DIGITAL TRANSFORMATION OPPORTUNITIES FOR HUNGARIAN WOODWORKING COMPANIES, WITH A SPECIFIC FOCUS ON MANUFACTURING OPTIMIZATION

Thesis Booklet

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Introduction

I have been closely involved in Industry 4.0 for a few years through my consultancy work. I thought it would be interesting to develop a survey that could answer the question of how to quickly identify the development potential of Industry 4.0 and what practical conclusions this research could have.

This thesis aims to combine my years of industry expertise and applied industry research to provide practical guidance to industry colleagues and company management by processing a so-called Industry 4.0 maturity survey through applied research methods.

In this thesis, I aimed to provide a comparison; thus, in addition to the woodworking companies examined, I also reviewed other companies in the industry. The Model Factory in this study is a metal industry company that supplies window hardware to the wood industry sector. This company already uses Industry 4.0 solutions, thereby establishing a connection with the industry under study.

However, the main goal was to quantify attainable benefits. I was able to use the example of this company to demonstrate the tangible, practical results of Industry 4.0 developments based on process improvement. In this example, I present the quantified results of TPM (Total Productive Maintenance) as a process management tool.

The thesis aims to elucidate that process organization always provides the basis for future Industry 4.0 targeted improvements; my method can predict the return on investment of these improvements.

My research topic focuses on the digital transformation possibilities of woodworking companies. I wanted to assess the current level of digitalization in the wood industry and determine whether the need and potential for further digitalization exists and, if so, in which directions the potential is visible in the individual companies.

"Industry 4.0 is like the rain: it's coming, but it's unclear whether it will flood the whole industry away or turn everything around. Therefore, companies need to have a strategy about how to deal with this situation because those who fail to do so will condemn their companies to death in the competitive market." [1]

Research Methodology

The Industry 4.0 research aimed to develop a method that would allow a company's Industry 4.0 maturity to be quantified relatively quickly – i.e. in a one-off survey – and to provide the company with a quick guide on areas where it would be worthwhile to improve, and in which areas the most effective use of the available Industry 4.0 tools would be.

A total of 21 companies participated in the survey, although close to 40 were invited (a participation rate of ~50%, which is typical for quantitative research methods). An interesting feedback is that many companies did not wish to participate in the survey, despite it being anonymous and free. A large proportion of the companies surveyed (76%) are small and medium-sized enterprises (SMEs). Companies in this sector are more concerned about data and system disclosure, while larger companies tend to be prouder and more open about their results.

The maturity survey methodology identifies development potential, which maps the company according to the degree of digitalization. The mapping should be adhered to according to the following categories to ensure that no important areas are overlooked:

1. Product
2. Machinery/manufacturing technology
3. Manufacturing process (value stream)
4. Business processes (serves multiple manufacturing processes)
5. Strategic management

During the research, I chose a method that combines the traditional in-depth interview technique with a questionnaire-based, guided criteria judgement technique [2]. Neither of the previously mentioned techniques alone would have been sufficiently effective and robust to conduct the survey. Defining the concepts and categories to be used, in conjunction with the company surveyed, is a crucial part of the survey. Without these concept clarifications, the assessment could include different values due to different interpretations. A so-called scale question survey was chosen, which, according to the literature, can be used to quantify emotions and attitudes.

The most common type is the grading type modelled on school grading, which grades the question from 1 to 5.

The maturity assessment meetings essentially have three steps.

- The first step involves a conversation with the company's decision-makers. This step clarifies the project purpose and, for the reasons described earlier, the concepts of Industry 4.0. The company should be classified by size, turnover, number of employees, and its position in the manufacturing value chain. In addition to Industry 4.0 awareness, the discussion should determine the existence of a formalized corporate strategy and an Industry 4.0 strategy. Briefly, the core challenges the company faces and the labor supply situation.

- The second step is to review the manufacturing plant logistics, which should be considered in terms of the material flow (from receipt of raw materials to delivery of the finished product). Defining the main product groups should also be considered at this stage. The logistics overview of the manufacturing plant includes examining the technological processes and assessing the visualization techniques used, possible management habits, and interpersonal relationships.
- The third step involves completing the questionnaire together. Sometimes it is difficult to identify all the data immediately (e.g. the machinery survey). In such cases, companies can provide the surveyor with the data at a later stage.
- The fourth step is to evaluate the questionnaires and provide feedback.

General Findings

- The experience of consultants and the evaluation of the quantitative research results indicate that the conditions in woodworking companies are very similar to those in other manufacturing industries – ownership structure and size are more likely to determine the answers to the questions. There is no fundamental difference in the development of Industry 4.0 in companies in the wood industry and companies in other industries in Hungary. Perhaps the automotive industry and the automotive TIER1 suppliers are different in some respects, as they have specific requirements from their customers.

