Utrecht University

Department of Public Administration and Organisational Science

Master Thesis

Modelling the Public Sector

Using Discrete Simulation Modelling (DSM) for the analysis of throughput times of court cases in the Justice system of the Netherlands.

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Abstract

This study shows how simulation modelling can contribute to the public sector research. Currently not much research has been conducted in this field, which is unfortunate since it can (ex ante) provide us with insights in the effects of policy decisions, without having to interfere with reality. This creates more legitimacy and credibility for policy changes. This requires a logistic perspective on the public sector. To show how simulation modelling can contribute to the public sector, we develop a discrete event computer simulation for the analysis of logistic changes in the trade laws system. Two models are created, based on the existing court district *Midden-Nederland*, location Utrecht in the Netherlands. The first model is based on the current system, and the second model is based on the suggested interventions by the government, the ministry of justice, and the administration of justice in their program "Kwaliteit en Innovatie Rechtspraak"(KEI). In total five experiments test the two systems, to see how the interventions change the throughput time of the trade law cases. The study shows that due to the changes of KEI, the average throughput time can decline, however, it is established that the system becomes less resilient towards external and internal pressure. The example of the court system shows how (discrete event) simulation modelling is a useful tool for the public sector, albeit not in optimal use yet.

1. Introduction

Public organisations have a large impact on the life of citizens, and having an optimal working public system is worth pursuing. Within the public administration there have been many reforms in its organisations and processes, which are a response to the needs of citizens and events happening in society (Bouckaert, 2010). A large reform is the change of perspective from old public administration to new public administration. This reform comes down to a trade-off between economic and democratic values. The old public administration tends to focus on steering, whereas the new public management (NPM) focuses more on serving and seeing the citizen as a client (Denhardt and Denhardt, 2000). In NPM, private sector ideas and practices are implemented in the public sector. Governments outsource services if possible, and provide services internally as efficiently and effective as possible. This means organisations reform, and processes are optimized. The public organisations go from a top-down rule system towards a more flexible system, adjusting to the needs of the citizens (Bovens and ‘t Hart, 2007).

Going towards a flexible and efficiency oriented public sector, requires different processes, and although the reform of these processes are done with the right motives, conflicting views, institutional norms and rules and contextual factors make it hard to implement policies (Kristianssen and Olsson, 2016).

A difficulty with changing public processes, is that it is hard to estimate the policy outcome in advance. Experimenting with the public domain is challenging and sometimes impossible, because it influences people directly and costs a lot of time and resources. The research conducted on policy analysis is usually ex post. It seems strange that we implement polices of without having real ex ante research on the effects of policy changes, especially since they affect so many citizens. Having a tool by which ex ante research is possible will increase the legitimacy and credibility of the policy change.

A method that is capable of showing the effect of policy decisions upfront is simulation modelling. In the private sector, this method is already often used to decide on the right policy. Since private sector ideas and practises are implemented in the public sector, why not use the research methods as well? Especially since many of the public processes, can be seen as logistic processes due to their bureaucratic character. For example, the request of a residence permit needs to be applied at the immigration and naturalization office, from which a procedure through the administrative system is started. The bureaucratic characteristic of the public sector makes simulation modelling extremely suitable for exploring public policy of process changes.

It is our view that the future of policy making is based on simulation research. This type of research makes it possible to explore the outcome of changes upfront and can give more insight in policy decisions from a logistic perspective.

Simulation refers to building a model of the system and experiment with this model in order to determine the response of a system to changes in its internal structure and inputs. Usually, it consists of a simplified representation of a system that is too complex for direct analysis. Thus, the simulation model is smaller, cheaper, and simpler. Its purpose is to analyse and understand the behaviour of a system as a function of actions and alternative scenarios (Maria, 1997). By modelling a part of a system, this study is able to show the effect of the logistical changes, without having to interfere. It makes it possible to answer "what if" questions, show the outcome of certain policies in advance, and supply information on policies.

This study elaborates how this research method is useful for the public sector, by doing a research towards the process change within the law system. This research is not only methodologically innovative, but also requires a new perspective on the public sector. The public service can be seen as a logistic process, like an assembly line. Let's take the example of a law process. A court case starts at the beginning of the line, with the prosecutor. In each phase a server, like the defendant, the prosecutor, the administrative employee, or a judge, processes the case and sends it to the next server. This process can be changed in order, service times, reply times of the defending or prosecuting, etc. Changes in the laws make it possible to change the process. This study shows that simulation studies contributes not only to private companies, but also to public administration, jurisprudence, political science, and other public fields. As an example of how simulation modelling contributes to understanding the outcome of a policy change, this study continues with the process changes in the law system.

The law in the Netherlands is generally seen as jurisprudence of high quality. In order to safeguard this quality, constant maintenance and innovation is necessary (Broeder, O.J., 2014). After all, laws are both a safeguarding for citizens and a source of protection against the government, as well as an instrument for the government to influence the behaviour of citizens and companies (Bovens, 't Hart & van Twist, 2007). Having a strong and modern rule of law enhances core values like equality, trust in the system, and safety. To keep the quality of jurisprudence high, every three years the administration of justice makes a program with focus points. At the end of the period 2011-2014, a study among involved parties and professionals has been performed, to look for points of improvement. The research showed that almost a third of the respondents thought the process time of cases is too long. More than 60 per cent of the Dutch citizens are dissatisfied with the length of procedures in administrative and civil right.

To respond to these dissatisfactions, the administration of justice set objectives for the year 2018 (Agenda van de Rechtspraak, 2014).

One of these objectives is to decrease the throughput time of court cases with 40 per cent compared to 2013. The throughput time is the time from the start of the case, until the point where a case leaves the system. In most of the cases this is the point of the end verdict, however, it is also possible a case gets withdrawn or a settlement is made. Part of this throughput time is the processing time, which is the time a party, lawyer, or judge works on the case. Only a small part of the total time consists of this process time, and most of the throughput time is waiting time. By changing the procedures, the administration of justice hopes to decrease the throughput time with 40% (Agenda van de Rechtspraak, 2014). The procedures are to be simplified and digitalized, allowing cases to be dealt with much quicker.

