BPIC 2020: Process mining in the organization of business travel process of Eindhoven University of Technology

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Abstract. The annual BPI Challenge 2020 sets the following task aimed at Process Mining (PM) skills development – to research the dataset consisting of business trip events of Eindhoven University of Technology (TU/e) employees in order to further improve the business process.
The provided data includes the information in the space of 2 years: travelling permits and several types of requests: domestic declarations, international declarations, prepaid travel costs and requests for payment.
The process owner expects to receive the information on declaration data throughput, process differences for declaration groups as well as the existence of bottle necks in the process of preparing and getting travel authorization.
Process mining algorithms allowed us to evaluate the real state of the business process, identify bottle necks and anomalies, propose reliable and valid recommendations on business process improvement.
The technical part of the research was carried out using Python under Jupyter notebook. The following PM tools were used: Disco software (fluxicon) and ProM as well as pm4py, GraphViz packages.

Keywords. BPI Challenge, Process Mining, event log, domestic/international declarations, travel.

1   Introduction

In the current economy one of the key objectives of any company is to reduce costs and transaction processing time. The main way to gain competitive advantage over other market participants is to implement high technology and automate various processes making them ultimate user-friendly and lowest cost for the company.

A business trip is a journey taken for business purposes.

Arrangement of business trips is a labor-intensive, time consuming and expensive process with many participants: employee, supervisor, budget owner, director, travel administration and others.

Companies regardless of their business area have procedures in place for arranging the travels and reimbursement of costs as well as lists of participants and patterns of department interaction.

Normally a business trip consists of 2 stages: travel arrangement and preparing of travel expense report. In practice the process flow turns out to be complicated, uncontrolled and nontransparent, which leads to excess time and cash expenses for the company.

Numerous steps of the procedure automatically increase the risk of delays, down time, losing important documents and as a result financial losses for the company.

We believe that the main steps of travel arrangement should be intuitive for every participant and executed with minimum time expenses.

Our primary focus is to perform data analysis and provide statistically proven recommendations how to optimize business trips arrangement in terms of cost effectiveness and optimal employment of resources.

2   Planning

Inefficiency and bottlenecks of processes lead to loss of resources such as time and cash as well as overload of several items, duplication of transactions.

Traditional approaches used to identify problems in processes are time consuming and highly dependent on subjective assessment. For this reason using data mining methods helps to focus on identification, analysis and optimization of business processes based on event log data.

PM allows avoiding long-term interviews of employees and manual modeling that can contain factual errors or incorrect interpretation on the basis of incorrect data. It is sufficient to download the necessary information from the event logs serving as aggregator of data from different sources. PM systems analyze log files, group all events according to identifiers and time and create the actual business process model.

In other words the technology is able to collect data from different information systems used in the company and draw up a precise process map. Using PM we can find practical actions of the process participants that have decreased a given index.

The questions answered by PM can be split up into 2 groups:

1. Performance issues (efficiency of processes);

2. Coordination of processes issues.

Process visualization lets you detect unnecessary cycles and actions, "time loops" and losses, task switching to different employees, force majeure situations that require a lot of time and resources to cope with. All inefficient and unnecessary activities, errors and delays in the process flow are shown in terms of available facts.

The benefits of implementing the tools of process analysis are especially noticeable with regards to procedures involving several departments. In this case process visualization allows to stop engaging extra participants, optimize the number of steps, avoid unnecessary cycles and approvals.

In our work we have planned the following analysis steps:

- Processing of the anonymized log files
- Automated creation of the process map
- Analysis of the whole process event chain
- Optimization of the processes

The process owner indicated several questions of interest that we have grouped into key units and plan to analyze: the process throughput, bottlenecks, identification of deviations, search for the ways to optimize the process.

We will analyze timeframes of every working element of the process and actions of its participants. In order to assess the model's consistency we will analyze its specific scenarios and try to identify possible discordance of log files and the process model.

We expect that the analysis of reconstructed business processes model will identify the following: unnecessary approval cycles, cancellation of previous actions, "ping-pong" of employees, delays in functions execution, redundant actions in the process, needless or inefficient participants and above all exceptions in the processes that occur because of employees' mistakes and require significant resources for correction.

3 Our understanding

The research topic of BPIC 2020 is the process of business trips arrangement for TU/e staff. This section describes our understanding of the procedure and the data provided by the University.

3.1 Understanding of the data

We were provided with the event logs containing data from 2017 (only two departments) and 2018 the full TU/e.

Every line in the event log represents a separate event. Every event carries the information on the underlying case and its registration time.

The data is split into travel permits and several request types, namely domestic declarations, international declarations, prepaid travel costs and requests for payment.

According to the challenge description the data is anonymized in such a way that no TU/e internal IDs are visible in the final dataset, i.e. all identifiers are freshly generated.

Staff members cannot be identified in the data. Instead, for all steps, the role of the person executed the step is recorded.

The event logs contain the following case IDs:

- declaration ID for domestic and international trips;
- declaration permit ID for travel permits;
- request for payment ID for prepaid travel costs;
- request for payment ID for payment requests.

The analyzed dataset consists of 270 211 events for 32 999 cases:

- Domestic Declarations: 10 500 cases, 56 437 events: DomesticDeclarations.xes
- International Declarations: 6 449 cases, 72 151 events: InternationalDeclarations.xes
- Prepaid Travel Costs: 2 099 cases, 18 246 events: PrepaidTravelCost.xes
- Travel Permits (including all related events of relevant prepaid travel cost declarations and travel declarations): 7 065 cases, 86 581 events: PermitLog.xes
- Requests for Payment (should not be travel related): 6 886 cases, 36 796 events: RequestForPayment.xes.

