



Vulnerability Within the Czech Automotive Supply Chain

Zdeněk Toušek¹, Jana Hinke², Barbora Gregor³, Martin Prokop⁴

Abstract

This study aims to explore the vulnerability within the Czech automotive supply chain. To explore the vulnerability, analyses based on the comparison of both monetary and time-based characteristics, namely profitability, cash flow ratio, indebtedness, and cash conversion cycle, respectively, were employed. The underlying dataset comprises from financial statements of individual companies belonging to the automotive supply chain in the Czech Republic during the period 2011–2018. This supply chain is defined NACE 22, 27, 25, 24 in Tier 1 (raw material producers), Tier 2 (value-adding parts producers, and Tier 3 (components manufacturers and assemblers). Empirical evidence has revealed several findings: within the supply chain itself, Tier 1 companies generate higher profitability and free cash flow accompanied by lower indebtedness and the fastest cash conversion cycle. Thus they are better positioned to withstand current crises than companies from Tier 2 and especially Tier 3 sub-segments.

Keywords

Cash, Indebtedness, Profitability, Supply Chain, Vulnerability, Working Capital

I. Introduction

Car manufacturing is a very significant sector for the Czech economy with an annual production of 1.44 million cars (in 2018), with top worldwide production intensity (No. 2 with 134 cars produced on 1000 inhabitants) and export capabilities (approx. 93% of cars were exported in 2018). Automotive industry (manufacturing of motor vehicles, trailers and

¹ Czech University of Life Sciences Prague, Kamýcká 129, 165 00 Prague, Czech Republic.
E-mail: tousekz@pef.czu.cz.

² Czech University of Life Sciences Prague, Kamýcká 129, 165 00 Prague, Czech Republic.
E-mail: hinke@pef.czu.cz.

³ Charles University in Prague, Ovocný trh 5, 116 36 Prague, Czech Republic.
E-mail: malinska.barbora@gmail.com.

⁴ Czech University of Life Sciences Prague, Kamýcká 129, 165 00 Prague, Czech Republic.
E-mail: marprokop@raz-dva.cz.

spare parts) counts for 9% of Gross Domestic Product, employs 180Ths people (15% of total manufacturing workforce in the country) and represents 24% of total industrial production, 27% of revenues of manufacturing industry and 20% of overall Czech exports – all figures for 2018 (Czech Statistical Office, 2020 and Automotive Industry Association of the Czech Republic, 2020).

Typical feature of the Czech economy is significant mutual interdependency, i.e., other clusters of manufacturing industry are partial sub/suppliers to automotive industry, thus taking part in Global Automotive Supply Chains – hereinafter the acronym GSCs (Automotive supply chain is constituted not only by manufactures of motor vehicles, semi/trailer and spare parts, but also by related supplying manufacturing industries such as manufacturing of textiles, rubber and plastic products etc.). For example: contribution of plastic/rubber products and textile manufacturers to automotive industry is 25.8% and 16.1%, respectively – figures for 2018 (Ministry of Industry and Trade of the Czech Republic, 2019).

GSCs are typical for automotive industry mostly formed by specialist suppliers facing a rather oligopolistic environment or dependency on one or few customers (exclusive frame agreements etc.), thus exposed and vulnerable to external shocks resulting in its disruption both on demand and supply side.

II. Literature Review

The imperative for longevity of an organization is goods and services production available to customers in the most convenient place, time, and price. Supply chains contribute to achieving this organizational goal. In the last few decades, a paradigm shift, with organizations competing among one other as supply chains more in the market than individual brands, has been observed and this shift has brought about the importance of cooperation in supply chains (Yerpude et al., 2020).

The automotive market is highly competitive and highly technological (the modern complexity of automotive products makes it more difficult to manage suppliers in the automotive industry). The effective competitive advantages (e.g., availability and processes of geographical distribution) are based on the stable development of certain countries (Aleshkova et al., 2019). Investigating factors of supply chain performance and finding an optimum solution logically represent a way how to improve the performance of supply chain (Mareš and Janičko, 2022). Optimum efficiency and competitiveness must be sought in all links of the supply chain both individually and as a whole.

Dibben et al., (2020) suggest that automotive companies, in the context of global supply chains, are shifting costs to their suppliers and thus they can disrupt established relationships. The vulnerability of this segment is also discussed by Manello et al. (2016), who argue that an economic crisis fuels a strong reorganization process, which increases heterogeneity and results in a growing imbalance in the automotive production system. Brandenburg (2016) confirms that economic crises act as amplifiers, but they do not cause a reduction in efficiency. Based on the evaluation of cost-effectiveness and working capital performance trends between 2002 and 2010, this author shows that many companies in the supply chain of cars failed to manage costs and working capital in a balanced manner with

added value in the unfavorable economic period, which resulted in significant value losses. Sakuramoto et al. (2019) evidence by their research that profitability differs based on the underlying supply chain structure. Horizontal structure of supply chain (applicable and typical for traditional car manufacturers) features lower profitability due to the higher related transaction costs. Contrary to this, new competitors implementing the vertical supply chain structure face better profitability.

However, the problems of supply chains do not lie only in costs. Badakhshan and Ball (2022) have evidenced that disruptions in the physical flow of inventory are just as important as disruptions in financial flows – especially for the immediate linked members of the supply chain. Due to the supply chain disruption, the automotive industry is now facing the problem of inventory waiting times at different nodes, which affects the supply chain's overall efficiency (Ada et al., 2021).

According to Guan (2007) joint integration with external counterparties (both suppliers and customers) as well as internal integration (processes, functions etc.) may help to gain competitive advantages within the supply chain. Financial supply chain analysis to examine working capital management by time cycles in the automotive supply chain is used, for example, by Lind et al. (2012) because it is an applied method that offers a holistic view of the supply chain from beginning (raw materials production) up to the final customers. Hong and Najmi (2020) assess the supply chain quality of nine industries using return-on-assets (ROA), days-sales-outstanding (DSO) and current ratio (CR). Their research showed that higher profitability (measured by ROA), shortened DSO and the corresponding level of CR introduced stability into the supply chain, or more precisely prevented major disruptions across whole supply chain by implementing indicators of financial performance.