In order to provide these changes, the government, the ministry of justice, and the administration of justice started the program 'Quality and innovation jurisdiction' (Kwaliteit en Innovatie Rechtspraak (KEI)). KEI will be used to facilitate simplification, standardisation, and digitalisation of procedures and will permit innovations in the procedures (Agenda van de Rechtspraak, 2014). The changes in the process should provide quick, accessible, and professional jurisdiction (Veiligheid en Justitie begroting, 2016).

This study uses simulation modelling to determine the effect of the policy changes of KEI on the throughput time of court cases. Through this simulation, the different court systems are modelled and multiple scenarios are tested. The changes of KEI are simplification, standardisation and digitalisation, and they can be seen as interventions to change the logistical system. The models of both the current system and the new expected system are used to compare the systems and explore the effect of the changes on the throughput time.

Therefore, the research question for this study is: **How do the KEI interventions to improve logistic handling, affect the throughput time of trade law court cases?**

This study looks into the trade law cases dealt with by the Court in Utrecht, part of the district *Midden-Nederland*. These are cases that deal with monetary amounts above 25,000 euros. According to employees of the court, this is a sector in which the throughput times are extremely high, and there is a need for quicker process (Conversation employee court, 17/6/16). Trade law in the district *Midden-Nederland* is the first part of civil law that will be changed by KEI. This Court will start with a pilot to test the new system. Also, trade law is a jurisdiction in which there is not a high variation. This means that there are not many possible exceptions of the standard procedure.

The data for this research is obtained by looking into regulation- and process literature, having conversations with employees, and collecting statistical data out of the data system of the court in Utrecht. The literature and conversations with employees are used to create the right model of the system. This provides insight in the system and its processes. It is important to create a model that is as close to reality as possible, and feedback meetings secure the validity of the research. The statistical data is explored in order to provide the input for the model.

The relevance of the project is two folded. First of all, this study shows the effect of certain policy decisions in advance of the implementation. By using data out of the real world the system is modelled and experimented with, without any effect on reality. Without having to infer, this research explores the policy decisions in advance, and shows the utility of ex ante simulation research.

Secondly, having a lower throughput time is beneficial for society. In a research by the SEO Economic research, commissioned by the WODC, the economic and social effects of long throughput times of civil and administrative law were studied (Feslö et al, 2007). Intuitively, one could say that having more time to process a case might have its benefits. It means there is more time to plan and work, and more room to prepare, for both the representative parties and the judiciary. However, this is a theoretical benefit - and not supported by research. What research shows is that a longer process time can lead to additional work, emotional consequences, delay in the verdict, and influence the quality of the verdict. The longer a process takes, the more stress and insecurity the involved parties experience (Feslö et al, 2007).

Having a longer lead-time increases the chance of having a staff switch during the case. This in turn leads to more needed time to prepare. The delay has to be communicated to all parties, which leads to more delay (Feslö et al, 2007). Delays and extra work, increase the costs of process representatives. These costs are passed on to the client, the legal insurance, or the representative's organisation. The government finances the salary of judges and staff; money of the state is used, so inefficient jurisdiction also has an effect on the public treasury.

Besides monetary and emotional effects, there also exists a chance that delays affect the quality of the verdict. When a process takes too long, it is possible that the verdict of the judge is not executable anymore, or the outcome of the verdict changes. For example, in 2011 a man got a sentence 'discount' because of the long lead time (PZC, 2011). The quality of a trial can decline due to changes in memory of the witness (Feslö et al, 2007). Combined, these factors underline the importance of a fast process trial.

In this study, the focus is not on the quality of the court cases and if this is influenced by the decreasing throughput times. Previous research shows that having a smaller throughput time can positively affect the court case quality. This research focuses on using simulation modelling in order to evaluate an intended policy change in a service oriented public organisation.

This study starts with a theoretic framework on the logistic management and simulation modelling. In this chapter, logistic management is elaborated. This chapter also shows why this is applicable to the public sector. The second paragraph of the second chapter explains why logistic management often uses simulation modelling to explore policy decisions. Then, three different types of modelling are explored, system dynamic-, agent based-, and discrete event modelling. The third paragraph shows how these methods are useful for the public sector. The third chapter specifies the research case, starting with the current state of the procedural law, followed by how KEI will change this process.

After the theory and case description, the methodology elaborates the used method and techniques, specifying the data gathering and validation of the research. Chapter five presents the simulation with the corresponding assumptions, analysis of the problem and the input analysis. Here, the two models are established, one corresponds with the current system and the other with the system with the new rules of KEI. With these two models it is possible to explore how simplifying, standardizing and digitalizing the system influences the throughput time of the court case. Chapter six presents the results of the research and chapter seven presents the analysis. The study finishes with a conclusion on how the field of public administration and informatics can combine their strengths to explore more features of the public field.

2. Theory

Logistic management

Logistics management is the governance of a logistic system, which exists of a system and its environment. A system can be defined as: "*a collection of entities, e.g. people or machines, that act and interact together toward the accomplishment of some logical end*" (Law & Kelton, 2001). This can be a part of a company, the whole company or a chain of companies. For example one can think of the process of getting the luggage on a plain towards the luggage claim. This is a process with employees, transporting belts and machines. These recourses in the chain are connected to each other and have a certain relation towards one another. Together these elements are used to add value, e.g. they perform a set of given operations in the work flow (Monhemius, 1985). The whole combination of servers and their underlying relationships is the structure of a system. There is a connection between the employees unloading the baggage and the machines sorting the suitcases in the airport. Working together according to an efficient pattern, can optimize the amount of luggage dealt with, or decrease time between the airplane and the baggage claim.

Logistics management deals with all levels of the planning and execution of an entity flow. In most cases these entities are products and logistic-management deals with their manufacture and/or distribution process. This type of management tries to control and influence the flow of goods by making decisions on multiple levels.

