

INVENTORY MANAGEMENT IN INDUSTRIAL PROCESSING ENTERPRISES IN THE CONTEXT OF CRISIS CONDITIONS

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Purpose: The purpose of this article was to assess changes and trends in the main parameters characterizing inventory management in industrial processing enterprises in 2006-2009, 2010-2013 and 2018-2022.

Design/methodology/approach: The analysis covered business entities by Divisions of Section C - "Manufacturing" in relation to four crisis situations. The research undertaken is descriptive, spatial-temporal and critical analysis - the changes and deviations of selected indicators from average values in periods of prosperity are indicated. The presentation of the research results includes descriptive form and graphical form in the form of figures. The numerical data came from the Statistics Poland website.

Findings: In the majority of manufacturing enterprises, all crisis situations had an adverse effect on inventory management. The exceptions were D17, D21 and D32 enterprises, which showed no negative sensitivity to crisis situations.

Research limitations/implications: The geopolitical and macroeconomic situation has impeded most of the favorable trends after the post-pandemic "rebound" in 2022. For this reason, it was difficult to clearly assess the impact of the energy crisis on inventory management at the surveyed companies.

Originality/value: The originality of the study lies in the fact that it was carried out for four different crisis situations and was concerned with assessing changes in the parameters characterizing inventory management, rather than assessing the value of indicators.

Keywords: Inventory management, industrial processing, crisis situation.

Category of the paper: Research paper.

1. Introduction

1.1. Crisis situations in business operations

In an era of unpredictability, destabilization, disinformation, it is increasingly difficult to make rational decisions. This is accompanied by uncertainty, understood as “a situation in which it is impossible to predict the probability, independent of the will of the decision-maker, of future states of phenomena or the course of processes” (Redziak, 2013). On the other hand, economies seeking to raise standards of resource management and care for the environment are obliged to operate on the basis of the principles of sustainable development. This concept is defined as the ability to continuously learn, adapt to changing conditions (Grudzewski, Hejduk, Sankowska, Wańtuchowicz, 2010), in which the process of integrating political, economic and social activities takes place, with preservation of natural balance and sustainability of basic natural processes, so as to ensure the ability to meet the basic needs of the present and future generations (Siekierski, Rutkowska, 2008). In addition, global, widespread consumerism drives economic entities and entire economies, according to the statement that “man has lost the awareness that he is part of the natural environment and in his greed, fueled by the market model of the economy, in which money is the only thing that matters, he has forgotten that the overriding characteristic in his activity should be the pursuit of the common good” (Rutkowska-Podołowska, 2016).

The imbalance between expectations and the ability to meet them influences the emergence of a crisis, which, according to one definition, is defined as “a situation in which there are serious economic problems; manifested by a lack of sufficient financial resources, stunted economic development, and an insufficient amount of goods or raw materials for sale” (The Great Dictionary of the Polish Language of the Polish Academy of Sciences).

The origins of the term crisis can be traced back to the Greek language *krinein* and points to the verbs sift, separate, choose, decide, judge, while the noun derived from it *krisis* means selection, resolution (Kopaliński, 2000). In the current time, the term is conjugated by all grammatical cases and applies to almost every sphere. It is due to the complexity and severity of factors that a few years ago did not pose such a big threat, especially economically. Among the most significant are those of global scope, resulting from the geopolitical situation, the rapid spread of diseases or climate change. The current geopolitical situation, as a result of Russia's war with Ukraine, has created further adverse circumstances, including an energy crisis, waves of refugees and migrants, rising inflation, disruption of global food supply chains, or a slowdown in the energy transition and other measures designed, by design, to prevent a climate catastrophe (Soroka, Pająk, 2023). It should be borne in mind that the war involves many countries in military, financial and humanitarian aid to Ukraine, putting additional strain on their budgets. In addition, the war has “become another factor aggravating the economic downturn by triggering an energy and food crisis” (Prokopowicz, 2023). The energy crisis,

caused on the one hand by a significant reduction in the availability of energy resources, and on the other by the diversification and investment of European economies in renewable energy sources, is an additional source of the food crisis. The availability of energy is essential for the proper flow of all processes in logistics chains, from procurement through production, storage, distribution, to the sale of food products. Additional factors restricting the flow of goods, including food, were the broken logistics chains caused by the COVID-19 pandemic¹.

The crisis caused by a biological agent, such as a pandemic, was a global crisis of intensified intensity, weighing down most economies and industries. In addition, it was a crisis that was sudden, unpredictable as to the direction of change and gave a sense of danger. In the literature, such a situation is referred to as a “black swan” (Wolniak, 2022; Kisielnicki, 2021), which is supposed to emphasize the exceptional unpredictability, uncertainty, even disbelief of the situation. The aforementioned crisis was characterized by many features typical of a crisis, which have been described in the literature, such as: (James, Gilliland, 2004):

- complexity caused by many interacting and intertwining factors,
- lack of panaceas and quick solutions,
- universality, expressed in the fact that under certain circumstances no one is completely immune to it and can be sure never to experience it.

Another important feature to add is the lack of a margin of time to react quickly and make the right decisions so as not to escalate the crisis.

A crisis is the culminating phase of a crisis situation. “Every crisis is a crisis situation, but not every crisis situation is a crisis phase. Every crisis situation can trigger a crisis multiple time” (Otwinowski, 2010). It is dynamic in nature and is a process indicating “a sequence of events taking place over a certain period of time, which are a threat to the existence of the company and make this existence impossible” (Zimniewicz, 1990). It should be kept in mind that “every crisis situation is different, so each should be treated individually. There are no ready-made prescriptions, but through analysis of crisis situations, simulations and experience from past crises, one can acquire skills to effectively identify the symptoms of a crisis and take effective management actions during a crisis situation” (Kaczmarek-Śliwińska, 2015). In addition, it is important to “identify problem situations, which makes it possible to avoid the surprise that a sudden crisis situation can be. This implies the need for continuous analysis of problem situations” (Ciekanowski, Stachowiak, 2011).

Crisisogenic situations are those that foster or cause crises (Dictionary of Polish Language). Virtually every organization at any time is confronted with an emergency situation, i.e., a crisisogenic situation (Gościński, 1989). The opposite of such situations is an opportunity,

¹ The COVID-19 epidemic state began on March 20, 2020 (in accordance with the Ordinance of the Minister of Health of March 20, 2020, on the declaration of an epidemic state in the area of the Republic of Poland). As of May 16, 2022, it was replaced by a state of epidemic emergency, which lasted until June 16, 2023 (in accordance with the Ordinance of the Minister of Health of June 14, 2023, on the cancellation of a state of epidemic emergency in the area of the Republic of Poland). On May 5, 2023. The World Health Organization (WHO) declared the end of the COVID-19 pandemic (End-of-epidemic-emergency-status).

which, properly exploited with favorable factors and rapid adaptation to surrounding changes, can turn into success. In an enterprise, however, “success is rarely (...) a permanent and immanent feature” (Urbanowska-Sojkin, 1999).

According to the definitions cited, the author's interests lie in the analysis of crisis situations that have occurred in recent decades, which will be developed later in this paper.

1.2. Inventory management as a management area

An important area of management in a manufacturing enterprise is inventory management. In the literature, studies and definitions are mainly concerned with materials management, understood as “the process of rational circulation of materials in the enterprise related to the acquisition, transportation, receipt, transfer and release of materials needed for production” (Niziński, Żurek, 2011) or “an area of economic activity that encompasses the totality of phenomena and processes related to the management of materials at all levels of management” (Statistics Poland, Publications, 2016), and the basis of this economy is to secure the continuity of the implemented economic processes (Janik, Paździor, Paździor, 2017). Thus, inventory management is an area of activity of an economic entity in which any movement or stoppage of inventory, economically and logistically justified, is important, ultimately affecting the bottom line. With inventory management being “a process involving the allocation of disposable resources among various uses” (Dach, 2001), then inventory management can mean the disposition and allocation of inventories in accordance with the purposes of their use in a certain unit of time.

