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Process Mining as a Means of Improving the Reliability of Road Freight Transportations

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Abstract

The introduction of digital solutions in the automotive industry is often accompanied by a significant gap between the expectations and needs of the leaders of transport and logistics companies and the real business results achieved through the Transportation Management System. The causes of this phenomenon largely depend on the human factor, i.e. irrational actions of personnel who inefficiently use digital technology. The prerequisites for such actions are low competencies of employees, unfair attitude to work, sabotage. Accordingly, this leads to deviations in the transportation process, which can lead to violations of the conditions for the transportation of goods. From the point of view of the concept of reliability of road freight transport, this can be defined as a failure. Failures caused by the varied actions of managers when working with the Transportation Management System were extremely difficult to diagnose. Direct monitoring of managers during the working day is often fraught with various organizational difficulties, and is difficult to implement for a long time to identify ineffective staff activities. The concept of Process Mining, which has been known among scientists and researchers of information systems for more than 10 years, is currently of great interest in business. The paper examined the issues of improving and reorganizing the activities of managers of a transport company based on the mining of the TMS Autobase event log. Based on the results of the study, recommendations were made aimed at developing the digitalization of the transportation process, suggesting an increase in transportation reliability.

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1. Introduction

Information is one of the four most important resources of an enterprise, along with material, financial and human resources. The concept of information logistics links the interchange of electronic documents (EDI - electronic data interchange) with material and financial flows, as well as with the business activities of personnel (Dimitriadis and Koh, 2005; Hsu and Wallace, 2007). Prior to the widespread use of information technology, document management in logistics activities was formed from primary accounting documents - invoices, waybills, trip tickets, which confirmed the movement of goods and vehicles. The emergence of information systems for supply chain management (SCM), enterprise resource planning (ERP-system) and transport management system (TMS) at the initial stage of their development actually displayed the workflow existing at enterprises (Gunasekaran et al., 2017; Siddiqui and Raza, 2015; Singh and Teng, 2016). Paper documents were transferred to information systems in almost unchanged interface. With this approach, the business processes of the transport and logistics company were often completely preserved or rather poorly transformed. This was partly explained by the requirements of regulatory documents, which did not keep pace with the development of information technology. However, the lack of improving the efficiency of the business process when they are directly transferred from paper workflow to electronic is also largely due to the fact that IT specialists who implement information systems often have low competencies in the field of logistics.

The implementation of information systems, as a rule, is preceded by a stage of analysis of enterprise business processes, which is based on interviewing employees of the enterprise (Tbaishat, 2017). The success of interviewing is largely due to the experience and communication skills of an IT specialist, who will be able to arouse the trust of employees of the enterprise, to win them over (Chemingui, 2019). It should be noted that in some cases employees may not be interested in disclosing information about business processes because of their own low competencies, as well as because of an unfair attitude to their work (negligence, theft, etc.). Therefore, business processes formalized as a result of interviewing often reflect the subjective opinions of certain employees who are difficult to integrate, because describe local situations at this particular workplace or in this department (Reinkemeyer, 2020). Another approach that allows to collect the source material for the analysis of business processes is direct observation of the operations of employees in the performance of their daily tasks: receiving orders for transportation, processing waybills, distribution of applications for transportation by vehicles (Pérez and Costa, 2018). However, this approach is quite easy to implement directly in the office, where managers work with documents and with the information system.

An important feature of the transport and logistics company is that a number of its business processes take place outside its territory. For example, a company driver carries out transportation at several points of delivery, where he unloads and loads goods. Upon arrival to the customer, he can stand idle waiting for loading or unloading, which will be an ineffective action from the point of view of business processes. The reasons for waiting can be various factors, for example, late arrival or, conversely, earlier arrival to the customer, a large line of vehicles for loading or unloading, malfunctioning of loading and unloading means. Accordingly, the rhythm of the transportation process is violated, which ultimately can lead to an increase in the delay time. This phenomenon associated with the nonfulfillment of its obligations to the customer can be interpreted as a failure (Sternberg et al., 2013). The use of GPS/GLONASS vehicle monitoring systems in general does not fully reflect the transportation process. Indeed, thanks to monitoring systems, it is possible in real time to determine the location of a truck, its speed. However, if the vehicle does not move, then the dispatcher can only observe the immutability of its location without understanding the causes of downtime.