The provided data has the following main attributes indicating the information about business trips and related events (Table 1):

Table 1. Overview of the available data attributes

Attribute	Our understanding
Id	Unique identifier of the process step. It contains the information on process stages: preparation of documents, business trip, travel expenses.
org:resource	Resource of the event. It can be either a staff member or the system.
concept:name	Actions taken within the event.
time:timestamp	Time stamp. It shows the date and time of the event.
org:role	Role of the person who executed the step. The resource recorded in the data is the system, a staff member or unknown, or the data is missing. Staff members can take on 5 values: employee, supervisor, director, administration, budget owner.
case:id	Unique identifier of the process instance for domestic / international declarations. Events cluster in process instances keyed by case:id.
case:concept:name	Name of the process instance. Attribute value

	case:concept:name = case:id.
case:DeclarationNumb er	Declaration number. It shows the data on unique declarations and sometimes can receive the value unknown.
case:Permit Organiza-tionalEntity	Organizational structure. It represents the entity where the employee who has travelled works.
case: BudgetNumber	Budget number in terms of which the trip is paid.
case:RequestedBudget	Travel budget requested by the employee.
case:Permit Budg-etNumber	Travel budget number approved by the authorized person.
case:PermitRequested Budget	Travel budget approved by the authorized person.
case:Amount	Amount of the expenses related to the trip.
case:OriginalAmount	Actual expenses related to the trip.
case:AdjustedAmount	Adjusted travel budget.
case:RequestedAmount	Amount of travel expenses requested by the employee.
case:Overspent	Excess expenditure flag. It can take on true or false values.
case:OverspentAmount	Difference between the approved and actual expense amount.
case:TotalDeclared	Total declared travel cost.
case:Permit ID	Identifier of the travel permit.
case:travel permit number	Travel permit number.
case:TaskNumber	Task number. Array containing 6 unique values, or the data is missing.
case:Permit TaskNumber	Task number approved by the authorized person.
case:ProjectNumber	Project number in terms of which the business trip is made.
case:Permit Project-Number	Project number approved by the authorized person.
case:Rfp_id	Identifier of the request for payment.
case:RfpNumber	Number of the request for payment.
case:CostType	Cost type. It contains zero values.

3.2   Understanding of the process flow

The provided data consists of 2 types of TU/e staff business trips: domestic and international.

Various declaration documents (domestic declarations, international declarations, prepaid travel costs and requests for payment) correspond with the same process.

Based on the information provided by the process owner we understand that several actions should be performed with regards to every declaration document. The figure 1 shows the expected process flow for domestic and international trips including the main process activities. The options of activities are described in the Table 2.
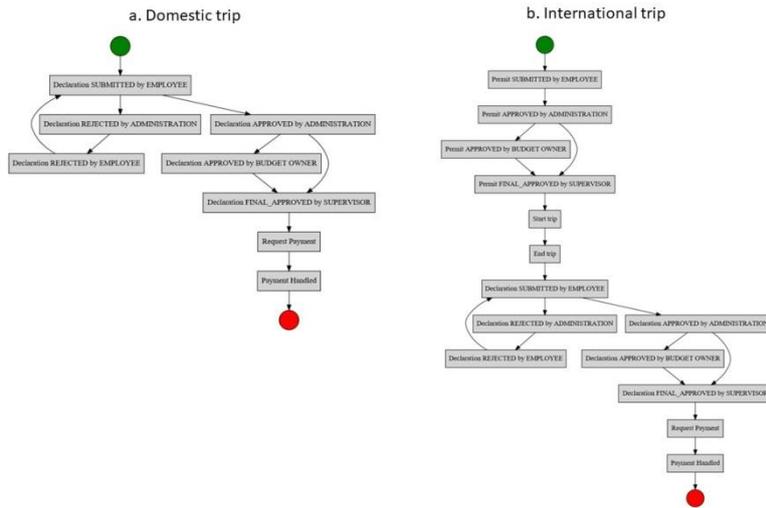

Fig. 1. Expected flow of the business travel process: a. domestic trip, b. international trip

Table 2. Description of activities

Activities	Our understanding	Role	Value
Permit			
submitted	Submission of a travel permit	Employee	Can be the starting point
approved	Approval of the travel permit	Administration / supervisor	
final_approved	Final approval of the travel permit	Supervisor / director	
rejected	Rejection of the travel permit for refinement	Employee / administration / supervisor / budget owner / director / missing	Can be the ending point
Declaration			
submitted	Submission of a declaration	Employee	Can be the starting point
saved	Saving of a declaration	Employee	Can be the starting

			point
approved	Approval of the declaration	Administration / supervisor / budget owner	
final_approved	Final approval of the declaration	Supervisor /director	
send reminder	Sending of a reminder of declaration submission	Undefined	
rejected	Rejection of the declaration for refinement	Employee / administration / supervisor / budget owner / director / missing	Can be the ending point
Request			
submitted	Submission of a request for payment	Employee	Can be the starting point
approved	Approval of the request for payment	Administration / supervisor / budget owner	
final_approved	Final approval of the request for payment	Supervisor / director	Can be the ending point
rejected	Rejection of the request for payment for refinement	Employee / administration / supervisor / budget owner / director	Can be the ending point
request payment	Request of payment	Undefined	Can be the ending point
Payment Handled	Processing of payment	Undefined	Can be the ending point
Start trip	Start of the trip	Employee	
End trip	End of the trip	Employee	

The process flow differs for domestic and international trips due to the specifics of business trip arrangement:

— for domestic trips no prior permission of authorized person is needed, i.e. an employee can undertake these trips and ask for reimbursement of the costs afterwards;

— for international trips permission is needed from the supervisor. This permission is obtained by filing a travel permit and this travel permit should be approved before making any arrangements.

