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For Loan Processing a Fuzzy Process Mining

Orhan Engin[1]*, İbrahim Ethem Yazici[2]

[1,2]Department of Industrial Engineering, Faculty of Natural Science and Engineering, Konya Technical University, Konya, Türkiye

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Research Article

Abstract − Process mining has been used extensively in recent years to develop the steps of the business and it is an important technique to remove waste and reduce process costs. The aims of this study indicate congestion, workflow which lived a long time, and stuff or system statistics in the banking real estate transaction process. The process mining practice is applied in bank business loans. In the bank process, the most used and complicated business is a bank loan transaction. The process mining implementation pattern is created with sample and flow gains of process development. Then, the new workflow is designed and the pattern is executed. In the first stage of the total loan period, 7.84 hours of earnings are obtained. Visualizations of the process have been affected with the help of fuzzy model algorithms necessary for a huge number of incidents and activities. Workflow analysis and gathering information for studies were to be effortless with the support of fuzzy models. As a result of the analysis based on the flows, the knowledge pool is created by getting the know-how such as the average duration of the process and the deviations in the users or systems. The results indicated that process mining is a significant methodology for developing bank loan transactions and enhancing their performance.

Keywords − *Banking loan transaction process, flow visualization, process mining, process pattern, work flow development*

1. Introduction

Process mining (PM) is applied to analyze complicated processes in service industries. The bank loan transaction process is the most complicated business in a bank service. Credit transactions, which are the main activities of banking, are differentiated by many variables. In particular, because of the high level of control points and transactions in the loans used by firms, their processes are long and complicated. As these flows are not uniform, output studies cannot be predicted. The data obtained from bank loan processes cannot be used sufficiently in process design and improvement studies and are stored collectively. One of the major points here is the complication of flows and many counts of check and approval operations. PM operates previous bulks of data and supports performing the necessary improvements more efficiently by helping to control whether the process is better readable or not, to desired process. In the banking sector, where workflows and approvals are highly completed to an enterprise, PM plays an important role both in terms of end-to-end flows and effectiveness through the improvement of flows and provided that flows occur in the wanted flow. In recent years, various studies have been carried out in the literature on the stages of PM and how to resolve them with Workflow s. In different sectors, PM acts a great job of decreasing costs, making flow developments, and particularly shortening durations.

There are a few types of research considered about PM to improve the steps of the process in service industries. Li et al. (2011) applied the PM to resolve the info of care data. They constructed a knowledge maintenance process model. They applied this proposed method to the knowledge management system. Fernández-Llatas

[1] oengin@ktun.edu.tr

[2] ethemyazici@gmail.com

*Corresponding Author

et al. (2013) presented a PM technology for human behavior modeling. They tested this approach using real patients in a nursing home. De Weerdt et al. (2013) generated a PM for the multi-faceted analysis of business processes. They made a case study in the financial services industry. Caron et al. (2013) developed a comprehensive rule-based PM approach. They investigated a complete set of enriched process event data. Weber et al. (2013) proposed a framework for analyzing PM algorithms. They considered business processes as probability distributions over traces of activities and mining algorithms in terms of their ability to learn such distributions. Lee et al. (2014) generated an intelligent system. They used fuzzy association rule mining with a recursive PM algorithm. They determined the relationships between production process parameters and product quality. Okoye et al. (2014) developed a novel approach for automated learning. They detected changing trends in learning behaviors and abilities through the use of PM techniques. They applied this approach to the semantic annotation of activity logs within the learning process. Werner (2017) investigated the use of PM to improve the process of financial audits. Huang et al. (2017) developed a service composition approach based on PM. They considered both the practical business and the execution information in the environment between devices and users. Erdogan and Tarhan (2018) introduced a goal-driven process evaluation method based on PM for healthcare processes. They applied the proposed method to the surgery process of a university hospital in Turkey. Orellana et al. (2018) proposed a software component in the Hospital Information System. They integrated the Variants Miner plugin of the ProM tool and the temporal perspective of PM. Roldán et al. (2018) developed a systematic protocol for the application of PM to analyze and improve multi-robot missions. Yazici et al. (2020) emphasized the applicability of the PM methodology in real estate processes and the analysis techniques that can be done. In this study, all real estate processes were handled and the processes were redesigned by performing detailed analyzes and fuzzy model-based visualizations. In addition, process development studies were completed by examining the achievements in detail. Dogan (2021) evaluates eleven process mining technologies using a six-step methodology called spherical fuzzy AHP (SFAHP), which combines the analytic hierarchy process (AHP) with spherical fuzzy sets (SFS). The study ranks the technologies based on eight criteria determined by literature review and expert suggestions, and concludes that Minit is the best alternative technology based on the most relevant criteria: price, process discovery, and process analysis and analytics. The study also considers the effect of changes in the importance level of criteria on alternative rankings by performing a one-at-a-time sensitivity analysis. Valensia et al. (2021) utilized the fuzzy miner algorithm to discover student learning patterns in the Learning Management System (LMS) of Telkom University. They used historical data stored in the system and three tools, Jupyter Notebook, Disco, and ProM, to process and analyze the data. The study highlighted the importance of measuring significance and correlation, with metrics like frequency and correlation, and concluded that the fuzzy miner algorithm can model student learning patterns in LMS well. Arpasat (2022) utilized the Fuzzy Miner and Social Network Miner algorithms to identify process bottlenecks and improve the efficiency of the banking service. The paper provides an overview of process mining and discusses the Fuzzy Miner algorithm, which identifies process patterns and generates a data flow model from an event log by eliminating redundant activities or paths. The paper also introduces the Social Network Miner analysis method, which investigates similar operator paths in each event to identify patterns such as hospitalization or doctor cooperation patterns. Bahaweres et al. (2022) discusses the application of process mining and robotic process automation (RPA) in the context of the purchase-to-pay process. The author uses the Fuzzy Miner Algorithm to analyze event logs and identify repetitive activities that can be automated with RPA. The article also presents a case study of three vendors and calculates the potential ROI of implementing RPA in their processes.

Currently, there is no reported paper on the PM technique for bank real estate transactions. The contributions of the paper are summarized as follows:

- The proposed PM technique is first used in bank loan transactions,
- The Workflow of the bank loan transactions is first defined by the PM technique,
- The resource statistics of the bank loan transactions are first calculated by PM technique,
- The bottlenecks of the bank loan transactions are first determined by PM technique,
- The costs of the bank loan transactions are reduced,
- The bank transactions process is improved and the processing time is shortened.

