

DUPONT ANALYSIS OF POLISH AGRI-FOOD INDUSTRY SELECTED SECTORS – LOGISTIC ASPECTS

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Abstract: The food industry is one of the most important branches of the Polish economy, primarily because of its significant contribution to GDP. Simultaneously, it is a branch wherein logistics is very important, and the structure of logistic networks is characterized by a high level of complexity. The paper presents the results of research on the complexity of logistics structure and the level of advancement of logistics solutions in selected food industry sectors. In addition, the results of a study on the relationship between the complexity of logistics networks, the advancement of logistics systems and the four aspects of productivity: efficiency, profitability, liquidity and debt are also presented. For this purpose, a number of financial indicators were used based on the methodology proposed under the so-called du Pont Pyramid.

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1. INTRODUCTION

Agriculture and agri-food production have always played a significant role in the Polish economy, and our country has and continues to be seen as an important food producer in the European market. According to the Polish Central Statistical Office (GUS) mass statistical data currently Poland is the sixth largest exporter of food in the European Union (EU), and food products sold accounts for more than 1/5 of total industrial output. In the food branch, about 16% of all employees in Poland were employed. The value of food exports accounts about 13% of the total value of Polish exports. Simultaneously, especially after accession to the EU, due to the necessity to adapt to European standards and regulations, the Polish agri-food industry has undergone very significant structural and technological changes. Nowadays, it is the source of many innovations and the place of applying modern technologies. One of the most important areas for modernization and implementation of innovation are resource management and logistics. The reason is the very complex structure of logistics networks within which food producers operate.

On average, a food company in Poland acquires agricultural products from 98 suppliers, offering 102 different assortment items for 137 customers. However, in the dairy industry, for example, there are 441 suppliers, 48 assortment items and 1375 buyers. Similarly, in the group of the largest companies employing 250 or more employees there are 278 suppliers, 222 assortment items and 1396 customers (Jałowicki, 2016). All this necessitates an increase in the complexity and level of advancement of the internal logistics systems of food companies. These systems must also be adapted to manage and coordinate large-scale co-operation processes often dispersed within multidimensional logistic networks. Therefore, logistics systems are now operating on the basis of integrated Enterprise Resource Planning (ERP) systems and/or using dedicated software for strict logistics applications such as Warehouse Management System (WMS), Supply Chain Management (SCM), Customer Relationship Management (CRM), Supplier Relationship Management (SRM) and Electronic Data Interchange (EDI). Increasingly, IT resource and logistics systems are referred to as integrated Logistics Information Systems (LIS) (Cimmin-Wattiau & Akoka, 1996; Helo & Buczs, 2005; Perdana, 2012; Kubasáková, Kampf & Stopka, 2014).

The close synergy of logistics and ICT systems has yet another significant consequence. In both business practice and research, at the turn of the 1980s and 1990s, there was a fundamental contradiction, which was called Solow's paradox of productivity, after the name of its explorer. Generally speaking, it is that investing in increasingly modern ICT technologies and systems does not translate directly into companies productivity growth, above all in financial results (Solow, 1987). The research conducted by the Polish food companies showed that the paradox of

Solow's productivity is about the same level of resources management and logistics solutions as information systems (Jałowiecki, 2016).

It should also be emphasized that the Polish food sector is highly diversified internally. It consists of 11 major industries. In terms of the number of companies, bakeries dominate, which is about 42% according to REGON data. Nonetheless, there are also industries such as tobacco which account for only 0.2% of the entities, or oil and fat, accounting for about 1% of the companies.