In practice, in order to avoid losses during vehicle downtime, in addition to monitoring the vehicle with GPS/GLONASS, visual monitoring is also used using cameras installed in the cab or directly by the manager who is on the truck ride with the driver. The first option is rarely used mainly during transportation of especially valuable goods in order to understand what is happening with the driver. The second method is also not rational, because a manager cannot travel constantly (Villarreal et al., 2017). Such joint truck rides are carried out for inspection purposes on an occasional basis in order to collect information about events occurring during the truck ride. Obviously, in subsequent truck rides without the inspector manager, business processes may have deviations for various reasons, including delays. In practice, to reduce the variability of the transportation process, for example, control points for certain territorial zones, which a truck must pass on its route, are established (Sai et al., 2020).

This time interval, taking into account all kinds of delays on the way, is determined empirically based on statistics from previous truck rides. Accordingly, the observance of this time window for staying in a certain area rests with the truck driver. This approach was implemented using an adapted GPS/GLONASS monitoring system. However, it does not provide data collection on possible causes associated with the variability of the transportation process during the voyage.

Possible deviations, for example, an increase in loading time or whether unloading is already determined after the fact after the vehicle has returned from the truck ride based on the driver's entries in the trip ticket. After that, the dispatcher already enters data on the passage of each section of the route in the TMS. Such a business process for the dispatcher work was implemented in the TMS "Autobase" developed by us on the basis of preliminary interviews with the employees of the dispatch department. This business process, obviously, reflects the ideology of paper workflow. The experience of implementing the TMS "Autobase" developed by us showed that such automation of the transportation process no longer fully satisfies a number of enterprises with large fleets of vehicles (Kurganov et al., 2020). The reasons for this dissatisfaction are:

- significant load on the dispatcher when the vehicle returns from the truck ride, associated with the entry in TMS of data on events that occurred on the route;
- incomplete information about events in the truck ride, which the driver reflects in a paper trip ticket;
- extremely low responsiveness of the dispatcher to events that may occur on the route of the vehicle, and, consequently, a decrease in the reliability of transportation.

2. Research Methods

Modern information systems, including ERP and TMS, record all user actions in a special file (log file or event log). For information systems using SQL databases, this file is a transaction log containing SQL queries made by users. In fact, the transaction log contains digital traces of each user. Currently, the identification of user actions from the event log is associated with the concept of process mining, on the basis of which the reconstruction of enterprise business processes is carried out (Thiede et al., 2018). As a result of the process mining, the following tasks are solved (Ingvaldsen and Gulla, 2012):

- "What is really happening?" - opening process;
- "Are we doing what has been agreed?" - verification of compliance;
- "Where are the bottlenecks?" - analysis of effectiveness;
- "How to change this process?" - process improvement.

Since the transaction log in TMS Autobase is a text file, the initial stage of the process mining included identifying individual SQL queries of each user and the time intervals during which they were executed. The result was a structured event log containing the user name, transaction number, execution time, name of the SQL query, a fragment of which is shown in Fig. 1. This example reflects the work of 8 users during 2019 and contains about 70 thousand events. The company operates about 500 vehicles.

Currently, there are a number of solutions and services for extracting business processes on the market, for example, Celonis, Disco, Kofax, etc., which are specialized software for process mining (Turner et al., 2012). For the analysis of transport business processes, we used the Microsoft PAFnow application. The purpose of this study was the need to find bottlenecks in the work of the transport company with the existing TMS in order to reduce the variability of the transportation process, thereby increasing the reliability of transportation. As a result, proposals should be formed and justified to improve this information system, which will increase the efficiency of managers and the enterprise as a whole.