The variability of declaration documents flow depends on the result of their processing:

- request / declaration is rejected – in this case the document is rejected, the employee refines and resubmits the declaration, or the employee also rejects the request;
- request / declaration is approved – in this case the document is then forwarded to the next approval step by the authorized person.

If approved, the request is then forwarded to the budget owner and after that to the supervisor. If the budget owner and the supervisor are the same person, then only one of these steps is taken. In some cases, the director also needs to approve the request.

After all documents are approved, an employee files a claim for reimbursement of travel expenses (request for payment). This can be done as soon as costs are actually paid (e.g. for flights or conference registration fees), or within 2 months after the trip (e.g. hotel and food costs which are usually paid on the spot).

4   Analysis

Before starting the process mining we need to convert the event logs in such a way that they become optimal for search and analysis steps.

In order to understand the process better we have filtered the event log to include only complete cases. Systems usually record data permanently therefore the provided event log can contain several cases that have not finished yet by the last registered date.

The objective of data processing step is to create different representations of the event log objects, clear the provided data of collection errors: processing of gaps, duplicates, outlying cases.

According to the challenge description the process owner described the workflow for 2018 and pointed out that for 2017 there were some differences as this was a pilot year and the process changed slightly on several occasions. As the provided dataset contained events pertaining to 2 years, we cleared the data of the objects with unfinished activities in 2018.

For this purpose we uploaded the data to Jupiter notebook and used programming language Python and Pandas library to group the events by unique identifier of the process instance for domestic and international declarations (case:id). Afterwards we filtered the events by time stamp and cleared of all records not related to the analyzed period.

As a result the cleared data contained 44 614 events for 7 959 domestic declarations and 55 726 events for 4 776 international declarations pertaining to 2018.

4.1   Process mining

At this stage we tried to answer the questions raised by the process owner. We examined the performance of the process, time intervals of completing parts of the process, identified deviations and bottlenecks.

We have taken the course «Process Mining: Data science in Action» (Coursera) developed by talented Dutch scientist Wil van der Aalst and put into practice the provided methods of process modeling.

We used the provided event logs as input data used for process analysis. We uploaded them to Disco (fluxicon), set the parameters of mining and obtained the actual process map using Play-In method (Figures 2, 3).
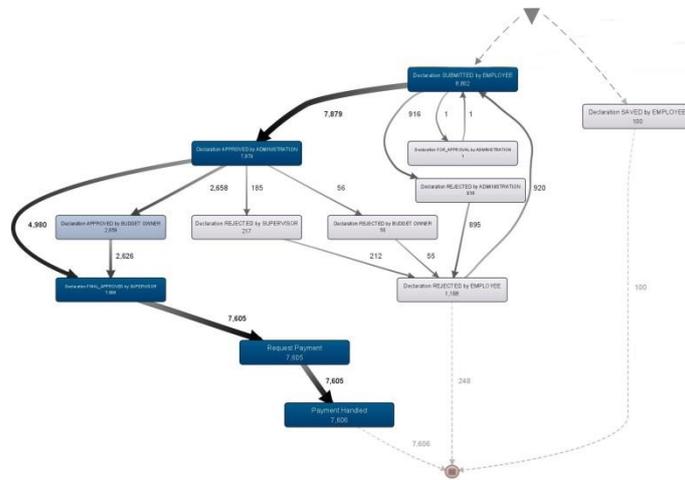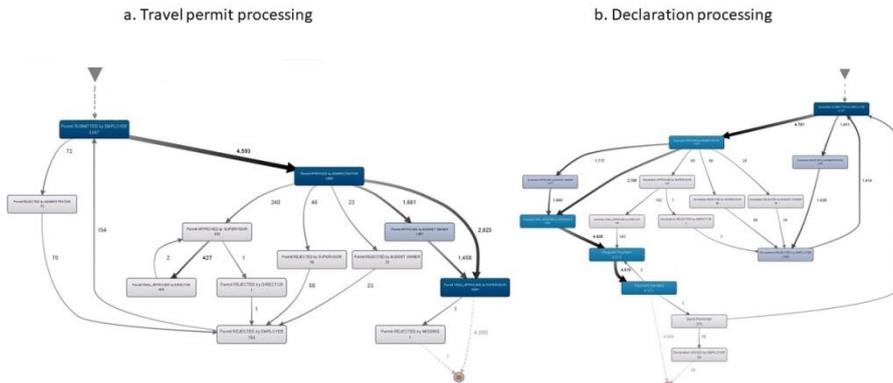

Fig. 2. Process map 1: Domestic trip

Fig. 3. Process map 2: International trip (a. travel permit processing, b. declaration processing)

Disco (fluxicon) helped us visualize the process steps for domestic / international declarations. Activities highlighted in deep blue take place more often. Edges connecting activities demonstrate the amount of cases. By manipulating metrics we can get useful information on duration, frequency of cases and activities. We can also assess the process in terms of performance and time consumption. We used statistical tools to evaluate different cases, activities and resources.

4.1.1 Throughput analysis

We analyzed the process flow of domestic declarations (DomesticDeclarations.xes) for 2018 with the use of Disco (fluxicon) and detected that most domestic declarations (91%) were processed within 17 days from submission to payment which exceeds the mean case duration of 10,7 days (Figure 4).

On the other hand the processing time of 9% declarations was higher than 17 days (up to 250 days). It indicates significant loss of time in the process and adverse impact on the throughput.

Fig. 4. Distribution of case number by duration (domestic trips)

Afterwards we analyzed the data on international trips and identified that 77% of the whole sample (3 677 cases) were processed within 95 days.

The mean processing time of international declarations equaled 75,1 days from submission of travel permit to payment. It should be noted that this approach does not allow to assess the process objectively as it includes the waiting time till the trip start (after getting the approval) as well as the journey time itself that can be different. For example, in one popular event sequence the waiting time took 60% of the whole process duration.