The paper is organized as follows: Section 2 gives information about PM, and Section 3 showed the application of the PM approach in bank business loans. Furthermore, in Section 3, PM studies are shown, and executing

the fuzzy-model-based Celonis program, the activity log is visualized, in Section 4 gives results and discussion, Section 5 presents the conclusion and future work.

2. Materials and Methods

Each transaction in today's information technologies consists of event data. PM techniques make it easier to access detailed information as it becomes hard to ensure and comment on the essential info from the ever-expanding bulk of data (Castellanos et al., 2009). Later the case of processes from the event log, the relevance of the flow should be checked. In this state, said suitability control, the check of the model, and log, and the control of deviations should be noted (Aalst et al., 2007). Event logs are the most important part of PM. Activities are included many events. When using PM techniques, they are shown other results. For example; transaction start-up times, resource information that initiates and executes the activity, business information that affects events, and so on. PM has 3 steps which are discovery, conformity, and development. The discovery aims at extracting the actual process from the event logs. In the conformity check, the process is compared with the existing processes and the logs are checked to see whether the actual process is in progress. The development step, which is the final implementation step, is to improve the existing model. In these studies, inefficient steps are determined, and the exploration of bottlenecks and service levels are examined. While aiming to convert discovery data from application types to models, conformity control and development methods aim to obtain an output with event logs and models (Force, 2011). The PM methodology is given in Figure 1.

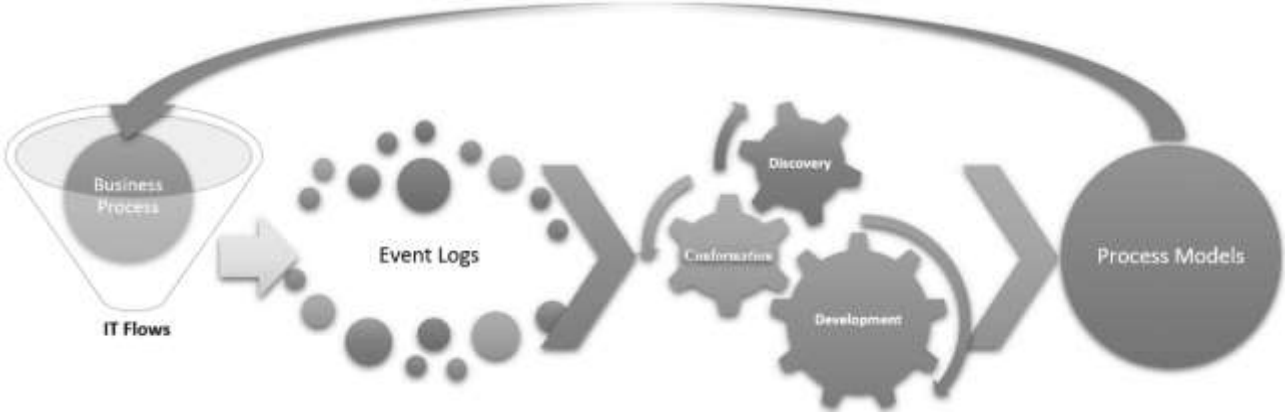

Figure 1. Stages of PM

In this study, the log information of the loan transactions applied in the last 3 months, which are in the bank loans, which are the most used by the bank and are more complex than other jobs, are used. In this context, firstly, work was carried out to obtain the data from the system used and to bring it into a suitable format for process mining. Afterwards, the obtained data was tested and it was checked whether it was suitable for the study. As the data became available, the steps of process mining were applied. In addition to the steps highlighted in the literature, analyzes that can be made from the data obtained were revealed.

3. Experiment

This study aims to show congestion, workflow which lived a long time, and stuff or system statistics by applying PM methodology in bank business loans which are the most used and more complicated than other works. In this context, firstly, the study is carried out to obtain the data from the user system and to bring it into the appropriate format for PM. Afterward, the data obtained are tested and examined for the study. As the data became available, the steps of PM are implemented. In addition to the steps highlighted in the literature, analyses that could be made from the data obtained were revealed. As a result of these analyzes, a more efficient application of PM is provided.

3.1. Determining the Data Format

The following work has been done to align the layout of the event logs tables with the standards used in PM:

- Each ID is given a unique ID for each project,
- Time spent in off-hours is calculated separately,
- For each station; the start and end dates have been assigned and defined as unique, the process has been defined, and the duration has been calculated.
- Pool times and processing times are separated,
- Virtual stations are created and activities are connected.
- The information columns are added to examine the business information of the transactions,
- It is ensured that the transactions performed in the sub-processes within the business process are shown through a single stream,
- The following format is created as a result of the studies:

○ Case Id	○ Branch name	○ Type of loan	○ Payment type
○ Activity	○ Region name	○ Customer no	○ Guarantee status
○ State start date	○ Branch no	○ Suffix no	○ Processing location,
○ State end date	○ Subflow number	○ Customer type	○ Connected project
○ Resource	○ Currency code of loan	○ Person type	○ Commitment
○ Action name	○ Associated flow number	○ Product	○ Encouragement
○ Duration	○ Amount of financing	○ Goods/services type	○ Proposal number
○ User title	○ Currency code of financing	○ Project status	○ Project number

3.2. Preparation of Sample Data

As a result of the studies carried out with information technologies, sample data sets have been formed to check the conformity of the desired format. These data sets are revised in the changes made after each information technology study. Works have been repeated until the final format conformity.

Testing data

The sample data sets coming from the information technologies unit are taken out from the main banking system with the support of the business units and the findings are determined. According to the findings, decisions are taken and transferred to information technologies. This continued until the final data set.
Within the scope of tests, the following actions are done.

- Compliance with the prepared format is examined,
- Start-up dates are determined,
- Processing times are determined,
- Whether the numbers are singular or not is checked
- The business information is checked,
- The situations in the data are being checked
- Virtual situations are being checked,
- Whether there is a need to separate,
- Whether or not there is no data,
- The data format is checked for deficiencies.

Data analysis

After combining the data in a single file, studies are carried out on which analyzes are to be done, analysis of which platforms could be performed, and data are analyzed.

Determination of analysis items

To obtain standard analysis outputs for each report, the following items have been created.

