Industry 4.0 and Modern Maintenance in Today's Hungarian Vehicle Industry

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L Juhász[1] and L Pokorádi[2]

[1] production leader, Komax Thonauer Kft., Cserszegi u. 2-6, H-2092 Budakeszi, Hungary

[2] full professor, Óbuda University, Institute of Mechatronics and Vehicle Engineering, Népszinház u. 8, H-1081 Budapest, Hungary

j.laszlo92@stud.uni-obuda.hu

Abstract. This paper presents survey results conducted in the domestic automotive industry. In this context, current trends in the maintenance sector were examined. In particular, the effects of smart manufacturing and modern devices on maintenance were addressed. The authors analysed the given responses and looked for correlations between them.

1. Introduction

Automotive companies are welcoming the ongoing digital revolution and looking towards incorporating Industry 4.0 technologies. Industry 4.0, also called the fourth industrial revolution, can be seen as a collection of various technologies [6]. According to Morauszki, Industry 4.0 is the fourth industrial revolution, which is a combination of information technology and automation [12]. The opportunities and solutions provided by Industry 4.0 are already being used by automotive companies; one of these main components is the IoT (Internet of Things).

Maintenance is one of the most important aspects of industrial and production environments [4]. IoT presents several potential research opportunities and raises development challenges in modern computing technological advancements, while encouraging a new paradigm; where sensors and actuators are managed as common infrastructure, offering multiple concurrent services and intelligent data aggregation to many users [5].

Previous research of the authors was addressed as to, how the tools of this digital revolution affect maintenance processes. In this regard, Augmented Reality (AR) [11] and the influential impact of the Industrial Internet of Things (IIoT) were examined [7].

However, an important question is in what respect do these trends affect the industrial actors of Hungary; to what extent have they appeared in their general professional strategy. In our study, we are looking for an answer to, what are the current more general trends, for Hungarian maintenance professionals interested in the issue, and to what degree do the new types of technologies appear in them.

The most developed industry in Hungary is the automotive industry. In Hungary, innovations concerning an entire company and maintenance processes usually appear here for the first time. Therefore, our micro-experiment was conducted among automotive operators in the form of a questionnaire survey.

With the survey, our goal is not only to shed light on the current state of the domestic automotive industry, but also to get a general impression from professionals about current trends in the sector and to identify connections between the trends. Another goal is to test our sampling and evaluation method.

For these reasons, in our survey, we combined the deeper, more nuanced benefits of qualitative research with the larger number of items in quantitative questionnaires [1][9].

The study consists of the following chapters: In Section 2, we present the sampling process and categorize the results obtained. In Section 3, we explore the relationships between responses. Finally, the authors summarize the study results and articulate their future research objectives.

2. Contents of the questionnaire

All three questions were defined in a free explanatory form to bring all hidden opinions to the surface. Respectively, as with the three answers, we asked for three aspects with which we can increase the connections between the answers.

To obtain the opinion of experts on modern factories and advanced maintenance, the following three questions were formulated in the questionnaire:

1. Based on what characteristics would you characterize the general level of development of a factory? Please specify three aspects.
2. What characteristics would you use to characterize the development of a maintenance process? Please specify three aspects.
3. How would you describe a smart factory? Please specify three aspects.

Another question was the nationality of the ownership structure of the respondents' company. Practice shows that there is a significant difference in usage of digitization and modern technologies in Hungary, depending on whether the company culture is Hungarian or some other nationality [13].

2.1. Systematization of results

The questionnaire was completed by a total of 18 respondents and after data processing, all the responses proved to be suitable. Thus, in connection with the first round of filling, we already had sufficient data to obtain a comprehensive picture about the experts' opinion and this enabled the examination of correlation between different trends.

Although the answers were received in text format, all answers contained typical topics. For example, for the first question we received the following specific answer:

"Machinery; capital; management".