User	Tran	Data	Activity
asd	1021	01.01.2019 5:40:00	UPDATE DBA.LIST
asd	1021	01.01.2019 5:40:00	INSERT INTO DBA.LIST_MARSHRUT(ID_LIST_MARSHRUT,ID_MARS...
asd	1021	01.01.2019 5:40:00	INSERT INTO DBA.LIST(ID_LIST,NOMER_LIST,DATA_LIST,DATA_1,DA...
asd	1021	01.01.2019 5:40:00	INSERT INTO DBA.LIST(ID_LIST,NOMER_LIST,DATA_LIST,DATA_1,DA...
asd	1021	01.01.2019 5:40:00	UPDATE DBA.LIST
asd	1021	01.01.2019 5:40:00	UPDATE DBA.LIST
asd	1021	01.01.2019 5:40:00	UPDATE DBA.LIST_MARSHRUT
asd	1021	01.01.2019 5:40:00	UPDATE DBA.LIST
asd	1021	01.01.2019 5:40:00	INSERT INTO DBA.LIST_MARSHRUT(ID_LIST_MARSHRUT,ID_MARS...
asd	1027	01.01.2019 17:31:00	UPDATE DBA.LIST
asd	1007	02.01.2019 5:39:00	INSERT INTO DBA.LIST_MARSHRUT(ID_LIST_MARSHRUT,ID_MARS...
asd	1007	02.01.2019 5:39:00	UPDATE DBA.LIST
asd	1007	02.01.2019 5:39:00	UPDATE DBA.LIST
asd	1007	02.01.2019 5:39:00	INSERT INTO DBA.LIST(ID_LIST,NOMER_LIST,DATA_LIST,DATA_1,DA...
raschet	1015	02.01.2019 6:50:00	UPDATE DBA.LIST
raschet	1015	02.01.2019 6:50:00	UPDATE DBA.LIST

Fig. 1. TMS “Autobase” event log.

Obviously, most modern information systems have rich functionality. However, in each enterprise, employees use the functionality of the information system in their own way. Therefore, the next step was the analysis of user behavior by TMS “Autobase” in this enterprise. Of the eight users, the largest number of operations was identified among managers with the logins “ASD” and “Raschet”. At the same time, the manager with the Raschet login, the maximum number of operations occurred on the following requests (Fig. 2)

- UPDATE_LIST – change of trip tickets (~ 45%);
 - UPDATE_LIST_MARSHRUT – change of driving directions (~ 44%);
- For a manager with an ASD login, the maximum number of operations occurred on the following requests (Fig. 3)
- INSERT_LIST – input of trip tickets (~ 44%);
 - INSERT_LIST_MARSHRUT – input of driving directions (~ 45%).

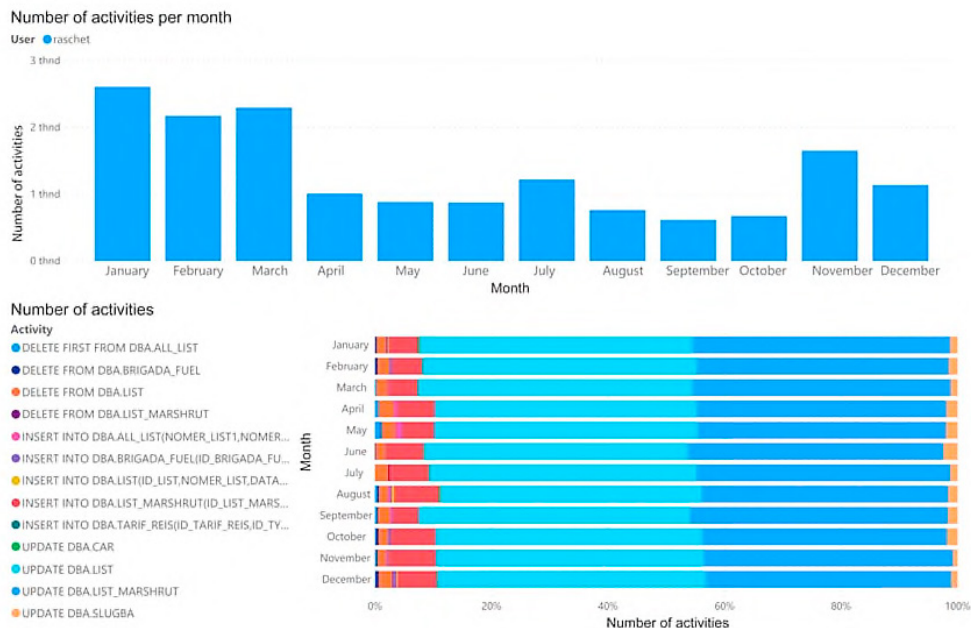


Fig. 2. Dynamics of activities in 2019 by user Raschet.

