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Research Paper

Measurement of logistics processes for potential optimization purposes at enterprises based in a Hungarian county

Károly Szabó * and László Szabó

Budapest Business University. Budapest, Hungary

* Correspondence: szabo.karoly@uni-bge.hu

Abstract: Daily logistics processes and supply chains make up complex systems which can be affected by many factors (e.g., production technology, infrastructure, daily traffic, weather, or ad-hoc problems). As part of this research, an investigation was conducted to determine how such factors influence the daily material flow of enterprises in Zala County, one of Hungary's 19 counties. With the help of qualitative sampling, we identified which variables affect logistics processes. As an initial step of the research, classic and modern trends of logistics software support were compared through a literature review. Results show that the lack of simulation forecasting is a serious deficiency for applied technologies. In the second part of this paper, we identify the measurable variables and their significance on future simulations with the help of a qualitative method. This research has been a precursor to our long-term research approach, in the scope of which company processes are modelled and subsequently improved through simulation.

Keywords: logistics; strategy; planning; simulation; Zala County

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1. Introduction

Supply chains have reached a very high level of efficiency. However, recent events shed light on the fact that endlessly optimized systems are not only vulnerable to ad-hoc problems, but their everyday operation has certain limitations. The latter issue should definitely be supplemented with Just in Time and lean management. In fact, the world's leading companies have been operating based on these principles in recent decades, and, as a result, they typically do not create safety stock. So, in a vis major situation, JIT-based producers simply cannot manufacture any more (especially if shortage of raw materials is considered) (Pató & Herczeg, 2020).

In addition, previous research points out that one-time deliveries and purchases have become more and more difficult due to the congestion of transport routes (Gubán et al., 2017). To explore these everyday difficulties, we decided to map supply chain solutions. After a first contextual review, it became evident that a logistics simulation system based on inner company data could be very useful. Also, on the long run it could be rewarding to create a decision support software based on such simulations.

After gaining an insight into the subject, the first step of the research was the determination of the territory of the sampling (Gubán & Hua, 2014). Being a logistics junction, Zala County was chosen as the test area for the study. Also, investments of recent years in the region have made the territory even more suitable for research. The most significant investments include developments in the vicinity of the county seat, Zalaegerszeg: roads R76 and M70, the Zalaegerszeg test track, the construction of the Logistics Terminal, the Tank Factory and the plans of highway M9 (Szabó et al., 2020) (of course, our long-term goal is to extend research to other regions, too).

Following the delimitation of the territory, we also had to establish the basic research design of the study. After the adaptive review of qualitative and quantitative methodologies, qualitative sampling was selected, and a systematic literature review was produced. The literature review was chosen for the understanding of the context and previous results as qualitative sampling can help at the selection of the variables to be measured.

One of the main aims of the current study is to understand the whole context of the supply chain simulation and learn about the most important previous results. The second goal is the determination of the measurable variables through qualitative methods. Through the semi-structured interviews, we try to identify the measurement method of logistics processes at Zala County based enterprises. Within this, the main question is what inner logistics processes should be measured for a simulation model and are there any delays/problems connected to these variables (if at all)?

2. Theory and hypotheses

As mentioned earlier, at first sight, existing studies shows that there are many techniques and methods available to improve the supply chain. In connection with these methods, we would like to continue the processing of further literature in the same way as described in Kása et al.'s study (Kása et al., 2014). The results so far show that we can only analyze these processes at the model level, without intervening in the real system. Several of the modeling solutions examined in the literature can be used well, and we would like to proceed in a similar way during our research, as e.g., in Gubán's study. The mathematical model in the literature was developed by the LOST Research Group a few years ago (Gubán, 2015; Kása et al., 2016). For theory development, we examined a wide range of literature, based on which we defined the following research questions and hypotheses (Kovács & Kot, 2016; Dima, 2013; Bednar & Modrak, 2015; Velychko, 2015).

- Q1: What does the literature say about the usual approach in the field of in-enterprise resource planning?
- H1: Based on the literature, the classic approach is still dominant and despite certain developments, there are no quantifiable results for supply chain simulation based on inner company database.
- Q2: What inner logistics processes should be measured for a simulation model and are there any delays/problems connected to these variables (if at all)?
- H2: Road traffic has the largest effect on the supply chain, but weather, infrastructure, technology and ad-hoc problems are also significant and palpable issues for enterprises in Zala County.