In order to manage the logistic chain, information is needed about the system and relation between the resources in the system. Information is a key element, however in logistic management one often finds complex and uncertain elements. Information in these systems is often hard to come by. Systems are complex when there are many aspects which have to be taken into account, and with an increase in complexity there is a higher need for information. A system has a high uncertainty when quantities or service times are stochastic, instead of deterministic. This means that the quantities and service times are not known in advance. For example, one does not know how many customers will enter a store in advance. It is possible to determine, based on previous results and data, a probability distribution. So in order to deal with these variables, statistical models can be used (Monhemius, 1985).

Logistic systems always exist out of subsystems. At one point there is a waiting line or a reservoir to store the entities flowing through the system, and there are servers that can handle the entities flowing. The server processes an entity as soon as it is idle. This can be done in 3 ways. First in first out (FIFO) serves the entities in order of arrival. RANDOM means that each entity has the same change of being served next, and Last in First out (LIFO) serves the last entity entering the queue. However this can be complicated by priority rules, determined by the managers of a system (Geurts, 1985).

With different time patterns in demand and supply of servers, a queue arises (Geurts, 1985). For example: if there are two machines in line and the second machine processes the product of the first machine. When the first machine produces two items per minute, while the second machine can only process one item a minute, a waiting line increasing to infinity occurs. Also, breakdowns or pauses of the servers can result into a waiting line.

In order to solve a queue, one must know the characteristics of a queue. This involves the input, the processing by the server, and the output. If the two first factors are known, one can calculate an estimate of the output (Geurts, 1985). However, the input of a process often stochastic and variable, instead of deterministic and set, which means it is not predictable what our input is and we can only make educated guesses based on data from the system. The input can also be influenced by the waiting capacity and the potential customers (or entities). The latter factor can be explained by a case of a waiting line at the post office. Customers seeing a line may influence their decision to enter the line, this however has no influence for a waiting line of products in a machine (Geurts, 1985).

After the processing of an entity the output can be determined. Which output is important to calculate depends on the client of the research. One might be interested in the average queue line or reservoir use, the waiting time in the queue or reservoir, the throughput time, or other factors. Based on the information out of the system a policy decision can be made.

Within logistic management there are three types of decisions distinguishable; strategic, tactical and operational decisions. Strategic decisions are long term decisions and are involved with the structure of the flow of goods. For example in which type of product will be produced, or where the factory is necessary. Tactical decisions are semi long-term decisions and are made to determine the size of the overall flow, like how many product must be produced in a month. The last type of decision, the operational, is mostly short term. On a detailed level the flow can be stimulated or maintained, like the decision of making 30 product of a special type that day (Monhemius, 1985).

Logistic management is often used in companies with a production line or a distribution system. Both the public and private sector use this type of management for their stock, their production and/or the distribution. However, this study looks in to the use of logistic management in service provision, like the jurisprudence. This research sees the justice system as a logistic system. Just as in logistic it is a system with a flow of entities. The entity in the system is a court case itself.

It occurs when an individual starts a case, which moves through the system and passes different servers, like the judge, the court clerk, and the accused party. In the jurisprudence the flow through the system is more abstract. However, there is a relation between the servers and there is a flow of entities (court cases) between them. Each of the entities changes or adds something to the case, and has a certain service time in which this is done. They are bound by underlying relationships. These services times and demands from citizens can make queues arise just as there would be a queue in a logistic manufacturer system. In order to make these queues as short as possible, and to keep the lead time as short as possible, the court system can make decisions to optimize this process.

In this type of system there are also decisions made on operational, strategic and tactical level, even though this system is more bound to laws. The strategic decision to implement KEI will change the system on a tactical and operational level, and tries to influence the flow of the entities.

Seeing the jurisprudence as a logistic system is innovatory. When one says logistic, people often think of manufacturer of products, or logistics of cars, people or trains. This research contributes to the idea that logistics can apply to more than touchable objects, and expand to the public spheres.

To research the logistic system, the research method of simulation modelling is quite often used. Due to the characteristics of logistic management, simulation modelling is extremely useful. The state of a system can be modelled and the flow of entities can be simulated in that model. Without changing the actual system, one can create a new system, or optimize the existing system. The system can be modelled and experimented with in order to make well-founded decisions. The next part looks deeper into the theory of simulation modelling.

Simulation & modelling

Modelling means to make a representation of a system, in which the construction and working of the system of interest is given. The purpose is to analyse and understand the behaviour of a system, as a function of actions and alternative scenarios. Making the model of a system operate, is called the simulation of a system. With a simulation the approximation of behaviour of the real system can be studied. This has to its advantage that many different configurations can be experimented with, without having to change the real system. Experimenting with reality is most of the time too expensive, has large impacts, or reality is not made yet (Maria, 1997). Especially in logistic problems modelling is often used. For example, designers of an airport can first model the layout of the terminal, to optimise the check-in service desks before (re)building a terminal. It can be determined how many desk have to be build, how many queues must be made, the traveling distance between the check-in and the passport check and other features. This study in advance can support (policy) decisions and after the simulation a system can be altered or build. Not only an airport can be the subject of study, also city halls, hospitals, factories, etc.

Because of the previous experimentation, the chance that the change fails is reduced. Unforeseen bottlenecks, under- or over-utilization of resources can be prevented, and an optimized system can be presented after modelling (Maria, 1997).

The variables in a simulation are either stochastic or deterministic. In simulations there is often a combination of deterministic and stochastic variables, and therefore analytical calculation is not possible. A simulation makes use of the computer to evaluate the model numerically. In the simulation model output measures can be implemented, providing data for each time a model runs. Every time a model runs the output is different because of the stochastic variables. Therefore, a simulation has to be done multiple times (Law & Kelton, 2000). The multiple runs together make the output data, which is used as data for the research. The model runs for different scenarios, which results in multiple datasets. These sets are compared to one another in order to see whether there is a significantly difference. The data files can be seen like the data of survey research. Making models, is therefore part of an experimental research design. Instead of experimenting with reality, researchers can experiment with a model of reality (Law & Kelton, 2000).

Making a model enables the researcher to predict the effects of changes in the system. These predictions are made to apply to the real system, so that is why the model should be a close representation of reality (Maria, 1997). On the other hand should the model not be too complex. A complex model would make it impossible to experiment with and too hard to understand. Every model has its limits, and assumptions have to be made to establish a reasonable model. These assumptions define the scope of a model. Because of these assumptions the model becomes a representation and not the real system itself (Maria, 1997). This means that there is a trade-off between a realistic model and a simple model.