Wang (2019) argues that one of the widely used metrics for measuring corporate governance effectiveness and the internal need for external financing is the cash conversion cycle (CCC), which refers to the time interval between cash outflows from purchases and cash inflows from sales. The cash conversion cycle (CCC) and its components as the measure of working capital management and different profitability ratios, such as gross profit margin, EBIT margin, and return on assets (ROA) are used by a wide range of authors – such as Yilmaz and Acar (2019), who evaluate the effect of the cash conversion cycle on profitability in Omani companies in a four-year period. Another author is Chang (2018), who elaborated globally on relationship between cash conversion cycle and corporate performance based on the international data sample covering different countries. In this study a negative relationship between cash conversion cycle and firm's performance has been revealed, thus confirming that firm's profitability enhancement can be achieved by the application of the aggressive working capital strategy. Nevertheless, the extent of this approach implementation is predominantly driven by firm's position within the supply chain (the effect for low-end positioned firms can even be reversed). Others (e.g. Deepa et al., 2016 or Doruk and Ergun, 2019) examine the impact of the cash conversion cycle on the financial performance of individual companies or segments. However, within supply chains, trade-offs between the conflicting cash conversion cycles of individual supply chain members (e.g., the invoice due date of one firm is the receivable due date of another firm) must be made by finding optimal values for financial parameters and parameters of inventory

decision making (Badakhshan et al., 2018). Ambadapudi and Matai (2021) confirm that the state of working capital management, assessed by cash conversion cycle days, varies at different levels within the supply chain, making deeper-tier suppliers much more vulnerable to financial risks. The CCC has been used in this sense by, for example, Zhang et al. (2017), who chose it as a network optimization model tool; Tsai (2017) uses this metric to optimize supply chain cash flow risk management, as the cash flows of individual supply chain links typically lag behind operating or overall profits and have higher volatility than profits, making them less predictable. Sim and Prabhu (2022) use CCC to examine the impact of credit risk on the liquidity of supply chain links. Talonpoika et al. (2014) have even adjusted the CCC to account for prepayments as part of working capital for those supply chain companies that achieve prepayments to a significant extent. The need for more studies based on conducting periodic analyses in the automotive industry is emphasized by Oh et al. (2020).

It is generally perceived that supply chain management significantly impacts financial performance of any company taking part in it, e.g., Ellmar and Liu (2002), Hofman and Locker (2009). Even direct evidence about link between supply chain performance and stock exchange price has been provided by Singhal and Hendrick (2002). Timme and Williams-Timme (2000) showed that financial figures such as working capital is a common indicator for measuring the performance of supply chain. As Farris and Hutchinson (2002) proposed working capital measures (i.e., cash conversion cycle) are composite performance metrics for assessing how well a company is managing its capital. According to Lambert and Pohlen (2001) these figures reflect operational performance in financial terms and can be derived from financial statements (in some case publicly available). Not only single firm's working capital drivers, but also their dynamic is captured by this working capital metric.

From supply chain perspective, it would be interesting to know who oversees what activity. Howorth and Westhead (2003) are suggesting the focal companies of supply chain (typically bigger and more powerful ones) force smaller companies to accept their trade terms (payment conditions etc.). Consequently, these smaller companies enforce these unfavorable trade terms into those yet smaller. Contrary to it, smaller and successful firms do not possess power to redress this issue, thus are involuntary participating as a net fund providers in the supply chain. Then the question, based on the power usage within supply chain, is whether weaker supply chain members are pushed to finance against their own interests the working capital for their powerful partner companies Munson et.al (1999). Further Rafuse (1996) argued that no net system benefit as is proposed/expected by supply chain management will arise from this asymmetrical dependency situation. In consequence, smaller and weaker participants need to adjust their increasing borrowing and associated administrative costs.

Also, other scholars have tackled the issue of supply chain structure in the literature, e.g., Blackman and Holland (2006) and Wheelen and Hunger (2002) suggesting the idea of industry supply chain construction based rather on cooperative than adversarial strategies applied by relevant participants. Modified construction of automotive supply chain proposed by Heneric et al. (2005), which is based on the assumption that suppliers in

the automotive industry are organized in sequential levels (which are alternatively called tiers) shall serve well to the purpose of this paper as a preliminary research methodology. Therefore, consequently three basic levels (tiers) of the supply chain were defined: Tier 1 as a system/module supplier is providing the EOM with prefabricated, customized components for its production, Tier 2 is producer/supplier of special spare parts/components serving both the EOM and Tier 1 and Tier 3 is engaged in routine low value-added production, typically serving Tier 2 and exceptionally Tier 1. Since primary focus at this moment is to observe the supply chain from raw material production to components assembly perspective, Original Equipment Manufacturers (with abbreviation: EOM) are not subject of the analysis. The application of this supply chain structure concept was also preferred due to Czech Invest's extensive investigation about relevant firm's affiliation to the tiers. Many authors have tackled the issue of supply chain organization and its impact on the firm's performance both globally and domestically. Working capital management seems to be one the important aspect influencing the overall firm's profitability, which is pre-determined by firm's position within the supply chain. Therefore, further analyses of both monetary and time-based characteristics namely profitability, cash flow ratio, indebtedness, and cash conversion cycle respectively shall be employed.

In accordance with the facts stated above, the following hypotheses have been formulated:

- H1: There are significant differences within automotive supply chain in working capital management efficiency.
- H2: Cash Conversion Cycle remains stable over the observed period of time both on supply chain and individual Tier's levels.
- H3: Tier 3 is the most vulnerable to any external shocks due its subordinated position within the Czech automotive supply chain.

III. Methods

The completed financial statements (audited were applicable) of individual companies belonging to automotive supply chain and carrying out their business activities in the Czech Republic during the period 2011–2018 were foundation of this study. Data were predominately collected from the Commercial register and internal resources of Česká spořitelna, a.s. Financial statements of foreign parent companies and consolidated and group financial statements were removed to avoid potential double counting. This supply chain is defined as sub/deliveries of Czech automotive industry represented mainly by following NACE (NACE stands for Nomenclature statistique des Activités économiques dans la Communauté Européenne) 22 – Manufacturing of rubber and plastic products, 27 – Manufacture of electric equipment, 25 – Manufacture of fabricated metal product, 24 – Manufacture of basic metals etc. The final balanced dataset (after all adjustments relying mainly on exclusion of foreign companies/branches and entities with unbalanced/incomplete financial data series) contains annual financial figures of 145 firms, thus constituting 1.160 firm-year observations, representing approx. 10–18% of all firms (from turnover point of view in 2018) acknowledged by the CzechInvest (2019) as participants in the Czech automotive supply chain (CzechInvest is national business and investment development agency serving as a state contributor). Contrary to e.g., Lind et

al. (2012) that applied restriction on the annual sales volume, no special cut-off points were imposed on raw data. Since significant part of automotive supply chain in the Czech Republic are Small and Medium Enterprises (SME), therefore applying such a restriction could lead to omitting important part of the Czech automotive industry. Please see Table 1 for descriptive analysis.