An important concept besides inventory management is efficiency, understood as efficiency, effectiveness, productivity, profitability, economy (Bielski, 2002; Kondalkar, 2010) and is among the “properties that determine the essence of the enterprise as a business entity, it conditions the functioning of the organization and determines its development” (Kulińska, Rut, 2013). In the literature, the concept of efficiency is combined with the efficiency of the production process (Koliński, 2011), logistics activities (Mesjasz-Lech, 2012) and the aforementioned inventory management, including supply, production and marketing inventories (Modi, Mishra, 2011).

Inventories are an important group of components in the assets of manufacturing enterprises². They represent useful but idle resources with a certain economic value (Vrat, 2014). They can be considered in logistic and accounting terms. According to the logistics view, it is a certain amount of goods, located in the logistics system continuously unused, intended for later processing or sale (Klepacki, 2022). It's having something in excess, so a stockpile isn't what you absolutely need at any given time (Krawczyk, 2020). Inventories, being properly

² According to Statistics Poland figures, in industrial enterprises, inventories accounted for an average of 20% in total assets and nearly 40% in current assets in 2022, including about 25% in beverage enterprises and nearly 60% in tobacco enterprises (based on Statistics Poland / Subject areas / Business entities. Financial performance / Non-financial enterprises).

stored goods, are excluded from the logistics transfer, and people and appropriately adapted premises and equipment are involved in their handling and storage. It is worth noting that inventories arise as a result of two important discrepancies: the intensity of supply streams is different from the intensity of consumption streams, and/or actual consumption is different from planned or forecast consumption. According to the accounting treatment, inventories are tangible current assets - materials acquired for consumption for own use, finished products (goods and services) manufactured or processed by the entity that are fit for sale or in the course of production, semi-finished products and goods acquired for resale in an unprocessed state (Accounting Law). Information on the size of a company's inventories is located in its balance sheet (Appendix 1 to the Law), in item B.I, broken down into materials, semi-finished and work-in-progress products, finished products, goods, and advances for supplies and services.

Inventories are classified according to different areas. According to one of them, inventories can be divided into two groups (Skowronek, 2023):

- inventories in the sphere of production (stocks of materials, semi-finished products and products in the course of production processes), which serve enterprises in normal production activities and whose sales are sporadic,
- inventories in the sphere of distribution (stocks of finished products, goods), which are in the disposal phase at producers in their warehouses, logistics and distribution centers, wholesale and retail networks.

In a market economy, enterprise decision-makers are interested in proper inventory management, including efforts to maintain optimal inventory levels. The size of inventories, their structure and dynamics depend on the volume and structure of production, unit consumption of materials, seasonality, complexity of manufacturing, as well as the length of individual supply cycles. Also contributing to this is economic globalization, understood as “the process of eliminating boundary barriers to the operation of the market, the consequence of which is the integration of the world economy” (Szymański, 2004), facilitating the movement of inventory in national and international logistics chains.

Inventory management is a challenge for almost every enterprise. It should focus primarily on inventory turnover, which makes it possible to shape the level of inventory and possibly reduce it (Skowron-Grabowska, 2009). This is one of the areas affecting cost levels (Zimoń, 2015), company's result and sales profitability (Koumanakos, 2008). It is integral to consider the often mutually exclusive economic and logistical aspects. According to the economic aspect, inventory levels, both raw materials and finished products, should be kept as low as possible in order to minimize the cost of handling them (including maintenance, ordering, storage, insurance, handling, impairment). This translates into lower availability of finished products and the possibility of not meeting customer demands. Thus, the logistics aspect aims to ensure the continuity and dynamism of production, adapting to the needs of customers and maintaining a certain reserve of inventory. Customer satisfaction and minimal inventory shortages are important, while keeping inventory costs as low as possible (Reddy, 2021).

However, stock levels that are too low can “lead to inventory depletion and be a consequence of production interruption and/or loss of a customer for whom time to obtain a particular good may be the highest priority” (Gołębiowski, 2016).

According to another criterion, inventories are classified into rotating and non-rotating. The former result from synchronization of regular supplies with their current consumption and uninterrupted demand. Non-rotating inventories, on the other hand, are divided into seasonal inventories, related to the seasonality of the acquisition of raw materials or sales of finished products, promotional inventories, accumulated mostly as a marketing offer, and safety stocks. The purpose of the latter is to offset estimation error and protect the company from unexpected and unwanted inventory depletion (Priniotakis, Argyropoulos, 2019). They ensure the rhythmicity of production and reduce the risk of uncertainty about the volume and timing of deliveries. When these stocks begin to exceed the needs for hedging, they become excess stocks (Fertsch, 2008).

In the literature, the evaluation of inventory management is related to the authors' approach to the subject matter addressed, and studies have been conducted based on, among other things:

- surveys (Kolińska, Koliński, 2013),
- selected financial analysis tools (Czerwińska-Kajzer, 2014; Bieniasz, Gołaś, 2012),
- share of inventories in the structure of current assets (Comporek, 2016),
- evaluation of external and internal determinants of inventory management efficiency (Nesterak, Kołodziej-Hajdo, 2006),
- evaluation of inventory turnover (Skowron-Grabowska, 2009).

Due to the relevance of the problem of maintaining a minimum level of inventory with its constant availability, this study aims to assess the changes and trends of the main parameters characterizing inventory management in industrial processing enterprises in 2006-2009, 2010-2013 and 2018-2022. Referring to the adopted objective, the hypothesis was made that crisis situations negatively affect the proper inventory management in industrial processing enterprises. The study is an attempt to add to the literature with research on deviations of indicators depicting inventory management caused by crisis factors.

2. Materials and methods

The presented research is part of the author's ongoing research work. The survey covered business entities by Divisions of Section C - “Manufacturing”. In order to ensure clarity of the text and figures, the numbers of Departments were used in the designations and descriptions³:

³ According to the Polish Classification of Business Activities PKD.

- PP - Industrial processing.
- D10 - Manufacture of food products.
- D11 - Manufacture of beverages.
- D12 - Manufacture of tobacco products.
- D13 - Manufacture of textiles.
- D14 - Manufacture of clothing.
- D15 - Manufacture of leather and leather products.
- D16 - Manufacture of wood and cork products, except furniture; manufacture of articles of straw and plaiting materials.
- D17 - Manufacture of paper and paper products.
- D18 - Printing and reproduction of recorded media.
- D19 - Manufacture and processing of coke and refined petroleum products.
- D20 - Manufacture of chemicals and chemical products.
- D21 - Manufacture of basic pharmaceutical substances and drugs and other pharmaceutical products.
- D22 - Manufacture of rubber and plastic products.
- D23 - Manufacture of other non-metallic mineral products.
- D24 - Manufacture of metals.
- D25 - Manufacture of fabricated metal products, except machinery and equipment.
- D26 - Manufacture of computers, electronic and optical products.
- D27 - Manufacture of electrical equipment.
- D28 - Manufacture of machinery and equipment not elsewhere classified.
- D29 - Manufacture of motor vehicles, trailers and semi-trailers.
- D30 - Manufacture of other transportation equipment.
- D31 - Manufacture of furniture.
- D32 - Other manufacturing of products.
- D33 - Repair, maintenance and installation of machinery and equipment.

The analysis covered the years 2006-2013 and 2018-2022, which involved four crises. The research undertaken is descriptive, spatial-temporal and critical analysis - changes and deviations from the average values during periods of prosperity are indicated. The presentation of the research results includes descriptive form and graphical form in the form of figures. The numerical data came from the Statistics Poland website. According to the author's opinion, the indicators selected for the study provide a relevant and universal basis for conducting an assessment of inventory management in manufacturing enterprises. A classification of the indicators used in the study is included in Table 1.