- Enterprise Resource Planning (ERP) is crucial as it requires a certain degree of organization. A consciously- and well-implemented ERP system provides the framework upon which additional processes can be built using digitalization tools. Of course, this is also true in reverse, as only companies that have thought through their processes and taken the necessary organizational steps have been able to implement a well-functioning ERP.
- However, conscious organizational development and process focus are only present in about 30% of companies.
- Every company has outstanding solutions that should be shown, learned, and presented as best practice examples. Industry alliances and collaborations could be a great help for shared development.
- A well-trained workforce has proved to be a bottleneck almost everywhere. The level of manual work in the enterprises surveyed is high, with 80%-85% of the workers being manual workers.

Figure 1 shows the industry breakdown of the surveyed companies. The firms participating in the survey fell into two groups – a wood industry group and a group containing other industries. As anticipated during the visits, the study results revealed that the wood industry has no specific characteristics from an Industry 4.0 perspective.

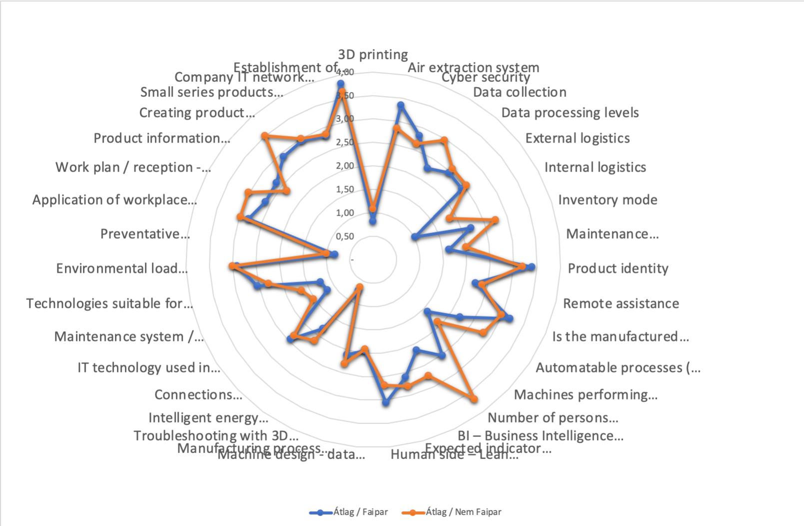

Figure 1: Industry 4.0 survey results – All questions by industry [3]

The two groups studied have very similar Industry 4.0 outcomes, or in other words, the potential available, i.e. they are industry-independent.

The industry cross-section indicates that there are essentially three areas with very low scores:

- 3D printing
- Internal logistics
- Maintenance

Nearly 50% of the companies included in the study were in the wood industry. Here the role of additive technologies such as 3D printing was significantly smaller. Unlike plastic products in the plastics industry, wood products require no complex production tools, molds, or prototyping equipment. In the latter, some molds are expensive to produce, and if the prototype needs to be changed, the whole process may need to be repeated, which is why the technology used in other industries for prototyping and small-batch production is not yet widespread. However, as wood raw material sources become scarce, wood-based printing and extrusion technologies will become more important; hence, material-additive manufacturing will become increasingly important in the wood industry. Its potential could become a significant factor in the future, especially in building product manufacturing (e.g. window profiles, thermal bridge-free coupling elements).

Internal logistics and maintenance show potential worth paying attention to and taking steps to improve. Most companies – especially smaller ones, regardless of the industry – see big value in machine acquisitions. Everyone is creating opportunities to buy new machinery because they feel it is a bottleneck. Process management solutions, which, in this case, include maintenance or improving internal logistics, are not regarded as relevant tasks. The precise starting point was when the Ministry of National Economy announced the knowledge transfer program. Companies have succeeded in acquiring new machines through many tenders. Some machine manufacturers provide examples that although a purchased machine runs only at 40% capacity, the customer remains interested only in the possibility of speeding up the feed. Thus, customers prefer buying machines or increasing machine speed over considering optimization.

In summary, the reduction of wood raw material resources, the energy crisis, and the increase in labor costs have prioritized using automated or Industry 4.0 production equipment and optimizing factory logistics. The ordering principles of optimization can be export and energy use aspects, whose optimization application, alongside the currently less-considered additive manufacturing technologies and maintenance aspects, will become even more valuable.

The Model Factory

Roto Elzett Certa Ltd. has conducted several innovative projects that have led to it being awarded the title of Model Factory in 2018. Through their example, the question of whether it is an anomaly or an opportunity to combine Industry 4.0 and TPM (Total Productive Maintenance) can be answered. [4]

The name Roto Elzett Certa is revealing in itself because it encapsulates the history of the Hungarian Elzett factory with its centuries-old tradition and the innovative thinking of the German parent company, Roto. Together, they constitute today's leading hardware and fittings manufacturer.