Because we asked for three parts for each of the three explanatory questions, we also received three different aspects each. These aspects were treated as a separate response. To make a proper comparison, the aspects were clustered, i.e. they were classified into a certain set of features according to their topic, and then clusters were named according to their features. In the example above, "machinery" response was grouped into the Technology and Innovation group, "capital" response into the Market and Financial Process group, and "management" response into the Humanities group.

"Machinery"	"Capital"	"Management"
{13}	{12}	{16}

This is how the different groups were formed. For example, in the Digitization and Tracking {14} group of the first question, the following answers were received:

- Industry 4.0 development;
- Digitization;
- Introduction of Industry 4.0;
- Real-time production tracking;
- Digitization;
- Digital development;
- Digitization;
- Traceability.

Clustering was performed for all responses to all three questions to create a well-comparable array of information. After summarizing the groups, one table per question was obtained (see Tables 1-3). In these tables, each cluster is listed in ascending order and individually identified (e.g., in question 1, the number is {1X}).

Table 1. *Characteristics of the general level of development of a factory*

Nr.	*Cluster Name*	*pcs.*
{11}	Efficiency, quality and delivery reliability	10
{12}	Market and financial process	9
{13}	Technology and innovation	8
{14}	Digitization and tracking	8
{15}	Automation	7
{16.	Human	5
{17}	Other	4
{18}	Process approach	3

Table 2. *Characteristics of the development of a maintenance process*

Nr.	*Cluster Name*	*pcs.*
{21}	Traceability, measurability	11
{22}	Plannability	9
{23}	Professionalism	7
{24}	Preventive, predictive ratio	6
{25}	Speed	5
{26}	Machinery and equipment	4
{27}	Regularity	4
{28}	Cost effectiveness	4

Table 3. *Features of a smart factory*

Nr.	*Cluster Name*	*pcs.*
{31}	Digitization	14
{32}	Speed, efficiency	10
{33}	Automation	9
{34}	Process focus	5
{35}	Plannability	4
{36}	Communication	4
{37}	Environmental Protection	2
{38}	Other	1

2.2. Connections of opinions

To explore the relationship between the development of maintenance processes and modern factories, the relationships between each response were examined. It was recorded, after giving an answer group to one of the questions, what answer group the respondent gave to the following questions. This is how the relationships between the response groups were established. Based on this, three connection matrices (Question 1 - Question 2, Question 2 - Question 3 and Question 1 - Question 3) were obtained, as illustrated in Figure 1.