The paper presents the results of research on the relationship between the complexity of the logistics structure and its level of sophistication and four aspects of productivity: the efficiency of food companies, their profitability, liquidity and debt level. A similar situation applies to the size of the food business. Large entities employing 250 or more employees represent only 0.8% of all enterprises, while the smallest micro-enterprises employing up to 9 employees account for 76% of the total. In addition, food products are characterized by varying levels of complexity, which translates into a large variety of production and storage technologies (Van Donk & Van Dam, 1996; Greenfield & Southgate, 2003; Sassenrath, Heilman, Luschei & Benett, 2008; Spiertz, 2012). Such fragmentation is quite characteristic also in other EU countries (Mangina & Vlachos, 2005).

2. OBJECTIVE AND SCOPE OF RESEARCH

The research results presented are part of a larger research project focusing on exploring the various aspects of Solow's paradox in the Polish food industry. The main objectives of this part of studies were to assess the complexity of the logistics structure and the level of its advancement in selected sectors and groups of food companies, and to identify and assess the relationship between them and the financial indicators used to assess the different aspects of the productivity of the surveyed entities.

The first source of data was the results of a survey conducted in 2010–2012 among 511 food companies in Poland. These data included a wealth of information on the general characteristics, logistics and IT solutions used in these companies. Due to the limited number of responses to the survey questionnaire, the fish and tobacco industries were excluded. The second source of data was the annual financial statements filed by companies in the National Court Register (KRS). It was possible to identify 410 (80.2%) reports of the companies participating in the survey, the results of which were the first data source. By far the worst results were identified by microenterprises employing up to 9 employees, including only 2 reports (3.3%). The cause was undoubtedly the lack of obligation to submit financial statements by the smallest companies.

Synthetic indicators labeled LCI (Logistics Complexity Indicator) and LAI (Logistics Advancement Indicator) were used to assess the complexity and the

level of logistics in the companies studied. Both indicators have been defined and detailed described in previous work (Jałowiecki, Jałowiecka & Olejniczak, 2014; Jałowiecki & Jałowiecka, 2014).

In the basic version of the du Ponta scheme, five financial indicators are taken into account (Fig. 1). In the research conducted we decided to use more financial indicators that are not used in the basic version of du Pont analysis.

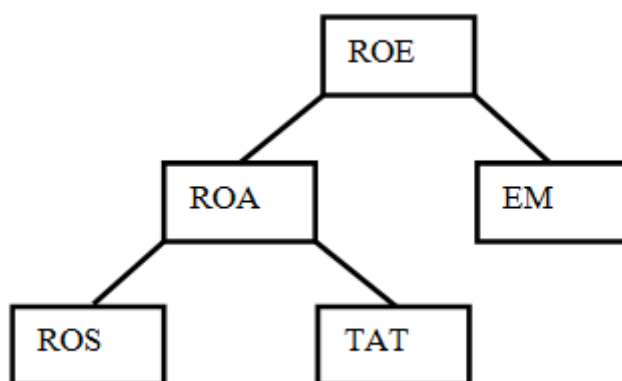


Fig. 1. Du Pont scheme of selected financial indicators

Consequently, two performance indicators, three profitability ratios, two liquidity ratios and two debt ratios were used in the studies. Two performance indicators were TAT (Total Assets Turnover) and IT (Inventory Turnover) calculated according to formulas (1) and (2). Three profitability indicators were original du Pont ratios: ROS (Return of Sales), ROA (Return of Assets) and ROE (Return of Equity) calculated according to formulas (3) (4) and (5). Two liquidity indicators were CR (Current Ratio) and QR (Quick Ratio) calculated according to (6) and (7) formulas. Three debt indicators were DR (Debt Ratio), LTDR (Long-Term Debt Ratio) and EM (Equity Multiplier) calculated according to formulas (8), (9) and (10).