Table 1: Sample descriptive analysis

	Number of firms 2018	Total assets 2018 min (in '000 CZK)	Total assets 2018 max (in '000 CZK)	Sales 2018 min (in '000 CZK)	Sales 2018 max (in '000 CZK)	Working capital share on Total Assets 2011	Working capital share on Total Assets 2018
Tier 1	26	86.606	5351727	88.265	9.220.398	16.41%	10.17%
Tier 2	54	11.707	4.313.557	8.571	4.70923	16.03%	11.29%
Tier 3	65	6.588	2.007.741	11.948	2.795.840	17.77%	19.25%

Source: own processing (2023)

Further, division of firms among predefined Tiers suppliers is derived from the CzechInvest classification lease note that some of the companies may belong to multiple supply chain tiers. Therefore, the prevailing production of each company served as an assignment criterion to the single tier.

To achieve consistent and comparable financial figures across whole sample following assumptions were imposed. Only tradable account receivables and account payables were considered (e.g., intragroup accounts receivable not taken into the account). From the time perspective (both for account receivables and payables) only due pay and overdue within one year are contemplated. Finished goods, work in progress and raw material constitute the inventory. Since any advance payments (both received and/or paid) represent only insignificant items on companies' balance sheet, they were omitted from the working capital calculation. Companies' business cycle underlies working capital fluctuation during the fiscal year. But in the automotive industry, seasonal fluctuation is rather modest, and so the working capital levels of the end of the fiscal year represent the need of working capital well.

To study differences of working capital management among Tier 1, Tier 2 and Tier 3 and also from a general supply chain perspective, both monetary based as well as time-based characteristics were employed. In the case of monetary based characteristics, more cash flow driven approach was applied by utilizing following variables (i) profitability calculated as EBTDA (Earnings Before Taxes, Depreciation and Amortization) margin (2), (ii) generated free cash flow ratio (3), (iii) indebtedness (4) contrary to other scholars referring typically to the net working capital as a different between current assets and liabilities Ross, Westerfield and Jaffe (2005) and Gitman (2006).

$$EBTDA = \text{Operating profit (loss)} + \text{depreciation and amortization} - \text{interest expenses} \quad (1)$$

$$EBTDA \text{ margin} = \frac{EBTDA}{TO} \quad (2)$$

$$\text{Cash flow ratio} = \frac{EBTDA - CAPEX}{TO} \quad (3)$$

$$\text{Indebtedness} = \frac{TBD}{EBTDA} \quad (4)$$

where TO refers to the total turnover, CAPEX refers to the capital expenditures and TBD refers to the total bank debts (volumes at the end of relevant fiscal year).

The indebtedness represents external senior (both short and long term) debt bearing interest typically in the form of granted bank loans since the Czech economy is a bank-driven economy (banks are still playing crucial role in the capital reallocation), i.e., trade credit is not considered. Other forms of external senior debt such as issued corporate bonds are not so common alternatives due to underdeveloped local capital markets (for instance corporate bonds count approximately 0% of financing in 2018).

As proposed by Richards and Laughlin (1980) cash conversion cycle (CCC) is used as a time-based indicator to measure how long cash is retained between purchase and sale. This time-based working capital measure is important for both an accounting based and operations management-based perspective. As presented by Lind et al. (2012) cash conversion cycle consists of cycle times of inventories, account receivables and account payable and is defined as:

$$CCC = DIO + DSO - DPO \quad (5)$$

where DIO refers to days inventory outstanding, DSO refers to days accounts receivable outstanding and DPO refers to days accounts payable outstanding calculated as follows:

$$DIO = \frac{INV}{TO} * 365 \quad (6)$$

$$DSO = \frac{AR}{TO} * 365 \quad (7)$$

$$DPO = \frac{AP}{TO} * 365 \quad (8)$$

where INV refers to the inventory, AR refers to the tradable account receivables and AP refers to the tradable account payables (volumes at the end of relevant fiscal year).

From enhanced view of CCC can be recognized that its performance is more operational in nature than financial. Empirical studies (i.e., Soenen (1993)) have proved that shorter

the cycle time, the higher present value of net cash flows generated by the assets, thus the higher the value of the company is. Other works by Cote and Latham (1999), Ward (2004) established a correlation between the enhancement of working capital measures (e.g., CCC) and the overall corporate profitability of a single company. Therefore, the CCC metric is component for increasing shareholder value.

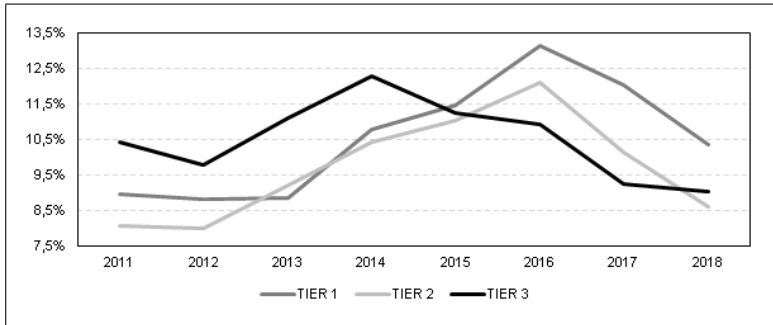
IV. Results

In the first part of this chapter, the attention will be paid to the obtained results from the individual tier perspective, in subsequent text, the interest will be directed to the whole automotive supply chain perspective.

Single Tier’s Perspective

Figure 1 shows development of annual average EBTDA margin of all sub-segments in the period from 2011 to 2018. The EBTDA calculation was chosen to reflect different levels of external indebtedness (and related total amount of net interest expenses paid) between Tier 1, Tier 2 and Tier 3 sub-sectors. While in case of Tier 1 sub-sample the average margin loss (Interest expenses divided by turnover) caused by interest expenses amounts to 0.4pp, both Tier 2 and Tier 3 lose on average 0.5pp of their margin. It is believed that selected profitability calculation shows a realistic view of the total profitability level of single sub-samples.

