# The Evaluating the Financial Health of an Inter-Company Network - Evidence from the Automotive Industry

Jaroslava Pražáková,[1] Sandra Šindlerová[2]

**Abstract:** The aim of this paper is to assess the financial health of firms involved in an inter-firm network based on supplier-customer relationships. A real fragment of the automotive supply network was analysed. The financial health of each part of the network was assessed using a combination of the following bankruptcy and solvency models: IN01 model, Index Solvency, Taffler's model and Kralick's QT. The results of the bankruptcy models, K-means cluster analysis and functional analysis were complemented by core periphery analysis. By using these methods together, it was possible to identify the centre and periphery of the network and assess the differences in their financial health.

**Keywords:** networks, bankruptcy predictions, financial health, automotive industry
**JEL Classification:** G30, G33, M21

## 1 Introduction

Globalization, rapid development in the technical field and the development of production, information, management or communication technologies, caused an irreversible change of the environment. For this reason, economic entities are significantly interconnected, thereby improving their competitiveness and maintaining sustainable development (Tao, Cheng & Zhang, 2017). Networks are becoming the dominant organizational form of the economy and is referred as the network economy (Fiala 2008). Historically, the study of networks has been mainly the domain of a branch of discrete mathematics known as graph theory. In addition to the developments in mathematical graph theory, the study of networks has seen important achievements in some specialized contexts, as for instance in the social sciences. Social networks analysis focuses on relationships among social entities, or economic transactions between corporations (Boccaletti, Latora, Moreno, Chavez, & Hwang, 2006). Recently, the networks whose structure is irregular, complex and dynamically evolving in time are often the main subject of the research studies.

As reported by Rombach et al. (2014), networks are used to model systems where businesses interact with each other and are represented by nodes and their connections are represented by edges. For that reason, we can see the structure of the network represented by nodes and links (edges). Even though there is no hierarchical order in networks, we can identify nodes that are essential for network functionality. Zhang, Marin and Newman (2014) divide the network into a densely connected core and a sparsely connected periphery. Helo & Hao, (2019) add that the core–periphery structure is always detectable, no matter how weak it is. Understanding which nodes serve as hubs or authorities can provide insights into the resilience of networks. The centralities are measures that evaluate the importance of a node in a network based on the importance of its neighbours. This means that a node is considered significant if it is connected to other significant nodes.

The network resilience is also affected by financial health of the integrated nodes (companies). A financially healthy company is better positioned to withstand economic downturns and unexpected financial challenges. It maintains a balance between risk and return, ensuring stability in operations (Valášková, Nagy, 2023). Understanding financial health aids stakeholders in making informed decisions regarding investments, expansions, or operational changes. Metrics derived from financial health analyses can guide strategic planning (Kamal, 2024). Overall, financial health encompasses various dimensions that are critical for the sustainability and growth of organizations. By focusing on liquidity, solvency, profitability, and operating efficiency, companies can ensure they are well-equipped to navigate the complexities of the business environment while achieving long-term success. Bankruptcy prediction methods can be divided into three main groups: bankruptcy models (based on discriminatory, probit, or logit analysis), neural networks and generic algorithms (for example Pet and Jones, 2012) and decision trees. We found several studies that provided an overview of bankruptcy models, discussed their advantages and disadvantages, methods, and prediction accuracy (Alaka et al., 2018; Du Jardin,

[1] University of South Bohemia in České Budějovice, Faculty of Economics, Department of Accounting and Finance, Studentská 13, 370 05 České Budějovice, Czech Republic, smoloj@ef.jcu.cz
[2] University of South Bohemia in České Budějovice, Faculty of Economics, Department of Accounting and Finance, Studentská 13, 370 05 České Budějovice; Czech Republic, sindls01@ef.jcu.cz



https://doi.org/10.32725/978-80-7694-102-1.43

2018; Kovacova et al., 2019). Other research studies focused on the bankruptcy models refer to core authors in this field of study (Gu et al., 2017; Ouyang et al., 2018; Wang et al., 2017, Soukal et al., 2023). In our research we decide to use the four models from the first group.

## 2 Methods

The aim of the paper is to evaluate the financial health of enterprises involved in an inter-company network built based on supplier-customer relationships.

**Used methods:**

**The network construction:** the individual components of the network were identified using the Snowball method. this method is widely used in sociology and network theory in cases where it is difficult to identify the components of the network in another way. Studies discuss it in more detail for example: Naderifar, Goli & Ghaljaie (2017). We have identified a network fragment of 11 companies operating in the automotive industry.