$$TAT = \frac{NRE}{TA} = \frac{NRE}{FA + CA} \quad (1)$$

$$IT = \frac{NRE}{INV} \quad (2)$$

$$ROS = \frac{NP}{NRE} \quad (3)$$

$$ROA = \frac{NP}{TA} = \frac{NP}{FA + CA} \quad (4)$$

$$ROE = \frac{NP}{EC} = \frac{NP}{FA + CA - LPL} \quad (5)$$

$$CR = \frac{CA}{STL} \quad (6)$$

$$QR = \frac{CA - INV - STP}{STL} \quad (7)$$

$$DR = \frac{LPL}{FA + CA} \quad (8)$$

$$EM = \frac{TA}{EC} = \frac{FA + CA}{FA + CA - LPL} \quad (9)$$

$$LTDR = \frac{LTL}{FA + CA + LPL} \quad (10)$$

where:

- NRE – Net Revenues from Sales and Equivalent
- TA – Total Assets
- FA – Fixed Assets
- CA – Current Assets
- INV – Inventory
- NP – Net Profit
- EC – Equity Capital
- LPL – Liabilities and Provisions for Liabilities
- STL – Short-Term Liabilities
- LTL – Long-Term Liabilities
- STP – Short-Term Prepayments

The relationship between the LCI (logistics complexity) and LAI (logistics advancement) synthetic indexes was assessed on the basis of Spearman's rank correlation coefficient, and their significance was checked by a statistical test based on the standard normal distribution or t-Student, depending on the size of the individual subgroups.

3. RESULTS

By analyzing the complexity of the logistics structure, it is clear that the larger the company, the more complex the logistics network is, and consequently the more complex resource and logistic systems it uses (Tab. 1). This is illustrated by

the significant correlation between the size of employment and the complexity of logistics ($\rho = 0.471$; $z = 12.070$; $z_{\alpha/2} = 1.645$; $p < 0.001$; $\alpha = 0.05$). Industry categorization, in terms of complexity of logistics, allowed them to be classified into three groups: the highest (LCI value greater than or equal to 2.36); Average (LCI value from 2.08 to 2.36) and lowest logistic complexity (LCI less than 2.08). The first group includes fruit and vegetable companies, oil-fat, dairy and large (250 and more employees) companies. The second group includes meat companies, foodstuffs, beverages and medium (50 to 249 employees). The third group includes grain and starch companies, feedstuffs, bakeries, small (10 to 49 employees) and micro (to 9 employees).

Table 1. Minimum, average, maximum, and normal range limits for complexity (LCI) and advancement (LAI) of logistics levels

Group of companies	Logistics Complexity Indicator					Logistics Advancement Indicator				
	min.	avg.-sd.	avg.	avg.+sd.	max.	min.	avg.-sd.	avg.	avg.+sd.	max.
meat	0.94	1.66	2.19	2.71	3.30	0.80	1.56	2.16	2.76	3.66
fruits and vegetables	1.02	1.97	2.47	2.96	3.39	1.07	1.81	2.38	2.96	3.47
oil and fat	2.09	2.13	2.38	2.63	2.78	1.32	1.45	2.15	2.87	3.22
dairy	1.56	2.11	2.57	3.03	3.36	1.31	2.08	2.65	3.21	3.65
cereal and starch	0.69	1.51	1.96	2.41	2.99	0.87	1.36	1.99	2.61	3.74
bakery	0.55	1.51	1.70	2.17	2.71	0.43	1.21	1.75	2.28	3.25
groceries	1.36	1.73	2.15	2.56	3.17	0.86	1.52	2.09	2.67	3.20
feed	1.20	1.63	2.02	2.41	2.59	1.38	1.69	2.13	2.56	2.88
beverages	1.55	1.82	2.28	2.73	3.18	1.16	1.56	2.29	3.02	3.50
micro	0.55	1.38	1.88	2.38	3.12	0.43	1.33	1.88	2.42	3.55
small	0.76	1.25	1.68	2.10	2.40	0.79	1.20	1.63	2.06	2.44
middle	0.43	1.83	2.34	2.85	3.30	0.45	1.75	2.38	3.02	3.62
large	1.73	2.25	2.70	3.14	3.39	1.68	2.27	2.83	3.40	3.74
all	0.43	1.43	1.98	2.54	3.39	0.43	1.37	1.99	2.62	3.74