Building a model is based on data gathered out of the system and/or theory of that system. Existing relations in the system are used for the building relations in the model. Data on the input variables need to be gathered out of the real system. It ensures that the simulation is a close representation of reality. The data needs to be analysed in order to determine the input values in the model. In advance the systems relationship have to be observed too. Without these relations, making a model would not make sense. Every detail of the system has to be known to make a model. This means that before making a model there is a whole process of researching the system, gathering data and analysing the data. Only after this phase one can continue to creating a model and running the simulation in order to gather data. This means that causal modelling a theory-driven research method, and offers no theory building option. Modelling is especially useful to test hypothesized relations (Berman, 1998). Still, a researcher can explore difference relationships between the variables to determine the robustness of different models of a system.

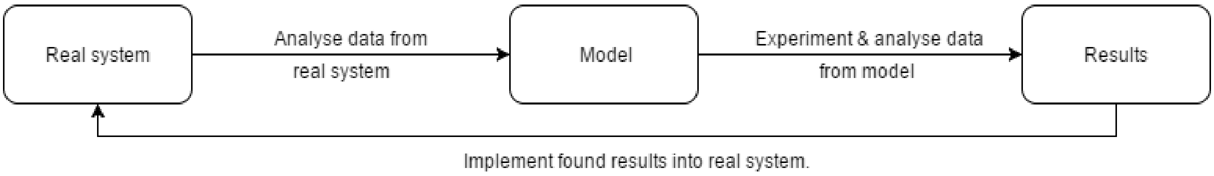


Figure 1Circle of Simulation research.

Once the model is made, the performance of a system can be evaluated for longer period of time (Maria 1997), whereas real life experimenting is limited to a certain time period. Doing multiple measurements with for example a survey takes a lot of time and effort, before one can say something with certainty. With simulation modelling reality is transformed to a model, and time can be manipulated in the process and speeded up. What would take four weeks to measure in real life, could take minute to measure in a model. This also applies to the adaptability of a model. Changes can easily be made in the variables and different scenarios can be tested. Whereas in real life this would take a lot of time and effort to change and test. Because of the use of simulation the costs of a research can be reduced.

In simulation modelling there are three large paradigms: System Dynamics (SD), Discrete Event (DSM) and Agent Based (AB) simulation. SD is mostly used for continuous processes, while AB and DSM work with discrete processes (Borshchev & Filippov, 2004). Continuous simulation represent systems which change continuously over time, whereas discrete simulations only change with the multiplication of a whole (Law & David Kelton, 2000). This can be explained by the difference between using the entity

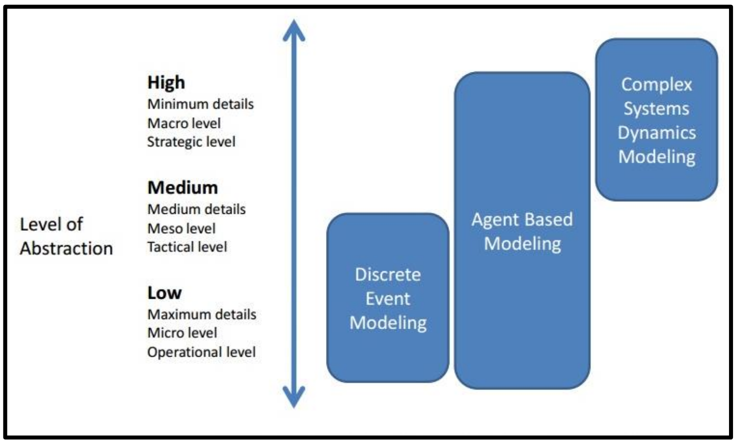


Figure 2 Simulation at different levels

of water or of a person. You can say half a litre water arrives at a point in time, but you would not say one half of a person would pass at one point in time. Water can therefore be seen as a continuously changing entity and persons as a discrete changing entity.

SD has the characteristic that it mostly deals with systems of a high level of abstraction, with low details, and on a macro level. Another characteristic of SD is that it is able to deal with a lot of feedback loops. A feedback system means that the system reacts to its own past actions (Ahman & Simonovic, 2000). It follows a non-linear logic, and anticipates on the rise of new patterns and interactions. It starts with a system and based on certain decisions or interactions between the systems components, there can be delays, increases in size or effects and the performance may change. The difference between the simulation methods also lies in the level of abstraction in the use. System dynamics looks to the larger picture and concentrates on the flow in the system (Borshchev & Filippov, 2004). On this level the strategic decisions are made (Koliba & Zia, 2011). As we saw earlier in logistic management, these decisions are long term decisions and are involved with the structure of the system.

For example, in 2000, Ahman and Simonovic, modelled the reservoir for flood management. In order to optimize its performance they used SD to establish how large the flooding reservoir should be. The entity in this case was water and it changed continuously over time. It depended for example on the upstream flow of water, the downstream flow of water, the current level in the reservoir, and other factors, on how large the outflow of the reservoir could be (Ahman & Simonovic, 2000). This is an example of a very continuous process, though less abstract. A second example with a higher abstraction level is the research of Ghaffarzadegan, Lyneis and Richardson. In 2011, they explored the use of system dynamics in the public policy processes. They described the system of Temporary Assistance to needy families, as in figure four. Depending on actions like ‘job finding’ and ‘recidivism’ the magnitude of the TANF families and post TANF families changed. The concepts in the research are abstract, and the insight of the system is given. The research mostly described the flow and not so much the exact outcomes on an operational level. The system interacts, has feedback loops, and depends on a lot of factors.