Table 1.
Classification of the study area

| Manufacturing enterprises by PKD | Indicators analyzed | Crisis situations/ scope of research |
|--|--|---|
| Scope D10-D33 and collectively all industrial processing enterprises | 1. Share of inventories in current assets | The Global financial crisis 2006-2009 |
| | 2. Share of materials in inventories | The Eurozone crisis 2010-2013 |
| | 3. Share of semi-finished and work-in-progress products in inventories | The COVID-19 crisis 2018-2021 |
| | 4. Share of finished products in inventories | The COVID-19 crisis + Energy crisis 2018-2022 |
| 5. Share of goods in inventory | | |
| 6. Profitability of materials (1) | | |
| 7. Profitability of semi-finished and work-in-progress products (1) | | |
| 8. Profitability of finished products (1) | | |
| 9. Profitability of goods (1) | | |
| 10. Rotation of materials (2) | | |
| 11. Rotation of semi-finished and work-in-progress products (2) | | |
| 12. Rotation of finished products (2) | | |
| 13. Rotation of goods (2) | | |
| 14. Liquidity of materials | | |
| 15. Liquidity of semi-finished and work-in-progress products | | |
| 16. Liquidity of finished products | | |
| 17. Liquidity of goods | | |
| 18. Material intensity | | |

(1) The numerator of the formula includes the item "Financial result from sales of products, goods and materials"

(2) The denominator of the formula includes the item "Revenue from sales of products, goods and materials".

Source: own elaboration.

Inventory structure ratios provide information on the degree of immobilization of current assets in a company's inventory. The higher the proportion, the lower the elasticity of current assets. This may indicate lower asset liquidity as a result of lack of demand for inventory, or improper inventory management. The share of individual inventory items in their total value indicates the degree of the company's commitment to a particular type of inventory. Too high a share of materials relative to the share of finished goods may indicate problems with sales, or an overly conservative procurement policy.

Inventory profitability ratios indicate the efficiency of their involvement. The higher the values, the better their utilization. It is a good idea to analyze this type of indicators in relation to industry data. A dangerous situation may be indicated by negative values of the discussed group of indicators, which is the effect of generating a loss already at the stage of balancing revenues from the sale of products, goods and materials with the costs of obtaining them.

Turnover ratios in days indicate how many days elapse between the delivery of inventory to the company and its sale. A decrease in the turnover value is mostly perceived positively, as it indicates faster liquidity of inventory, its efficient management, shorter storage period, lower handling costs, and, as a result, a more favorable financial result. In addition, there is a lower demand for capital, which is "frozen" in inventory for a shorter time, and this in turn improves liquidity. An increase in inventory turnover in days can be interpreted as a deterioration in management efficiency or overstocking, the reasons for which can range from lack of demand through overproduction and seasonal sales.

Liquidity is the flexibility of converting assets into money. Inventory liquidity determines the degree to which trade payables are covered by inventory held. The higher the value of the indicator, the higher the degree of immobilization of inventories, and thus the lower their liquidity. When too low a value of the indicator takes place, the entity is obliged to settle trade payables additionally with other current assets than inventories. At the same time, this may indicate their rapid turnover or disposal of inventories due to production or sales downtime.

Material intensity indicates how much material is used to produce a unit of finished product. Too high a share or an increasing trend of this indicator is not always perceived positively and can mean a reduction in demand, production problems or downtime. Inventory intensity, on the other hand, means what proportion of inventories falls into a unit of earned income from the sale of products, goods and materials. An increasing trend may indicate a decrease in the efficiency of inventory management, its liquidity or an extended period of storage. It should be borne in mind that the magnitudes of these indicators are conditioned to a large extent by the specifics of production, the actual need for material consumption in the production process or seasonality. It should be added that the inventory intensity indicator was omitted from the final study, as it is a reflection of the inventory turnover indicator, with a difference - inventory turnover is calculated in days, while inventory intensity is calculated as a percentage.

The final part of the study presents the directions of changes in the magnitudes of the indicators studied, which took place in the analyzed companies during the two-year crisis periods in relation to the two-year period before the crises.

The general magnitudes of the indicators are presented in the figures, while the detailed ones are presented in the tables.

3. Results and discussion

The research conducted in this study deals with situations triggered by two financial crises, as well as pandemic and energy crises with global economic consequences. The aforementioned crises, along with the adopted research time, are illustrated in Figure 1.



Figure 1. Crisis situations with the adopted time ranges of the study.

Source: own study.

The end of the first decade of the 21st century saw a global financial crisis. It began in 2007 in the US, but was reflected in global markets after September 15, 2008, following the collapse of US investment bank Lehman Brothers Holding Inc. (Kołodziejczyk, 2016; Józwiakowski, 2015; Romiszewska, 2011). The relocation of the crisis to the remaining countries caused a crisis of confidence in financial institutions, exponential changes in stock prices and destabilization of stock markets, which translated into an economic slowdown in these countries, a decrease in consumption, an increase in unemployment, a halt in investment, or a collapse in global trade.

At the turn of 2009/2010, another crisis outlined itself, being the Eurozone crisis, also known as the debt crisis (Gajewski, 2013; Węc, 2020). It was the result of a number of factors, including serious problems in financing budget deficits, an increase in the public debt of some countries, inadequate supervision of the financial sector or a bad loan portfolio, especially mortgages (Poliński, 2017; Węc, 2020; Kraciuk, 2013). For the Eurozone crisis, the previous global financial crisis was the “ignition spark” (Węc, 2020), a delayed wave of its effects (Adamowicz, M., Adamowicz, T., 2018) whether the aftermath of a negative development impulse (Nazarczuk, 2013). The economic slowdown of the eurozone countries also marked the Polish economy, as evidenced by the size of the basic macroeconomic indicators.

The next of the crises discussed, was triggered by factors of biological origin and concerned the aforementioned COVID-19 pandemic. Although at the beginning its scope covered only the PRC, in a very short time it spread to almost all countries of the world, including as a result of the easy and rapid movement of the population. The effects of the crisis, in its initial phase associated with a sharp reduction in the economic activity of countries, included stunted and reduced production volumes, disruptions in the flow of goods, negative financial developments that affected households, economic entities and entire economies (Bukowski, Gawroński, Olszewska, 2023). The reduction in economic activity has also had positive consequences, related to global reductions in carbon emissions. This, in turn, has contributed to the environmental focus on decarbonizing the energy sector in line with the EU's climate goals, and the European Green Deal launched in late 2019 aimed at reducing the impact of the climate crisis⁴ (Latest EU climate action, 2022).

In February 2022, the still ongoing pandemic crisis was “fueled” by another militarily motivated crisis. Russia's aggression against Ukraine forced European countries to significantly reduce and become less dependent on imports of Russian fossil fuels, and thus to spread renewable energy sources, with additional financial burdens. These situations triggered the so-called “energy crisis,” which contributed, among other things, to the breaking of logistics chains, an increase in the price of goods, including energy, business disruptions and the “waiting time” of companies as to the course of the economic situation and its impact on the

⁴ According to a press release dated 28/11/2019, the European Parliament has declared a climate crisis (European Parliament declares climate crisis).

conduct of business. The crisis has also adversely affected food security, global food affordability, or the increased mobility of people and goods across all modes of transportation (Market effects..., 2024).

The selection of research periods in the mentioned crises was linked to the indicator of the general business climate⁵ industrial processing enterprises and, in addition, an indicator of the current overall economic situation of these enterprises. The development of the size of these indicators is presented in Figure 2.

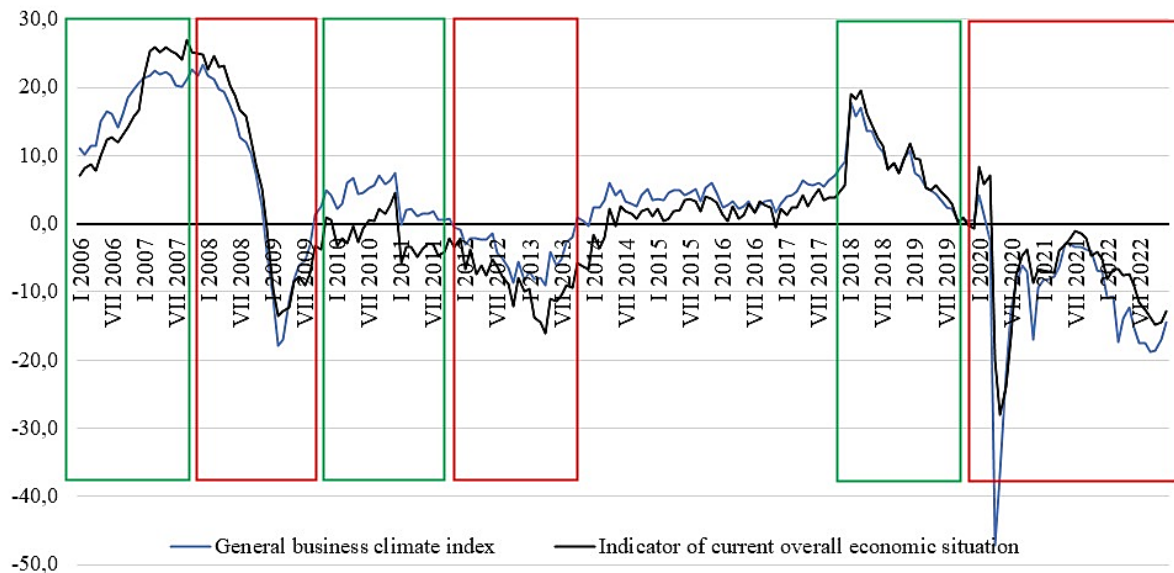


Figure 2. The values of indicators of the general business climate and the current general economic situation of industrial processing enterprises against the background of crisis situations.

