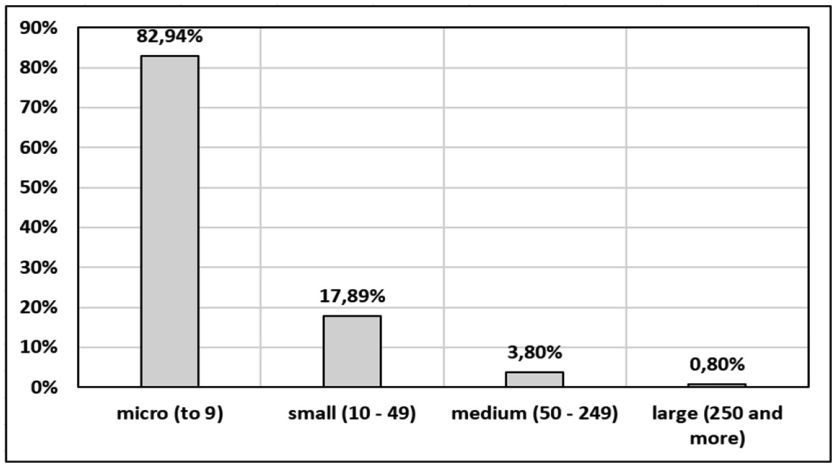

Figure 2. Diversification of food enterprises in terms of employment in 2015
Rysunek 2. Zróżnicowanie przedsiębiorstw spożywczych pod względem wielkości zatrudnienia w 2015 roku

Source: own study.

Morris, British-American Tobacco, Japan Tobacco International and Imperial Tobacco. Also, companies producing oil and fat products are very few. They constitute only 1.02% of entities belonging to the food sector.

Also in terms of the size of employment between individual groups of enterprises there are quite large differences in the number of entities. The vast majority are micro enterprises employing up to and including nine employees. The number of entities is steadily decreasing with the increase in the employment size group (Figure 2). As a consequence of The SME sector (small and medium-sized enterprises) comprises 99.2% of business entities operating on the food market.

The choice of the food sector as a research area, in addition to the interesting diversity of enterprises belonging to it, both industry and in terms of employment, was also dictated by the lack of research results in this area. Considering the results of research conducted earlier, the large diversification of the food industry and the industry in terms of size promised a good chance of checking the heterogeneity of the occurrence of the Solow productivity paradox.

Data source and methods

Source data used in the study came from a survey of 512 companies in the Polish food sector. The survey contained 56 questions that could be classified into three groups: general questions, solutions used in the field of resource management logistics, and solutions in the field of logistics information management together with ICT supporting them. Out of 11 food industries, the research did not cover two: fish and tobacco. The reason was the small number of enterprises belonging to these industries that responded to

the survey. However, all four groups of employment sizes in line with the classification used by the Central Statistical Office (GUS) were included. Consequently, the surveyed enterprises were divided into nine industries: meat, fruit and vegetable, oil and fat, dairy, cereal and starchy, bakery, food, feed and beverage production, and into four employment size groups: micro enterprises (up to nine employees), small enterprises (from 10 to 49 employees), medium (from 50 to 249 employees) and large (250 and more employees).

To assess the level of advancement of solutions in the field of logistics information management based on ICT technologies used in the surveyed enterprises, a dedicated IAI (ICT Advancement Index) was used, which was created as a result of aggregation of six characteristics of the surveyed enterprises (Table 1).

Index IAI values have been determined for individual enterprises as well as for all surveyed industries and employment size groups as the arithmetic mean value belonging to a given subgroup of entities.

The study used the value of the IAI indicator and selected characteristics of the surveyed enterprises (employment size, investments scale, financial situation, position on market) in a categorized form. Two methods of categorizing the values of examined variables were used and compared. The first method A consisted in evenly dividing the range of the value of the examined variable into a fixed number of intervals of the same width in

Table 1. Components of the synthetic indicator of the level of sophistication of information management solutions (IAI)

Tabela 1. Składniki wskaźnika syntetycznego poziomu zaawansowania rozwiązań w zakresie zarządzania informacją (WZI)