The above survey was also conducted at Roto Elzett Certa Ltd. The link between TPM and Industry 4.0 made it interesting to compare the results with the situation when TPM was introduced. For this reason, a retrospective assessment was also performed by way of exception. This required the help of company staff. Figure 2 illustrates the maintenance-relevant questions of the questionnaire and the corresponding evaluation from 2011 and 2018.

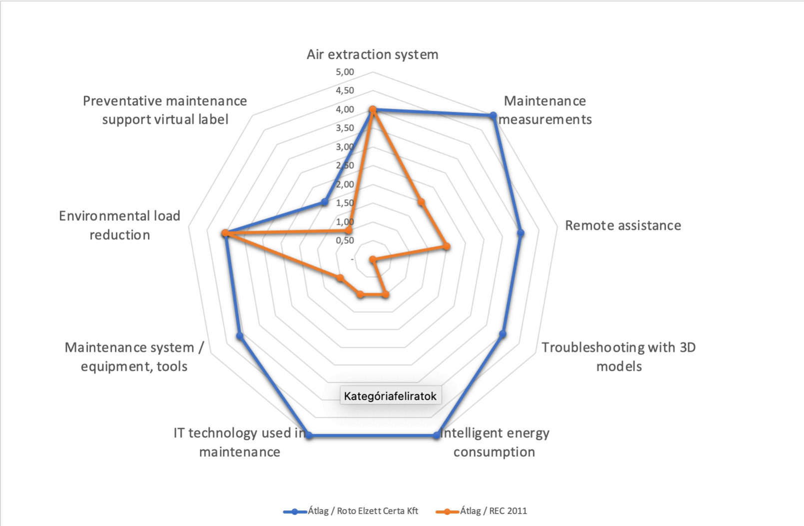

Figure 2: Comparison of survey results 2011 vs 2018 [5]

The TPM project created the need for data-driven measures to improve machine utilization, i.e. a data collection system that allows continuous monitoring (in 2011).

The second line of analysis was downtime data processing for the model factory. As a result of a project started in 2011, downtime data for the dismantling machines have been available since 2012. In the category of machine failures, the company identifies mechanical breakdowns specific to the machine unit and does not include downtime caused by equipment or electrical breakdowns. Based on these data, Figure 3 diagrams the ratio of machine failures to planned production time.

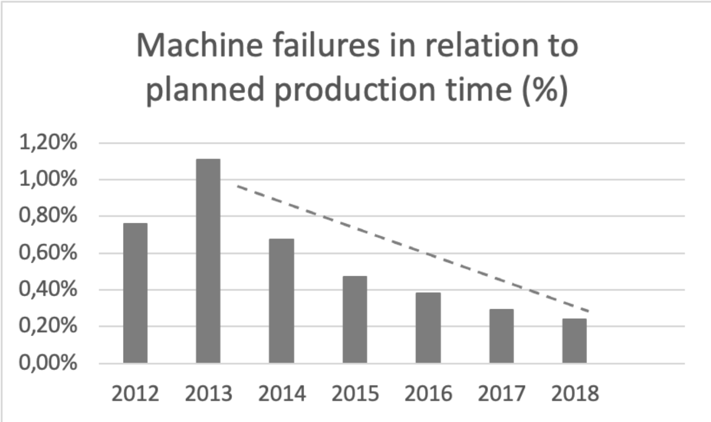

Figure 3: Machine failure in relation to planned production time [5]

Clarifying data access was the aim of the first period following the introduction. During this time, the company has undergone several important developments, including developing data collection interfaces for the OEE (Overall Equipment Effectiveness) system in 2012, which simplified data entry for operators.

Since the model factory uses ERP, specifically SAP, it became essential to ensure SAP compatibility with the records. Parts previously stored in drawers, with or without a separate identifier, have been transferred to the ERP system instead of the previous vague records system. A major advantage of this is the fast maintenance response through easy searchability (2013).
The next step was developing the MES (Manufacturing Execution System) system, which allows the continuous monitoring of production in real-time, partly automatically with data from the ERP and partly from the reports of the operators' stops.

Two strands of research show that I4.0 development based on well-organized processes generates measurable results.

The thesis combines many years of industrial experience and applied research methods.

The applied research results should be put into practice; it also offers useful tools to help companies and their managers on the obligatory, but far from clear, digitalization path.