Source: own compilation based on Statistics Poland data.

The state of the economy of manufacturing enterprises during the period under review was characterized by significant dynamics. Figure 2 frames in green the years in which the economy of these enterprises was in a favorable situation, while in red are the years of bad economic conditions. The latter constituted the background of crisis conditions, which were the basis of the research conducted. The largest negative dynamics occurred in April 2020 and concerned the COVID-19 crisis. At that time, the value of the general business climate index fell to -47.2, a difference of as much as 64.9 points compared to +17.7 in January 2018. The crisis began abruptly and intensely, and the restrictions imposed by the state on the conduct of business and the functioning of society, resulted in the exclusion of most industries from normal operations. Undoubtedly, a large decrease in the index in question took place in the global financial crisis, with 41.2 points (from +23.3 in December 2007 to -17.9 in February 2009). A much milder reduction took place in the Eurozone crisis, by 16.4 points. The change in the value of the

⁵ The general business climate index reflects the state of the economy in general or in a particular branch of the economy. It is calculated as the arithmetic average of the balances of responses to monthly survey questions on the current and expected economic situation of the enterprise. When the indicator is greater than zero, a “good” business climate is recorded. Otherwise, the climate is assessed as “bad” Statistics Poland/ Meta-information / Glossary / Terms used in official statistics.

general business climate index in the energy crisis was not easy to diagnose. Referring to the pre-pandemic period, its largest reduction was 36.5 points (from +17.7 in January 2018 to -18.8 in October 2022), while in relation to the year before the outbreak, it fell by 15.9 points (from -2.9 in May 2021 to the aforementioned level of -18.8). Given that there was still an epidemic state until May 2022, and then an epidemic emergency state, assessing the impact of the war and the related energy crisis was not possible to clearly indicate in this research. The index of the current overall economic situation, compared to the index of the general business climate, showed more optimistic figures in the financial, pandemic and energy crises, while more pessimistic figures in the eurozone crisis.

All of the aforementioned crises projected the basic macroeconomic parameters to a greater or lesser extent, as shown in Figure 3.

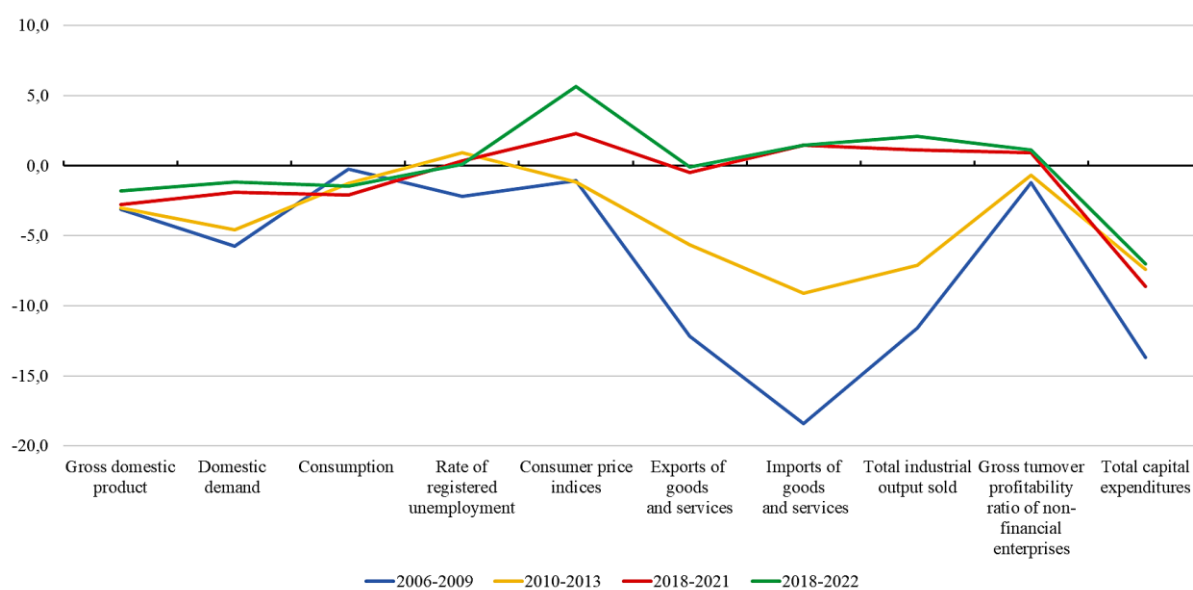


Figure 3. Basic macroeconomic parameters against the background of the studied crisis situations.

Source: own compilation based on Statistics Poland data.

Changes in macroeconomic parameters were calculated as the rate of dynamics of the two-year period of the crisis situation in relation to the dynamics of the two-year period before the crisis situation. As Figure 3 shows, each crisis affected the economy differently. In the global financial crisis, imports and exports of goods and services, total capital expenditures, total industrial output sold, and, to a lesser extent, domestic demand declined significantly. In the Eurozone crisis, the situation was similar, but to a lesser extent. During the last two crises, the values of the analyzed parameters were similar. In both situations, total capital expenditures decreased significantly, and to a lesser extent gross domestic product, domestic demand and consumption. In addition, the energy crisis contributed more than the COVID-19 crisis to the increase in the consumer price index.

In order to give an idea of the surveyed enterprises, Figure 4 shows their structure by the number of entities in each division of the PKD and by the revenues generated from the sale of products, goods and materials in 2006 and 2022.

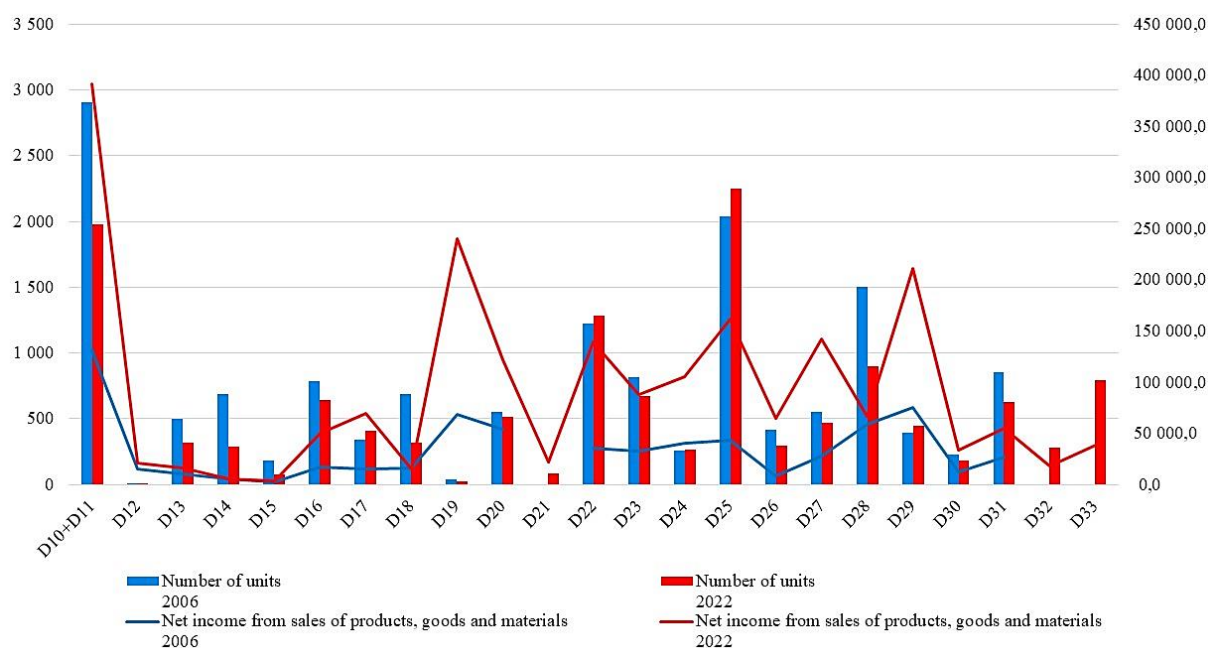


Figure 4. Structure of enterprises of Section C - Manufacturing by number of entities (left axis) and by revenue from sales of products, goods and materials (right axis) in 2006 and 2022.