Figure 1: EBTDA margin of automotive suppliers

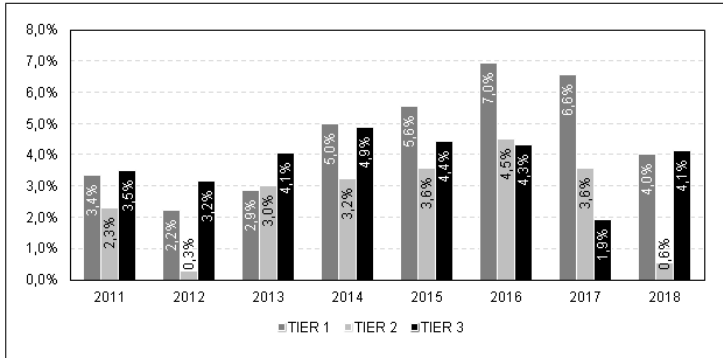


Source: own processing (2023)

In the years from 2012 to 2014 all sub-segments experienced EBTDA margin increase. Tier 3 companies generated on average 1.48pp higher EBTDA margin in comparison to Tier 1 and Tier 2 companies. During the period from 2011 to 2014 total European personal car production increased from 15.7mn produced units to 18.05mn produced units. Tier 1 suppliers, who are almost exclusively dependent on the automotive sector (high level of specialization resulting in full firm’s production within automotive supply chain), were able during this period to improve fixed costs coverage and were able to realize economies of scale more than its suppliers from Tier 2 and Tier 3 sub-sector (probably due to their lower level of specialization, i.e., only partial participation on automotive supply chain from final

firm’s performance perspective). Therefore since 2015 can be observed reversed trend and the whole profit generated by all automotive suppliers is distributed unequally between Tier 1, Tier 2 and Tier 3 suppliers with the highest profit generated by Tier 1 suppliers. This fact is also confirmed by free cash flow ratio generated by single sub-segments as depicted in Figure 2.

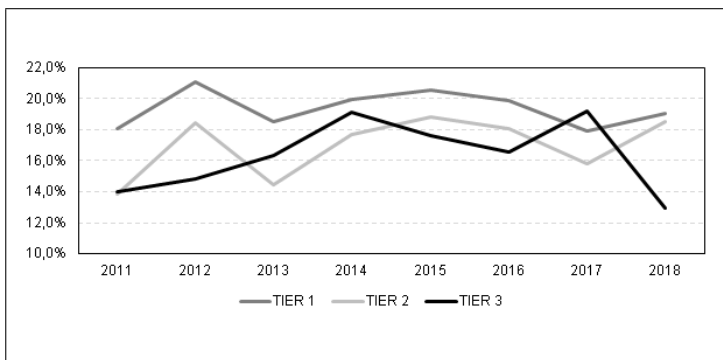
Figure 2: Free cash flow as % of turnover



Source: own processing (2023)

Up to the year 2014 Tier 3 achieved the highest annual average free cash flow rates due to the slower recovery of car production itself because of financial crises in 2008 and 2011, which in this case was offset by another type of production (only partial dedication to the automotive supply chain production). In the period from 2014 to 2018 Tier 1 was able to generate the largest free cash flow in relation to turnover in comparison to Tier 2 and Tier 3 despite the fact the capital expenditure ratio (Investments / Fixed assets) of Tier 1 was the highest and relatively stable almost in the whole observed period as captured by Figure 3.

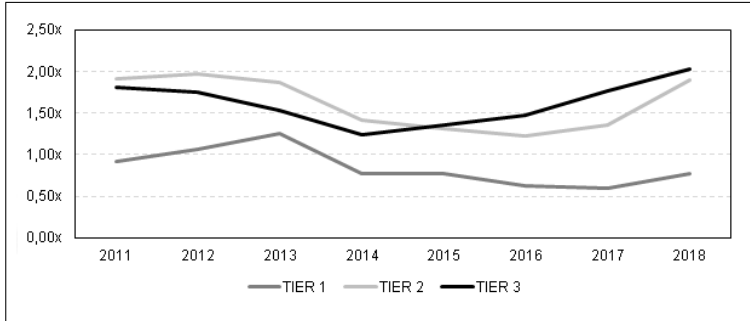
Figure 3: Capital expenditures as % of total assets



Source: own processing (2023)

Higher average profitability (Figure 2) and better ability to cover investments from generated average free cash flow (Figure 2) should be reflected in the total average external indebtedness of single sub-sectors. The Figure 4 summarizes development of total average external indebtedness of Tier 1, Tier 2 and Tier 3 suppliers.

Figure 4: Indebtedness as net debt to EBTDA

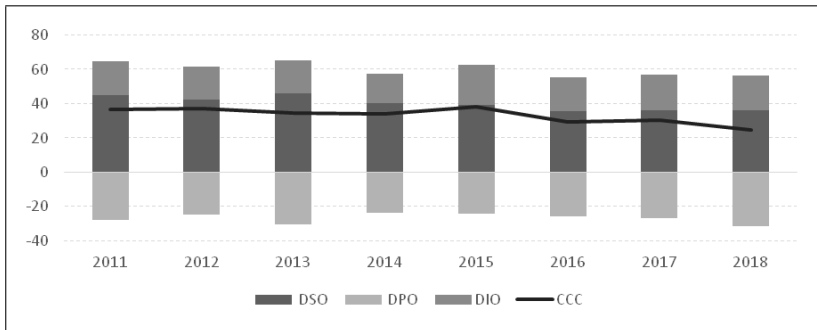


Source: own processing (2023)

Significantly lower average total indebtedness was observed accompanied also by lower costs associated with servicing these external debts (both due to lower granted loan volumes and lower charges applied by lenders) of Tier 1 suppliers in comparison to Tier 2 and Tier 3 suppliers over whole period. Tier 1 suppliers are therefore better positioned to finance necessary investments, changes in working capital or potential negative impacts of economic fluctuations.

Cash conversion cycle as time-based characteristic should demonstrate the length of whole production cycle on sub-segment level, which is predefined by conditions of customer’s payments (DSO) and supplier’s credit (DPO) and requirement of inventories demand (DIO).