**Financial health**: The data used for this analysis was drawn from financial reports from the year 2022. To estimate the financial health of individual elements of the network, four financial prediction models are used: Taffler index, IN01 index, Kralicek Quick test, Credibility index. The equations and interval for evaluation are below:

**Taffler Model** (Agarwal & Taffler, 2007)

$$T = 0.53 \cdot x_1 + 0.13 \cdot x_2 + 0.18 \cdot x_3 + 0.16 \cdot x_4 \tag{1}$$

where: x1 = earnings before taxes (EBT) / short-term liabilities; x2 = current assets / total liabilities; x3 = short-term liabilities / total assets; x4 = (financial assets – short term liabilities) / (operating costs - depreciation). The distress zone is below 0.2; the grey zone is between 0.2 and 0.3 and the safety zone is above the 0.3 level of T.

**Kralicek Quicktest (1993)**

$$Overall\ position = (q_1 + \mathrm{q}_4)/2 + (\mathrm{q}_2 + \mathrm{q}_3)/2 \tag{2}$$

where: The evaluation scale uses the point evaluation (q1 – q4) from 1 up to 5 for each financial ratio (x1 – x4). The final grade (overall position) is the arithmetic average of evaluated ratios of financial stability and revenue position (i.e. q1, q2, q3 and q4). Financial ratios are: x1 = equity / total assets; x2 = operating cash flow / revenues; x3 = EBIT / total assets; x4 = (liabilities + loans – cash) / operating cash flow. Note that CF according Kralicek is calculated as Profit(loss) current year +(-) changes in reserve funds +(-). Kralicek considers a company with final grade better than 2 as creditworthy. And a business with a score higher than 3 can be considered as a bankrupt company.

**Credibility Index (1993)**

$$IB = 1.5 \cdot x_1 + 0.08 \cdot x_2 + 10 \cdot x_3 + 5 \cdot x_4 + 0.3 \cdot x_5 + 0.1 \cdot x_6 \tag{3}$$

where: x1 = Cash Flow / Total liabilities and Equity; x2 = Total Capital / Total liabilities and Equity; x3= EBIT / Total Capital; x4 = EBT / Revenues; x5 = Inventory / Total Assets; x6 = Equity / Total Capital.

**IN 01 index**

$$IN01 = 0.13 \cdot x_1 + 0.04 \cdot x_2 + 3{,}92 \cdot x_3 + 0.21 \cdot x_4 + 0{,}09 * x5 \tag{4}$$

where: x1 = Total Assets / Total liabilities; x2 = EBIT /interest expenses; x3= EBIT /Total Assets; x4 = Revenues /Total Assets; x5 = Current Assets / Total Assets.

**The network structural characteristics:** the density of the network, centralities, hub and authority algorithm and Core and Periphery analysis was performed in software UCINET.

**Overall evaluation of the results:** The results of network structural characteristics are compared with financial health evaluation. The results of the individual bankruptcy indices are used as input data for cluster analysis. The K-means analysis with 2 clusters was performed.