Similarly to complexity of the logistics structure, also relation between level of advancement of logistic solutions used in agri-food companies and employment size was found ($\rho = 0.479$; $z = 12.334$; $z_{\alpha/2} = 1.645$; $p < 0.001$; $\alpha = 0.05$). This was undoubtedly a consequence of strong relationship between complexity of logistics and advancement of logistics solutions used ($\rho = 0.829$; $z = 33.471$; $z_{\alpha/2} = 1.645$; $p < 0.001$; $\alpha = 0.05$). Typically, the greater complexity of systems requires the use of more advanced and, consequently, more efficient organizational and technological solutions.

Company performance is measured primarily by the use of different resource turnover indicators. The higher the value, the greater the resource is used. The most important turnover indicator is TAT, whose value informs about the productivity of all the assets that a company has. TAT values are strongly determined by the industry within which a company operates. As a consequence, the industries with high human capital and low capital-intensive industries will inevitably also

have higher TATs, while in high capital-intensive industries, the situation will be reversed. The highest average level of total assets turnover was found in the meat industry (137.3% of the average for the food sector) and oil and fat (134.5%) (Table 2).

Table 2. The value of financial indicators used in the research on the effectiveness of the performance, profitability, liquidity and debt of food companies

Group of companies	Effectiveness		Profitability			Liquidity		Liabilities		
	TAT	IT	ROS	ROA	ROE	CR	QR	DR	LTDR	EM
Meat	3.34	50.25	0.06	0.02	0.16	1.20	0.92	0.57	0.44	2.92
fruits and vegetables	1.14	4.56	0.01	-0.03	0.13	1.74	0.82	0.60	0.76	3.69
oil and fat	3.27	20.59	0.05	0.02	0.45	1.34	0.75	0.68	0.40	2.80
Dairy	2.35	22.08	0.04	0.02	0.08	1.57	1.11	0.47	0.30	2.17
cereal and starch	1.88	20.46	0.01	0.00	-0.03	2.36	1.57	0.48	0.19	1.92
Bakery	2.28	34.88	0.19	0.08	0.29	2.88	1.50	0.36	0.14	1.58
Groceries	1.91	12.81	0.11	0.06	0.26	1.78	1.21	0.52	0.26	5.09
Feed	2.33	14.11	0.01	-0.04	-0.03	1.77	1.18	0.52	0.19	2.69
Beverages	2.03	12.81	-0.04	-0.04	0.18	1.38	0.71	0.78	0.79	2.31
Small	2.42	32.11	0.13	0.05	0.22	1.78	1.31	0.45	0.26	2.01
Middle	2.43	35.47	0.07	0.05	0.18	1.44	1.02	0.56	0.45	2.92
Large	2.43	25.05	0.04	0.01	0.18	1.39	0.98	0.57	0.27	5.96
All	2.43	32.52	0.11	0.04	0.21	1.67	1.22	0.48	0.30	2.49

In an analogous way, the value of the IT index is used as a gauge of inventory recovery rates. Thus, the higher value of this indicator means better inventory management, primarily by reducing the time and costs of freezing financial resources through the accumulation and storage of excessive inventories. Of course, this also means lowering the level of risk associated with the possible reduction or loss of value of over-collected and stored stocks. The best stock management was found in meat companies and bakeries and in small enterprises (10–49 employees) and medium-sized employees (50–249 employees). By far the worst average characteristics of stock management were in fruit and vegetable companies. It is interesting to note that small and medium-sized foodstuffs enterprises are significantly better off than the largest companies employing 250 or more employees (Table 2).

The values used in the ROA (total assets), ROS (net sales), and ROE (equity capital) informs about the portion of the unit value of each of these characteristics. Interpretation of the value of these indicators is relatively simple, the higher they are, the more favorable the situation of the economic entity. For all three of these characteristics, their profitability decreased as the employment of the surveyed companies increased. The highest profitability was found in bakery and other groceries and oil and fat in equity. The lowest profitability on all four characteristics was found in the feed, beverage and cereal-starch industries (Table 2).