- General situation: This table indicates opinions about where the issues are, and highlights the points to begin flow design.
- State analysis: the duration of the states in the process is calculated.
- State action analysis: With the actions taken by the states, the steps that have the most impact on the time have been analyzed.
- Transaction based analysis: The results of the case are examined and their durations and periods are revealed. In this work, the end-to-end finishing duration of the incident is calculated.
- Effect of work steps on duration: Resource, waiting between states and idle times are separated and their relations with each other are revealed.
- Resource analysis: Which resources have an impact on the workflow duration is examined.
- Flow-based analysis: Relevant flows and sub-flow that make up the main flow are examined and the flows which took the most time are studied.
- Control of data by users: By checking the average duration of the diverse users doing a similar task, differentiation between the users has been shown.
- State-based analysis of resources: The actions taken by the users of the same state are investigated and their behavior is revealed.
- Pool, user, and waiting time analysis: The times in the flow's congestion, Workflow which lived a long time and stuff or system statistics deployment according to the source, Workflow which waiting a long time and idle times and the most duration depletion ones are shown.
- Path/variant control: Business flows are taken out from the log and the data flow ratio and turn ratio are shown.

3.3. Determination of Analysis Methods

The points on which the calculations can be made and which results can be meaningful are investigated. These are given as follows,

- Average calculation
- Standard deviation calculation
- Count calculation
- Min and max calculation
- Median calculation
- Quartile calculation
- Zscore calculation
- Correlation calculation
- Regression calculation

Analysis of generated items

The substances are analyzed and presented below.

- General Situation
- Analytical Data Analysis

All the data are evaluated by the analytical team and a T-test is used to determine which parts should be focused on. T-test has been used in the study to compare the average durations for each action. This test is used to determine whether the average durations for each action are significantly different from each other. The results are presented with t-values and p-values for each action. The t-value shows the magnitude of the test statistic, while the p-value indicates the probability of the test statistic being found in a particular distribution. Results are considered significant if the p-value of the test statistic is less than the alpha value. This indicates that the average durations for each action are likely to occur for a different amount of time. The results are given in Figure 2.

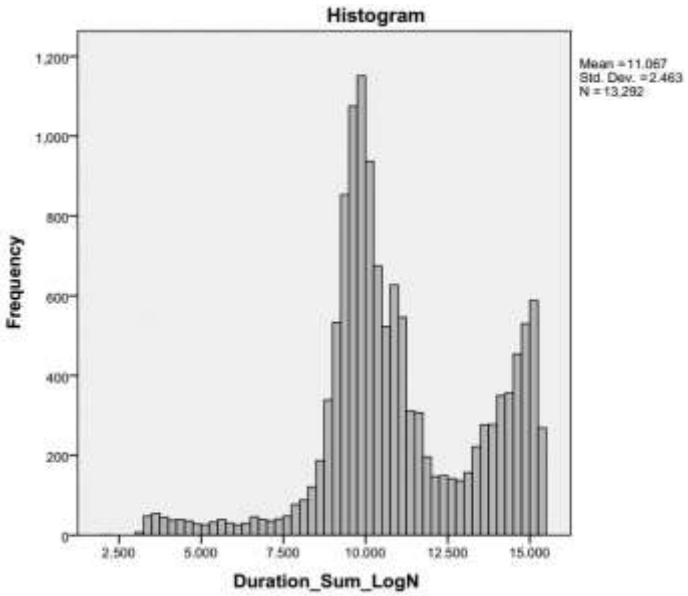

Figure 2. Result of T-Test

When the histogram in Figure 2 generated without any data discrimination is examined, it can be seen that the distribution is not suitable for normal distribution. For the reason of this distribution, all other business columns are tested and the payment type is found to be effective in this distribution.

Therefore, it is focused on the type of payment and confirmed that this breakdown could not be analyzed in a single cluster. The histogram analysis of individual payment types is given in Figures 3 and 4. It is seen that the histogram originates from the right side of the advance type and the left side from the advance payment type.

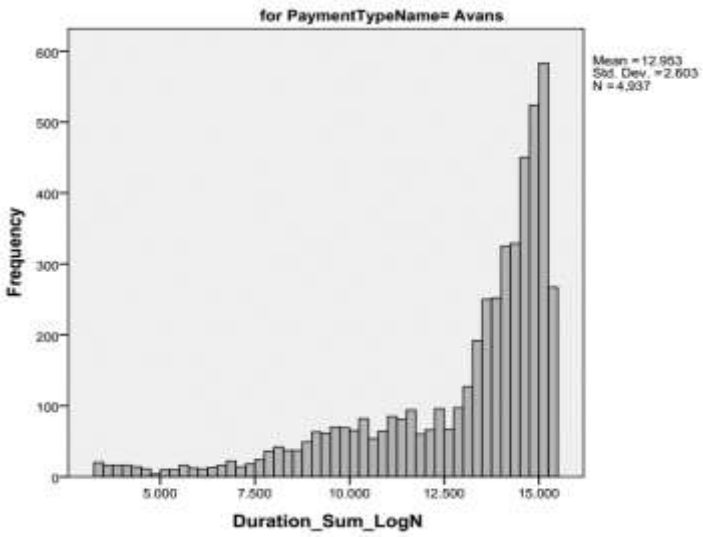

Figure 3. T-Test advance payment result

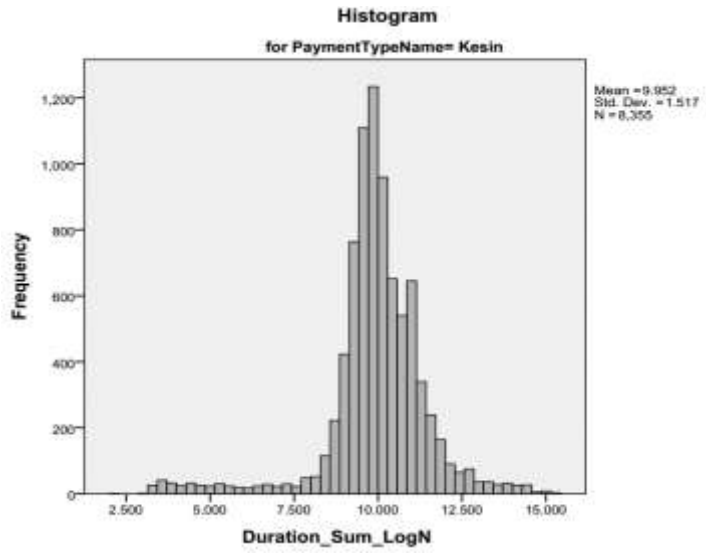

Figure 4. T-Test exact payment result

As a workflow, it is decided that the payment type at the beginning of the project should be examined separately because of the way of doing business. As a result of this analytical study, its accuracy has been tested.