3. Methodology

In order to achieve our aim to implement a decision support system based on supply chain simulation, we have to study the theoretical background of current ERP systems. We choose a systematic literature review to justify hypothesis H1. In this segment of the research we used the search engine of Scopus, where we searched for the terms "logistics simulation", "material requirement planning" and "just in time production". The searches were narrowed down to the most relevant 10 results in the case of each term, which forms the basis of this study. Eventually, qualitative sampling is applied to justify hypothesis H2. The relationship between the problems identified in the literature and the problems specific to Zala County was unknown, as previous studies had only focused on the simulation of the entire supply chain. (Gubán & Hua, 2014). For this reason, we decided to use a quantitative basis to justify H2 as this approach allows us to learn about more complex processes (Babbie, 2008). All this is done with an understanding and adaptive review of qualitative and quantitative methodologies (Horváth & Mitev, 2015; Lewin, 1946). Having established our methodology, our first task was to determine the specifics of qualitative sampling, including the research framework, query location and method. The questionnaire was structured as follows:

- Lead-in questions, which reveal important information;
- Strategic question about the logistics of the given company;
- Operational question about the logistics of the given company;
- Limitations, failures, negative effects in logistics;
- Logistics software support.

(See the final questionnaire in the annexes.)

In the qualitative research, we aimed to make at least 10 interviews. From the Zala County Foundation for Enterprise database we chose companies with the following characteristics (filtration): at least 10 employees, significant material flow (min. weekly orders) and willingness to participate in the research. After the selection, 70 companies were invited for research collaboration. We planned to make interviews with those companies that first responded to our request. The planned timeframe was 3 months, from 1 December 2020 to 28 February 2021. The planned location of research was at the premises of each company. (Saunders et al., 2009; Király & Géring, 2016).

As stated earlier, our main task was to identify the basic approaches for supply chains software support as part of the literature review. Therefore, we used the search terms "logistics simulation", "material requirement planning" and "just in time production". These terms generated a large number of irrelevant results apart from the relevant ones, so we narrowed the search. For filtering, we decided to use the most relevant and cited 40 in the case of each term, which yielded a basis of the study. We received the following results for the searched terms (see Table 1 below).

Table 1. Search results of the literature review. *Source: Authors' own*

Searched terms	Number of results
Logistics simulation	137
Material requirement planning	2532
Just in time production	6718

In the qualitative sampling phase, we successfully interviewed 10 company representatives as planned. Altogether we had 17 positive responses for participation by companies. As after the first 8 interviews no new information was revealed, for strategic reasons, we stopped at conducting 10 interviews. All interviews were made at the premises of the enterprises where only the researchers and the representatives were present. When the managers were interviewed for sampling, questions were asked in the same order. We used semi-structured interviews with the same set of questions, which gave the interviewees the opportunity to answer according to their own responsibilities and experiences. Questions were not made available in advance to the representatives, they first saw the questions at the interview. The main elements of the interviews are summarized in Table 2. The duration of each interview was different, but they were typically between 30 and 60 minutes. We interviewed only one representative at a time. During the interview, we asked the questions in order and the interviewees' answers were recorded and then typed. Due to the time factor, answers were recorded in handwriting and transcribed later.

Table 2. Qualitative interviews of enterprises in Zala County. *Source: Authors' own*

No.	Industry	Size (No. of employees)	Interviewee	Date
1.	Transportation	10	Owner	10/12/20
2.	Printing industry	56	Managing director	17/12/20
3.	Education	32	Director	18/12/20
4.	Wood industry	25	Logistics manager	29/01/21
5.	Electronic assembly	>250	Sales manager	29/01/21
6.	Automotive	26	Owner	01/02/21
7.	Hospitality	10	Owner	01/02/21
8.	Manufacturing	10	Sales manager	13/02/21
9.	Tool manufacturing	51	Managing director	26/02/21
10.	Clothing	13	Production manager	28/02/21

4. Basic operation of supply chains

Logistics systems are basically closed-chain systems which include several actors. The central, key actor is the production company. Other members of the system are suppliers, users and possible intermediate members (e.g., logistics service providers – transportation, warehouses, etc.). The role of the system is to ensure appropriate material flow through the closed chain. The typical supply chain contains a supplier, a production company and a customer. The flow can be interrupted by intermediate hubs (external companies responsible for warehousing) to bridge geographical distances. In parallel to the flow of materials, the flow of information is also an important part of the supply chain.

The structure of these logistics systems can usually be divided into three parts: purchase, production and sales logistics (Halászné Sipos, 1998; Szegedi, 2012; Qu et al., 2019).