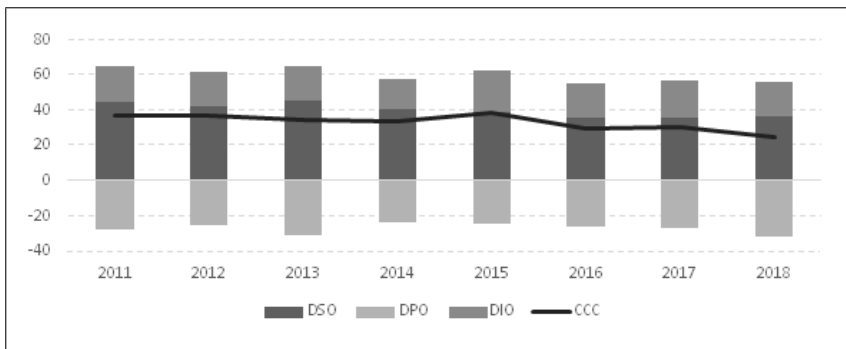
Figure 5: Tier 1 Cash conversion cycle



Source: own processing (2023)

For Tier 1 (Figure 5) cash conversion cycle has decreased by significant 12 days (highest drop among sub-segments) ending with average value of 24.8 days (2018). Which is predominantly driven by reduction of days accounts receivable outstanding (−8.6 days). Contrary to this, the number of days of accounts payable outstanding increased by 3.6 days. Interestingly days inventory outstanding remained relatively low (compared to other sub-segments) and stable over the observed period (average value 20 days). Also for Tier 2 (Figure 6) cash conversion cycle has shortened by 11.2 days. This change was predominately driven by reduction of DSO (−10,4 days). On the contrary, DPO were extended by 2 days whereas inventory being once again the most stable part of working capital with DIO oscillating around average value of 32.5 days.

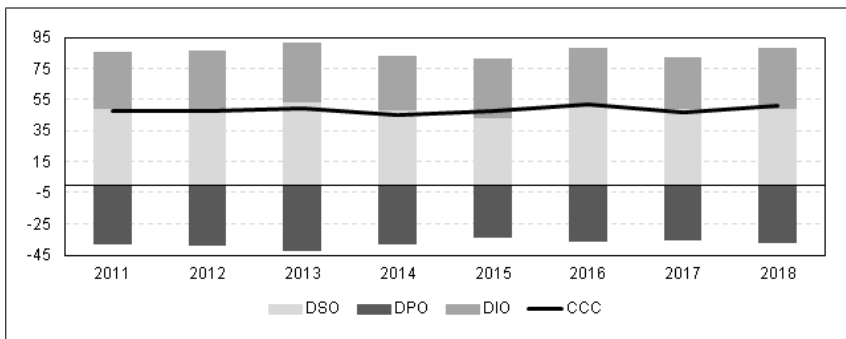
Figure 6: Tier 2 Cash conversion cycle



Source: own processing (2023)

Cash conversion cycle for Tier 3 (Figure 7) has, in contrast to other sub-segments, experienced prolongation by 3.7 days. Days accounts receivable outstanding have remained stable days and days accounts payable outstanding were reduced by 1.5 days while DIO increased by 2.9 days.

Figure 7: Tier 3 Cash conversion cycle



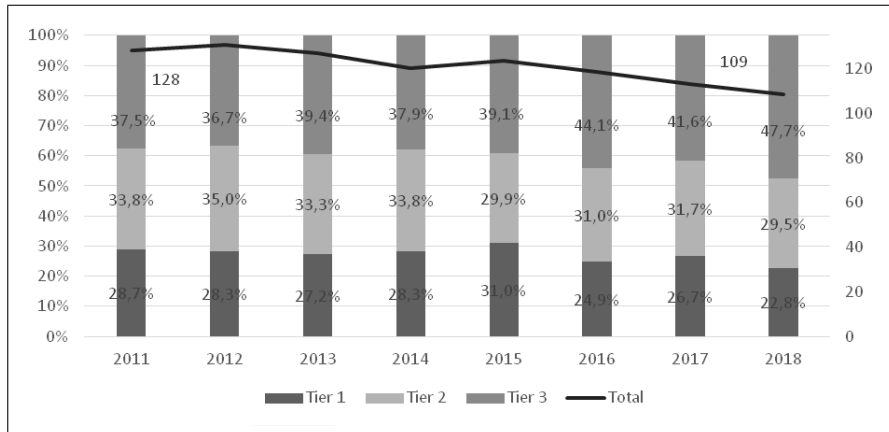
Source: own processing (2023)

Supply Chain Oriented Perspective

In this section the cash conversion cycle analysis is focused on the general supply chain concept to explore the sector dynamics of the industry-wide working capital management as well as the contribution of the individual tiers to the industry-wide cash conversion cycle. Similarly, to Hofman and Kotzab (2010) approach cash conversion cycle of whole supply chain is specified as the sum of particular sub-segments’ cash conversion cycles that are forming relevant supply chain.

As depicted in Figure 8, cash conversion cycles for all Tiers are positive, i.e., Czech automotive supply chain ties up significant amount of working capital and for relatively long period of time. For Tier 1, Tier 2 has cash conversion cycle decreased by 12.08 days, 11.23 day and adversely increased for Tier 3 by –3,7 days. Leading to shortening supply chain cash conversion cycle from 128.3 days to 108.8 days (i.e., app. 16% reduction) over the respective period (2011–2018).

Figure 8: Share of particular Tiers on supply chain cash conversion cycle



Source: own processing (2023)

V. Discussion

The average share of a particular Tier is decreasing the closer its product gets to the final customer (valid throughout all years), i.e. Tier 1 achieved lowest share value contrary to Tier 3 with highest ones implicating more efficient working capital management similar to Pirttila et al. (2010) and Losbichler et al. (2008). Also based on the participation share of individual sub-segments on the total supply chain cash conversion cycle can be derived position/market power of each of them within this supply chain. Interestingly shares of Tier 1 and Tier 2 have been diminishing over the time (drop by 5,9% and 4,3%, respectively) contrary to Tier 3 that experienced significant prolongation equal to almost 10%.

Achieved average value of cash conversion cycle for the Czech automotive supply chain is relatively high 121.35 days with relatively high variation of 12.6 days. For comparison, Lind et al. (2012) report average cash conversion cycle of European automotive supply chain

equal to 67 days over the period 2006–2008. This suggests that the relationship between working capital and sales remains almost unchanged. Pirttila et al. (2010) reached the same conclusion about the CCC in their study of the pulp and paper industry, and Losbichler et al. (2008) found similar results. Conversely, while the CCC remained stable in the automotive industry's supply chain, its components – days account receivables outstanding (DSO) and days account payable outstanding (DPO) – underwent significant changes, whereas the change in days inventory outstanding (DIO) was minimal. Typically, changes in DSO and DPO balance each other out, causing the CCC to reflect changes in DIO. Notably, at every stage of the automotive industry, the turnover time for accounts receivable decreased. This suggests that companies prioritized managing accounts receivable and emphasized collecting payments from customers.

In contrast, within the Czech context, there is a significant disparity, with values in the Czech supply chain being nearly double. This is mainly due to relatively high accounts receivable, averaging 130.2 days. Other working capital components also showed relatively high values, with accounts payable at 98.7 days and inventory at 89.2 days. These figures represent the average for the period from 2011 to 2018.