Components of the IAI index	Values
The fact of having one comprehensive information system.	1 for positive answer, 0 for negative response
IT support for five areas of logistics activities: transport, inventory management, packaging and returnable logistics, warehouse management, order management	1/5 for each affirmative answer
The way of providing information in the internal circulation (inside the organizational structure of the enterprise)	0 for failure to provide information, 1/6 for the declaration of oral communication in internal circulation, 2/6 for transmission on paper, 3/6 by telephone, 4/6 by fax, 5/6 by e-mail (e-mail) or instant messengers, 1 via computer programs
The method of transferring information in the external circulation (between the enterprise and market partners)	above
The level of comprehensiveness and technological advancement of your information system	0 for the lack of any information system, 1/5 for having an FA (Financial and Accounting) system, 2/5 for EDI (Electronic Data Interchange) system, 3/5 for MRP (Materiel Resources Planning) system, 4/5 for ERP (Enterprise Resources Planning), 1 for BI (Business Intelligence)
Method of preparing and using forecasts	0 for no formal forecasts prepared, 1/5 for production depending on the supply of raw material, 2/5 for production based on orders received, 3/5 for using only archival data from the enterprise for forecasts, 4/5 for using only market data, 1 for using both categories of data

Source: [Jałowiecki and Jałowiecka 2013].

accordance with formulas (1). The second method B, in order to determine the ranges of values of the studied variables, uses the division by mean value and fold standard deviation according to formulas (2). Both classification methods have been previously used in researching the differentiation of the level of sophistication of logistics solutions and systems in food enterprises [Jałowiecki 2019].

$$\begin{aligned}
&\text{very low} = 1 \quad \text{for } \min(x) \le x \le \overline{x} - s_x \\
&\text{low} = 2 \quad \text{for } \overline{x} - s_x < x \le \overline{x} - \frac{1}{2} \cdot s_x \\
&\text{middle} = 3 \quad \text{for } \overline{x} - \frac{1}{2} \cdot s_x < x \le \overline{x} + \frac{1}{2} \cdot s_x \\
&\text{high} = 4 \quad \text{for } \overline{x} - \frac{1}{2} \cdot s_x < x \le \overline{x} + s_x \\
&\text{very high} = 5 \quad \text{for } \overline{x} + s_x < x \le \max(x)
\end{aligned} \tag{1}$$

Where: $\overline{x}$ – average value of IAI index;
s_x – standard deviation of IAI index.

$$\begin{aligned}
&\text{very low} = 1 \quad \text{for } \min(x) \le x \le \min(x) + \frac{1}{5} \cdot \big(\max(x) - \min(x)\big) \\
&\text{low} = 2 \quad \text{for } \frac{1}{5} \cdot \big(\max(x) - \min(x)\big) < x \le \frac{2}{5} \cdot \big(\max(x) - \min(x)\big) \\
&\text{middle} = 3 \quad \text{for } \frac{2}{5} \cdot \big(\max(x) - \min(x)\big) < x \le \frac{3}{5} \cdot \big(\max(x) - \min(x)\big) \\
&\text{high} = 4 \quad \text{for } \frac{3}{5} \cdot \big(\max(x) - \min(x)\big) < x \le \frac{4}{5} \cdot \big(\max(x) - \min(x)\big) \\
&\text{very high} = 5 \quad \text{for } \frac{4}{5} \cdot \big(\max(x) - \min(x)\big) < x \le \max(x)
\end{aligned} \tag{2}$$

In examining the relationship between IAI values and selected characteristics of the surveyed enterprises, a linear regression model was used. The coefficient of determination R^2 was used to assess the fit of the estimated linear regression models. His definition is so common and known that it was decided to omit it at work.

For comparative purposes and due to the use of data in categorized form to assess the strength of the relationship between the level of sophistication of ICT solutions used and selected characteristics of the surveyed enterprises, the χ^2 independence test was also used according to the formula (3).

$$\chi^2 = \sum_{i=1}^{k} \sum_{j=1}^{l} \frac{\left(n_{ij} - \hat{n}_{ij}\right)^2}{\hat{n}_{ij}} \tag{3}$$

Where: i – number of categories of the first characteristic examined, e.g. employment size;
j – number of categories of the second characteristic examined, e.g. employment size;

n_{ij} – subgroup size in the multi-division table for row i and column j;
$\hat{n}_{ij}$ – theoretical size of the subgroup in the multi-division table in row i and column j.