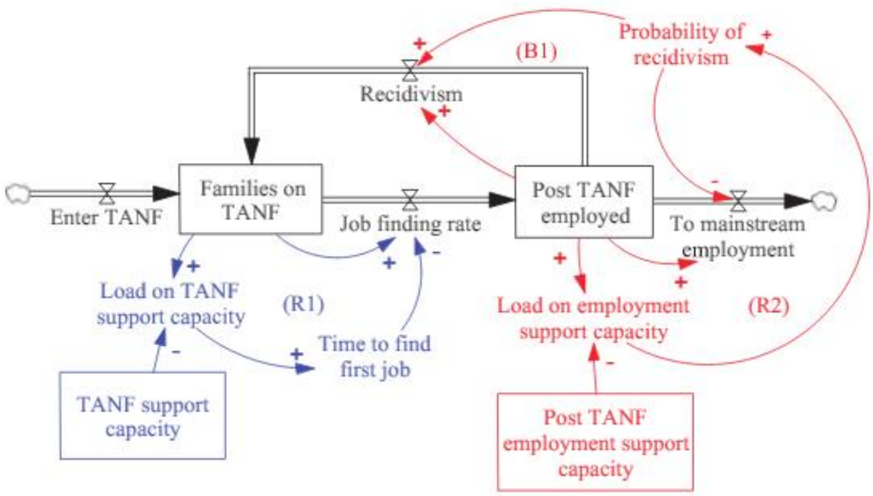


Figure 3 SD Flow chart TANF, by Ghaffarzadegan, Lyneis and Richardson (2011)

In the midsection of the abstraction spectre there is agent based modelling (AB). This type of modelling combines the micro, meso, and macro levels of systems (Koblia & Zia, 2011). On AB modelling there are no universally agreed definitions, since there still is a debate going on about what kind of properties an 'agent' should have. The most important feature of AB is that the model is decentralized, there is no place in the model where the global system behaviour is determined (Borshchev & Filippov, 2004). For every individual agent the behaviour is defined. All the agents live together in one environment ant they are interacting with both each other and the environment. The global behaviour results out of the emerging of all these individual behaviours. This is why it can be seen as bottom-up modelling (Borshchev & Filippov, 2004). It works from the detailed level of a system to an aggregated system and is especially useful for modelling emergent behaviours, structures, functions and actions between the agents, which arise due to the bottom-up dynamics (Koblia & Zia, 2011).

In 2006 Gorman et al. did an AB research towards drinking behaviour. The social behaviours are not shaped by the social structural forces from about, but from the local dynamic interaction (Gorman et al, 2006). They define three types of agents, the non-drinkers, the current drinkers and the former-drinkers. They specify the behaviour of these agents and how they change between these types. What are the chances that a non-drinker becomes a drinker, a current-drinker becomes a former-drinker, and a former-drinker becomes a current-drinker? They also specify how this behaviour would change when another bar opens in a neighbourhood, and what happens if people come in contact with other drinkers. They look into these chances for an individual, and accumulate an estimation for the population (Gorman et al, 2006).

Discrete event modelling, also Discrete Simulation Modelling (DSM) called, is the last of the three types of modelling. Decisions made on strategic level, will change the process on lower levels. These strategic decisions can be modelled in advance and can look into details on micro level. It has a linear logic, which means that the models usually are composed as a rational sequence of events (Koliba & Zia, 2011). Discrete event modelling assumes that the change of the system is a response of a discrete event. This means that the system changes a countable number of time. The changes at these point of times are called events, however not every event changes the state of the system. Sometimes in events changes are scheduled, or decisions on changes are scheduled (Law & David Kelton, 2000). In a model there are entities, resources and events which describe the flow of the entities through the system and how recourses are shared (Borshchev & Filippov, 2004). These entities might be people, objects, documents, tasks, messages or of another kind, and when they enter the system, they follow the process described by an event model or a flowchart. Entities can be waiting in queues, processed by servers, have a delay, split, combined, etc. (Borshchev & Filippov, 2004).

An example of this type of simulation research is the analysis of a mammography clinic, by Coelli et al (2007). When a patient enters the clinic and the x-ray technician is busy, the patient enters a waiting line. Only when the technician is free again, the next patient can be helped, this is based on a FIFO system. This example is discrete because the change in the system is the entering of a patient, there are no half patients. They are all seen as one whole patient, one 'customer'. This research had the goal to minimalize the waiting time of the patients. A couple of the variables in the study where the maintenance time, the interarrival time of patients and the amount of staff (Coelli et al, 2007).

Mostly service providers, manufacturers, logistical processes benefit from DSM. According to Koliba and Zia (2011): "*Their applications in models of complex policy and governance system may be used to capture the rationalized processes which follow a logical sequences of discrete events*'. Since DSM deals with set entities and events the abstraction level for this type of modelling is low. This makes it useful for decision making on all three levels. The strategic, operational and tactical decisions can be modelled in advance to gain insight in these decisions. It can give insight in decision making on issues like, the production for a month, determining the maximum size of the flow, or on a lower level, which server/machine should be deleted to improve the process, but also decisions for new production or changes on existing processes.

DSM is the proper technique to be used for researching the court system as a logistic system, for two reasons. First of all the court system is bound to laws and rules, to which it should comply, which makes agent base modelling unfit. Secondly ,we earlier already establish that the court system also is a system with a state and entities flowing through it.

Every time a server starts or finishes the service on a case, a discrete event occurs. In the system, it is not possible to only start half a case, either a case gets started/finished or not. It is a system on a high detailed, operational, micro level. DSM modelling is extremely useful for queueing modelling, which we find in logistic systems. Not only does it make sense to use DSM for logistic systems, it also makes sense to use it in the public domain. In the next part we will discuss why the public domain and simulation modelling should be combined.

Public domain and simulation modelling.

This part shows why the public sector is suitable for simulation modelling, and why there is a need for simulation modelling. First of all, there is a larger need for experimentation, more than in other fields, since once implemented policies are not easily reversible. However the ability to experiment with reality is low, since experimenting with reality takes a lot of recourses. The outcomes of public policy influence many and the stakes are high (Ghaffarzadegan et al., 2011). Implementing a less optimal policy can have negative effects on society and result in loss of welfare. Using modelling shows correlations in systems and demonstrates the effects of policies, without interfering in the real system. This makes it possible to do prior research of policy changes. Simulations can optimize a new or current system, without making irreversible or having expensive changes. Due to simulation modelling, experimenting with the public sector becomes possible and accessible.