Current financial liquidity ratio CR is a measure of an enterprise's ability to pay its liabilities based on current assets including accrued stocks and accruals with low liquidity. As a result, liquidity is poorly secured at an appropriate level. For this reason, a quick QR liquidity indicator is usually used simultaneously to measure the ability to adjust short-term liabilities based on highly liquid assets. In general, the financial liquidity of Polish food companies decreased with employment size growth both in terms of working assets and highest liquidity assets (for CR: $r = -0.31$; $z = -6.54$; $z_{\alpha/2} = -1.64$; $p < 0.001$; $\alpha = 0.05$; for QR: $r = -0.33$; $z = -6.97$; $z_{\alpha/2} = -1.64$; $p < 0.001$; $\alpha = 0.05$). Polish food companies were characterized by satisfactory ability to regulate their liabilities on the basis of current assets (CR = 1.67). Only members of the cereal and starch industry had an average of a little too high a level of accumulation of funds, while meat companies had a slightly lower capacity to regulate their obligations. Taking into account high liquidity assets, the sector was also satisfactory, but the QR value of 1.22 was only marginally higher than the lower limit of the range considered as optimal. Too low ability to regulate their liabilities on the basis of high liquid assets were found by those in the beverage, oil and fat, fruit and vegetable and meat sectors. In turn, the highest of this type of capacity was characterized by cereal-starch and bakery (Table 2).

The equity multiplier EM is used to evaluate the share of equity in the firm's total assets, which means that it can be used indirectly to assess the level of financial debt of an economic entity. If EM is equal to 1, then equals Return on Equity (ROE) and Total Assets (ROA). In such a situation, the company's business is financed exclusively from its own resources. The higher the value of the capital multiplier, the higher is the share of foreign capital in the financing of the economic entity. Oil-fat companies were financed primarily from own resources. In turn, the largest share of foreign capital was financed by large companies and from the fruit and vegetable sector. It was also found that shifting the center of gravity of financing from equity to foreign capitals as the employment of the surveyed enterprises increased. According to the golden balance sheet rule, Polish food companies were characterized by a level of debt close to the optimum. The biggest debt was the beverage industry and the smallest bakery. Food business companies were financed mainly on the basis of foreign capital, with their proportion to equity increased with the increase in employment. Three industries most financed on the basis of foreign capital were companies producing other groceries, fruits and vegetables, and oils and fats. On the other hand, the bakery industry was financed to a large extent on the basis of equity. The study also used two debt ratios: general (DM) and long-term (LTDR). The average long-term debt in the food sector was low, with the largest beverage and fruit and vegetable sectors, the smallest in the bakery, cereal, starch and feed industries. Interestingly, in medium-sized enterprises, long-term debt was nearly double that of small and large entities (Table 2).

The use of more advanced logistics solutions and systems in the Polish food industry, as a rule, has a destructive effect on the efficiency of asset using in the vast majority of industries and groups of employment, which is confirmed by Solow's productive paradox. In groups of companies characterized by the most complex structure of logistics networks and the internal organizational structure of logistics systems: fruit and vegetable, oil and fat, dairy and beverage companies as well as companies with medium and high employment level of advancement of logistics stimulated greater rotation and thus higher efficiency of stock using (Table 3).