Pirttila et al. (2019) highlight differences in managing specific working capital elements within the Russian automotive supply chain, resulting in a potentially negative CCC, which is quite unusual compared to Western supply chains due to their dynamic market mechanisms. Brandenburg (2016) completely overlooked this issue, while Lind et al. (2017) noted only one company that achieved a negative CCC by tightly integrating suppliers into its supply chain. Moss and Stine (1993) studied retail firms and demonstrated that the CCC length was inversely related to average sales. The smallest 20% of companies had a significantly longer CCC compared to the largest 20% in their dataset.

Losbichler and Rothböck (2006) elaborated on financial information of 7,000 companies over the time frame of 1995–2004 extracted from Amadeus database. Reporting average decrease of cash conversion cycle by less than 3 days from 56 days in 1995 to 53.9 days in 2004. They also raised important supposition of supply chain organization, whether there are supply chain echelons and/or companies with “self-serving” working capital initiatives managing their own cash conversion cycle at the cost of their up/downstream supply chain partners. By linking industry sectors which mutually interact each other their analysis showed that most powerful industry sector is often able to reduce its own cash conversion cycle on larger scale than supply industries. Demonstrating it on example food supply chain, where food stores were able to decrease its average cash conversion cycle from 1.5 day in 1995 to –11,5 days in 2004 contrary to food manufacturing industry experienced increase in its average cash conversion cycle from 51,9 days in 1995 to 53,3 days in 2004.

Reasons for this discrepancy may be following: i) Since, there was no imposition of any cut-off point with respect to companies' performance, underlying sample is broader, i.e. containing not just publicly traded companies, where certain size, market power are presumed also associated with achieved better contractual conditions, ii) Observation period of time starts from 2011 just after financial crisis that impacted car industry severely resulting in relatively unfavorable contractual conditions, iii) It seems that rather “self-serving” approach with respect to working capital management was prevailing among

companies within Czech automotive supply chain than cooperative one leading to further deepening differences among subsectors.

As the calculation has shown, there are significant differences in working capital management among sub-segments of the Czech automotive supply chain from both monetary and as well as time perspective, thus hypothesis H1 can be confirmed as valid. It appears that Tier 1 (sub-segment closest to the final customer) can manage its working capital in the most efficient way facing relatively high profitability contributing to the highest free cash flow ratio despite simultaneously the highest capital expenditure ratio, accompanied by the lowest total external indebtedness and at the end resulting in the shortest cash conversion cycle. Thus, the evidence of diminishing downstream value-added decomposition was found consistent with conclusions by Pirttila et al. (2010) and Losbichler et al. (2008). Similarly, Modi's (2012) study suggests that Indian automakers tend to adopt an aggressive approach to managing working capital. Other authors, including Deloof (2003) and Lazaridis and Tryfonidis (2006), also confirm that an aggressive working capital management strategy is linked to higher profitability, irrespective of the industry or sector. Conducted analysis revealed two key findings about dynamics and structure of cash conversion cycle within Czech automotive industry. First, the actual length of cash conversion cycle both on particular sub-segment and the total supply chain level is significantly out-competing supply chains in developed countries with lengths of the CCC of underlying sample being almost two-fold. Second, there is significantly different participation of each sub-segment on total cash conversion cycle improvement over the respective period. It seems that Tier 1 (shortening by 12 days) and Tier 2 (shortening by 11.2 days) are benefiting from overall shortening trend of total cash conversion cycle over the inspected period whereas within Tier 3 the cash conversion cycle was extended by 3.7 days. Therefore, proposed hypothesis H2 must be rejected.

Hypothesis H3 presuming subordinated position of Tier 3 companies within the Czech automotive supply chain can be confirmed since Tier 3 is outcompeted by other Tiers almost in all observed characteristics. The question is how these companies could survive so far under this condition. Possible explanation may be that Tier 3 companies (at least some of them) are not fully specialized/dedicated just to the automotive industry. They commonly have extended their activities beyond car production. Simultaneously the credit policy of local banks was favourable to finance working capital needs, thus enabling companies to cope with shortage of internal resources.

VI. Conclusion

The underlying idea of this text is to test the vulnerability of the Czech automotive supply chain from working capital perspective. Empirical evidence has revealed several findings regarding tiers and the whole automotive supply chain.

Within the supply chain itself Tier 1 companies generate higher profitability and free cash flow accompanied with lower indebtedness and the fastest cash conversion cycle. Thus, they are better positioned to withstand current crises than companies from Tier 2 and especially Tier 3 sub-segments.

At the same time unequal profit distribution and overall position of single sub-sector within the production chain creates potential risk for whole Czech automotive industry given by higher risk of insolvencies and bankruptcies on Tier 2 and Tier 3 levels, which can shut off the supply of single components and undermine the final car production.

Although it seems at first sign that the CCC of the Czech automotive supply chain has improved over the respective period of time (reduced by app. 15%), empirical evidence is suggesting rather opposite view due to: i) Positive and long cash conversion cycle tying up significant amount of working capital in comparison with parallel supply chains in other developed markets and ii) Unequal participation of particular Tiers on this reduction confirming existence of asymmetric dependencies among Tiers, where the weaker members (particularly Tier 3) are “forced” against their own interest finance working capital for the most powerful members (particularly Tier 1), which are thus applying rather “self-serving/adversarial” rather than “cooperative” approach.

Therefore, based on the above-mentioned facts it is believed that the Czech automotive supply chain remains relatively vulnerable to any external shock (increase of interest rates, disruption of supply chains leading to longer deliveries etc.).

Further elaboration would deserve the explanation of discrepancies between the Czech and parallel supply chains in neighboring countries, more precisely what are the underlying reasons for the Czech supply chain members lagging its competitors. Also, deeper understanding of prevailing approach of the powerful members of supply chain (strong preference of adversarial rather than cooperation option) would be needed (role of capital origin etc.). Finally, potentially rethinking the position of the Czech manufacturing industry (especially automotive-related production) within the knowledge-based economy, where manufacturing itself generates relatively low value-added and becomes more vulnerable to any shocks, would be desirable.