Because the χ^2 test of independence used only identifies a significant or not statistical relationship, the following factors were used to assess its strength: T-Czuprow indicator according to formula (4) and V-Cramer indicator according to formula (5).

$$T_{xy} = \sqrt[2]{\frac{\chi^2}{n \cdot \sqrt[2]{(k-1) \cdot (l-1)}}} \tag{4}$$

$$V_{xy} = \sqrt[2]{\frac{\chi^2}{n \cdot min\,(k-1, l-1)}} \tag{5}$$

Where: n – sample size,
k – number of categories of x variable;
l – number of categories of y variable;
χ^2 – value of empirical test statistics.

The only major limitation of the above coefficients used to assess the strength of the relationship between the studied variables is the inability to indicate the direction of this relationship as is the case with correlation coefficients.

Obtained results

The average IAI value for all surveyed enterprises was $\overline{x}$ = 2.03, and the standard deviation was s = 0.99. Consequently, the coefficient of variation was w = 49.1%. Therefore, the differences in the absolute value of the IAI should be assessed as not very high. A typical range of variation for the IAI value was from x = 1.03 to x = 3.02, which meant that 352, or 68.9% of surveyed enterprises, belonged to the range of variation.

Considering the researched food industries, definitely the highest level of advancement of ICT solutions used was found in dairy enterprises, while definitely the lowest in bakeries, cereal and starch enterprises and producing feed. Such results were obtained using both methods of categorization A and B (Figure 3). The obtained results confirm the fact that the most advanced information management solutions are used in industries with the most complex technological processes, while the least advanced in industries characterized by not very complex technologies in the production of food products [Jałowiecki 2018].

By examining the level of advancement of ICT solutions and systems in individual employment size groups, a very strong relationship was found between the increase in employment volume and the higher value of the IAI index. This situation took place both using the categorization method of the surveyed enterprises A and B (Figure 4).

The study of the relationship between the level of advancement of solutions in the field of logistics information management based on ICT and the scale of investments made by food enterprises has clearly demonstrated a strong relationship between both characteristics. The higher the investment level, the higher the level of ICT solutions and

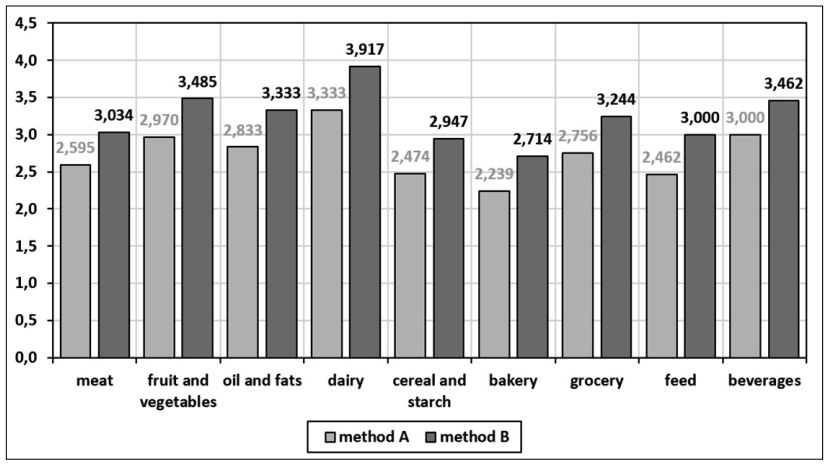

Figure 3. Average IAI index values in the analyzed food industry sectors in Poland
Rysunek 3. Średnie wartości wskaźnika WZI w badanych branżach przemysłu spożywczego w Polsce

Source: own study.

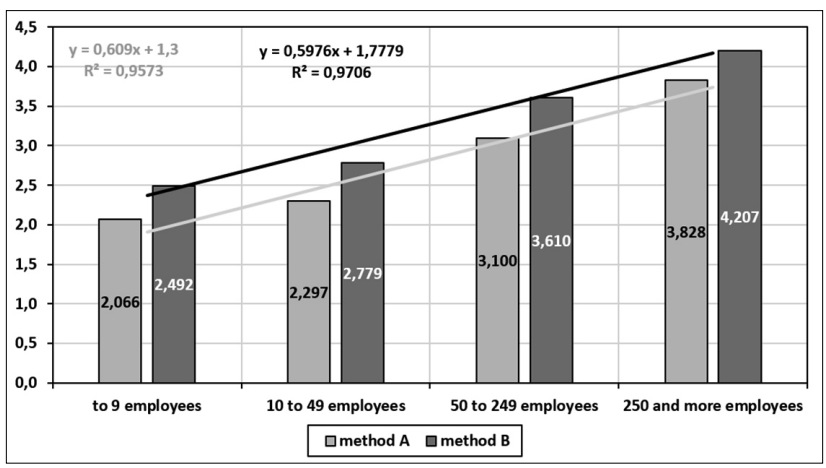

Figure 4. Average IAI index values in the analyzed food industry sectors in Poland
Rysunek 4. Średnie wartości wskaźnika WZI w badanych branżach przemysłu spożywczego w Polsce