Therefore we decided to break up the throughput calculation into 2 phases:
travel permit processing;
international declaration processing for finished trips.

The calculation showed that the throughput of obtaining travel permit amounted up to 7 days for most cases (88%) which is almost 2 times longer than the mean value (4,3 days). For the rest of travel permits (12% cases) the processing time lasted from 7 to 201 days.

The throughput of declaration processing for finished trips measured up to 28 days for 89% cases which is almost 2 times longer than the mean value (15 days). For the other cases (11%) it took from 28 to 293 days to prepare trip report.

In general the analysis demonstrated that it took up to 24 days to complete 2 processing phases for 75% cases.

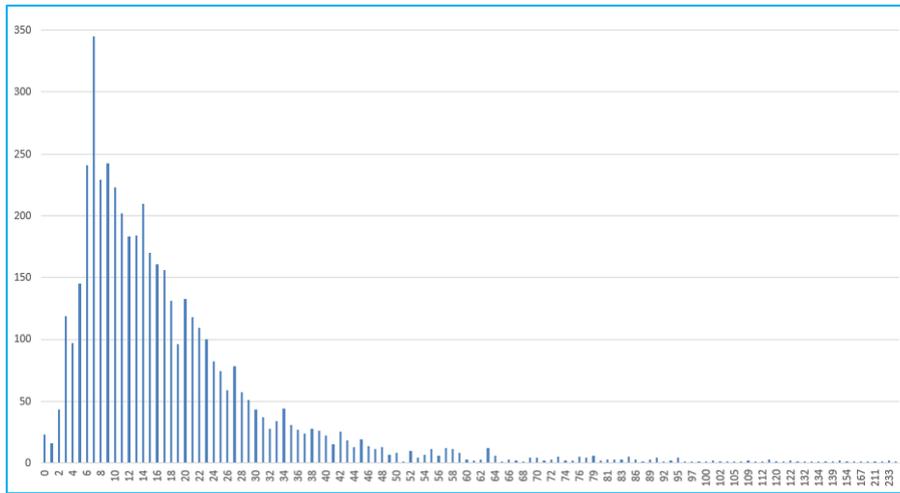The corresponding figure is provided below (Figure 5).

Fig. 5. Distribution of case number by duration (international trips)

According to the analysis results the mean processing time of international trips (both travel permit and declaration processing) is twice as long as the processing time of domestic trips. Thus we detected that arranging domestic trips is an easier process flow than the procedure for international trips (there is an extra step of obtaining a travel permit). Besides, longer duration of international declarations processing can be caused by the amount of required documents as well as possible deviations / existence of bottlenecks in the process.

In addition we evaluated the throughput by time intervals breakdown. For this purpose we analyzed the distribution of cases in work.
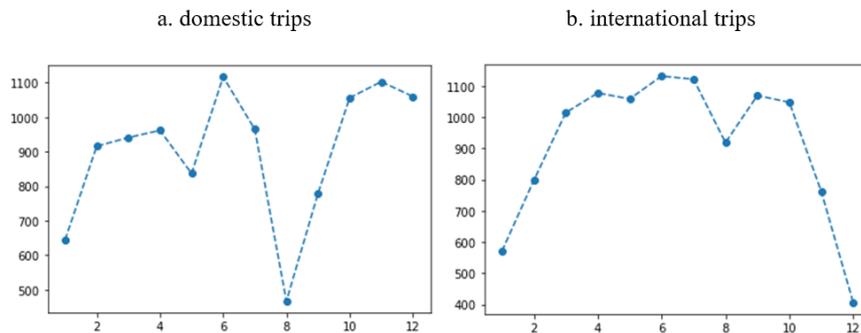

Fig. 6. Cases in work broken down by month (a. domestic trips, b. international trips)

It may be concluded based on the graphs (Figure 6) that since the beginning of the year there is a smooth growth of processed declarations number. It can be related to New Year holidays and vacations. The biggest peaks are observed in July and October. Most business trips are taken in these months. Moreover there is a significant decrease in August which is most likely caused by summer vacations.

We can assume that peaks correspond with travel declarations for the trips that took place prior to the end of the academic year (May) and after its start (September). It is worth mentioning that during the peak period the process throughput has a negative trend (documents processing time rises up to 9,5 days) due to increased staff work load.

In order to assess the throughput and find solutions for process improvement we analyzed the duration of every step of the process.

For this purpose we drew process graphs with edges weights calculated as mean time (days) per edge (Figure 7).
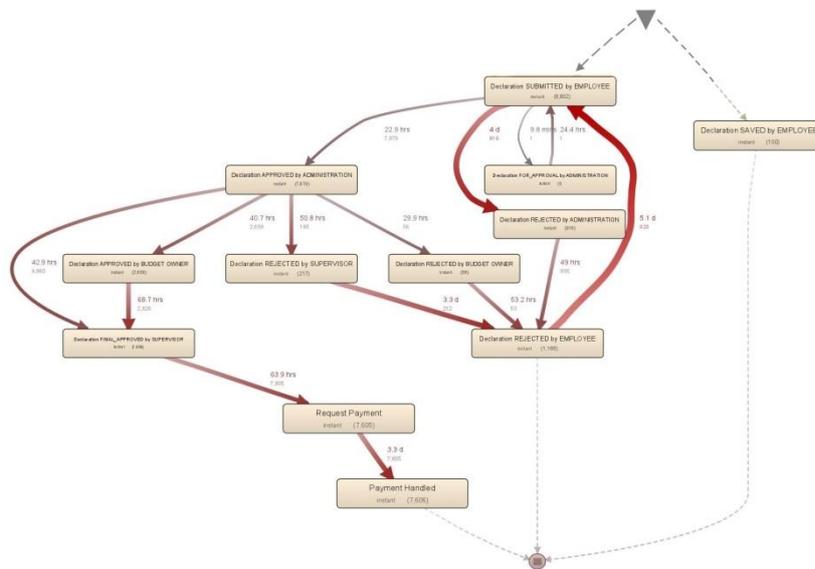

Fig. 7. Throughput of domestic trips

Analysis indicated that in most cases domestic declarations were sent for approval to the travel administration and the supervisor (66%), while the other declarations were additionally submitted for approval to the budget owner (34%). In the first instance the mean throughput equaled 8,7 days, in the latter case it amounted to 11,5 days. Only 0,5% of all domestic declarations were rejected at any stage, out of which half of the cases were finished and employees took no further action.