The public field deals with complex and wicked problems. This is due to the complexity of the public field itself and its environment. The impact of decisions, the different stakeholders, the use of networks, and fluid environment, can lead to policy resistance. Wicked problems are unstructured, which might make it difficult to find cause and effect. It adds complexity and uncertainty. Some might say that modelling is not possible in with these problems (Weber & Khademian, 2008), however modelling is a tool which can take feedback loops into account and anticipate policy outcomes (Ghaffarzadegan et al., 2011). Modelling can be used for both larger problems on strategic level, as smaller problems on operational level.

A complex system needs multiple perspective to gain more knowledge about the system, since in the public environments consensus is often not found. In public policy, one has to persuade different stakeholders, with different interest. In a private company the interest are often clear and singular, whereas in the public sector there are different organisations, pressure groups and stakeholders both inside as outside of the government, with different interest (Ghaffarzadegan et al., 2011). There is not one decision maker with power, but a tussle of multiple parties wanting to influence a policy. Informing and persuading stakeholders in an effective way can lead to the development of good policy, focussed on long-term outcomes (Ghaffarzadegan et al., 2011). Using modelling as an experimentation method, it can show the outcomes of different policies. It can be used as a tool to inform multiple parties and give scientific evidence for policies. Which leads to more legitimacy and credibility for policy changes. If the knowledge about a system increases, the decisions to change that system is more informed, making policy success more likely.

Simulation is therefore a method which can apply to the public domain. It has a large applicability for research topics, also for the public sector studies. There is already some use of modelling in the public domain.

System dynamics is already used for public health, energy and environment, social welfare, security and sustainable development (Ghaffarzadegan et al., 2011). However the use of SD in public policy is low, and Ghaffarzadegan and his colleagues (2011) suggest that policy making can benefit from doing small system dynamics models. AB modelling is mostly used in demographic, social, economic and environmental field (Billari, 2006). Examples can be found in papers on civil violence (Epstein, 2002), urban evacuation (Chen & Zhan, 2008), and driving behaviour (Dia, 2002).

The use of discrete event modelling lies mostly within the logistics. Simulation researches in the public field, have been done in hospitals, for example in improving emergency departments (Duguay & Chetouane, 2007). These however only include the flow of people through a building. This can be expanded towards more abstract levels, since the public administration processes tends to have bureaucratic character. We can not only look at humans arrive in a waiting room, and move between counters, but also look at cases, files, documents moving between departments.

This research will show this with an example in the judicial system. We have earlier discussed how logistic management, can be a perspective for the court system, and how simulation modelling is a method which can explore the changes in the system. By expanding towards a more service oriented system, we expand the use of modelling and expand the ways of exploring the court system. This provides us with new insights in how the system works, and how the innovations will change the system and the throughput times. We can answer the "what if" question and in advance predict the outcome of KEI. Showing that this works, can lead to more public systems being studied and optimized by using simulation modelling, leading to effective processes. For the law system, an effective system would mean fast justice. In the next part we explore the procedural law in the Netherlands, the changes made due to KEI and why this can be seen as an logistic change.

3. Case description

Procedural Law in the Netherlands, the current system.

Procedural law is the act of applying laws by a judge. If a person, an organisation, the public prosecutor, or the government wants to submit a case to the judge, the procedure of a legal case is put into operation. In most cases, the lawsuit is dealt with in the district where the defendant is living (de Rechtspraak, 2013). Since 2013, there are eleven districts: *Amsterdam, Den Haag, Gelderland, Limburg, Midden-Nederland, Noord-Holland, Noord-Nederland, Oost-Brabant, Overijssel, Rotterdam* and *Zeeland-West-Brabant* (Meijknecht, 2013).

The justice system in the Netherlands consists of three domains: civil law, criminal law and administrative law. The differences between these laws are the legal entities involved in the cases. In civil law, citizens or organisations start legal procedures against each other. In criminal law, the public prosecutor sues citizens or companies that they believe have performed a criminal act. Administrative law is between the civilians or organisations and the government (Rechtspraak en Geschillenoplossing, Rijksoverheid). Each sector is divided in to separate departments, for example military, family, trade, foreigners and taxes (de Rechtspraak, 2013). A special part of the justice system, ‘Kantonrecht’, deals with civil cases up to 25,000 euros, labour issues, rental issues, consumer’s affairs, consumer’s credit cases up to 40,000 euros and simple criminal cases, like speeding (de Rechtspraak, 2013).

This study looks into civilian law, which deals with cases between civilian entities and which requires a lawyer as a representative. In this domain, a civilian himself must activate this process; there is no organisation that will automatically trigger a court case. It is always about a civilian, actively suing another civilian. One of the sectors in civilian law is trade law, which specially deals with cases on industry, markets, contracts, and transactions. The reason to choose for trade law in this study is that it is the first sector in civil law that will change due to the implementation of KEI. The pilot is ready to be implemented in the court of Utrecht. After the implementation, it is possible to check if the effects seen in the model correspond with the effects in reality.

Another reason for choosing trade law is that it follows a fairly straightforward process. In this part of law, fewer exceptions of rules happen, which is desirable for applying simulation to law. With too many exceptions it becomes difficult to create a simple, transparent model which resembles reality. If there are too many exceptions that occur with a relatively small probability, we cannot make statements about the average case, with a high confidence level. However, if the cases are more or less similar, we can say with a higher confidence that the findings in the simulation agree with reality. Another reason to choose the trade law system is that the throughput times in this part of the law system is exceptionally high, according to an employee of the courthouse in Utrecht (Conversation with employee court, 17/6/16). This means that in this system there is much room to improve the throughput time, and smaller changes might have large consequences.

The throughput time is the time between the start of a case and the moment of the verdict. It may also be possible the case ends with mediations, settlement, or withdrawal. The common way to start a court case is by sending out a writ or *dagvaarding*[1]. A writ is a procedure started by a civilian or organisation towards another civilian legal entity. It is part of private law, and therefore does not involve government organisations (directly).