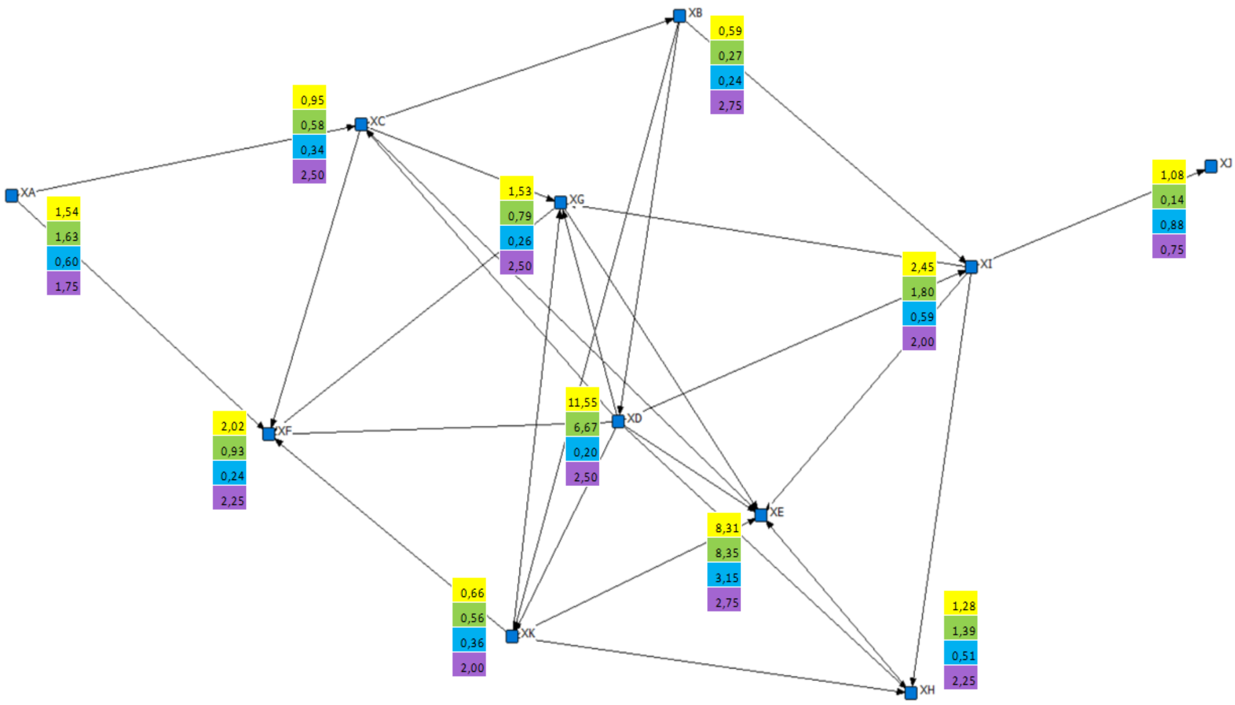
## 3 Research results

Individual parts of the network are identified based on real supplier-customer links between the companies. Due to the anonymity of the research, the companies are identified by abbreviations consisting of the letter X and the other letter assigned without reference to the original name of the company (from XA to XK). The mutual links between companies are marked by edges, and in the case of this network they represent the flow of materials in the network, with arrows corresponding to the direction of the flow. Recently, the car companies and their business partners have been dealing with factors that threaten their business, from chip shortages to supply chain issues. In addition, the companies labelled XF and XG are not only parts of the supply chain, but they are also companies where cars are assembled.

### Financial health analysis

The financial prediction models provide a comprehensive view of the financial situation of the companies analysed and their ability to remain stable in times of economic fluctuation. XE and XD are the best performing companies in the IN01 model. The model identifies these companies as the best performers, indicating their better financial health compared to other companies in the network. The Credibility Index (green marks in figure 1) confirms the results of the IN model and also ranks XE and XD as the top companies (yellow marks in the figure 1). In contrast, the Taffler's model (blue marks in Figure 1) identified only XE as a high performing company. Kralicek's quick (purple marks in Figure 1) test confirmed the results of the Credibility Index and the IN01 model with only a small change, with XE, XD and XG scoring best. This test reinforces the perception of these companies as financially stable. provide a comprehensive view of the financial situation of the analysed companies and their ability to maintain stability even in periods of economic fluctuations. The companies XE and XD achieve the best results in IN01 model. The model identifies these companies as the highest performers, indicating their better financial health compared to other businesses in the network. The Credibility Index confirms the results of the IN Model and ranked XE and XD as the top companies too. In contrast, the Taffler's model identified only XE as the company with high results. Kralicek' quick test confirmed the results of the Credibility Index and IN01 model only with a small change, when the XE, XD and XG companies achieve the best results. This test further reinforces the perception of these businesses as financially stable.