References

- Ada, N., Ethirajan, M., Kumar, A., Vimal, K. E. K., Nadeem, S. P., Kazancoglu, Y., Kandasamy, J. (2021). Blockchain Technology for Enhancing Traceability and Efficiency in Automobile Supply Chain – a Case Study. *Sustainability*, 13(24). <http://dx.doi.org/10.3390/su132413667>.
- Aleshkova, D. V., Smolina, E. S., Shepelev, A. V., Kandrashkina, O. O., Zharinova, I. A. (2019). Foreign Manufacturers in the Value Chains Creation of the Russian Automotive Industry. *Proceedings of International Scientific Conference on Global Challenges and Prospects of the Modern Economic Development (GCPMED)*. 57, 1108–1114. Samara, Russia. <http://dx.doi.org/10.15405/epsbs.2019.03.111>.
- Ambadapudi, H., Matai, R. (2021). State of Supply Chain Finance for Micro, Small and Medium Enterprise in India. *Proceedings of International Conference on Industrial Engineering and Engineering Management*, 243–248.
- Automotive Industry Association of the Czech Republic. (2020). *Basic automotive overviews*. Retrieved December 18, 2022, from www.autosap.cz.

- Badakhshan, E., Ball, P. (2022). Applying digital twins for inventory and cash management in supply chains under physical and financial disruptions. *Journal of Productivity and Performance Management*, 61(15), 5094–5116. <https://www.tandfonline.com/doi/full/10.1080/00207543.2022.2093682>.
- Badakhshan, E., Humphreys, P., Maguire, L., McIvor, R. (2018). Simulation-based system dynamics optimization modelling of supply chain working capital management under lead time uncertainty. *Proceedings of 9th International Conference on Intelligent Systems*, 934–938. Funchal, Portugal.
- Blackman I. D., Holland C. (2006). The Management of Financial Supply Chains: From Adversarial to Co-operative Strategies. *IFIP International Federation for Information Processing*. 226. Springer, Boston, MA. https://doi.org/10.1007/978-0-387-39229-5_8.
- Brandenburg, M. (2016). Supply chain efficiency, value creation and the economic crisis – An empirical assessment of the European automotive industry 2002–2010. *International Journal of Production Economics*, 171(SI), 321–335. <http://dx.doi.org/10.1016/j.ijpe.2015.07.039>.
- Chang, C. C. (2018). Cash conversion cycle and corporate performance: Global evidence. *International Review of Economics & Finance*, 56, 568–581. <http://dx.doi.org/10.1016/j.iref.2017.12.014>.
- Cote, J. M., Latham, C. K. (1999). The Merchandising Ratio: A Comprehensive Measure of Working Capital Strategy. *Issues in Accounting Education*, 14(2), 255–267. <https://doi.org/10.2308/iace.1999.14.2.255>.
- CzechInvest. (2019). *Participants in the Czech automotive supply chain*. Retrieved December 22, 2022, from <http://www.czechinvest.org/cz/Homepage/Novinky/Brezen-2014/Automobilovy-prumysl-Nejen-montovny,-ale-i-vyzkum-a-vyvoj>.
- Czech Statistical Office. (2020). *Transport – economic area*. Retrieved December 20, 2022, from https://www.czso.cz/csu/czso/13-1134-07-2006-3_1_3_doprava.
- Deepa, N., Sivakumar, S. D., Deshmukh, S. S., Malarkodi, M. (2016). Influence of Cash Conversion Cycle on Financial Performance of Coconut Oil Mills in Western Tamil Nadu. *Indian Journal of Economics and Development*, 12(1), 143–149. <http://dx.doi.org/10.5958/2322-0430.2016.00016.0>.
- Deloof, M. (2003). Does working capital management affect profitability of Belgium firms? *Journal of Business Finance & Accounting*, 30, 573–587.
- Dibben, P., Meira, J., Linhares, C., Bruce, R., Wood, G. (2020). Vanishing value chains, industrial districts and HRM in the Brazilian automotive industry. *International Journal of Human Resource Management*, 31(2), 254–271. <http://dx.doi.org/10.1080/09585192.2016.1233446>.
- Doruk, O. T., Ergun, B. (2019). The role of macroeconomic constraints on cash conversion cycle: evidence from the Turkish manufacturing sector. *Asia-Pacific Journal of Accounting & Economics*, 29(4), 1063–2022. <http://dx.doi.org/10.1080/16081625.2019.1636665>.
- Ellram, L. M., Baohong, L. (2002). The Financial Impact of Supply Management. *Supply Chain Management Review*, 6(6), 30–37.

- European Commission. (2020). *European Economic Forecast – Spring 2020*. Retrieved December 28, 2022, from https://ec.europa.eu/info/publications/european-economic-forecast-spring-2020_en.
- Farris II, M. T., Hutchison, P. D. (2002). Cash-to-Cash: The New Supply Chain Management Metric. *International Journal of Physical Distribution and Logistics Management*, 32(4), 288–298.
- Gitman, L. J. (2006). *Principles of managerial finance*. WorldofBooks, United Kingdom.
- Guan, Y. (2007). Financial management trend from the view of value-chain theory. *Proceedings of International Conference on Management Science and Engineering*, 20–23, Sydney, Australia.
- Heneric, O., Licht, G., Lutz, S., Urban, W. (2005). The European Automotive Industry in a Global Context. *Europe's Automotive Industry on the Move. ZEW Economic Studies*, 32. http://dx.doi.org/10.1007/3-7908-1644-2_2.
- Hofmann, E., Kotzab, H. (2010). A Supply Chain-Oriented Approach of Working Capital Management. *Journal of Business Logistics*, 31, 305–330. <https://doi.org/10.1002/j.2158-1592.2010.tb00154.x>.
- Hofmann, E., Locker, A. (2009). Value-based Performance Measurement in Supply Chains: A Case Study from the Packaging Industry. *Production Planning & Control*, 20(1), 68–81. <http://dx.doi.org/10.1080/09537280802685272>.
- Hong, S-J., Najmi, H. (2020). The Relationships between Supply Chain Capability and Shareholder Value Using Financial Performance Indicators. *Sustainability*, 12(8). <http://dx.doi.org/10.3390/su12083130>.
- Howorth, C., Westhead, P. (2003). The Focus of Working Capital Management in UK Small Firms. *Management Accounting Research*, 14(2), 94–111. [http://dx.doi.org/10.1016/S1044-5005\(03\)00022-2](http://dx.doi.org/10.1016/S1044-5005(03)00022-2).
- Lazaridis, I., Tryfonidis, D. (2006). Relationship between working capital management and profitability of listed companies in the Athens stock exchange. *Journal of Financial Management and Analysis*, 19(1), 26–35.
- Manello, A., Calabrese, G. G., Frigero, P. (2016). Technical efficiency and productivity growth along the automotive value chain: evidence from Italy. *Industrial and Corporate Change*, 25(2), 245–259. <http://dx.doi.org/10.1093/icc/dtv021>.
- Mareš, D., Janíčko, M. (2022). The Reliance of the Czech Economy on its Automotive Sector. *Central European Business Review*, 11(2), 1–17. <http://dx.doi.org/10.18267/j.cebr.285>.
- Ministry of Industry and Trade of the Czech Republic. (2019). *Panorama of the manufacturing industry*. Retrieved December 27, 2022, from <https://www.mpo.cz/cz/prumysl/zpracovatelsky-prumysl/panorama-zpracovatelskeho-prumyslu>.
- Modi, S. (2012). A Study on the Adequacy and Efficacy of Working Capital in Automobile Industry in India. *IUP Journal of Accounting Research & Audit Practices*, 11(2).
- Moss, J. D., Stine, B. (1993). Cash conversion cycle and firm size: a study of retail firms. *Managerial Finance*, 19(8), 25–34.
- Muhammad, M. S., Kerbache, L., Elomri, A. (2022). Potential of additive manufacturing for upstream automotive supply chains. *Supply Chain Forum*, 23(1), 1–19. <http://dx.doi.org/10.1080/16258312.2021.1973872>.