Figure four presents the flowchart of the procedure. The prosecutor starts the procedure by summoning another party to the court. The one summoned is called the defendant. In this part of the law, a lawyer is required for both parties. The court bailiff and the prosecutor's lawyer make sure the writ of summons is received by both the court and the defendant. In the writ is stated what the case entails, what the prosecutor hopes to achieve, and the evidence supporting the case. The defendant can reply to this summon either by agreeing or disagreeing with the prosecutor. If he agrees with the prosecutor, they can find a solution before the hearing in court, which can prevent procedure costs for both parties. If the defendant does not agree, he has to make this known at court. In the writ, a date is presented to the defendant, before which he has to make known that he disagrees with the demands of the prosecutor. This is called the *rolzitting*. Before this date, the defendant has to arrange a lawyer to represent him in court. A summon has to be received by the defendant seven days before the *rolzitting* and received at least a day before the *rolzitting* at court. All administrative deadlines in Utrecht are at 10:00 every Wednesday. At this *rolzitting,* there is also the possibility to ask for postponement, provided good reasons. If the court permits this request, the trial will be postponed for four weeks.

Still, the defendant is not obliged to respond at all, though when he does not respond to the matter, either verbally or written, and the lawyer of the defendant does not show at the *rolzitting*, the case will be judged by default two weeks later. This is called *verstek*. This default of

[1] *https://www.rechtspraak.nl/Hoe-werkt-het-recht/Rechtsgebieden/Civiel-recht/procedures/Paginas/Civiel-recht-Dagvaardingsprocedure.aspx#08314def-c5b2-4114-aec7-4a37aef77aca0*.

appearance can be restored by responding before date of the verdict. If done so, the 'normal' procedure will continue. At the *rolzitting* the administrative employee (AM) checks whether everything of the summons has been done correctly. The AM checks if the right forms have been handed in, if the counter party received the summons, and if there is the case of *verstek*.
After the *rolzitting* the defendant can respond by letter, which is called a *conclusie van antwoord*. Six weeks after the *rolziting* this has to be handed in at the court. In this written response, the defendant can react upon the demands by the prosecutor, with evidence supporting the point of view of the defendant. It can also contain a counterclaim.
Once the *conclusie van antwoord* is received, the Coordinating Secretary (CO) decides how the procedure continues. A case can be handed over to a judge for immediate assessment, which also happens if there is no *conclusie van antwoord*, a hearing can be scheduled for verbal evidence, or a written round can be started to gain more written evidence.

Written course

In case of a written process, the prosecutor can react upon the reaction of the defendant, this is called the *repliek*. Within six weeks this letter has to be replied to the AM. Upon this letter the defendant can reply within another six weeks, which is called the *dupliek*. Both parties can ask for a postponement of four weeks, provided that there are good reasons. If a *repliek* is not handed in, the case will not go to *dupliek*, but goes straight from the AM to the CO. After the *dupliek*, the AM hands over the case to the CO and he or she decides which judge will assess the case. This all depends on which judge is available and the specialisation of the judges. The judge assesses the case and based on the written evidence, he or she gives an interim judgement or make a final verdict. When further evidence is needed, this can be obtained in a continued written course or by scheduling a hearing to hear from both parties and the witnesses in person.