Also, using the process mining tool PAFnow, the business processes of Raschet users (Fig. 4) and ASD (Fig. 5) were reconstructed. According to these business processes (Fig. 4) we made the assumption that, in general, the main activity of the Raschet manager is actually changing the trip tickets and driving directions. That is, data entry in TMS “Autobase” about all events that occurred in the truck ride. To verify this assumption, we constructed the time distribution of the activities of the Raschet and ASD managers. This distribution is presented in Fig. 6. In this figure, two peaks are visible - at 6.00 in the morning (red graph) and at 18.00 in the evening (blue graph), which reflects the characteristic features of the activities of Raschet manager (red graph) and ASD manager (blue graph).



Fig. 3. Dynamics of activities in 2019 by ASD user.

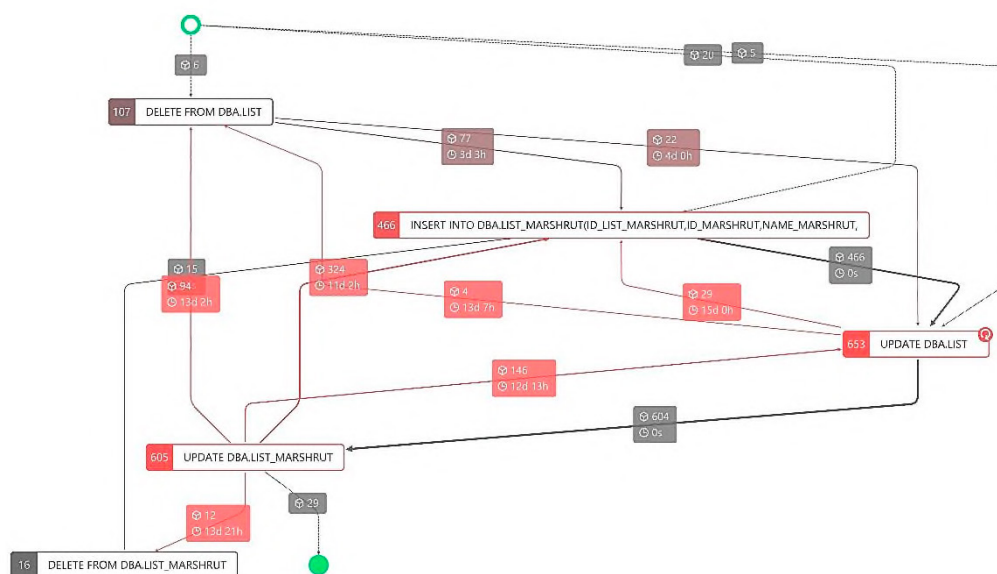


Fig. 4. Reconstructed Processes of Raschet user.