**Figure 1** Network structure



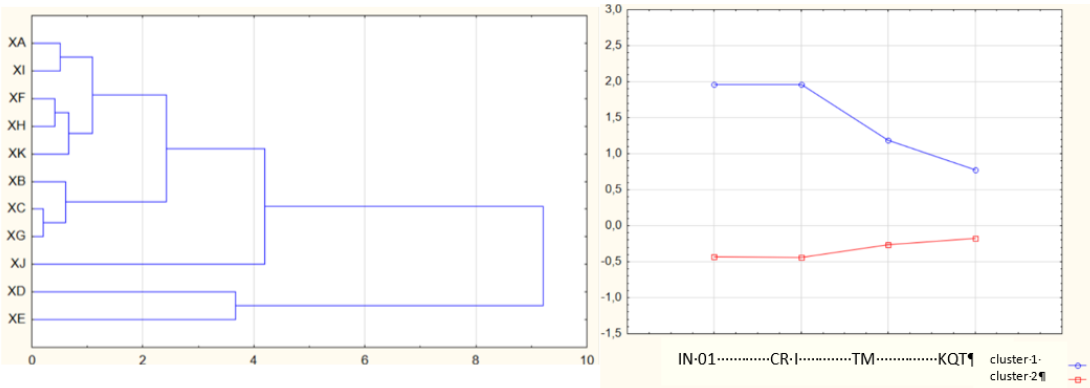

Source: Own processing in UCINET

36.4% of the enterprises create value and are classified as creditworthy by the IN 01 index. On the other hand, 18.2% of the enterprises are bankrupt. The assets of these enterprises are not sufficiently financed by equity capital, which means that they are financed by external sources. The remaining enterprises (45.5%) fall into the grey area. According to the Credibility Index, all enterprises are considered creditworthy and can be said to be financially stable. According to the Taffler model, 63.6% of the enterprises are creditworthy and 36.4% of the enterprises in this network are in the grey zone. This model suggests that most of the enterprises in this network are financially stable and are likely to remain so. No enterprises were classified as bankrupt using this model. The enterprises were divided into two groups according to the results and ratings of the Kralick's Quick test: the creditworthy group and the grey zone. The creditworthy group comprises

36.4% of the companies and was rated as stable by the model. The Grey Zone represents 63.6% of the sample, with no company rated as bankrupt. These calculations provide important insights into the financial health and stability of Network X.

In addition to financial indicators, the relative position of individual companies within the network is also a significant factor. The results reveal that the XE and XD companies not only demonstrate solid financial performance, as evidenced by the favourable outcomes of the predictive models, but they also illustrate a high degree of functional interconnectivity. This creates a financially stable hub of the X network with the potential to have a positive influence on other businesses in the network. Following the application of prediction models, a cluster analysis is conducted. This method is employed to group objects into clusters, with the objective of maximising the similarity of objects within a cluster while minimising the similarity between clusters. The criterion for this analysis is the degree of similarity between the entities. The values were initially standardised, and then Ward's method was combined with the use of Euclidean distances. This method is effective in grouping objects into homogeneous clusters. The results are confirmed by using the k-means method.

**Figure 2** Ward method and Euclidian distance dendrogram and average values of the clusters




Source: Own processing in STATISTICA cz

The enterprises are divided into two clusters (Figure 2), with Cluster 1 consisting of Company XD and XE and representing the core of the network. The remaining nine enterprises, depicted as cluster 2, represent the periphery of the network. The resulting distances allow us to conclude that the most typical company in the periphery is enterprise XH. This is due to the fact that it has the lowest distance from the mean of cluster 2, which is 0.10. Conversely, the most distant enterprise from the cluster mean is enterprise XB, with a distance value of 0.48. The company XJ has the lowest distance, which is representative of cluster 2 (distance value 0.01).

### A basic structural evaluation of the network

Using the Density overall method in the UCINET software, the density of the network was determined, which reached a value of 0.255. This suggests that the level of connectivity between nodes is relatively low in comparison to the maximum potential value. Moreover, the hubs and authorities of the Network X are identified according to the number of connections. The main nodes of the network are determined based on the connections. The most significant authority is the XF company, which is responsible for the dissemination of the majority of information, particularly within the domain of automotive manufacturing. The XD enterprise was identified as the primary hub, receiving and disseminating the bulk of the information and components within the network.

Subsequently, a core and periphery analysis was conducted using the UCINET software, which divided the network into a core and periphery. The network is structured around a core consisting of companies XE, XD, XF, XC, XI and XK, which are highly connected and are therefore likely to play a key role in the network. The periphery of the network includes enterprises XB, XH, XG, XA and XJ, which have lower connectivity and are probably less involved in the main flows of information and decision-making processes.