General Situation Dashboard

According to all records, the overhead status of corporate loan flows is given in Figure 5.

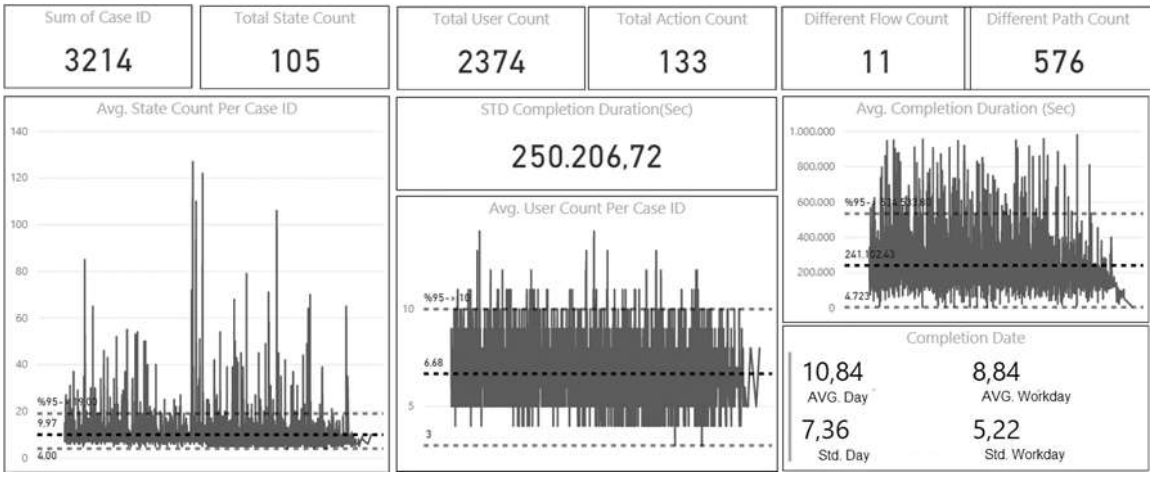

Figure 5. Summary information of Analysis

This table indicates opinions about where the issues are and highlight the points to begin flow control. According to the information obtained from the dashboard, the deviations in the flows are too much. These deviations can be caused by many different users as can be understood from the dashboard. When we pay attention to the number of processes and the number of different paths, we see that a standard flow and variable flow result from a large number of stations. So a path is used on a few average flows. However, when the brief info is analyzed, it can be viewed that the number of various paths is higher than that of 11 various flows. The count of actions can be viewed to be much various and reason for various paths of decision making. Flows and source times for end-to-end average finishing of a flow seem to be 2.78 days, and it can be viewed that the average finishing duration is 8.84 working days. It is also figured out from the table that the average of 10 flows for a stream to be finished and that it has taken 7 users.

3.4. State Analysis

For a total of 130 stations, the average and standard deviations of the trading units are analyzed and the highest deviations are researched. When the dates are analyzed, it can result that the invoice waiting for status for the closing of the loan project in the advance payment cases has caused a lot of deviations in time, however with the wait between the finalizations and how much of the waiting forms are formed. Considering the states in the advance payments cases, it is analyzed that the project creation pool, project creation, and project file closing director approval come to the fore as the time and number. Likewise, when the data is examined in the exact payment cases, the state that causes the most deviation is seen as project creation. However, it is observed that there is an effect on durations in the states were waiting for an interval, order payment between waiting.

3.4.1. State-action Analysis

In this section, the data are regressed analytically and as a result of repetitions, the effects of the highest and lowest state-action have been determined. Some examples are given below.

Advanced payment types

Referring to Table 1. it can be seen that the actions outside the approval of the approval and creation of projects have a much more prolonged effect on time than the other cases. When the first ranks are considered, the rejection / canceling action comes to the fore and their effect on the duration is very high.

As a result of the same table, it is understood that the price approvals of the branch project and general directorate have a time-limiting effect on other cases.

Exact payment types

Table 1 and 2 show that the rejection and cancellation has a significant effect on time, as in the preliminary projects and in the advance payment types. The approval of the general directorate may be determined to have a time-reducing effect, as in the case of advance payment types projects. States descriptions are given in Table 3

Table 1
Maximum and lowest impacts to duration –advance payment cases

State-Action Name	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
Maximum Impacts to Duration					
state1	9.511	1.842	.031	5.163	.000
state2	7.878	0.114	.185	69.405	0.00
state3	7.276	1.307	.011	5.568	.000
state4	6.937	2.018	.007	3.438	.001
state5	6.229	1.841	.007	3.384	.001
state6	6.035	1.848	.007	3.266	.001
state7	6.020	1.305	.009	4.612	.000
Lowest Impacts to Duration					
state8	-4.926	1.916	-.019	-2.571	.010
state9	-4.549	1.948	-.014	-2.335	.020
state10	-2.894	1.106	-.019	-2.617	.009
state11	-2.889	.925	-.067	-3.124	.002
state12	-2.583	.548	-.035	-4.713	.000
state13	-2.520	1.231	-.005	-2.047	.041

Table 2
Maximum and lowest impacts to duration –Exact Payment Cases

State-Action Name	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
Maximum Impacts to Duration					
state14	8.540	1.565	.009	5.456	.000
state15	8.321	1.109	.013	7.504	.000
state16	8.066	.078	.222	102.860	0.00
state17	7.842	1.110	.012	7.067	.000
state18	7.629	.202	.071	37.675	.000
state19	7.308	.646	.019	11.318	.000
state20	7.108	1.565	.008	4.541	.000
Lowest Impacts to Duration					
state21	-4.007	.910	-.081	-4.402	.000
state22	-3.068	1.577	-.012	-1.946	.052
state23	-2.085	.826	-.016	-2.524	.012
state24	-.995	.442	-.031	-2.253	.024
state25	-.590	.325	-.004	-1.816	.069
state26	-.479	.290	-.009	-1.649	.099

3.4.2. Transaction Based Analysis

The payment status of the realized transactions is advance payment type and exact payment type. The difference between mean and standard deviations is determined based on time and processing times between two periods. According to the status of the project, approval, rejection, and cancellation status of the closing process, the standard deviation is shown in Figure 6.