As for the implementation of a logistics system, basically there are two groups of elements responsible for the actual implementation: the flow of materials and the flow of information. Both are very important for logistics systems. The flow of materials helps production, while information flow supports control for the entire process, as well as contributes to prognoses and orders (Benkő, 2018).

Material flow is implemented physically through the following elements:

- Resources and absorbing elements
- Containers
- Collecting and distribution elements
- Connecting elements.

Resources and absorbing elements cover the production and the customer. Resources create value, while absorbing elements use value. Containers function as a kind of intermediate buffer, i.e., by interrupting material flow, as they help bridge long distances by storing products in suitable conditions (e.g., warehouses). The collection and distribution elements are responsible for picking up the products and their appropriate distribution (e.g., distribution warehouses). The implementation elements are responsible for information flow and can be divided into the following groups:

- Data collector
- Data transfer
- Data storage
- Data processing elements.

Data collectors are by definition responsible for collecting data. These can be barcode scanners but also tablets or other hardware devices installed at the workplace. In the case of older or offline systems, data collection can also be done on paper. Data transmission devices are the elements responsible for data transmission, let them be wired or wireless. Data stores are mostly high-capacity elements that are responsible for storing collected data. From Winchester computers, via NAS and server machines, there are many options available in this field. Data processing elements are responsible for the utilization of the data, as well as for the data sets to be converted into a form that is both useful and understandable for logistics workers. Logistics informatics will be explained in more detail later in this paper (Bányai, 2013; Tang & Veelenturf, 2019).

Concerning the literature in the field of the operation of logistics systems, we decided to focus on the physical material flow in the current research plan. The possible simulation of logistics services or the study of the logistics information flow can be added later, but in the methodology plan as an initial step we will focus on the material flow of enterprises and its simulation.

5. IT background of logistics systems

To describe the operation of IT background systems in a very simplified way, we could say that a system of this kind documents all the processes of the company and makes them available in a displayable form. Based on the received data, it prepares a prognosis, thereby providing decision support to users.

The main operational characteristics/criteria of the system are as follows:

- *Integrated:* it actually covers all the processes of the company and condenses them into one system, whether it is value-creating processes or tracking changes in inventory/materials;
- *Modular structure:* the system can be built from modules, with the advantage that it can be expanded, so users can only purchase those modules that they actually use;
- *Wide functionality/platform independence:* the first feature is relatively clear, since this type of software can only be successful if it can provide answers to the challenges that arise as widely as possible. The second feature is relatively general, since – just like ERP systems – other software must be compatible with as many devices as possible;
- *Reliability* also seems obvious, but in this case this property has a different meaning. Just consider that in the event of a system failure, a whole department or, in the worst case, an entire company may become inoperable. Accordingly, it is essential for ERP software to include a suitable help desk in addition to a reliable design (Demeter, 2014, pp. 205-211; Katuu, 2020).

To demonstrate the operation of the system through an example, let us outline the following: in the case of a closing stock the system estimates the quantity to be procured based on the given stock and future demand, and it creates a forecast. By the estimation, it gives a proposal (decision support) for the order (it usually highlights the fact that we are facing a shortage). Of course, this example does not take many things into account. In reality, the MRP modules of ERP systems are responsible for material management. The operation of MRP systems is practically organized along 3 priority domains:

- *Production management plan:* the central program that includes the periodical production plan(s) defined by the organization. The number of pieces to be produced is determined by the company's market forecasts and market needs.
- *BOM – Bill of Materials:* the installation guide for the components that are required for the finished product. The BOM contains not only the order of installation of the components, but also the required quantities.
- *Stock record:* shows the tracking of raw materials over time. It also includes the lead times required for material procurement, as well as production times (Schubert, 2007; Goldston, 2020).

The previously outlined operating principle (classic approach) has essentially remained the same over the years concerning resource planning software, but recently certain changes have been made to complement the potentials provided by ERP systems.

One such trend is the introduction of cloud-based ERP. Businesses commonly used on-site ERP applications and were reluctant to outsource core business applications to the cloud, but this has changed in recent years. Due to vis major situations (e.g., Covid), more and more businesses have started to use cloud-based ERP to take advantage of simpler implementation, lower costs, flexibility, new functionality, fewer internal IT resources and easy add-on capabilities (Elbahri et al., 2019).