Source: own compilation based on Statistics Poland data.

The largest group of companies was in D10+D11⁶ in 2006 and in D25 in 2022, which accounted for 19.41% and 17.11% of all manufacturing enterprises, respectively. The least numerous groups in 2022 were D12 (0.07%) and D19 (0.17%). The latter were characterized by high revenues from the sale of products, goods and materials, which accounted for 11.34% of all enterprises' revenues. Only D10+D11 enterprises had a more favorable result, whose revenue accounted for 18.44%.

The evaluation of inventory management should begin with an analysis of its share in the total assets of an enterprise or in its current assets. The latter is important from the point of view of operating activities, the size of which is determined by many factors, such as the specifics of the production cycle, the ease/difficulty of obtaining raw materials, legal regulations or the predictability of demand for manufactured products. The share of inventories in current assets in the surveyed companies for the analyzed period is shown in Table 2.

⁶ During the period under review, enterprises were classified according to PKD 2004 and PKD 2007. Following this, some mergers of divisions take place, while others were not present in the earlier version. According to the Ordinance of the Council of Ministers of December 24, 2007, on the Polish Classification of Activities (PKD), the PKD 2004 classification was used until December 31, 2009.

Table 2.

Share of inventories in current assets in the surveyed companies against the background of crisis situations

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2018 | 2019 | 2020 | 2021 | 2022 |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| PP | 31,7% | 33,1% | 32,6% | 31,4% | 32,1% | 33,1% | 33,9% | 33,3% | 35,4% | 34,9% | 34,0% | 37,6% | 38,5% |
| D10 | 34,7% | 36,6% | 34,1% | 31,0% | 32,4% | 34,0% | 33,7% | 33,6% | 33,2% | 33,7% | 35,8% | 34,9% | 39,5% |
| D11 | | | | 19,0% | 20,4% | 22,0% | 24,0% | 23,0% | 23,2% | 22,0% | 24,4% | 25,4% | 27,0% |
| D12 | 42,4% | 32,1% | 24,5% | 34,5% | 47,0% | 53,4% | 56,7% | 62,8% | 69,5% | 63,6% | 61,2% | 54,3% | 47,4% |
| D13 | 38,6% | 40,5% | 39,1% | 42,6% | 46,4% | 47,3% | 45,4% | 43,6% | 43,0% | 43,1% | 39,9% | 45,0% | 44,0% |
| D14 | 42,6% | 45,6% | 42,9% | 45,0% | 45,0% | 45,8% | 45,2% | 44,5% | 44,1% | 44,3% | 44,0% | 45,7% | 48,3% |
| D15 | 42,5% | 43,9% | 44,1% | 39,9% | 40,5% | 40,1% | 43,5% | 44,5% | 43,2% | 39,2% | 35,0% | 44,2% | 49,6% |
| D16 | 35,5% | 41,1% | 42,7% | 37,0% | 35,3% | 38,5% | 35,9% | 38,1% | 40,3% | 41,9% | 36,4% | 37,6% | 42,3% |
| D17 | 28,9% | 27,9% | 28,5% | 25,6% | 31,3% | 29,5% | 29,7% | 28,9% | 31,9% | 29,5% | 27,4% | 31,5% | 34,0% |
| D18 | 17,2% | 16,6% | 18,1% | 18,9% | 21,6% | 20,9% | 21,8% | 21,4% | 22,1% | 22,5% | 21,6% | 25,4% | 27,5% |
| D19 | 42,4% | 48,1% | 45,9% | 45,3% | 53,2% | 52,4% | 57,7% | 54,5% | 46,5% | 44,7% | 46,2% | 41,6% | 29,4% |
| D20 | 29,4% | 30,5% | 30,3% | 27,9% | 27,5% | 28,5% | 29,7% | 28,3% | 32,8% | 32,8% | 29,2% | 34,2% | 38,4% |
| D21 | | | | 30,3% | 32,2% | 38,0% | 32,8% | 34,1% | 35,4% | 29,0% | 30,4% | 31,2% | 36,6% |
| D22 | 30,0% | 32,0% | 30,1% | 29,3% | 29,0% | 30,9% | 31,3% | 29,8% | 34,8% | 34,2% | 31,8% | 38,0% | 38,0% |
| D23 | 26,8% | 28,5% | 30,6% | 31,2% | 31,1% | 30,9% | 33,1% | 32,1% | 33,8% | 34,1% | 30,6% | 33,1% | 37,6% |
| D24 | 33,6% | 30,4% | 34,5% | 33,1% | 33,4% | 38,4% | 43,6% | 46,6% | 49,9% | 44,3% | 39,5% | 44,3% | 44,9% |
| D25 | 32,8% | 34,6% | 34,1% | 33,5% | 32,5% | 31,4% | 32,0% | 32,2% | 36,6% | 36,0% | 34,4% | 41,1% | 43,0% |
| D26 | 28,9% | 27,8% | 26,7% | 27,1% | 28,2% | 26,0% | 26,4% | 27,2% | 31,2% | 28,7% | 27,6% | 39,2% | 40,0% |
| D27 | 26,8% | 28,0% | 28,4% | 27,1% | 28,0% | 28,8% | 30,2% | 30,1% | 37,0% | 39,1% | 36,5% | 41,9% | 45,4% |
| D28 | 31,7% | 34,2% | 31,9% | 34,7% | 35,4% | 35,8% | 35,4% | 35,5% | 35,2% | 33,6% | 32,7% | 36,7% | 40,9% |
| D29 | 23,1% | 23,2% | 24,5% | 19,5% | 22,0% | 21,3% | 22,0% | 21,9% | 27,2% | 27,9% | 28,5% | 31,6% | 31,0% |
| D30 | 36,4% | 35,5% | 37,6% | 38,5% | 34,0% | 34,1% | 37,4% | 38,9% | 44,1% | 41,8% | 46,2% | 45,0% | 46,7% |
| D31 | 33,8% | 36,7% | 36,7% | 33,3% | 37,6% | 36,3% | 37,4% | 35,2% | 33,7% | 37,7% | 35,2% | 41,3% | 41,6% |
| D32 | | | | 41,1% | 41,3% | 40,4% | 37,3% | 37,9% | 45,3% | 46,1% | 42,2% | 44,2% | 48,3% |
| D33 | | | | 23,5% | 21,6% | 19,3% | 18,1% | 18,1% | 17,5% | 19,4% | 27,4% | 35,5% | 34,0% |

In the surveyed companies, the level of inventories in the total value of current assets varied greatly. From 2006 to 2009, their highest share was in D19 enterprises (only in 2006 it affected D14), which was mainly due to the specifics of their operations. A characteristic change and increase in the share of inventories in current assets affected D12 enterprises, from the lowest level in 2008 (24.5%) to the highest in 2018 (69.5%). A number of factors contributed to this situation, including changing regulations, including the cyclical increase in the excise tax burden on tobacco products (Impact of Tobacco Production on the Polish Economy, 2020), the sensitivity of production to climatic conditions, and changing consumer awareness and habits. In contrast, the lowest share of inventories in current assets occurred mainly in D18 and D33 enterprises. This was mainly due to the nature of the business. It is worth noting that in most enterprises the highest share of inventories in current assets was in 2022. Thus, it can be concluded that the energy crisis was an important factor hindering proper inventory management, which was further marked by the highest inflation rate in the years under review (114.4 according to Statistics Poland sources). A broader view of the share of inventories in current assets against the background of crisis situations and, in addition, the value of inventories is illustrated in Figure 5. The calculated figures are the rate of increase in the average structure of two years in the crisis situation (in 2020-2022 it was the average structure of three years) compared to the average structure of two years before the crisis situation.