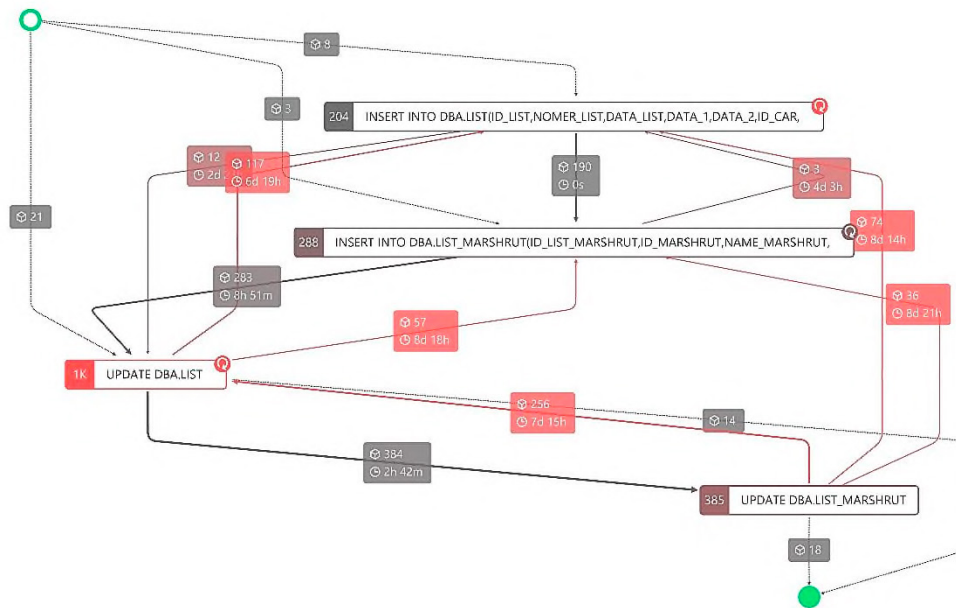


Fig. 5. Reconstructed processes of ASD user.

Activity Distribution by Hours

User ● asd ● raschet

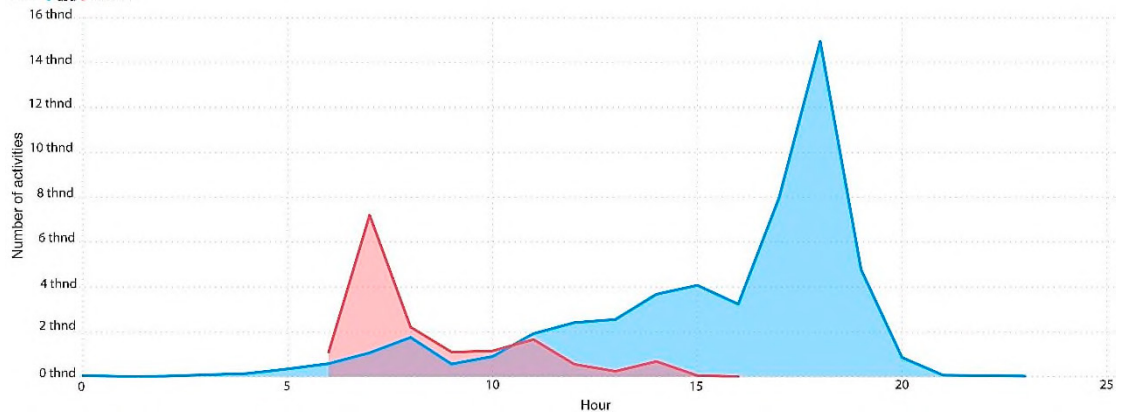


Fig. 6. Dynamics of activities by the hours of the day for users “Raschet” (red) and “ASD” (blue) during 2019.

Activities of user „Raschet”

Activity

- DELETE FIRST FROM DBA.ALL_LIST
- DELETE FROM DBA.BRIGADA_FUEL
- DELETE FROM DBA.LIST
- DELETE FROM DBA.LIST_MARSHRUT
- INSERT INTO DBA.ALL_LIST(NOMER_LIST1,NOMER_LIST2,...)
- INSERT INTO DBA.BRIGADA_FUEL(ID_BRIGADA_FUEL,BRI...
- INSERT INTO DBA.LIST(ID_LIST,NOMER_LIST,DATA_LIST,D...
- INSERT INTO DBA.LIST_MARSHRUT(ID_LIST_MARSHRUT,I...
- INSERT INTO DBA.TARIF_REIS(ID_TARIF_REIS,ID_TYPE,NA...
- UPDATE DBA.CAR
- UPDATE DBA.LIST
- UPDATE DBA.LIST_MARSHRUT
- UPDATE DBA.SLUGBA