- Munson, C. L., Rosenblatt, M. J., Rosenblatt, Z. (1999). The Use and Abuse of Power in Supply Chains. *Business Horizons*, 42(1), 55–65.
- Lambert, D. M., Pohlen, T. L. (2001). Supply Chain Metrics. *The International Journal of Logistics Management*, 12(1), 1–19. <http://dx.doi.org/10.1108/09574090110806190>.
- Lind, L., Pirttilä, M., Viskari, S., Schupp, F., Karri, T. (2012). Working capital management in the automotive industry: Financial value chain analysis. *Journal of Purchasing and Supply Management*, 18(2), 92–100. <https://doi.org/10.1016/j.pursup.2012.04.003>.
- Lind, L., Monto, S., Kärri, T. (2017, April 12). Categorizing working capital management practices in the automotive industry. *26th Annual IPSERA conference*, Balatonfüred, Hungary.
- Losbichler, H., Markus R. (2006). Creating Shareholder Value through Value-driven Supply Chain Management. *Managing Risks in Supply Chains*. Berlin, Germany.
- Losbichler, H., Mahmoodi, F., Rothboeck, M. (2008). Creating Greater Shareholder Value from Supply Chain Initiatives. *Supply Chain Forum: International Journal*, 9(1), 82–91.
- Oh, K., Dahee, L., Kim, D. S., Jeong, E. B. (2020). Panel Data Analysis of the Relationship between Cash Conversion Cycle Elements and Profitability in the Global Automotive and Electrical-Electronics Industries. *The Academic Society of Global Business Administration*, 17(2), 212–236. <http://dx.doi.org/10.38115/asgba.2020.17.2.212>.
- Pirttilä, M., Viskari, S., Kärri, T. (2010, May). Working capital in the value chain: cycle times of pulp and paper industry. In *Proceedings of 19th International IPSERA Conference: Supply Management – Missing Link in Strategic Management*. Lappeenranta, Finland.
- Pirttilä, M., Virolainen, V. M., Lind, L., Kärri, T. (2019). Working capital management in the Russian automotive industry supply chain. *International Journal of Production Economics*, 221, 107474. <https://doi.org/10.1016/j.ijpe.2019.08.009>.
- Rafuse, M. E. (1996). Working Capital Management. An Urgent Need to Refocus. *Management Decision*, 34(2), 59–63.
- Richards, V. D., Laughlin, E. J. (1980). A Cash Conversion Cycle Approach to Liquidity Analysis. *Financial Management*, 9, 32–38. <https://doi.org/10.2307/3665310>.
- Ross, S., Westerfield, R., Jaffe, J. (2005). *Corporate Finance*. McGraw-Hill/Irwin, Europe.
- Sakuramoto, C., Di Serio, L. C., Bittar, A. D. (2019). Impact of supply chain on the competitiveness of the automotive industry. *RAUSP Management Journal*, 54(2), 205–255. <http://dx.doi.org/10.1108/RAUSP-07-2018-0051>.
- Soenen, L. A. (1993). Cash Conversion Cycle and Corporate Profitability. *Journal of Cash Management*, 13(4), 53–58.
- Sim, J., Prabhu, V. V. (2022). The impact of credit risk on cash-bullwhip in supply chain. *Engineering Economist*, Early Access. <http://dx.doi.org/10.1080/0013791X.2022.2105463>.
- Singhal, V., Hendricks, K. (2002). How Supply Chain Glitches Torpedo Shareholder Value. *Supply Chain Management Review*, 6(1/2), 18–24.
- Wang, B. (2019). The cash conversion cycle spread. *Journal of Financial Economics*, 133(2), 472–497. <http://dx.doi.org/10.1016/j.jfineco.2019.02.008>.
- Ward, P. (2004). Cash-to-Cash is What Counts. *Journal of Commerce*, 5(7), 54.
- Wheelen, T. L., Hunger, D. J. (2002). *Strategic Management and Business Policy*. Eighth ed. Prentice-Hall, Pearson Education Limited, New Jersey.

- Talonpoika, A. M., Monto, S., Pirttila, M., Karri, T. (2014). Modifying the cash conversion cycle: revealing concealed advance payments. *International Journal of Productivity and Performance Management*, 63(3), 341–353. <https://doi.org/10.1108/IJPPM-12-2012-0130>.
- Timme, S., Williams-Timme, C. (2000). The financial-SCM connection. *Supply Chain Management Review*, 4(2), 33–40.
- Tsai, C. Y. (2017). The impact of cost structure on supply chain cash flow risk. *International Journal of Production Research*, 55(22), 6624–6637. <http://dx.doi.org/10.1080/002-07543.2017.1330568>.
- Yerpude, S., Singhal, T. K. (2020). Value Enablement of Collaborative Supply Chain Environment Embedded with the Internet of Things: Empirical Evidence from the Automotive Industry in India. *International Journal of Intelligent Information Technologies*, 16(3), 19–51. <http://dx.doi.org/10.4018/IJIIIT.2020070102>.
- Yilmaz, I., Acar, G. (2019). The Effect of Cash Conversion Cycle on Profitability in Omani Companies. *International Journal of Economics Management and Accounting*, 27(2), 269–290.
- Zhang, Y. K., Liu, S. F., Zhang, X. J. (2017). An Optimized Supply Chain Network Model Based on Modified Genetic Algorithm. *Chinese Journal of Electronics*, 26(3), 468–476. <http://dx.doi.org/10.1049/cje.2017.03.018>.