The width and color depth of the lines on Figure 7 demonstrate the longest steps of the process that affect the throughput and help identify bottlenecks. Thus the follow-

ing steps turned to be most time-consuming: declaration rejection by travel administration / employee, declaration resubmission by the employee.
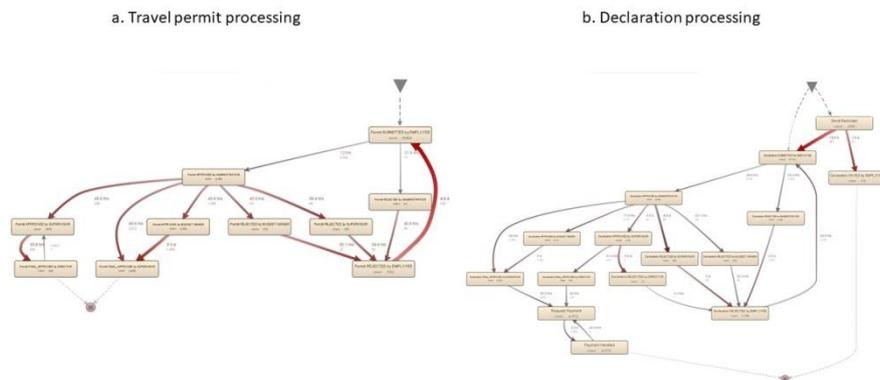

Fig. 8. Throughput of international trips: a. travel permit processing, b. declaration processing

The process flows of domestic and international declarations have similar approval procedures.

Most travel permits and declarations for international trips were sent for approval to the travel administration and the supervisor (55%), part of requests were submitted for additional approval to the budget owner (37%) and only minor part of requests were sent for approval to the director (8%). In the first case the mean throughput was 2,6 days for permits and 10,3 for declarations, in the second case it equaled 5,7 days for permits and 13,4 days for declarations, in the third instance it amounted to 5,3 days for permits and 12,6 days for declarations. 20% of all requests were rejected at different stages, out of which 3% cases were finished and employees took no further action.

Besides, in 64% cases after receiving a reminder employees submitted declarations within 13 days on average, in 3,9% cases the declarations were completed at the step SAVED. It is worth mentioning that reminders were sent on average 43 days after the trip end.

Figure 8 shows the most time-consuming process steps: rejection of the declaration by mandated persons / employee and declaration resubmission by an employee.

Declarations with the longest processing time were of special interest for us. Maximum deviations from the mean throughput belonged to:

14 cases of domestic declarations (lasting more than 150 days), mostly caused by lengthy approval (up to 6 months on average) by the travel administration (ADMINISTRATION role) due to mistakes in declarations or the necessity to get clarifications / make adjustments.

35 cases of international declarations (lasting more than 90 days), driven by violation of chronological sequence of steps (travel permit was submitted after or during the trip) and untimely submission of declaration by the employee.

Thus we assume that the fastest processing of declarations by the travel administration role corresponds with the execution of simple control functions (check of template, dates and etc.). Process steps performed by the roles of budget owner, supervisor and director have common long processing time because of complicated control functions (budget control, budget source, trip objective and etc.). The most long-lasting steps of the process are performed by the employee role, which is evidence of, for instance, the absence of informing about request status or necessary instructions / templates.

We additionally analyzed the resources of travel arrangement. So significantly more transactions are performed by employees than by the system:

83% transactions related to international trips were performed by employees and only 17% were executed by the system;

66% transactions related to domestic trips were performed by employees and only 34% were executed by the system.

In addition we tried to identify deviations in the process of international trips arrangement with the use of One-class Support Vector Machine carried out in Python library Scikit-learn.
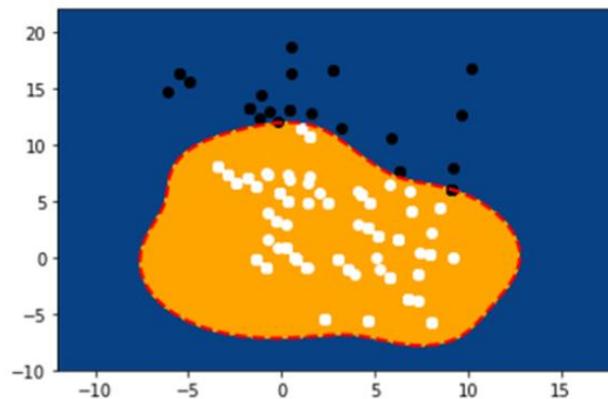

Fig. 9. Outlier detection

We used one-hot encoder for this purpose and converted the original log to numerical matrix where declarations are rows and unique process steps are attributes. The number of specified steps for every declaration is shown at the intersection. We used 0,5% as the threshold for outlier detection. Figure 9 demonstrates the algorithm output. It is apparent that some declarations stand out from the main cluster. Detailed analysis revealed that these declarations deviated from the standard procedure – the routing included the step Rejected.