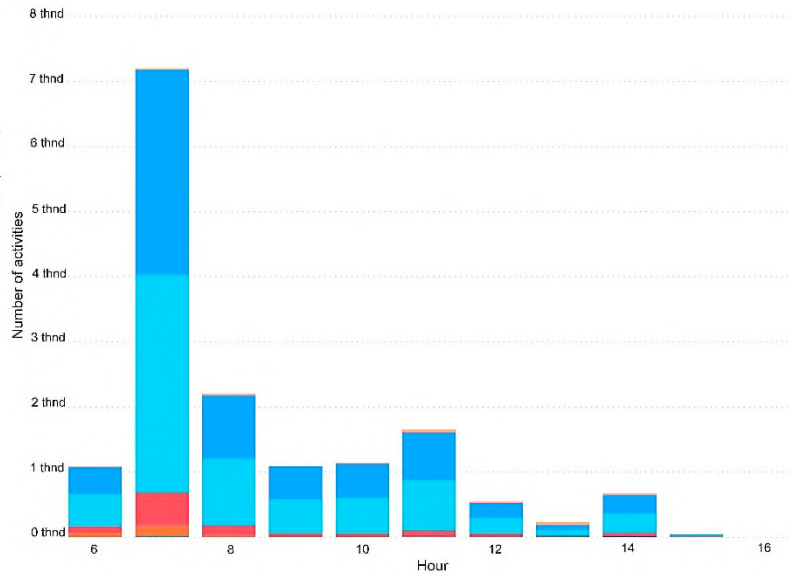


Fig. 7. Distribution of Raschet user operations by hours of day during 2019.

Activities of user „ASD”

Activity

- DELETE FIRST FROM DBA.ALL_LIST
- DELETE FROM DBA.BRIGADA_FUEL
- DELETE FROM DBA.CAR_MEN
- DELETE FROM DBA.CAR_SLUGBA
- DELETE FROM DBA.TRANSPORT
- INSERT INTO DBA.ALL_LIST(NOMER_LIST1,NOMER_LIST2,...)
- INSERT INTO DBA.BRIGADA_FUEL(ID_BRIGADA_FUEL,BRI...
- INSERT INTO DBA.CAR_MEN(ID_CAR_MEN,ID_CAR_GOS,...)
- INSERT INTO DBA.CAR_SLUGBA(ID_CAR_SLUGBA,ID_CAR,...)
- INSERT INTO DBA.LIST(ID_LIST,NOMER_LIST,DATA_LIST,D...
- INSERT INTO DBA.LIST_MARSHRUT(ID_LIST_MARSHRUT,I...
- INSERT INTO DBA.LIST_WORK(ID_LIST_MARSHRUT,ID_M...
- INSERT INTO DBA.TRANSPORT(ID_TRANSPORT,PUB,DAT...
- UPDATE DBA.CAR
- UPDATE DBA.CAR_MEN
- UPDATE DBA.LIST
- UPDATE DBA.LIST_MARSHRUT
- UPDATE DBA.MEN
- UPDATE DBA.SLUGBA
- UPDATE DBA.TRANSPORT

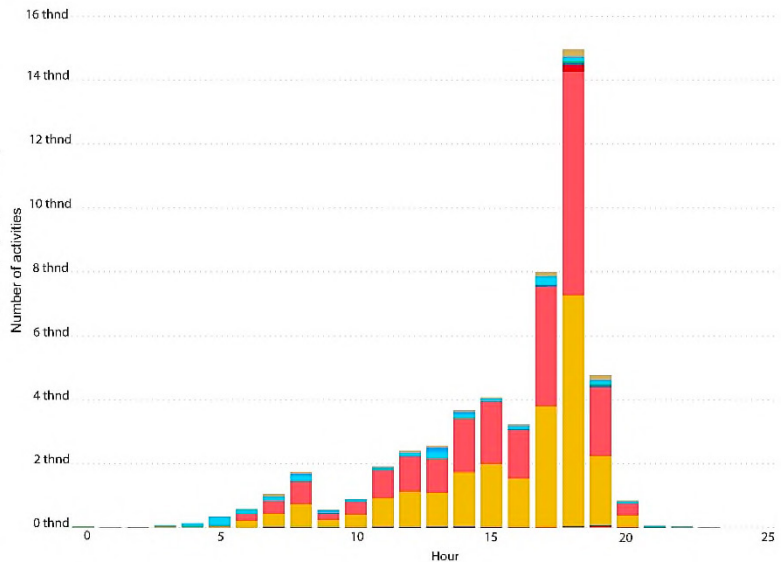


Fig. 8. Distribution of ASD user operations by hours of day during 2019.