Table 3. Correlation coefficients between the level of sophistication of logistics solutions used and financial ratios (gray background signifies statistically significant values)

Group of companies	Effectiveness		Profitability			Liquidity		Liabilities		
	TAT	IT	ROS	ROA	ROE	CR	QR	DR	LTDR	EM
meat	-0.16	-0.33	0.22	0.20	0.19	0.43	0.33	-0.24	-0.16	-0.24
fruits and vegetables	0.28	0.14	0.25	0.29	0.12	0.10	0.10	-0.47	-0.71	-0.42
oil and fat	-0.20	0.56	-0.29	-0.28	-0.68	-0.54	-0.34	0.41	0.82	0.63
dairy	-0.15	0.54	0.10	0.10	0.04	0.03	0.22	0.25	-0.04	0.07
cereal and starch	0.37	-0.66	-0.10	-0.56	-0.52	-0.45	-0.39	0.60	0.25	0.59
bakery	0.04	-0.34	-0.16	-0.64	-0.43	-0.37	-0.37	0.39	-0.64	0.12
groceries	0.16	-0.09	-0.29	-0.27	-0.25	0.06	0.08	0.39	0.38	-0.21
feed	0.34	0.33	0.67	0.53	0.23	-0.82	-0.82	0.65	0.64	0.57
beverages	-0.18	0.25	0.33	0.13	0.62	0.70	0.43	-0.69	-0.20	-0.19
small	0.02	-0.18	-0.19	-0.17	-0.09	-0.26	-0.39	0.29	0.11	0.26
middle	-0.06	0.28	0.18	0.22	0.16	0.04	0.04	-0.15	-0.17	-0.22
large	-0.35	0.18	0.11	0.02	-0.36	0.35	0.32	-0.16	-0.19	-0.43
all	-0.03	-0.21	-0.25	-0.26	-0.19	-0.21	-0.28	0.30	-0.15	0.25

Sector and employment group companies with the highest level of logistic network complexity and internal logistics systems were characterized by higher levels of logistics and information management, and higher profitability as a revenue surplus. In the least extent, this dependency was related to the return on equity. The only obvious exception to this rule was the oil and fat industry, which found Solow's paradox in relation to the profitability aspect of its own companies. On the other hand, companies belonging to industries and groups of employment in which their networks and logistic systems had the least complex structure were characterized by Solow's productive paradox in relation to its profitability aspect (Table 3).

In the food company groups of the average (meat, food and beverage and medium size sectors) and the highest (fruit and vegetable, oil-fat and milk and large) industries, most advanced logistic solutions stimulated greater financial liquidity. Only in three sectors: cereal-starch, bakery and feed and small enterprises, which were characterized by its lowest level, the advancement of applied

solutions and systems both for logistic and information management caused the deterioration of financial liquidity. This means that excluding these exceptions in the case of industries and groups of employment that are characterized by a higher degree of complexity in the structure of networks and logistic systems, Solow's productivity paradox was not about liquidity. It is also worth emphasizing that the meat and dairy sectors are the ones that have had to adapt to the most current legislation and quality standards in the European Union by implementing a number of new organizational and technological solutions. With the increase in employment in the surveyed food companies, the correlation between the sophistication of the logistic solutions used with financial liquidity changed from negative to positive. Thus, the impact of the level of advancement of applied logistics technologies on financial liquidity has changed from destabilizing to stimulating (Table 3).

In the meat, fruit and vegetable, bakery, beverage and medium-sized industries, the higher level of used logistic solutions advancement was correlated with lower levels of debt. On the other hand, in the oil-fat, cereal-starch, foodstuffs, feed and small businesses, the situation was reversed, the advancement of logistics was correlated with a higher level of debt. Only in the dairy industry have there been unambiguous and statistically significant relationships (Table 3).

4. CONCLUSION

The results of the research indicate that Solow's paradox of productivity did not occur first of all in branches and groups of enterprises characterized by the most complex networks and logistic systems. It seems that Solow's productivity paradox seems to be primarily related to groups of food businesses whose logistic chains are less complex. Thus, while the use of modern logistics and IT systems does not translate directly into the financial results of food businesses, it enables a more efficient management of financial resources, allowing for a reduction in the level of debt and, consequently, a greater degree of business activity on the basis of equity.

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BIOGRAPHICAL NOTES

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