Table 3
States Descriptions

State	State Description
state1	Funding project process-branch approve pool-branch reject
state2	Funding project process-project create- branch cancel
state3	General control project approve process-allocation approve pool for ındividual-allocation reject
state4	General control project approve process-allocation approve pool for corporate-allocation first level reject
state5	General control project approve process-manager approve pool-branch reject
state6	General control project approve process-general center price approve- project reject
state7	General Control Project Approve Process-Region Price Approve- Project Reject
state8	Funding Proposal Process- General Center Price Approve – Approve Micro Merchant
state9	Funding Project Process-Branch Project Approve-Branch Reject
state10	General Control Project Approve Process-Credit Risk Approve-Reject
state11	Funding Proposal Process- General Center Price Approve – Approve Medium Merchant
state12	Funding Proposal Process- Branch Refund Project-Send Project
state13	Funding Proposal Process- Branch Update Project-Approve
state14	General Control Project Approve Process-Credit Risk Approve-Reject
state15	General Control Project Approve Process-Manager Approve Pool-Branch Reject
state16	Funding Project Process-Project Create- Branch Cancel
state17	General Control Project Approve Process-Region Price Approve- Project Reject
state18	Funding Project Process- Branch Refund Project Pool-Project Cancel
state19	General Control Project Approve Process- Allocation Evaluation Pool-Reject
state20	General Control Project Approve Process-Region Price Approve- Project Reject
state21	Funding Proposal Process- General Center Price Approve – Approve Medium Merchant
state22	Outgoing Transfer Process- Treasure Approve Pool-Approve
state23	Funding Project Process- Branch Refund Project-Send Project
state24	Funding Proposal Process- General Center Price Approve – Approve Small Merchant
state25	General Control Project Approve Process-General Center Price Approve- Approve
state26	General Control Project Approve Process-Region Price Approve- Project Approve

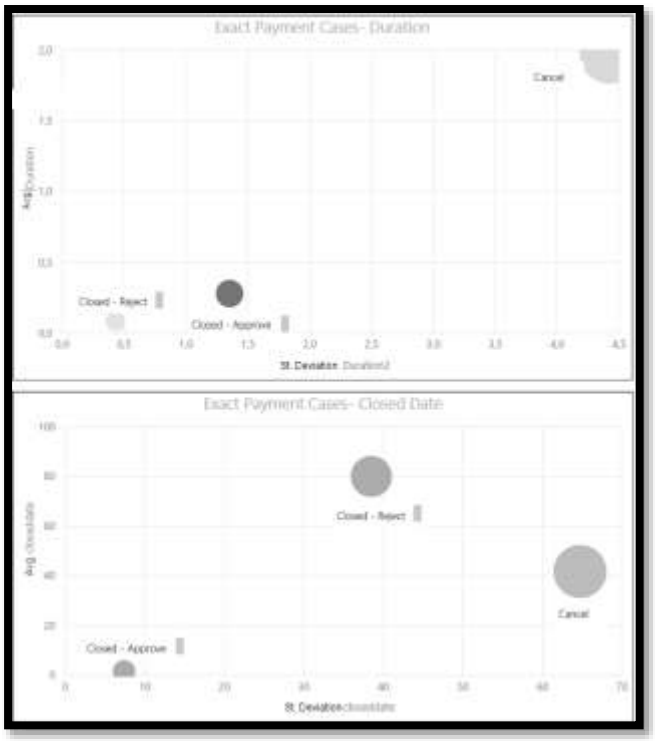

Figure 6. Differentiation of closed cases according to standard deviation –exact payment cases

One of the reasons for time deviations in the general situation table is that the periods of unfinished processes, as seen in Figure 7, are very long and cause resource and time costs. Particularly in the process of cancellation, there is a prolongation of both time loss and systemic date.

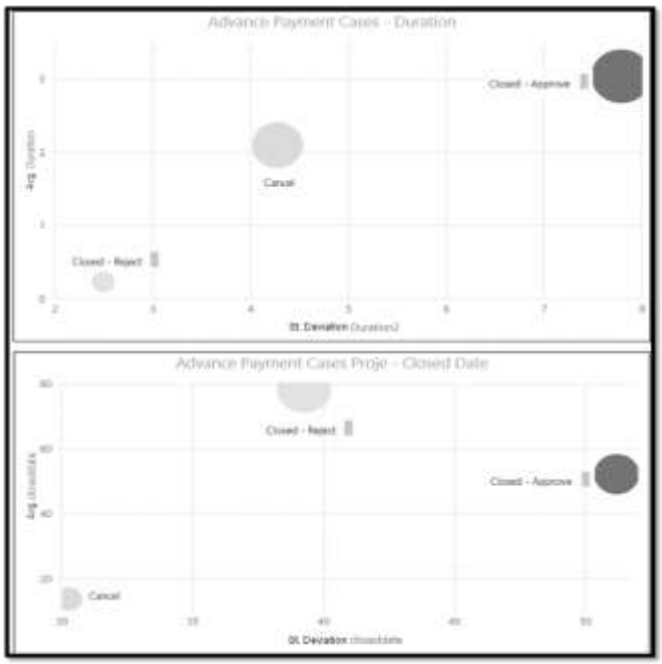

Figure 7. Differentiation of closed cases according to standard deviation –advanced payment cases

In the same way, shown in Figure 7, when the advance payment types projects are examined, it is revealed that the approved and completed flows take a lot of time both in terms of time and date.

3.5. Effect of Work Steps on the Duration

The correlation between the two dates between the pool, waiting, and processing times is shown in Figure 8.

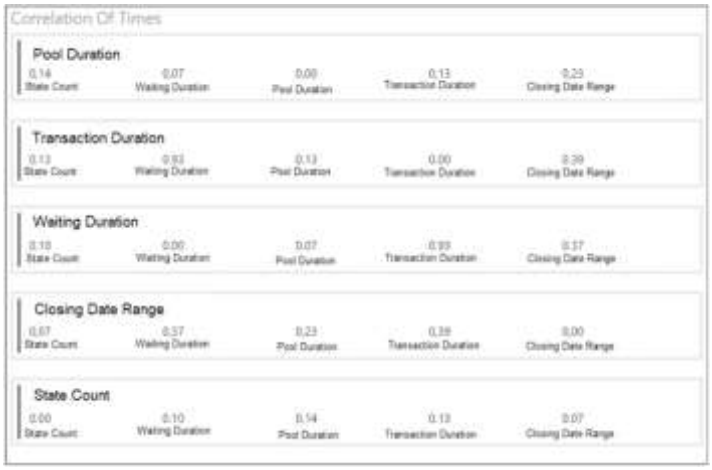

Figure 8. Correlation of time between two dates according to the pool, waiting, and processing times

The correlation test is given in Figure 8, the relationship between the processing time and the waiting time is high. However, the processing time or pool times appear to have little effect on the closing date range. In other words, the operations of the users do not affect the start-up date of the project very much.