In addition, the distributions of the operations of the Raschet user (Fig. 7) and ASD user (Fig. 8) by time of day were also constructed. The assumption that the activity of Raschet manager is completely devoted to updating the information in the trip tickets about the operation of vehicles in the truck ride turned out to be true. Based on the graphs presented in Fig. 6, it follows that not every trip ticket and driving direction that were formed at the preliminary stage of transportation planning is subject to updating.

3. Results of the Study

The above example showed (Fig. 9) that for driving directions, the probability of changes in the initially entered data is 23.19%, and for truck rides is 28.64% per year. These indicators mean the deviation probability of the parameters of actual truck rides from planned. Detailing what parameters (mileage, time of departure and time of return, type and mass of the cargo carried) were corrected during the truck ride, and therefore deviated from the planned ones in this study, was not carried out. However, already at this stage we can conclude that this enterprise should more carefully plan the truck rides of vehicles and exercise strict control over the implementation of truck rides (Kurganov et al., 2018).

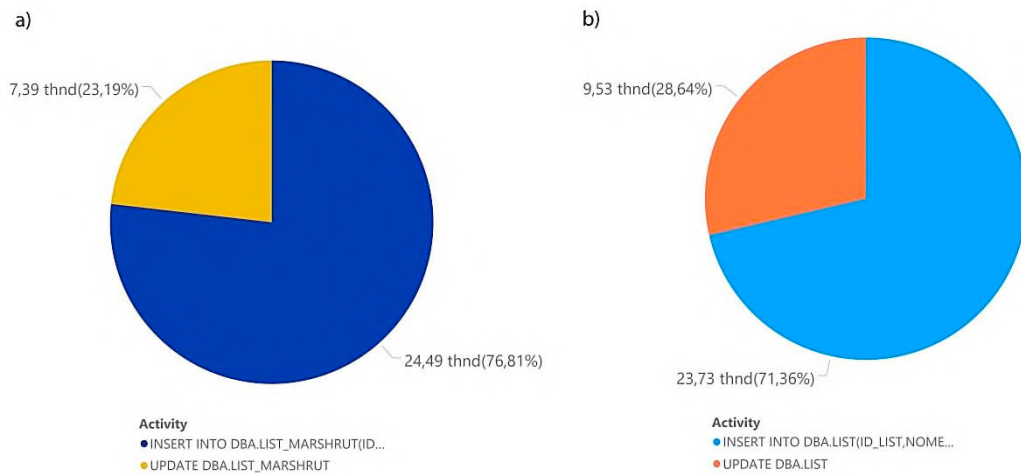


Fig. 9. Correlation of initially entered data in driving directions (a) and in trip tickets (b) to corrective changes.

4. Conclusion

Based on the study, recommendations were presented on the implementation of measures aimed at reducing deviations of truck ride parameters from previously planned. At the initial stage, the management of this enterprise decided to develop a special mobile application, which is supposed to provide all drivers. During the truck ride, the driver will have to promptly send information about all incidents that lead to deviation of the truck ride parameters from the planned via the mobile application. These incidents may include delays in loading and unloading, changes in the route, problems arising with the cargo and other reasons. Thus, at this stage, the task of increasing the efficiency of collecting data on deviations of the transportation process is solved. In addition, transferring this type of activity to drivers allows unloading a dispatcher with the Raschet login from performing many daily operations. In case of successful implementation of the transformation of this business process, an additional economic effect is also expected, associated with a reduction in the activities of the manager responsible for the correction of truck ride documentation. It should be noted that process mining allows to wring out the actions of users related to negligence and dishonest performance of their duties, which will affect the efficiency of the transportation process.

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