As a consequence we believe that machine learning techniques allow identifying deviations in processes and thus should be applied in conjunction with classical Process Mining methods.

4.1.2 Analysis of the process quality

In accordance with the process owner's expectations we analyzed the procedure of obtaining travel permits for international trips. We found out that 518 trips (10,8% cases) were not preceded properly by an approved travel permit, while for 266 declarations (5,6% cases) no permit exists. Payments were made for declarations without permits in 94% cases.

We classify the events specific to the identified deviations into 3 main groups:

- travel permit was approved after the trip;

- travel permit was approved during the trip;

- no travel permit was filed.

We believe that the main reason for deviations is the absence of "strict control" over declarations routing in the systems used. Moreover, we suppose that the existing process flow for international trips in TU/e does not allow getting a travel permit at short notice, for example, for unplanned or urgent business trips.

We analyzed the functions performed by process participants and realized that all travel declarations were submitted by the traveler. Mandated persons took part only in the approval of declarations:

- 86% out of 7 959 domestic declarations submitted by employees were approved by authorized personnel;

- 74% out of 6 157 international declarations submitted by employees were approved by authorized personnel.

The share of declarations re-submitted after required correcting (10% of domestic declarations and 19% of international declarations) affects the performance and reflects deficiencies of the existing guidelines for employees: e.g. regarding template filling in, choice of budget source / amount, purpose of travel, etc.

While answering the questions of the process owner we analyzed the timeliness of declarations approval by BUDGET OWNER (no more than 7 days). BUDGET OWNERS approved most declarations within defined deadlines, delays represented only a minor part of cases: 1% of domestic declarations (from 7 to 34 days) and 0,3% for international declarations (from 7 to 14 days).

Thus it can be concluded that after the set deadline for budget owner approval declarations were not automatically rerouted to the next step (FINAL_APPROVED by SUPERVISOR).

With respect to the process owner's interest we calculated that out of 33 international declarations submitted more than 2 months after the end of a trip 13 declarations were first rejected and 11 declarations were then re-submitted for approval. The provided data does not allow addressing this question regarding domestic trips.

In 2018 62% international declarations were booked for 729 projects, while it is impossible to assess this aspect for the other declarations (the attribute value is

UNKNOWN). No corresponding data is available for the similar analysis of domestic trips.

4.1.3 Cost estimation of travel expenses
We found out that 198 budget types are used to pay for international trips in TU/e, while domestic trips are paid within unified budget.

The provided data allows to evaluate budget utilization by departments only in terms of international trips (expenses were reimbursed for employees of 27 departments).

Travel budget is mainly used by the staff of 8 departments, their budget share is about 90% of paid travel costs. It may be assumed that the employees of these departments go on business trips more often (Figure 10).
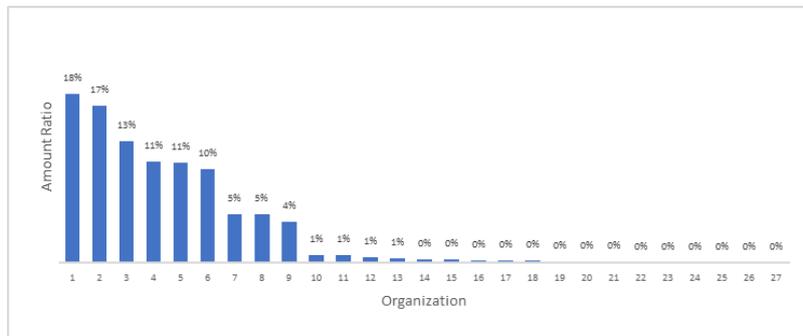

Fig. 10. Distribution of the budget between departments

All expenses of international trips are allocated to 729 projects. Costs of every project are linked to specific budget type. No corresponding data is available for the similar analysis of domestic trips.

It should be mentioned that only 65% of travel expenses have identified project allocation, the rest of payments cannot be evaluated as the attribute "case:Permit BudgetNumber" has the value UNKNOWN. We suppose there were deficiencies in data collection or its deliberate omission.

As part of the study we detected that the approved budget was overspent in 33% cases of international trips. At the same time the requested budget did not always correspond with actual expenses: 1 587 declarations had an expense overrun totaling EUR 548 404,9, and in 3 086 cases a lower sum was declared than the requested amount, the difference equaled EUR 1 318 904. Thus deficiencies in budget planning hinder optimal use of the company's funds available.