3.5.1. Resource Analysis

The effects of the sources on time were calculated analytically and regression was applied. For example, the highest and lowest impact sources are listed in Tables 4 and 5.

Table 4.
High and low impact resources-advanced payment type cases

Personal (P)	Unstandardized Coefficients		Standardized Coef-ficients	t	Sig.
	B	Std. Error	Beta		
High Impacts to Duration					
P-1	8.094	1.955	.015	4.140	.000
P-2	8.064	3.385	.009	2.382	.017
P- 3	7.341	1.701	.016	4.316	.000
P-4	7.165	1.198	.022	5.981	.000
P-5	6.966	1.695	.015	4.111	.000
P-6	6.661	1.384	.018	4.811	.000
P-7	6.256	1.197	.026	5.227	.000
Low Impacts to Duration					
P-1	-4.603	1.760	-.013	-2.615	.009
P-2	-3.855	.999	-.017	-3.857	.000
P- 3	-2.539	.896	-.011	-2.835	.005
P-4	-1.290	.570	-.008	-2.264	.024
P-5	-1.018	.401	-.010	-2.538	.011
P-6	-.995	.452	-.008	-2.202	.028

Table 5.
High and low impact resources-exact payment type cases

Personal	Unstandardized Coeffi-cients		Standardized Coefficients		
(P)	B	Std. Error	Beta	t	Sig.
High Impacts to Duration					
P-1	14.365	2.873	.016	5.000	.000
P-2	13.659	2.873	.015	4.754	.000
P-3	12.880	2.874	.014	4.482	.000
P-4	11.225	2.875	.012	3.905	.000
P-5	10.084	2.876	.011	3.506	.000
P-6	9.412	2.876	.010	3.272	.001
P-7	8.617	2.069	.013	4.165	.000
P-8	8.062	1.175	.021	6.864	.000
Low Impacts to Duration					
P-1	-4.527	1.177	-.016	-3.845	.000
P-2	-1.378	.619	-.024	-2.226	.026
P-3	.174	.068	.011	2.545	.011
P-4	.347	.103	.012	3.365	.001
P-5	.484	.176	.009	2.753	.006
P-6	.487	.137	.014	3.542	.000

In both project types, queue modeling resource assignments can be performed by taking these values into account in the improvements and analytical studies.

3.5.2. Flow Based Analysis

According to the payment status, the flows of the advance and the definitively decomposed transactions are considered in terms of processing times. By calculating the number of processes, the means, the standard deviations, and the z score of the flows are shown in Figure 9. It is done to determine which flows took the most time. When Figure 9 is examined, it can easily be seen that the significant amount of funding projects and the missing document control process have an impact on the average duration in both payment types.
In both project types, queue modeling resource assignments can be performed by taking these values into account in the improvements and analytical studies.

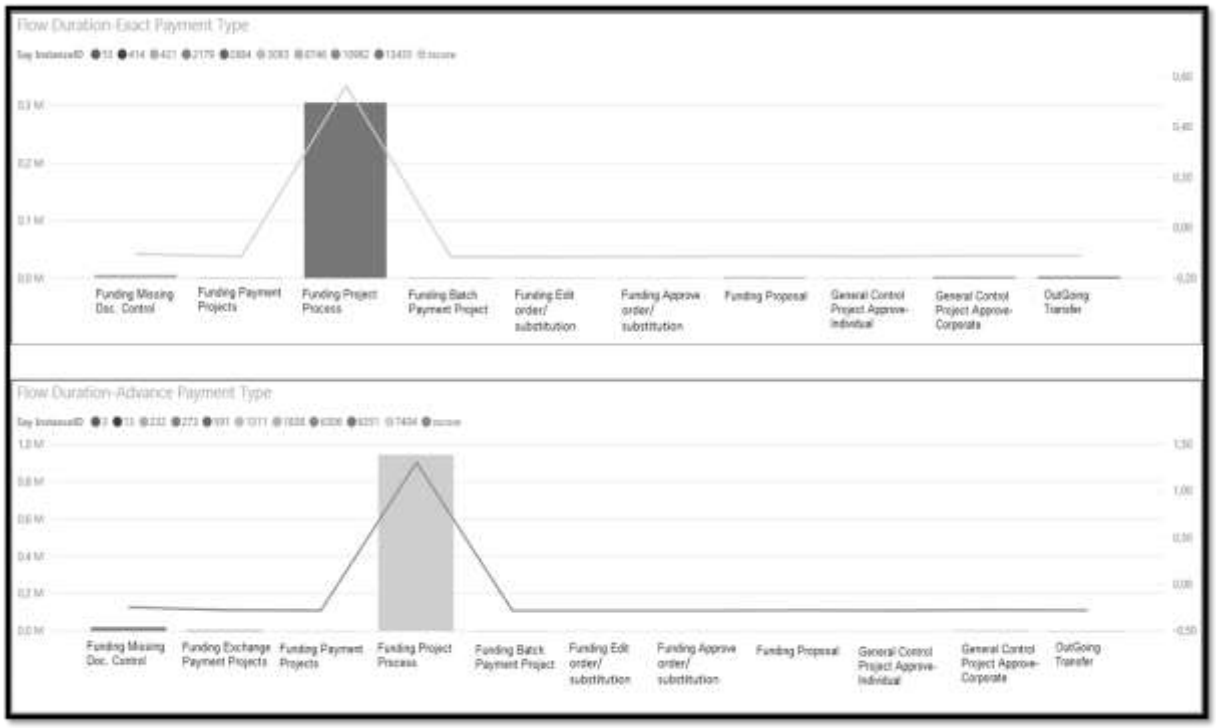

Figure 9. Total process duration of flows

3.6. Analysis of Transactions by Resources

Time and deviation are highlighted by examining the situation, for example, the payment manager approval status is listed in Figure 10.