Source: own study.

systems. At the same time, this relationship was somewhat stronger when the B categorization method was used (Figure 5).

The analysis of the relationship between the level of advancement of ICT technologies used to manage logistics information and the financial situation of Polish food enterprises regardless of the categorization method used (A or B) showed a very strong relationship

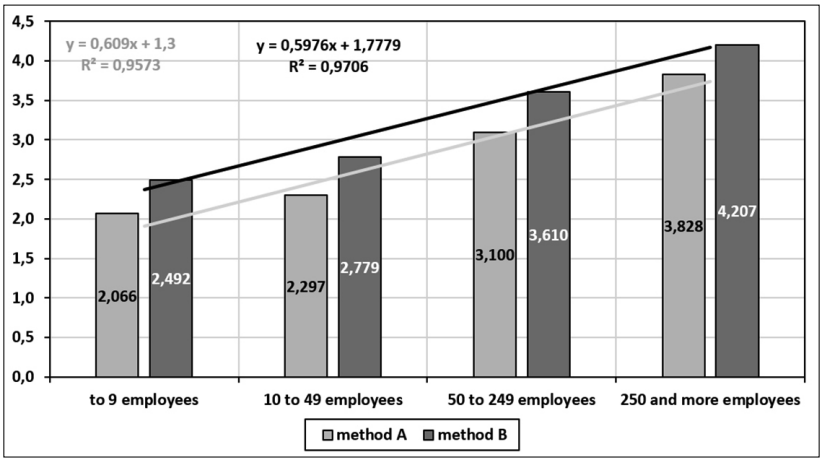

Figure 5. Average IAI values in groups of investment level in polish agri-food companies.
Rysunek 5. Średnie wartości WZI w grupach poziomu inwestycji w polskich przedsiębiorstwach rolno-spożywczych.

Source: own study.

between a higher IAI value and a lower ocean of financial situation (Figure 6). This situation confirms the existence in the Polish food sector of the Solow productivity paradox in its traditional form, i.e. that investments in modern ICT technologies do not translate directly into the financial result of economic entities making them.

In turn, the analysis of the relationship between the level of advancement of ICT solutions used primarily for logistics information management and the market position of the

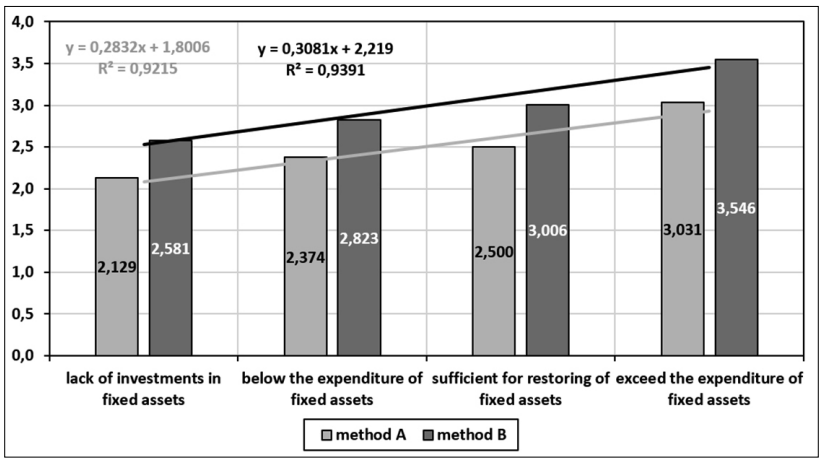

Figure 6. Average IAI values in groups of financial situation level in polish agri-food companies
Rysunek 6. Średnie wartości WZI w grupach poziomu sytuacji finansowej w polskich przedsiębiorstwach rolno-spożywczych

Source: own study.

company indicates a very strong positive relationship, i.e. the higher the level of advancement of ICT solutions and systems used, the better ocean market position of enterprises (Figure 7). In turn, such results seem to contradict the Solow productivity paradox in the Polish sector. It is also worth adding that they are very similar to each other using both methods A and B when categorizing the surveyed business entities.