In order to estimate travel expenses we performed comparative cost analysis of domestic and international trips.
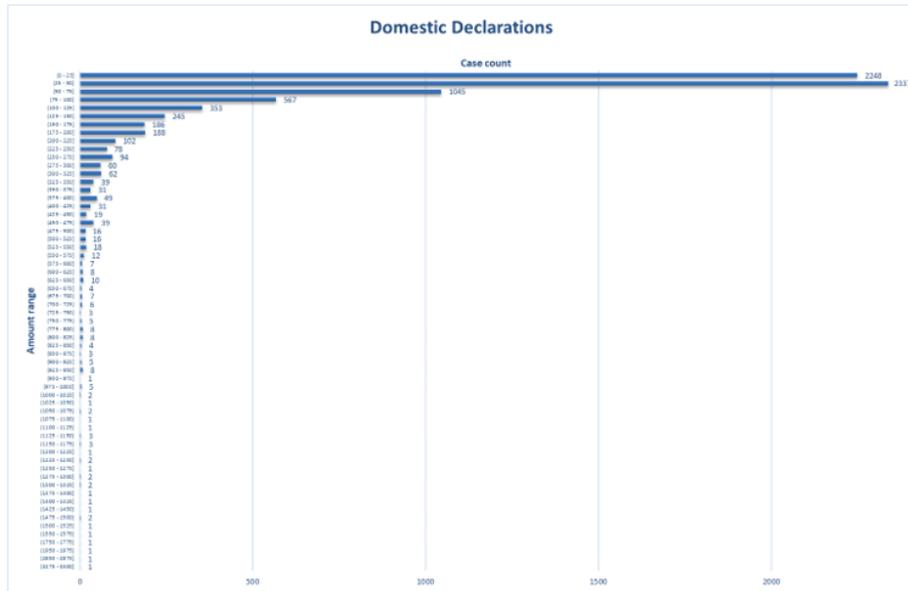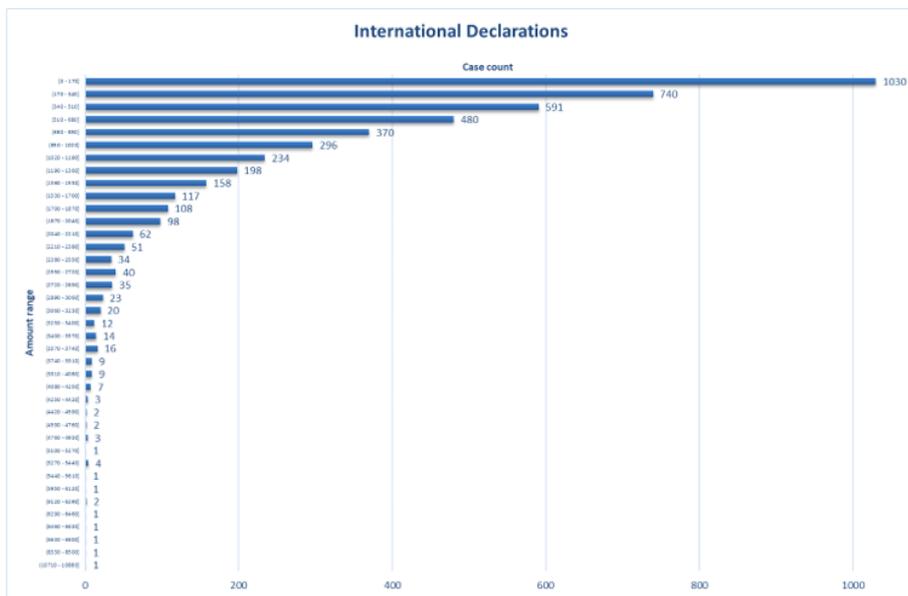
Fig. 11. Sum ranking of domestic trips

Fig. 12. Sum ranking of international trips

As per analysis total costs of domestic trips equaled EUR 695 677, expenses for international trips amounted to EUR 3 705 213.

The average cost of a domestic trip (EUR 87) was almost 9 times lower than the mean cost of an international trip (EUR 776). The largest share of domestic trips belongs to declarations under EUR 100, of international trips – declarations up to EUR 1000 (Figures 11, 12).

Besides, we noted that TU/e employees had taken 31 international trips (0,6%) costing over EUR 4000 (maximum EUR 10 766) which represented 4% of the total budget. We understand that expensive business trips take place in most large companies. Nevertheless, we recommend following the smart expense policy.

The research revealed that domestic trips were not prepaid. Out of 4 776 international declarations reimbursement of pre-paid travel costs was requested in 1 037 cases (21,7%). We assume the host party was the main source of funding or employees used their own funds and then received expense reimbursement.

We identified neither double payments, nor submissions of a request for payment instead of a travel declaration.

The study of Request for Payment.xes showed that most requests for payments were below EUR 300, while the largest share belonged to amounts up to EUR 100 (Figure 13). Considering the sum ranking of requests for payment we suppose these sums were mostly representation expenses.
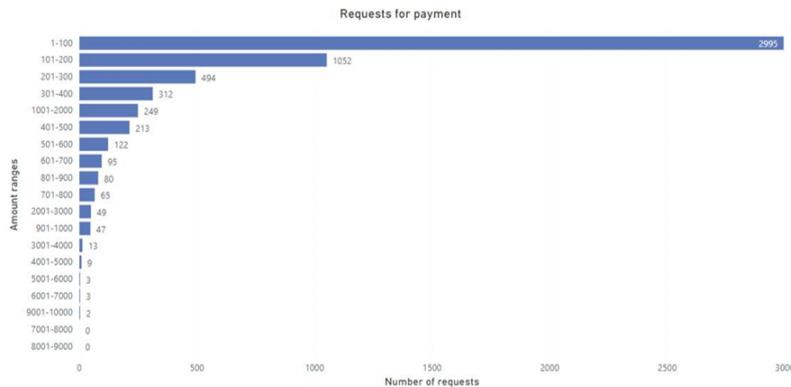

Fig. 13. Sum ranking of requests for payment

4.2 Project summary

Our main findings based on the process owner's questions are as follows:

- The throughput of travel declarations from submission to payment averaged 10,7 days for domestic trips and 19,3 days for international trips. Longer processing of international declarations is explained by process complexity (there is an extra step of obtaining a travel permit) as well as the requirement of an additional director approval in several cases. Moreover, the number of required documents and existing deviations and bottlenecks in the process influence the duration of international and domestic declarations processing.

- The throughput analysis at every process step including performance of different responsible roles showed that the fastest approval of declarations is done by the travel administration role due to simple control functions (check of template, dates, etc.). Longer processing time is common to the steps performed by the roles of Budget owner, Supervisor and Director due to control over budget, budget sources, trip objectives, etc. The most long-lasting steps of the process are performed by the Employee role.

  The following process steps are most time-consuming: declaration rejection by mandated persons / employee, declaration resubmission by the employee. In some cases, requests are rejected and resubmitted due to non-compliance with deadlines: out of 33 international declarations submitted more than 2 months after the end of a trip 13 declarations were first rejected and 11 declarations were then resubmitted for approval.