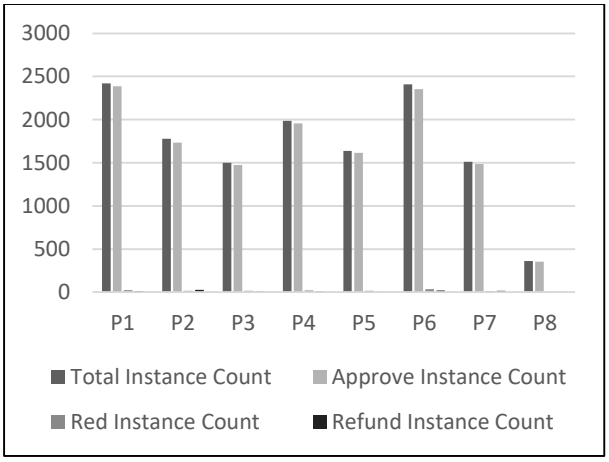

Figure 10. Analysis of transactions by resources

When Figure 10 is analyzed, it is viewed that the count of transactions is very high, but the behaviors of these users in the actions come to the fore. As seen in Figure 10, although the rate of rejections and returns is quite low compared to the number of flows, it is seen that some sources do not take the rejection action at all although the flow number is close.

Pool, user, and waiting time analysis

Pools, user, and waiting times are separated and average times and deviations of these periods are calculated and listed in Figure 11. When the analysis made for the advance payment types cases is analyzed, the average duration and standard deviation of the transactions of the fund allocation process flow, pool times, and user periods become high.

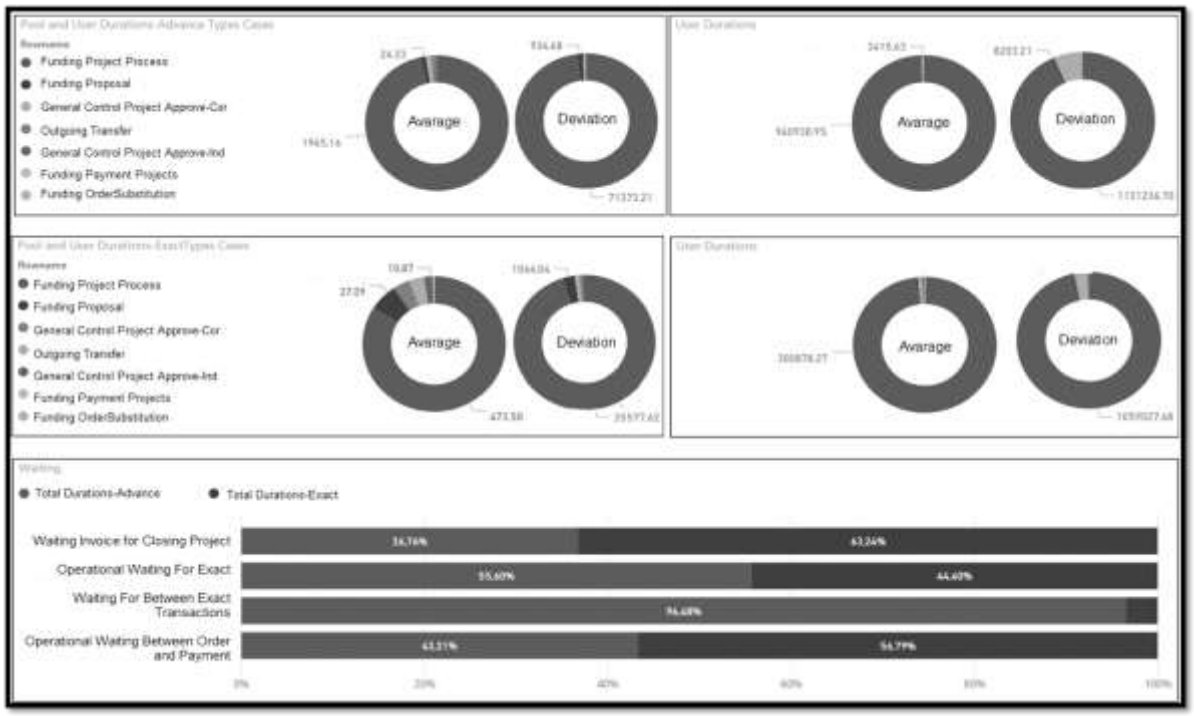

Figure 11. Pool, User, and Waiting Time Analysis

3.7. Stage of Process Visualization

After completing the analysis then the second step of the visualization piece was worked. When the flow visualization is fulfilled from the bulk incident data, the tangle which is another means of is spaghetti process has been formed. When these are used to crude data from less-structured processes, the outcome is generally just as unstructured and difficult to figure out. These "spaghetti" process shapes do not ensure any significant means from the event logs themselves and are for this reason unpractical to process analysts (Günther et al., 2007). The spaghetti process creates that make without using a fuzzy model (Yazici and Engin, 2020).

To realize visual checking and duration-based simulation, Celonis which is a fuzzy pattern-based application was used to get processes from the log bulk and visualized the bulk of the log using edge and node filters. The created data pattern is dedicated to Figure 12 (Yazıcı and Engin, 2018).

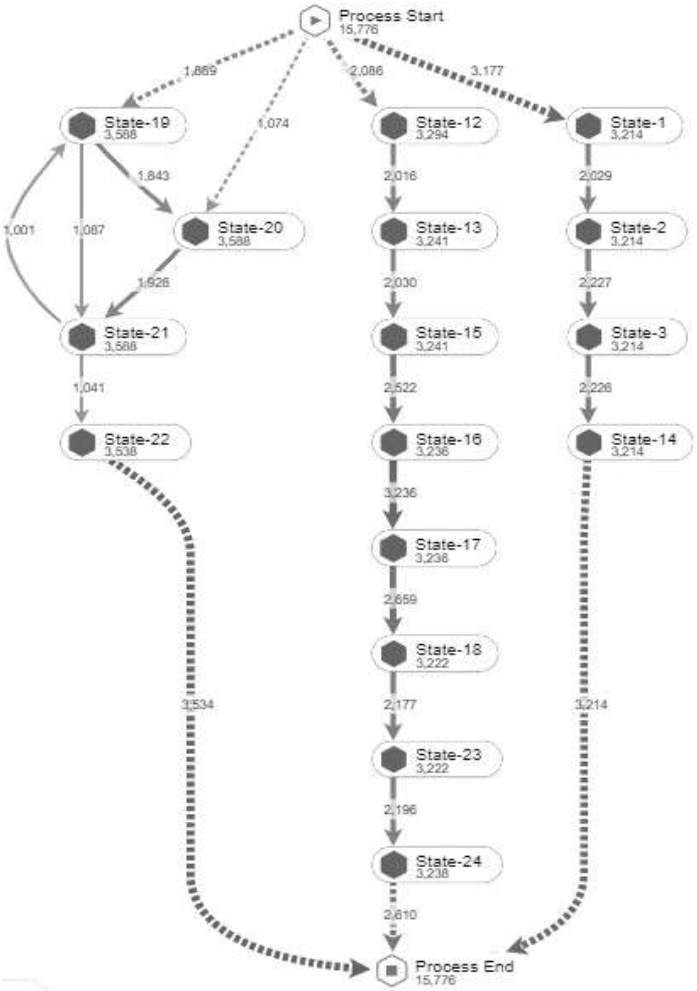

Figure 12. A Visual Structure of Data

Obtained contribution from research

The contribution obtained from the research was measured by using different analysis methods to understand the effects of different factors in the loan process. This study will help banks and researchers better understand the factors affecting the loan process.