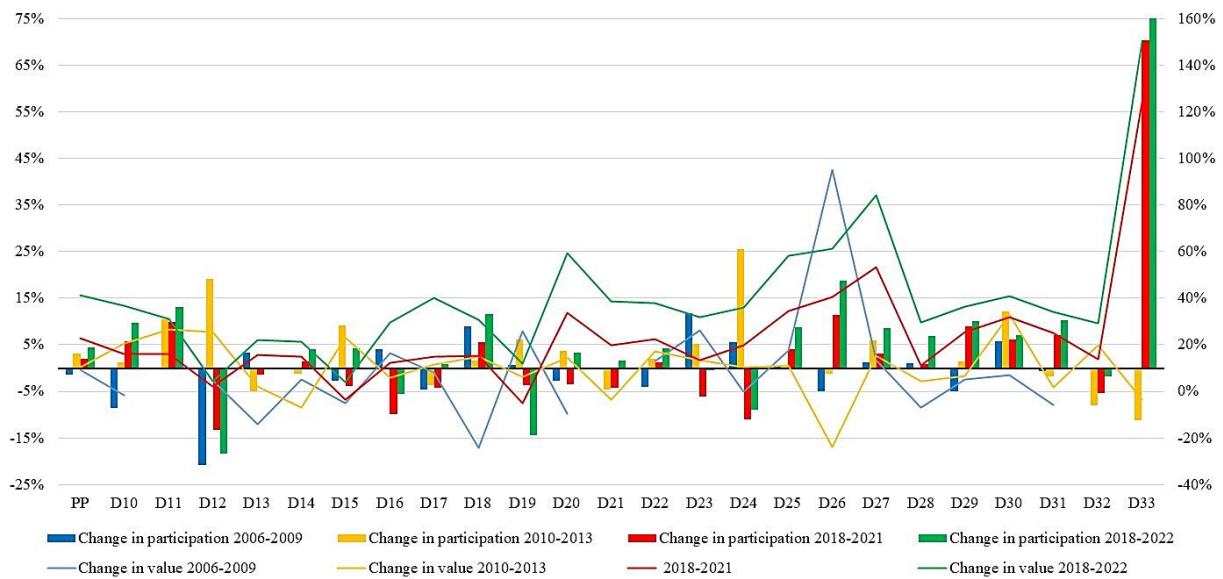


Figure 5. Changes in the share of inventories in current assets and the value of inventories in manufacturing companies by PKD Divisions against the background of the studied crisis situations.

Source: own compilation based on Statistics Poland data.

The share of inventories in the current assets of the surveyed enterprises fluctuated due to, among other things, the specifics of operations and production technology, inventory management strategy, seasonality, demand instability and crisis situations. This was particularly true for D33 enterprises, for which both the COVID-19-induced crisis and the energy crisis contributed to a significant immobilization of inventories (an assessment in 2006-2009 was not possible due to a different classification of PKD). This is evidenced by the increase in the share of inventories in current assets by 70% and 75%, respectively. In other companies, the changes were milder, mostly with an intensification in the energy crisis. In D12, D15, D19, D24 and D30, the Eurozone crisis mainly contributed to the slowdown in inventory movement, while in D23 the global financial crisis. On the other hand, however, crises may have contributed to a reduction in the share of inventories in current assets, such as in D16, D19 and D24 (pandemic crisis and energy crisis). It is worth noting that characteristic changes occurred in D12 companies. The share of inventories increased significantly in the Eurozone crisis, while it decreased in the other crises. However, it should be noted that in the pandemic and energy crises, this change was not the result of an improvement in inventory management, but only a decrease in the value of current assets. A significant increase in the value of inventories was noticeable in the last two crises in most enterprises, especially in D33, D27 or D20. In D26 companies, it was additionally noticeable in the global financial crisis, while it decreased in the Eurozone crisis.

Further research concerned the compilation of changes in the size of indicators analyzed in manufacturing enterprises separately for the adopted crisis situations, as shown in Table 1. For example, the material turnover rate in D10 enterprises in the period 2018-2021 was as follows in each year: 21.46; 21.29; 23.48; 26.69. In 2018-2019, before the crisis situation,

the average size of the index was 21.37, and in the crisis years (2020-2021) it was 25.08. The growth rate was thus 17.36%. The individual relations calculated in this way were used to select, separately for each group of companies, a synthetic indicator (conventionally SW), which is the average of the sum of all the indicators studied (listed in Table 1) according to their division into two groups:

- 1) stimulants - increasing volumes reflect a positive impact on inventory management (indicators from Table 1: Nos. 2, 3, 6, 7, 8, 9, 14, 15, 16, 17),
- 2) destimulants - decreasing magnitudes reflect a positive impact on inventory management (indicators from Table 1: Nos. 1, 4, 5, 10, 11, 12, 13, 18).

In the following figures 6-9, an attempt is made to classify the surveyed companies according to the synthetic indicator of SW, the size of which was reduced to a measurable number.

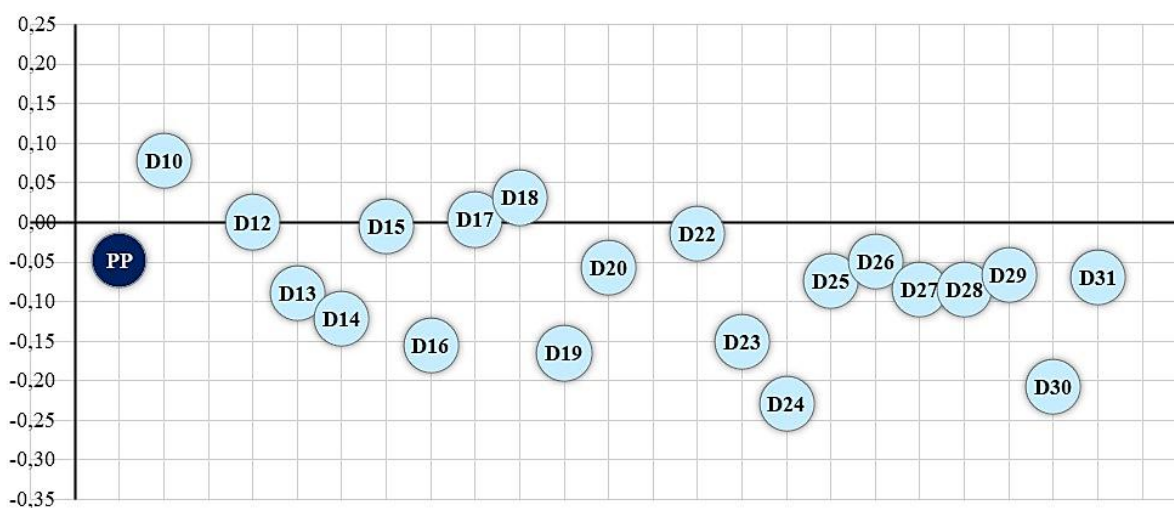


Figure 6. Classification of the surveyed companies in terms of the level of the synthetic SW indicator in 2006-2009 against the background of the Global financial crisis.

Source: own compilation based on Statistics Poland data.

The global financial crisis was marked by unfavorable trends in inventory management in almost all industrial processing companies, for which the synthetic SW index was at -0.05. The prevailing group of companies was in the negative zone of -0.23 to 0.0. The lowest value of the index was for D24 companies, at -0.23. This was due to a significant reduction in the profitability of all forms of inventory and an increase in its turnover in days. This, in turn, was the result of a reduction in demand for, among other things, steel and aluminum by related industries, which were also affected by the crisis. The group of enterprises that distinguished itself from the others by the positive magnitude of the index was D10 enterprises (according to the 2004 PKD classification). Their synthetic SW index was 0.08, which consisted of an improvement in profitability and a reduction in the turnover time of all forms of inventory, as well as its favorable internal structure.