An important development of the last period was the introduction of the two-level ERP. The usual practice until now has been that the central company of a company group introduced the ERP and the subsidiaries had to apply the same system. However, the subsidiaries did not need the entire system in many cases. So, by 2023 one of the most important ERP trends is the possibility of a reduced or specialized ERP implementation made available at "Tier 2" level (besides the usual "Tier 1" level ERP implementation) (Liebetrau, 2021).

Another significant step was the introduction of ERP systems to mobile devices. ERP providers have been offering access on mobile devices for some time, but it is only recently that this opportunity has become widespread. ERP solutions are constantly evolving to ensure that employees can access critical business data on the go, thus enabling back-end and front-end tasks to be completed (Erdiyana & Suharjito, 2019).

The last and most important trend is the advancement of artificial intelligence in ERP systems. AI and machine learning capabilities embedded in ERP systems work mostly behind the scenes to meet increased personalization needs and to improve a wide range of business processes. While in the past companies added AI functionality to some ERP systems, after the introduction more vendors now offer ERP software with these capabilities built-in (Wilson et al., 2022).

The application of artificial intelligence is primarily present in data analysis. As organizations collect more operational and customer data than ever before, they look to AI to provide valuable business insights based on this information. AI technologies scan vast amounts of unstructured information, quickly identify patterns and predict trends that cannot be detected by manual number crunching (Tijan et al., 2019). Although the analysis of ERP data was possible before, by 2023 the focus has already shifted to being able to implement predictive analyses based on these data with the help of artificial intelligence. For example, software with machine learning capabilities can comb through a maintenance company's machine repair data to predict when a failure is expected.

In the framework of industrial and applied research, the main trend is the above-mentioned AI predictive analysis of maintenance and customer data, but in academic research we can find examples of supply chain simulations. (Of course, the results of these studies are on theoretical level yet.) These models use mathematical algorithms and data inputs to mimic real-world supply chain processes allowing stakeholders to experiment with various scenarios and assess the potential impact of different decisions.

Among the existing simulation results, most of the studies use inventory management. Inventory management focused papers measure inventory turnover. (Inventory turnover is the rate that inventory stock is sold, or used, and replaced.) These papers give recommendations on economic order quantity (EOQ). These models try to simulate the seasonal distribution of order quantity (Terzi & Cavalieri, 2004; Tebaldi et al., 2023).

Another type of simulation aims at the reorganization of spatial or geographical routes. These types of research map the spatial location of stakeholders (e.g., suppliers) or workstations in the supply chain, and with the help of simulation give decision support for the most effective location (Sakai et al., 2019). Some of these studies try to expand the model with traffic simulation outcomes. The usual approach in this case is the Nagel-Schreckenberg model, which is a theoretical model for the simulation of freeway traffic (Staffeldt & Hartmann, 2019).

The third type of existing simulation is the decision-making-centered studies. As the first two types of studies use only quantitative methods, these types are closer to a qualitative approach. In the scope of these studies, researchers aimed to model the decision-making method and implement a decision-making flow chart or a decision tree. With the help of these tools, we can monitor the effectiveness of our decisions, e.g., the selection of suppliers, the positioning of our product or entry to new markets (Tordecilla et al., 2021).

After the analysis of the most relevant studies in the narrower topic, we can say that focus is still on the classic approach. As we see Table 1, the search results contain 2532 ERP related studies in addition to the 137 simulation-related ones. Of course, in itself, these data show nothing, but after the examination of the studies, it became clearly visible that the previously described simulation methods are not used in the industrial sector and currently they exist only on a theoretical or research level. Concerning the logistics simulation based on inner company data, we have not found any examples. If we compare the classic operations of software support and the latest development trends, it is obvious that the classic (non-predictive) approach is still dominant.

In summary, it can be said that there has already been a certain body of research regarding the simulation of the entire supply chain, but the processes inside the enterprises remain unknown for the time being (Bohács et al., 2016). *Based on the strength of the obtained results, hypothesis H1 was confirmed and became a thesis* as the complex picture of the literature shows that the classic approach is dominant and, despite certain developments, there are no quantifiable results for supply chain simulation based on inner logistics processes.

Examined region: Zala County

As we got a basic insight into logistics software trends, simulation possibilities and overall theoretical validation, we felt important to make the same validation on territorial aspects, too. Zala County has the logistics advantage of having five Capital Cities within a 250-kilometer range and compared to other regions in Hungary, short-distance transportation is very common. As a result, logistics play a significant role in the county's economic activities, making it an ideal location for the study. Furthermore, it is worth noting that ongoing development projects, such as the ZalaZone Automotive Test Track and Metrans container terminal, have a strong impact on logistics. Therefore, choosing this area for the research was a reasonable decision. Given the existing circumstances, current development trends, and the availability of data, we had the opportunity to obtain precise and accurate results for our long-term aims (Szabó et al., 2020).