In the credit transactions, the contributions obtained as a result of the study for shortening the time are presented below.

- Ensuring that the project is transferred automatically to banking operation and shipped to the next flow by the system in case controls are positive by providing specific information entry to process. That is calculated in the case of a gain. It is given in Table 6 (removal states of branch Project create, project approve)

Table 6.
Removal states of branch Project create, a Project approved

State	Count	Avg. Dura-tion(sec)
Funding Branch Project Create	14588	20045.08
Funding Branch Project Create Pool	14588	6296.165
Funding Branch Project Approve	12801	32.66464
Funding Branch Project Approve Pool	12801	358.7706
	Contribution Hour	7.45

- By automating the order/substitution process according to the information entered by the customers, order entry and order director approval activities are removed. The contribution is given in Table 7.

Table 7.
Removal order entry and order director approval state

State	Count	Avg. Duration(sec)
Funding order / substitution entry	13655	0
Funding order / substitution close	13646	0
Funding order / substitution refund	20	589.1
Funding order / substitution refund pool	20	0
Funding order / substitution director approve	13668	328.7109
Funding order / substitution director approve pool	13668	26.75241
	Contribution Hour	**0.26**

- Ensuring control of the amount by the system by matching the invoice amount to the invoice, removing the payment entry, and payment director approval activities are listed in Table 8.

Table 8.
Project Payment State

State	Count	Avg. Duration(sec)
Funding Payment Project director approve	14219	443.6278
Funding Payment Project director approve pool	14219	17.30748
Contribution Hour		**0.13**

- Removal of situations with very low rejection (general control, project payments status) at the results of the study, 7.84 hours of earnings are obtained.

4. Results and Discussion

The throughputs of the studies and the proposals for development have arisen after the incident logs are ensured. As an outcome of the studies based, the knowledge list has been made, such as the average time of the flows and the deviations in the users and systems. The studies made it feasible to watch out for the points to be improved in the flows. The following improvement suggestions are listed.

- Analysis of the state and flow and regression revealed that the average duration and deviation of the general control process is too high, as well as increasing the duration of the processes. Considering the general control process numbers and return conditions which are examined in detail, the necessity of improvement in the general control process has emerged.

- The results of the state analysis show that the average time and deviation of the transactions from the branch and the control of documents are high. Following the customer's acceptance of the proposal, the branch is expected to advance the transaction and receive general control approvals, if any, and then refer the transaction to credit operations. As result of this information, it is aimed to improve the process by suggesting that the controls made by the branch are made by the system. Thus, it is aimed that the transaction will be transferred to the operator directly with the controls made by the system after the entry of the proposal in the branch and the process will be faster than the branch.
- Within this scope, one of the proposals for quick bidding on the proposal system screen is to reduce and simplify the parameters on the screen. In this way, it is aimed to be able to give quick quotations with minimum information by minimizing unnecessary effort.
- When we examine the event logs on an activity basis and when they are asked together with the business knowledge in the domestic market studies, the main ideology of the project dissemination process is expected to be completed in the branch, while the step of identifying and questioning the trade is expected to be completed at the branch. At the end of the process, the increase in the rate of return increases the processing time in the ordering step. Controls to be made at the beginning of the process with the information obtained by the customer will enable the process to accelerate and reduce returns.
- When the results of the transaction-based analysis and the regression output are considered, it is determined that the cancellation procedures have a high number and duration effect. One of the previously unrecognized areas, the cancel status has to be examined.
- The progress of the transactions with 77 different actions leads to confusion in the workflow. The end of the process with a wide variety of actions also leads to 1041 different paths of advance payment cases for 745 advance payments for the exact payment cases in the flow of transactions. When the detailed analysis of the cancellation status is reached, it was found that the branch requested a refund from the credit operations and extended the transaction periods to return the transaction. The credit operation unit is proposed to give the authority to cancel
- However, the variability of the workload and durations in the sources has also arisen with the standard deviation higher than the average in the analysis results. It is recommended to develop the operation center queue model study to optimize the resources. User training can be given because different people can do the same job at different times.
- Work is required to ensure that the same customer does not pass through the same states. The flow applied to a new customer should not be applied to existing customers.
- A system integration study is required to reduce waiting times.

5. Conclusion

The presented research in the article focuses on the analysis and visualization of bank loan process using fuzzy process mining. The results obtained from the study can be used to optimize and improve the loan process.

One of the significant contributions of this research is proposing a method for visualizing bank loan processes. This method allows banks to monitor and analyze loan processes more effectively.

Furthermore, the findings of the research provide several ways to optimize bank loan processes. For example, removing or modifying certain steps in the loan process can help make the process faster and more efficient.

In this work, the PM implementation sample is made with the flows and flows profits relative to process improvement, and a new flow plan and the steps of PM were applied. The throughputs of the studies and the advice for development are defined after the case logs come by. As an outcome of the studies based on the transactions, the information pool is formed by obtaining the results such as the average duration of the transactions and the deviations in the sources. The analyzes carried out within the content of the study ensured the chance to keep focus on the points to be an improvement in the flows. The outcomes viewed that PM methodology is an efficient technique in business flow improvement and process design works.

In conclusion, this research provides a significant contribution to the analysis and visualization of bank loan processes using fuzzy process mining. The results obtained can help banks better understand and improve their loan processes. For future research, PM methodology may be used for some other service industrial processes.

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Author's Contributions

Orhan Engin: Supervision, Investigation, Methodology, Validation, Conceptualization.

İbrahim Ethem Yazici: Investigation, Methodology, Data curation, Writing-original draft, Visualization.

Conflicts of Interest

The authors declare no conflict of interest.

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