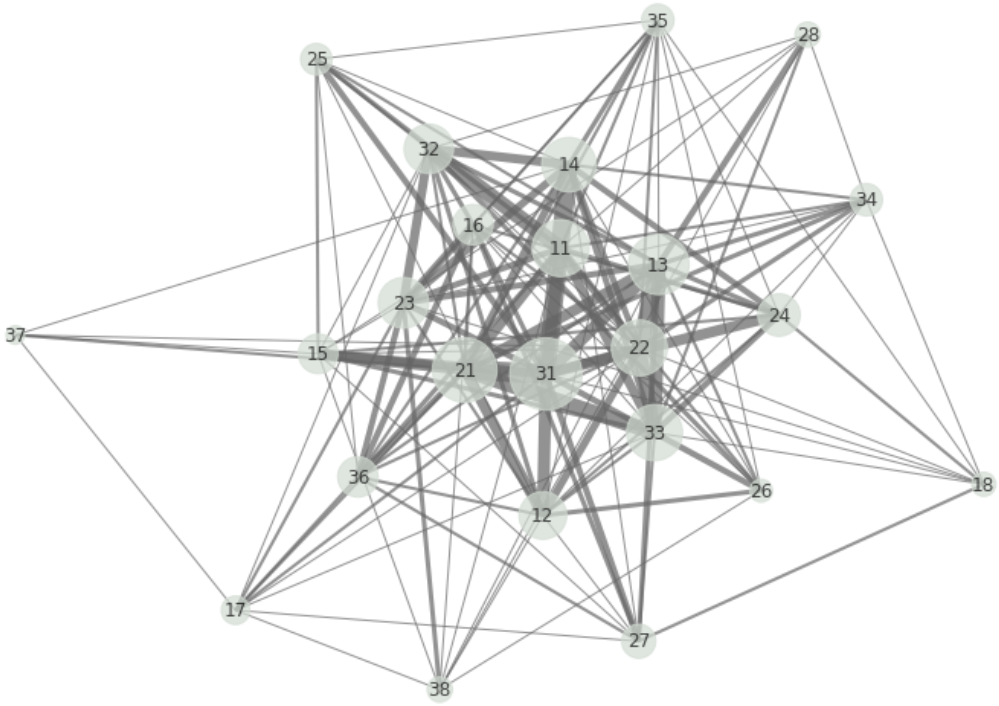

Figure 1. Joint network of the three connection matrices - all respondents

The answers were collected separately, where the company ownership is Hungarian. Here a total of 9 responses was received, as shown in Figure 2.

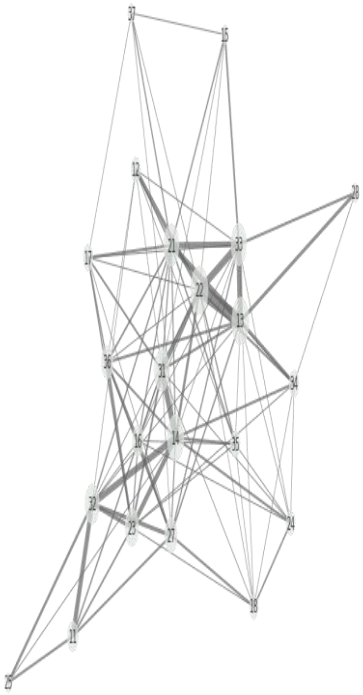

Figure 2. Joint network of the three connection matrices - Hungarian-owned companies

The strength of the connection of one node to another node is shown by their distance from each other and the thickness of the line between them. The size of the nodes is determined by the number of all their connections.

A relevant connection is one where there is a minimum of six connections between nodes, as this is exactly one third of the respondents. Besides, a connection must not only exist between two questions, but the three questions together must form a triangle. Based on these, three coupling matrices were obtained in the same way and were illustrated in Figure 3.

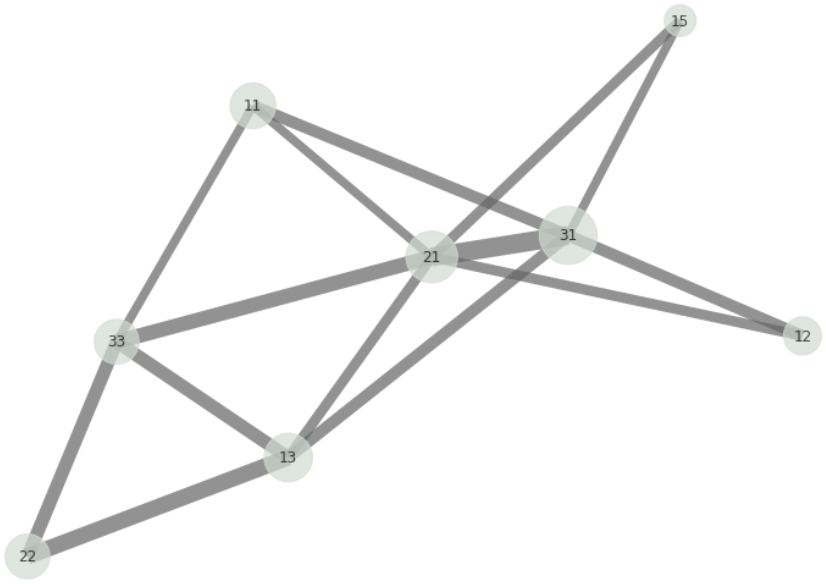

Figure 3. Joint network of significant connections - all respondents

A total of 9 Hungarian-owned responses were received. These were also examined for relevant relationships, where the relevance threshold was set for 3 relationships (one-third of respondents). The network of connections formed based on this classification is illustrated in Figure 4.