The results obtained with regard to the occurrence of the Solow productivity paradox seem to be somewhat contradictory. This is confirmed by the results of previous studies. However, the explanation of this contradiction should be sought in the selective occurrence of the aforementioned paradox in various aspects of productivity, such as operational efficiency, profitability, financial liquidity or level of debt, as well as in the diversity of its occurrence in various industries and employment size groups [Jałowiecki 2018].

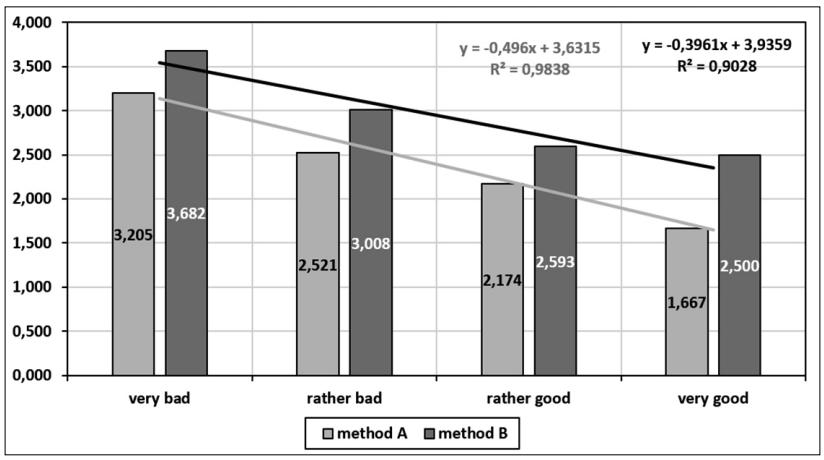

Figure 7. Average LAI values in groups of market position level in polish agri-food companies
Rysunek 7. Średnie wartości LAI w grupach poziomu pozycji rynkowej w polskich przedsiębiorstwach rolno-spożywczych

Source: own study.

As already mentioned, for the purposes of comparison, an χ^2 independence test was carried out to assess the statistical significance of the relationship between the level of advancement of logistics information management solutions based on ICT technologies and systems on the one hand, and employment, investment level, financial situation and market position on the other hand (Tables 2 and 3).

Table 2. Independence χ^2 test results for method A
Tabela 2. Wyniki testu niezależności χ^2dla metody A

Characteristics of enterprises	χ^2	$\chi^2_{\alpha,df}$	*p*-value	T_{xy}	V_{xy}
Employment size	144.847	21.026	< 0.001	0.287	0.309
Investments scale	434.357	21.026	< 0.001	0,521	0,560
Financial situation	65.637	21.026	< 0.001	0.194	0.209
Position on market	556.284	21.026	< 0.001	0.570	0.613

Source: own study.

In order to assess the strength identified as statistically significant relationships, the values of T-Czuprow and V-Cramer coefficients were determined, using the A and B methods of categorization of IAI index values (Tables 2 and 3).

Table 3. Independence χ^2 test results for method B
Tabela 3. Wyniki testu niezależności χ^2dla metody B

Characteristics of enterprises	χ^2	$\chi^2_{\alpha,df}$	p-value	T_{xy}	V_{xy}
Employment size	132.776	21.026	< 0.001	0.275	0.295
Investments scale	457.925	21.026	< 0.001	0.535	0.575
Financial situation	68.016	21.026	< 0.001	0.198	0.213
Position on market	578.667	21.026	< 0.001	0.582	0.625

Source: own study.

The results obtained using the A and B categorization methods of the IAI index were very similar. Definitely the strongest were the relationships between the level of advancement of IAI solutions and systems, and market position and the scale of investment. Both dependencies were positive (the increase of one variable was accompanied by the increase of the other). The relationship between IAI and employment was also significantly weaker, but also positive and statistically significant. However, the weakest relationship was definitely the weakest (the increase in one variable was accompanied by a decrease in the other) between the level of advancement of ICT technologies used and the financial situation of the surveyed enterprises.