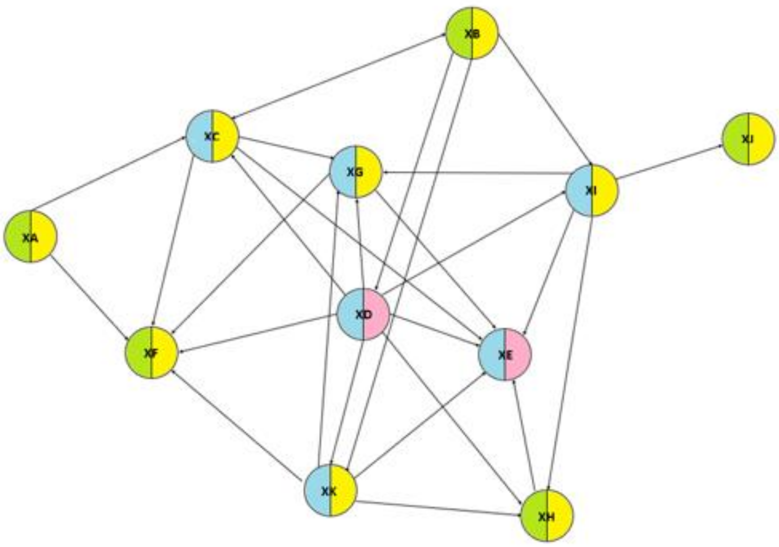
### Results comparison

It is assumed that the core part of the network is responsible for managing the information flow through the network and for influencing the network structure. The Core Periphery analysis identifies the six companies as the core (blue marks in Figure 3), whereas the cluster analysis based on financial health prediction models identifies only two companies as the core (pink marks in Figure 3). From the perspective of network structure, it can be assumed that the six core companies represent important nodes in the information flow, yet their financial health is not significantly different from the periphery of the network.

The exceptions to this are XE and XD, which are in excellent financial health and satisfy the condition of high interconnectivity in the network structure. Furthermore, they are indispensable to the network in terms of its functionality, given that they are a car manufacturer and therefore a crucial link in a demand-driven system. In defining the core, UCINET identifies those entities with a higher degree of interconnection, which are therefore regarded as having an impact on the stability of the network. Conversely, cluster analysis assesses financial stability based on the standardised values of prediction models.

The companies connected to the Network X show generally good financial health. XE and XD are the best performing companies according to the prediction models. On the other hand, the weakest enterprise is XB, which is labelled as bankrupt according to the IN01 model, probably due to low liquidity, indicating problems with repayment of liabilities. The Credibility index classifies XB as a creditworthy enterprise, but with a problematic economic situation, while the Taffler model and the Quick test place it in the grey zone. XB also relies more on external capital, which may be a way of financing its operations.

**Figure 3** Result comparison




Source: own calculations

## 4 Conclusions

The companies in network X operate in the automotive sector. The observed differences in their financial results are affected not only by their individual performance but also by their position among the other members of the network. Despite the presence of relatively weaker players, the network is nevertheless well-established, largely thanks to its anchor companies. In certain circumstances, the company at the core of the network may intervene in favour of a weaker network node located on the periphery. This is typically the case when the network requires the node due to its distinctive characteristics and functionality. Otherwise, they may be replaced relatively easily, given that the periphery of the network is often sparsely connected. The decision to replace or support a compromised network link is entirely at the discretion of the network core, taking into account the specific circumstances. However, it is essential to monitor the evolution of the relationships and the financial situation of the individual companies.

The greatest similarity between the financial health of the core and the periphery shows the Kralicek's Quick test and Taffler's model. In contrast, the IN01 model and the Credibility Index results support the theory of a better financial situation of the network centre compared to its periphery. The balanced results for the Kralick Index and the Taffler Index may reflect the fact that the evaluated industry has better financial health in general than the market average, and these companies reach the significantly higher performance.

Moving a company from the periphery to the centre of the network, or vice versa affects the network robustness. Gleissner (2023) presents the key characteristics of the robustness companies: high financial sustainability, robustness strategy as a driver of future financial performance and company value and high level of competence in dealing with risk. It can be concluded that these key characteristics are also important for entire enterprise networks. When a company moves from the periphery to the core, it can strengthen its position and the network through better connectivity, access to resources and increased financial stability. Conversely, a move from the core to the periphery can mean higher financial risk and lower competitiveness. The core of the network usually has better opportunities for collaboration, which contributes to the success of both the enterprise and the network.

The paper aimed to highlight the fact that in the future, it will no longer be sufficient to evaluate individual network links; instead, methodologies for evaluating the entire network will need to be developed. These newly formulated methods must be based not only on the evaluation of financial health, but also on the respect of the network position. Nevertheless, the development of such methodologies requires a comprehensive understanding of the structure of inter-organizational networks and a commitment to empirical research over an extended period.

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