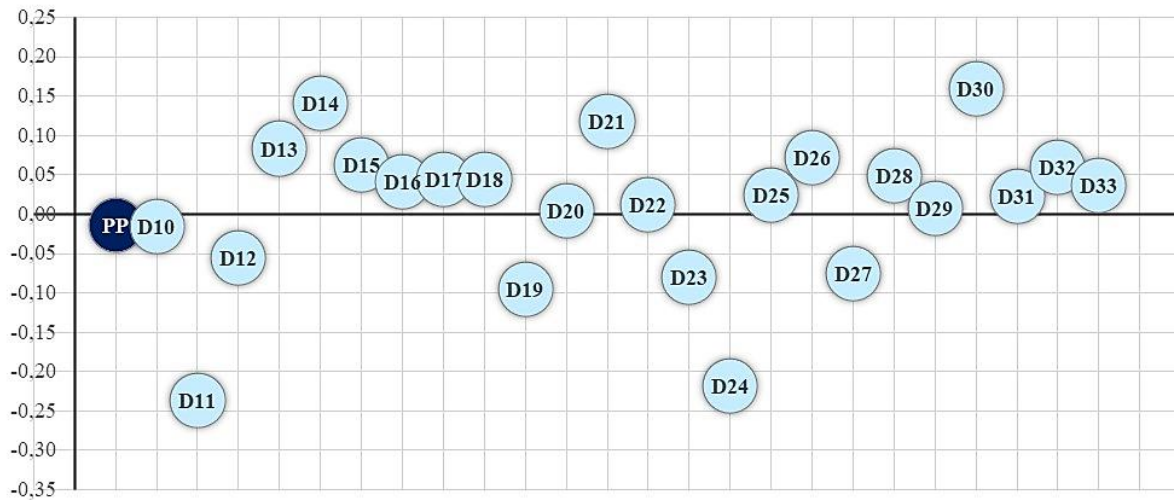


Figure 7. Classification of the surveyed companies in terms of the level of the synthetic SW indicator in 2010-2013 against the background of the Eurozone crisis.

Source: own compilation based on Statistics Poland data.

The subsequent Eurozone crisis in the wake of the global financial crisis brought a slight recovery in terms of inventory management. There was an improvement in the prevailing group of companies, mainly in the area of favorable inventory structure and increased liquidity. The crisis was not noticeable for all enterprises combined (PP), as the synthetic SW index was -0.01. The effects of the crisis were felt most by D11 (SW index value -0.24) and D24 (-0.22) enterprises. The latter did not rebound after the global crisis, inventory profitability continued to decline, and material intensity increased unfavorably. The situation was different for D30 companies. In the previous crisis, the synthetic SW indicator for this group was -0.21, while in the Eurozone crisis it rose to +0.16, mainly due to an increase in inventory profitability. However, it should be borne in mind that the production of other transportation equipment is also the shipbuilding industry, which collapsed in 2009 after the closure of the production shipyards in Gdynia and Szczecin (Rogala-Lewicki, 2023). With reference to D11 companies, it should be noted that all parameters building the synthetic index were unfavorable - the share of finished products and goods in total inventories increased, while the share of materials decreased, which may indicate a reduction in demand. In addition, the profitability and liquidity ratios of the various forms of inventories decreased significantly, turnover ratios in days lengthened, and the material intensity ratio increased.

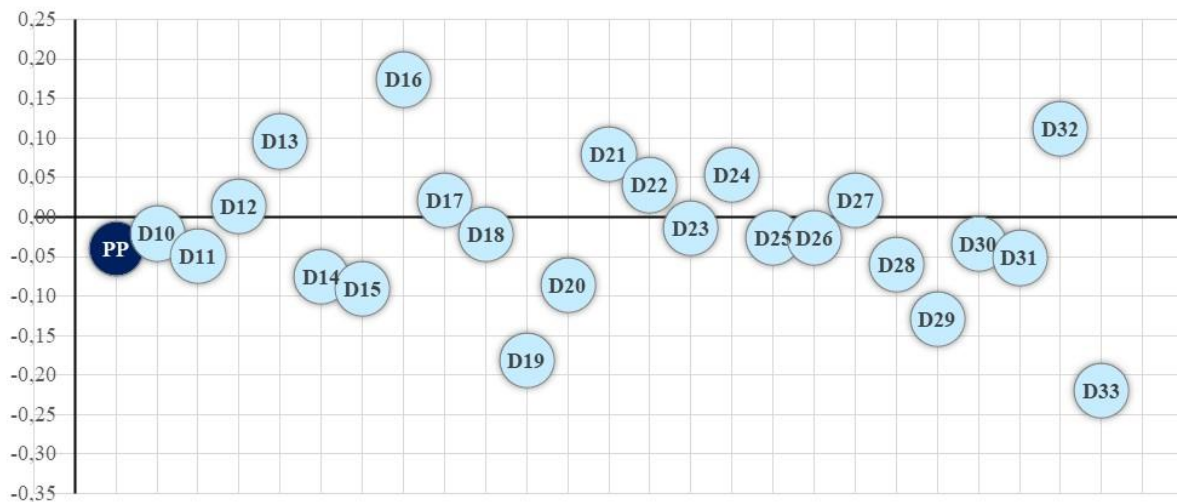


Figure 8. Classification of the surveyed companies in terms of the level of the synthetic SW index in 2018-2021 against the COVID-19 crisis.

Source: own compilation based on Statistics Poland data.

Over the 2018-2021 period, inventory management deteriorated in a number of enterprises, for which the SW index was in the range of -0.22 to 0.0. According to the average for all enterprises in Section C (PP), it ranked at -0.04. This situation was significantly influenced by an unfavorable increase in the turnover of mainly materials, semi-finished products and work-in-progress, as well as a reduction in the profitability of all forms of inventory and the liquidity of finished products and goods. D33 enterprises ranked the lowest (-0.22). It should be added that these enterprises are a specific group, whose business is based largely on the provision of services. The size of the index was influenced by the largest of all divisions by the reduction in inventory profitability and the increase in turnover, mainly of finished goods, semi-finished goods and work-in-progress. A large degree of deviation from other companies also affected D19 (-0.17) and D29 (-0.15). The reason for the deterioration of inventory management in these enterprises should be attributed mainly to the reduced profitability and liquidity of all forms of inventory, to which reduced demand and increased inventories contributed. It should be borne in mind that during the pandemic, especially in the initial phase, many enterprises did not operate at normal levels, hence the reduced demand for the products of these groups of enterprises.

The most favorable aggregate deviation in the COVID-19 crisis (+0.17) was for D16 enterprises. Since a broader analysis was not possible on the basis of general CSO figures limited to PKD divisions. In this situation, the author additionally used the PKO BP report (Industry Quarterly, 2023), according to which a significant improvement in the inventory management of these companies was due to a dynamic post-2020 increase in the production of wooden packaging, mainly pallets (D16.24). This situation was caused by an increase in demand for transportation services, including shipments of goods using pallets. The positive value of the SW index also occurred in enterprises D32, D13, D21, D24, D22, D27, D17 and D12. In the former (D32), the reason may have been an increase in demand for certain products,

such as sports equipment (increased physical activity), hospital beds (which was related to the construction of field hospitals for COVID-19 patients) and personal protective equipment (protective suits, masks).