Conclusions

Comparing the obtained research results on the differentiation of the level of advancement of logistics information solutions and systems based on ICT technologies with the same differentiation of the level of advancement of logistics systems, it should be stated that they are shaped in a similar way [Jałowiecki 2019]. This confirms the results of previous studies, according to which the traditional understanding of the Solow productivity paradox regarding ICT should be extended to include logistic solutions and systems operating in close convergence with the former.

On the other hand, comparing the results of analyzes of the relationship between the level of advancement of ICT solutions and systems with selected characteristics of the surveyed food enterprises obtained using methods A and B categorization of IAI index values, very similar results were obtained. A completely different situation took place during similar studies previously carried out for the level of advancement of solutions and systems in the field of logistics [Jałowiecki 2019]. In these studies, the methods used to categorize the LAI (Logistic Advancement Index) identical to those described in the paper, describe the level of advancement of logistic solutions and systems in Polish food enterprises. On the basis of the results of both studies, of course, one cannot prejudge the smaller or greater effectiveness of the methods of categorizing the values of synthetic

indicators IAI and LAI, but one should be aware that despite very many convergences in terms of differentiation of the level of ICT and logistics solutions, there are also significant differences.

This indicates significant differences between the differences in the occurrence of the Solow productivity paradox in the Polish food industry, which indicate the need for further in-depth research in this thematic area. Such studies should undoubtedly take into account more characteristics of IT solutions used in the surveyed enterprises.

References

Bell D., 1962: The End of Ideology: On the Exhaustion of Political Ideas in the Fifties, Harvard University Press, Cambridge.

Bell D., 1973: The Coming of Post-Industrial Society: A Venture in Social Forecasting, Basic Books, New York.

Borkowski B., 2003: Systemy informacyjne w rolnictwie na potrzeby Wspólnej Polityki Rolnej [Information systems in agriculture for the needs of the Common Agricultural Policy], Warsaw University of Life Sciences Press, Warsaw [in Polish].

Brynjolffson E., 1993: The Productivity Paradox of Information Technology, Communications of the ACM 36(12), 67–77.

Jałowiecki P., Jałowiecka E., 2013: Ocena stopnia zaawansowania rozwiązań w zakresie zarządzania informacją w polskich przedsiębiorstwach przetwórstwa rolno-spożywczego [Assessment of the advancement of information management solutions in Polish agri-food processing companies], Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu 15(3), 106–111 [in Polish].

Jałowiecki P., 2018: Paradoks produktywności Solowa w polskim przemyśle spożywczym [Solow's productivity paradox in the Polish food industry], Warsaw University of Life Sciences Press, Warsaw [in Polish].

Jałowiecki P., 2019: Advancement level of logistic systems in Polish agri-food industry, [in]: K. Michalski (ed.) Supply chain logistics management, Ekonomika i Organizacja Logistyki 4(4), 61–74. DOI: 10.22630/EIOL.2019.4.4.33

Krajewski K., Borkowski B., 2002: Organizacja, regulacje i informacja na rynku rolnym Unii Europejskiej [Organization, regulations and information on the agricultural market of the European Union], Warsaw University of Life Sciences Press, Warsaw [in Polish].

Machlup F., 1962: The Production and Distribution of Knowledge in the United States, Princeton University Press, Princeton, New Jersey.

Negroponte N., 1996: Being Digital, Random House Vintage Books, New York.

Solow R.M., 1987: We'd Better Watch Out, New York Times Book Review, New York Times, July 12, 36.

Tapscott D., 1997: The Digital Economy: Promise and Peril In The Age of Networked Intelligence, McGraw-Hill, New York.

Tapscott D., Ticoll D., Lowy A., 1999: Blueprint to the Digital Economy: Creating Wealth in the Era of E-Business, McGraw-Hill, New York.

Umesao T., 1963: Information Industry Theory Dawn of the Coming Era of the Ectodermal Industry, Hoso Asahi, Tokyo.

Correspondence address:

Piotr Jałowiecki, PhD, habil., Eng.
(https://orcid.org/0000-0002-3610-2151)
Warsaw University of Life Sciences in Warsaw – SGGW
Management Institute
Nowoursynowska St. 166, 02-787 Warsaw, Poland
tel.: (+48) 22 593 72 85
e-mail: piotr_jalowiecki@sggw.pl