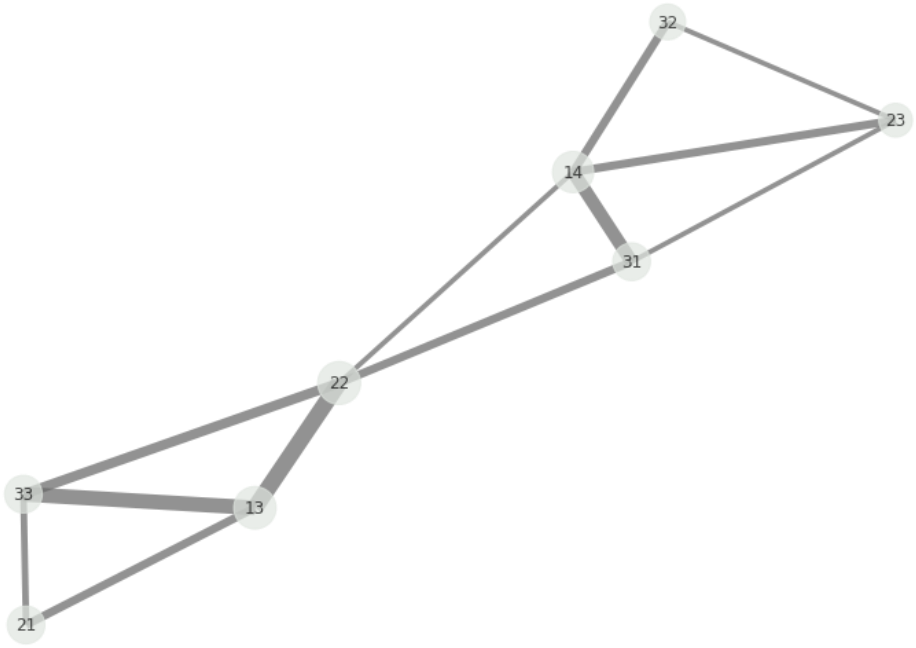

Figure 4. Joint network of significant connections - Hungarian-owned companies

3. Conclusions

The conclusions that can be drawn from the evaluation of the responses received are summarized below:

- The strongest link is between {21} traceability, measurability and {31} digitization for smart factories, which are also in the top of their response group.
- {11} efficiency, quality and delivery, {12} market and financial process, {13} technology and innovation and {15} automation are related to this main relationship in approximately equal proportions.
- The triangle "{11} efficiency, quality and delivery - {21} traceability, measurability - {31} digitization" clearly shows the presence of a modern quality culture among the responders; maintenance professionals committed to development. One of the key issues in quality assurance is traceability, which - with the rise of Industry 4.0 - can take digital form.
- A similar conclusion can be drawn from the triangle "{12} market and financial process - {21} traceability, measurability - {31} digitization". Remember, quality as well as customer satisfaction is also highlighted by the experts.
- A relatively stronger triple relationship can be discovered through the automation of advanced factories {13} technology and innovation, modern maintenance {22} plannability and smart factories {33}.
- There is no significant link between the {14} digitization of the advanced factory and the {31} digitization of the smart factories. According to this, those skilled in the art, see the achievement of smart factories in digitization in the first place, but a general advanced factory is mainly characterized not by this, but by, for example, efficiency, quality and delivery reliability.
- The strongest connection triangle of Hungarian-owned companies is "{13} technology and innovation - {22} plannability - {33} – automation". Compared to all respondents, the very strong {21} traceability, measurability - {31} digitization relationship does not appear at the domestic companies.

4. Summary

In our study, we presented a micro-experiment and its primary results regarding the current state of Hungarian automotive industry. The aim of the survey was not only to shed light on the specifics of the sector but also to obtain first-hand impressions from professionals, receptive to the issue of current trends and to identify links between trends. Due to the cultural differences in work organization, we examined the responses of Hungarian-owned companies separately. Another goal was to test our sampling and evaluation method. Based on our experience in preparing this study, we plan to develop and conduct a broader and deeper survey soon.

Acknowledgement

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