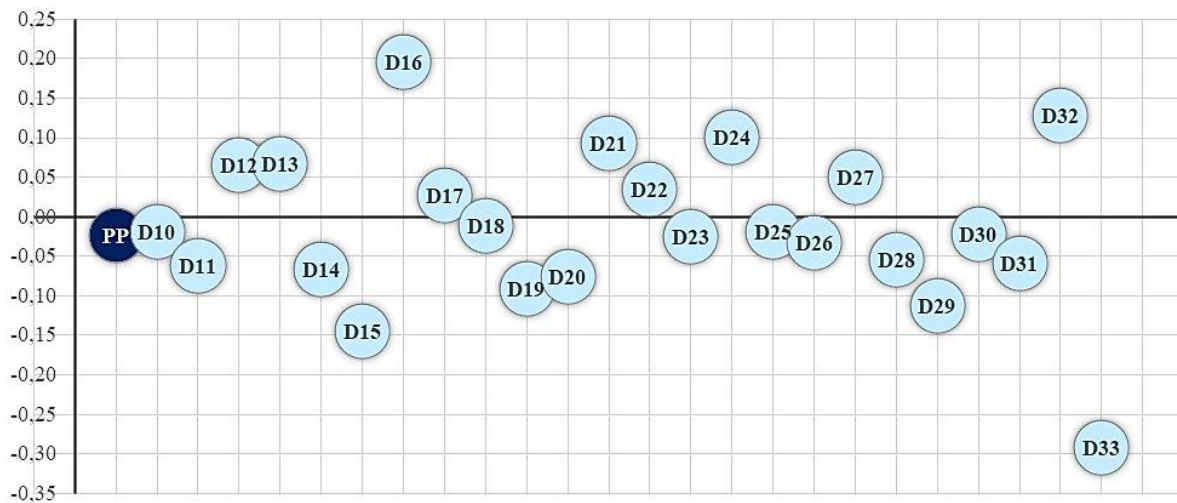


Figure 9. Classification of the surveyed companies in terms of the level of the synthetic SW indicator in 2018-2022 against the background of COVID-19 and the energy crisis.

Source: own compilation based on Statistics Poland data.

The extension of the COVID-19 crisis to include another energy crisis reinforced the reduced inventory management efficiency of the analyzed enterprises. Most of the enterprises were in the negative zone from -0.35 to 0.0. The lowest value of the index was for enterprises D33 - Repair, maintenance and installation of machinery and equipment (-0.35), which, as in the previous crisis, was caused by a significant increase in inventories, also in relation to current assets. This was compounded by a reduction in the profitability of inventories, an increase in material intensity and a prolongation of turnover in days, mainly of finished goods, despite an increase in the liquidity of the latter. In D19 companies, the persistently negative synthetic indicator is a derivative of a significant reduction in profitability, liquidity, as well as prolonged turnover, especially of semi-finished and work-in-progress products and goods. This situation has undoubtedly been influenced by rising prices, including fuel prices, and lower demand. In addition, it is worth mentioning that D19 enterprises are in second place in terms of the volume of carbon dioxide emissions among all manufacturing enterprises, with D23 being first (Transformation of Energy..., 2022).

Small positive values of the indicator in question occurred only in three groups of enterprises D16 (+0.07), D12 (+0.04) and D32 (+0.01). In D16 enterprises, this was a continuation of stabilized demand for palletized goods movement services. According to information in a report by the Polish Economic Institute (Impact of the war..., 2023), the war in Ukraine had a strong impact on industrial processing enterprises, regardless of size.

In order to systematize the research, a combined classification of enterprises was made in terms of the development of the synthetic SW indicator against all crisis situations, as illustrated in Figure 10.

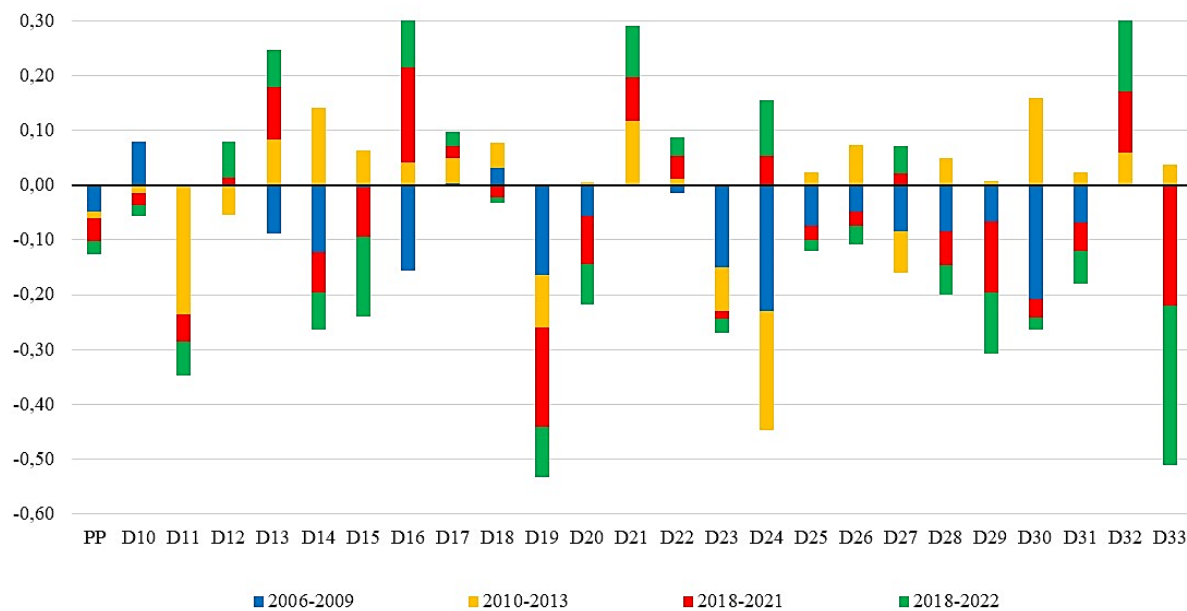


Figure 10. Total classification of the surveyed enterprises in terms of the level of the synthetic SW indicator in comparison with all crisis situations

Source: own compilation based on Statistics Poland data.

In terms of inventory management, all of the crises discussed occurred in D11, D20, D23 enterprises, and the most in D19. The vast majority of enterprises were vulnerable to the global financial crisis and the COVID-19 and energy crises. Also, a significant proportion of enterprises were not much affected by the last two crises in terms of inventory management. These are enterprises D12, D16, D22, D24, D27, D17, D21 and D32. The last three enterprise divisions were not affected by any of the crises in inventory management, even there was an improvement in this regard.

4. Summary

Conducted research, aimed to assess changes and trends in the main parameters characterizing inventory management in industrial processing enterprises in crisis situations. The research period was divided into four areas of observation:

- 2006-2009, against the background of the Global financial crisis,
- 2010-2013, against the background of the Eurozone crisis,
- 2018-2021, against the background of the COVID-19 crisis,
- 2018-2022, against the background of the COVID-19 and Energy crises.

Analysis of the figures and selected reports made it possible to formulate basic conclusions:

1. In the majority of industrial processing companies, all crises had an adverse impact on inventory management.
2. There were unfavorable changes within the profitability indicators of the total group of manufacturing enterprises in all crises. The largest unfavorable deviation occurred in the COVID-19 crisis (close to -19%), including the profitability of materials and semi-finished and work-in-progress products, averaging -21%. The smallest negative deviation was for the profitability of materials and goods in the Eurozone crisis, about -3%.
3. inventory turnover time in days lengthened by an average of 14% in the COVID-19 and energy crises, including as much as 94% in D33 - Repair, maintenance and installation of machinery and equipment enterprises, while in the eurozone crisis it shortened by an average of less than 2%.
4. The change in inventory liquidity levels in the Eurozone, COVID-19 and energy crises was favorable, by 5-9% on average for all companies. In the global financial crisis, on the other hand, it decreased by 6%, including as much as 87% in D12 - Tobacco Manufacturing enterprises, and concerned semi-finished and work-in-progress products. This indicated a significant immobilization of this form of inventory.
5. The geopolitical and macroeconomic situation inhibited most of the favorable trends in 2022 after the “rebound” after the pandemic. For this reason, it was difficult to clearly assess the impact of the energy crisis on inventory management in the surveyed companies.
6. Each of the divisions of industrial processing enterprises has internal specifics of their operations, conditioned by a number of factors, such as the length of the production cycle, the ease/difficulty of obtaining raw materials, legal regulations or predictability of demand for manufactured products, as well as seasonality and the warehouse policy strategy adopted by the enterprise.
7. The accepted hypothesis “crisis situations negatively affect proper inventory management in industrial processing enterprises” was not fully confirmed. The exceptions were:
 - a) D17 - Manufacture of paper and paper products.
 - b) D21 - Manufacture of basic pharmaceutical substances and drugs and other pharmaceutical products, and
 - c) D32 - Other manufacturing of products.

It can be concluded that these companies did not show negative vulnerability to crisis situations.

The author realizes that the adopted research path requires further development, which will be done in future publications.

Information

The article was written as part of the activities of the Center for Resilience and Competitiveness Research West Pomeranian University of Technology in Szczecin.

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