6. Possible simulation of supply chain based on inner processes

From the qualitative sampling we performed, we gained large amounts of information, which helped us narrow down the research scope and define the processes to be measured. If we compare the qualitative results with the processes described in the literature, we can notice that Hungarian and international studies as well as the interview discussions agree that the current supply chain and production strategies require re-planning, which gives rise to some critical remarks (Cselényi & Illés, 2009).

On the one hand, the existing studies do not go into detail to calculate a concrete loss of profit, and the delay times and the resulting losses are not quantified, either. On the other hand, even if we knew the figures, this would basically be a "benchmarking" problem. That is, we must examine what proportion is profit loss due to supply chain failures as opposed to the cost of a probable restructuring of the whole supply chain.

Despite these critical remarks, considering the overall picture, we can state that redesigning may be relevant for most logistics systems. If not for the full system, emergency strategies/new approaches (e.g., use of simulation) are necessary, which makes this study relevant.

Prior to the qualitative interviews, the main question was: how the given factors affect the material flow; and, perhaps even more importantly, is there any delay (if at all) at the local companies? Does the model to be developed have relevance?

Before conducting this research, it was already expected that road traffic would be somewhat predominant compared to other factors; and the qualitative sampling showed the proportion of this factor. The table below helps understand the ratios in this regard.

Table 3. Factors affecting the supply chain in Zala County. *Source: Authors' own*

No.	Industry	Road traffic	Weather	Infrastructure	Ad-hoc
1.	Transportation	x	x		
2.	Printing industry	x			
3.	Education	x		x	
4.	Wood industry	x	x	x	
5.	Electronic assembly	x			x
6.	Automotive	x	x		
7.	Hospitality	x			
8.	Manufacturing				x
9.	Tool manufacturing	x			
10.	Clothing			x	x

Based on the table, it is clearly visible that 8 out of 10 respondents have some sort of logistical issue arising from road traffic. The remaining factors (weather, technology infrastructure, ad hoc) were each mentioned three times altogether. The answers show that special attention should be paid to the modeling of road traffic during the simulation, and primary measurements are necessary in this field.

It is worth analyzing the problems of road traffic in depth because it greatly contributes to the identification of variables for future modelling. Among these, the most persuasive answer was the following: "*Apart from the Covid situation, especially road transport (e.g., daily traffic) plays a role, as well as the increased border crossing in many cases, and the administration associated with VAT.*".

On this basis, the problem must be divided into two parts. On the one hand, there is foreign material flow, where a significant factor is daily traffic, but customs and border crossing difficulties are also present to the same extent. In the case of domestic material traffic (second leg), only daily traffic is prominent. From the point of view of measurement, it is worthwhile to think about both domestic and cross-border measurement. It is important to highlight how businesses try to handle daily traffic fluctuations. The following answer provides some insight:

Question: How do the problems of raw material procurement affect the strategy (if at all)? (How is this issue solved?)

Answer: "*Looking for other purchasing routes. Although everyone does the same. As long as there is no raw material, there is no sale. In the worst case, it is necessary to buy from competitors in order to retain customers.*".

The first point in the answer, i.e., searching for new routes, legitimizes the development of simulation since with the help of a future application we can respond to this need. Currently, only alternative routes are being searched, but since this method has already reached its saturation point, with the creation of a possible decision support system, we can open a completely new dimension: temporal distribution. The second half of the answer shows the importance of logistics and the importance of the research itself. Essentially, if there is no raw material, then there is no production and that is the most harmful condition for a business.

Other effects – weather, infrastructure and ad-hoc problems – appeared in equal distribution. Weather problems are quite evident. Therefore, we will not explain them in detail. In terms of technological and infrastructural problems, lack of capacity can be predicted relatively well, since large-volume orders are often linked to seasonal fluctuation. Unpreparedness was a factor that we were unaware of before the research. After production, the picking process is impractical due to the unpreparedness of the products. There is a human factor behind this, but the problem could be overcome through software support or more effective use of the management system. In terms of ad hoc problems, the COVID-19 and Brexit are relatively well-known. Because of the UK's exit and the pandemic, many raw materials became difficult to obtain, and the flow of logistics materials increased several times due to administration and customs regulations. An interesting factor was the role of state regulations, in connection with which we received the following answer: "*When the state intervenes in the operation of the economy, it always upsets the system. The economy is expected to prosper, but state governance often limits opportunities across Europe.*". Some points in the answers derived from the subject of this research, but might be worthy of attention: inflation, the increase of road fees and minimum stock problems. All in all, at this point we can see measurable effects.