Thesis 01

I have designed a sector-independent questionnaire survey system to measure the digital readiness of domestic companies, which allows a quantified assessment of digital readiness. The customized survey system also allows for the design of effective Industry 4.0 development directions tailored to the specific characteristics of each company.
The survey methodology is presented in publication number P4.

Thesis 02

Based on my surveys of SMEs in the wood and other industries, I have identified the areas with the greatest potential for development, namely:

- 3D printing (wood printing);
- Internal logistics;
- Maintenance.

I quantify this as follows, based on the six questions below:

–	Preventative maintenance with 3D models	0.68
–	Preventative maintenance support with virtual labels	0.92
–	3D printing	0.96
–	Internal logistics	1.36
–	IT technology used in maintenance	1.47
–	Maintenance system/equipment, machines	1.48,

where the scores are the average of the numbers between 1 and 5 for the companies surveyed.

Thesis 03

Industry 4.0 development opportunities are not industry specific; there is no significant difference in readiness between the two industry groups (wood and other). The finding is published in detail in publication P7. The overall average score for the wood industry is 2.41 points, while the overall average score for the other industries is 2.42 points (see Figure 1).

Thesis 04

For the TPM system used in the Industry 4.0 metal industry model factory, I defined a new, refined OEE formula based on the analysis of the sample factory data as follows:

$$OEE = AQ \ X \ P = \frac{\boldsymbol{DBgy \ x \ n}}{\boldsymbol{Ttf - Tt\text{á} - Ttk}}$$

which allows for a more in-depth analysis of downtime.

Thesis 05

Based on the sample factory data for the metal industry Industry 4.0, I found that introducing Industry 4.0 solutions in the case of TPM systems generates additional downtime reductions, which in the case of the company in question, leads to cost reductions. This fact supports my hypothesis that a complex application of the different aspects of each industry leads to the fastest and most efficient progress in digital transformation.

I support this assertion by analyzing the model factory data from two directions (my own questionnaire and the model factory's machine station data). I have presented this in publication P7.

Thesis 06

Based on business surveys, I have found that the literature does not define TPM as a lean tool; however, it should be considered as a lean solution for the success of Industry 4.0 feasibility analysis. I have described this in detail in publication number P2.

Related Publications:

P1: Evaluating the surface stability of sanded wood: Part I.

Magoss, Endre; Molnár, Zsolt; Suri, Veronika; Fuchs, Ingrid (2019)

Published: WOOD RESEARCH 64(3):401-410.

P2: TPM vs. INDUSTRIE 4.0 – ANOMALIE ODER POTENTIAL?

Presented: Miskolc, Géptervezők Szemináriuma, 11.08

Published: GÉP, A Gépipari Tudományos Egyesület Műszaki folyóirata 2018/4. száma (lektorált)

P3: A szuperhősök kora lejárt – folyamatfejlesztés a gyakorlatban

Presented: Gyártás 2015 konferencia Budapest, BME 2015.11.20

Published: Gépgyártás Folyóirat LV.évf.2015/2. szám (bírált)

P4: A digitális átállás felkészültségének minősítése faipari kis és középvállalatoknál

SURI Veronika1, Suri János1, MAGOSS Endre1, Kocsis Zoltán1

Published: CD-n és nyomtatásban a Faipar 65:1 konferencia kiadványában (2019)

P5: FAIPAR 4.0 – A DIGITÁLIS ÁTÁLLÁS LEHETŐSÉGEI

Az Ipar 4.0 bevezethetőségnek felmérése faipari vállalatok átvilágításával – kérdőív

Suriné Lengyel Veronika, Suri János

P6: Az innovatív szervezeti kultúra, mint a fejlesztés egyik pillére.

Suriné Lengyel Veronika, Suri János

Presented: WEU Nemzetközi Konferencia 2004.05.06-07

Published: WEU Konferencia kiadvány

P7: SMALL AND MEDIUM-SIZED ENTERPRISES (SMES) IN HUNGARY: INDUSTRY 4.0 TRENDS AND CHALLENGES – in publication

Ádám Fazekas, Endre Magoss, Veronika Suriné Lengyel

References

[1] B. Tordai, „blog.szta.hu,” 10 2018. [Online]. Available: https://www.blog.szta.hu/a-mesterseges-intelligencia-elott-uzleti-intelligenciara-van-szukseg/.

[2] Suri János, SURI Veronika, MAGOSS Endre, Kocsis Zoltán, „A digitális átállás felkészültségének minősítésé, faipari kis és középvállalatoknál, Faipari Konferencia és Vásár, 2018.”.

[3] Own data.

[4] L. V. Suriné , „TPM vs. INDUSTRIE 4.0 – ANOMALIE ODER POTENTIAL?,” in *Gépipari Tudományos Egyesület*, Miskolc, 2018.

[5] Roto own data.

Figures