  The rate of request rejection at different stages (20%) and resubmission of corrected declarations (10% of domestic declarations and 19% of international declarations) as well as long duration of the named steps affect the process performance and should draw the management's attention.

- The throughput analysis in terms of time intervals identified common peaks in May and October caused by the growth of processed declarations number. Most business trips are taken in these months. We assume that peaks correspond with declarations for the trips that took place prior to the end of the academic year (May) and after its start (September). It is worth mentioning that during the peak period the process throughput has a negative trend (documents processing time rises up to 9,5 days) due to increased staff load.

- We additionally evaluated the resources of travel arrangement and noted that significantly more transactions were performed by employees than by the system: employees executed 83% transactions related to international trips and 66% transactions related to domestic trips, the system completed 17% and 34% transactions respectively.

- We identified bottlenecks in the process of obtaining travel permits / arranging international trips. We believe that high process variability is the evidence of missing unified routing for international declarations (50% international declarations follow non-standard routes). The absence of control points over documents' status at different process stages leads to wide spread of time intervals at the same steps for different declarations. We suppose that the existing process flow for international trips in TU/e does not allow getting a travel permit at short notice, for example, for unplanned or urgent business trips.

- The processing of domestic trips is in line with the standard procedure, 89% of domestic declarations follow the standard routing. Insignificant share of deviations does not affect the overall process.

- We did not manage to reveal the dependence of approval steps from the expense amount. We identified high variability of the sums sent for management approval. We suggest implementing a threshold for involving TU/e top managers into approval process.

- We found out that 10,8% trips were not preceded properly by an approved travel permit, while for 5,6% declarations no permit exists. Payments were made for declarations without permits in 94% cases.
- We analyzed the functions performed by process participants and realized that all declarations were submitted by travelers.
- Budget owners approved most declarations within the defined deadline (7 days), while delays represented only minor part of cases: 1% of domestic declarations (from 7 to 34 days) and 0,3% of international declarations (from 7 to 14 days). Thus it can be concluded that after the approval deadline for budget owner declarations were not automatically rerouted to the next step (FINAL_APPROVED by SUPERVISOR).
- 62% international declarations were allocated to 729 projects, while for the rest of declarations we could not assess this aspect (the attribute value is UNKNOWN). No corresponding data is available for similar analysis of domestic trips.
- In TU/e domestic trips are paid within unified budget, while 198 budget types are used to pay for international trips. Travel budget is mainly used by the staff of 8 departments, their budget share is about 90% of paid travel costs. It may be assumed that the employees of these departments go on business trips more often.
  The provided data enables to evaluate budget utilization by departments only for international trips (expenses were reimbursed for employees of 27 departments).
- We found out that costs of international trips were allocated to 729 projects and specific budget type: 65% of travel expenses had identified project allocation, the rest of payments could not be evaluated as the attribute "case:Permit BudgetNumber" had the value UNKNOWN. We suppose there were deficiencies in data collection or its deliberate omission. No corresponding data is available for similar analysis of domestic trips.
- The approved budget was overspent in 33% cases of international trips. The requested budget did not always correspond with actual expenses: 1 587 declarations had an expense overrun totaling EUR 548 404,9, and in 3 086 cases a lower sum was declared than requested, the difference equaled EUR 1 318 904. Thus deficiencies in budget planning hinder optimal use of the company's funds available.
- We also analyzed the average cost of trips: an average domestic trip (EUR 87) was almost 9 times less expensive than an average international trip (EUR 776). The largest share of domestic trips belongs to declarations under EUR 100, of international trips – declarations under EUR 1 000. Besides, we noted that TU/e employees had taken 31 international trips costing over EUR 4 000 (maximum EUR 10 766) which represented 4% of the total budget. We understand that expensive business trips take place in most large companies. Nevertheless, we recommend following the smart expense policy in order to improve the process efficiency.
- The research revealed that advance payment was requested for 21,7% international trips. We assume the host party was the main source of funding or employees used their own funds and afterwards expenses were reimbursed. Domestic trips were not prepaid.
- We identified neither double payments, nor submissions of a request for payment instead of a travel declaration.

- Most requests for payment were below EUR 300, while the largest share belonged to amounts up to EUR 100. Considering the sum ranking of requests for payment we suppose these sums were mostly representation expenses.

Our recommendations:

To review the existing guidelines for employees (make them easier and more user-friendly), use new technological tools: e.g. chat bot that can solve the problem of multichannel contact with travel administration and represent a single point of contact.

To implement or improve the automated form for travel declarations and travel permits that will include standard fill-in instructions and require minimal participation of an employee. It will reduce the amount of simple errors before submitting documents for approval.

To create and implement service level agreements for TU/e departments, work out KPIs for performance evaluation.

To develop automated monitoring of request processing steps, inter alia sending of notifications to employees about the status and step of their documents processing. To implement "strict control" over declarations routing.

The process owner should pay special attention to peak periods of declarations submission and consider all alternative opportunities to improve the throughput. We find it important to work out an automated report for the TU/e management, it should indicate the current status of requests processing at all process stages in order to take managerial decisions in real-time mode.

To consider the possibility of optimizing the role Administration by means of alternative procedures: e.g. work out standard templates with built-in control functions.

To revise threshold values of travel expense limits in order to use them more rationally.

For the purpose of cost reduction:

- To make the list of recommended hotels, means of transportation, and their categories depending of the employee's position when he/she is sent on a business trip;
- To practice early booking of hotels / tickets and other necessary options for a trip;
- To implement control over budget overspending.

Considering the international situation related to COVID-19, to choose the categories of business trips that can be transferred to alternative online channels.

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