We have clearly identified a number of negative factors, but the question still arises: is delay a factor at all in the material flow in Zala County? Table 4 below gives answers.

Table 4. Frequency of delays during purchase in Zala County. *Source: Authors' own*

No.	Industry	0	1	2	2-3	3
1.	Transportation		x			
2.	Printing industry				x	
3.	Education				x	
4.	Wood industry				x	
5.	Electronic assembly			x		
6.	Automotive					x (4)
7.	Hospitality				x	
8.	Manufacturing	x				
9.	Tool manufacturing			x		
10.	Clothing			x		

Four interviewees indicated "2-3 times" as the frequency of delays out of 10 occasions, which is an average of 2.5. One respondent indicated one occasion, three indicated two occasions, while one representative of a company did not experience any delay during everyday purchase. Based on 10 occasions 2.1 (!) delays occurred, which is more than 20% (!) of the cases. Since every fifth purchase of raw materials is delayed, we can rightly state that the previously identified factors cause a real delay in the local material flow. Of course, output material flow had to be examined, too. The question was whether production and delivery can compensate the delays of purchase. Answers are shown in the Table 5.

Table 5. Frequency of delays in sales in Zala County. *Source: Authors' own*

No.	Industry	0	1	2	2-3	3
1.	Transportation		x			
2.	Printing industry	x				
3.	Education		x			
4.	Wood industry			x		
5.	Electronic assembly		x			
6.	Automotive			x		
7.	Hospitality			x		
8.	Manufacturing	x				
9.	Tool manufacturing		x			
10.	Clothing		x			

Five of the responding representatives answered that they deliver late once in 10 occasions, while three said that they delivered late twice out of 10 times, while two representatives did not experience any delays during their daily deliveries. On the average it is 1.1 delays out of 10 occasions, which is still 10% of the cases. Based on this, we can conclude that despite the fact that production somewhat compensates for procurement delays, there is still a significant proportion of delays in the supply chain. Qualitative sampling shows that road traffic has a prominent role in the future model, but the other effects should also be measured. Overall, *based on the strength of the obtained results, hypothesis H2 was confirmed and became a thesis* and therefore road traffic will be the central element of our model.

7. Conclusions and proposals

Based on the answers received, road transport has a high priority role in modeling (its examination is a priority task). This result might have been expected as we think the saturation of roads is becoming an increasingly serious problem. In comparison with weather issues, road traffic is more palpable in everyday processes.

According to the results, it can be stated that it is also visible it is worth dealing with ad hoc and technological problems to a minor extent and the weather problems have the least importance. The lower importance of these dimensions among the answers is probably strongly connected to the perception of the problems. As traffic issues are a factor which is in sight and which can be influenced actively somehow, weather is a factor which only can be accepted by local companies on the level of perception. (They do not think about this factor as a predictable one.) In the case of the technological issues, local companies also treat this factor as a non-predictable dimension.

Based on the answers received, a delay rate of 20% may be typical of purchase and total around 10% for all deliveries. We currently do not know the reasons for these high delay rates – they need further examinations –, but probably these issues are in correlation with the efficiency of the use of logistics software, which will be examined in a next research project.

From the point of view of the simulation, there are other less relevant factors (COVID, Brexit, other ad hoc problems, the examination of which is yet to be decided).

We now have a clear picture of the situation in the county both in terms of the factors and the frequency of delays, which greatly served the overall goals of this research. After determining the weight of the main guidelines and factors, the next task was to determine possible measurement tools. Based on the results obtained, we will first simulate a specific route (e.g., Zalaegerszeg – Budapest), where the following influencing factors will be measured:

- Date/exact time
- Travel time
- Temperature

- Precipitation
- Wind
- Possible accident
- Other issues.

In the first phase of the experimental measurement, we will calculate the actual distance. While driving along the above-mentioned route by a single-seater vehicle, we will measure travel time with a stopwatch. After that, we will compare the measurements with a route planning application. If there are no significant differences, we will construct the model (for reasons of cost and environmental protection) from the measurements available in the given route planner. Of course, this methodology can be altered if quantitative sampling so necessitates.

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