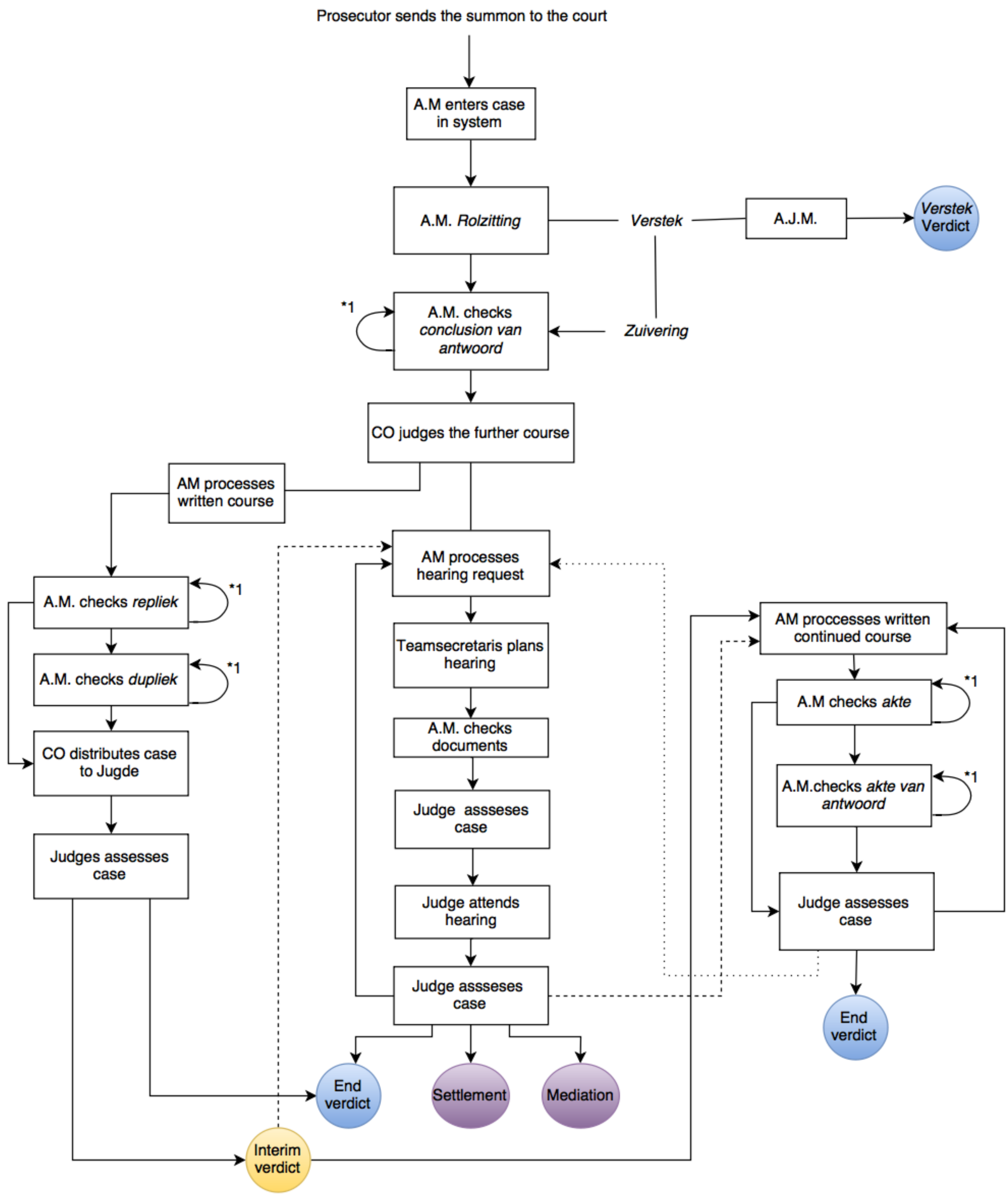
Hearing

In case of a hearing, either after the *rolzitting* or the written round, both parties are invited to come to the courtroom with their lawyers. In exceptional cases a judge might also visit a location that is of meaning in the court case. Both the defendant and the prosecutor have to make known on what dates they are able to attend a hearing. The team-secretary (TS) plans a meeting on which both parties and the judge are available. Next, the AM checks if every document is available for the judge and hands the case over. The judge attends the hearing and during this hearing the judge determines which method is best to use for the case. There are three types of solutions possible: mediation, settlement or an assessment by the judge. In mediation solutions are tried to be found for the problems in the case. Especially in cases where both parties have to collaborate in the future this solution is preferable. A settlement is when a judge tells the parties what he thinks of the case and tries to find a solution that is acceptable for both parties. This often occurs when a judge has the feeling the two parties are not that far away from each other in their requests. Both parties have to compromise their views and find a solution together. When both mediation and compromise are not possible, the court establishes a verdict on the case. At the end of the hearing the judge decides what the next step is in the process. If it is a final verdict, this is sent to both parties lawyers 4 to 6 weeks after the hearing, depending on whether an interim verdict was already given (Landelijk procesreglement voor civiele dagvaardingszaken bij de rechtbanken, 2016). A judge can also decide another hearing or written round is needed. Then the procedure reiterates.

Continued written round

If there is more evidence needed after a hearing or a written round there will be a continued written round. This resembles the written round, however the timeframes differ. The prosecutor gets four weeks to respond to the defendant's evidence/ statements. This is called the *akte*. The AM checks if the reply has been handed in after these four weeks, if this not the case, a judge automatically will be handed the case. If however an *akte* has been handed in, the defendant has four weeks to reply to this *akte,* by a written respond called the *akte van antwoord.* After the written round the judge gives his verdict, or decide another hearing or written round is needed.

The described process is how the process of the writ goes before the changes of KEI. However, the implementation of KEI changes the system, with the intended effect of decreasing throughput times. In the next part we look at what KEI actually entails.



*1: The Defendant / prosecutor can ask for postponement for the Rolzitting, Repliek, Dupliek, Akte and Akte van antwoord.

Figure 4 Flow chart Dagvaarding

Quality and Innovation (KEI)

The minister of Safety and Justice, and the Council of jurisdiction jointly want to modernise the justice system. Together they started the program Quality and Innovation of jurisdiction (KEI). This new program aims to make the administration of justice more accessible. According to Susskind (as cited in Mr-online, 2015), the reasons for the modernisation of the jurisdiction are three folded. For one thing, undertaking legal action is not affordable for a growing number of people. In addition, it becomes more possible to settle disputes alternatively. For example, eBay settles 60 million conflicts each year, without any interference of a judge (Mr.-Online, 2015). Finally, the technology keeps developing. Digital systems will replace the paper, making it more transparent and providing all the involved parties a clear overview on the case.

The three objectives to change the justice system are to simplify, standardize and digitalize the current system. This is done with two parallel approaches. One approach is to expand the legislation to simplify the administrative and civil law and digitalise the course of justice. On the 10th of December 2010, the house of Representatives (*Tweede Kamer)* approved, the implementation act which makes it possible to carry out legal trials digitally, in civil and administrative law. The second approach is the development of new work methods and changing processes (Broeder, 2014).

KEI will be implemented in all of the three sectors, civil, administrative and criminal law. In the sector or civil law the changes will occur in three phases. First, the trade receivables, (Civil 1.0), followed by canton cases (Civil 2.0) and finally the petitions (Civil 3.0). The first phase, civil 1.0, is put in motion by the publishing the new procedural laws on 21st of July in the national official journal of law (Intern Documents KEI, 2016). Because the law has been accepted by the Senate of the Dutch Parliaments, the first courts can start with the (pre)pilots for testing the new civil law process. *Gelderland* and *Midden-Nederland* are the two courts that are going to start working with the new system. In the pre-pilot, smaller attorney offices will test the digital system with fictitious cases. From November on, all attorneys will be able to use the digital system voluntarily. After optimizing the system, it is mandatory to litigate at these two courts. In the summer of 2017 all the court systems are obliged to use the new digital system (Intern Documents KEI, 2016).

This research intends to evaluate the development of methods and work processes in terms of digitalisation, simplification, and standardisation. The digitalisation regards changes due to the platform on which the process takes place (Broeder, 2014). In the future it is mandatory for professionals to undertake legal actions digitally. Through a digital portal they can start a procedure, view documents, follow the progress of the procedure, and receive the verdict of the judge (de Rechtspraak, 2015). It will be easier for a citizen to start a case, keep track on what has to be done and in what phase the procedure is.

Not only for a citizen there are benefits of digitalization, since the case is now digital, the files of the cases are clustered at one page, and easily accessible for the AM or a judge. It will be easier to check if certain documents are present, and some of the tasks can be taken over by the computer system. This means some tasks of the AM will disappear, and the service time for processing documents will decrease.

Standardisation and simplification are process innovations that concern the way a case is initiated and what the following processes are (Boeder, 2014). The duties of the judge change towards a stronger governing function. Earlier on in the process there is a hearing and the part of the *repliek/dupliek* disappears. The two parties will be able to respond in the hearing, and a judge can inquire in an earlier phase, what is needed to solve a case. The purpose of this is that a judge is able to guide the parties towards a solution in an earlier phase, which would shorten the throughput time of a case. Judges will be active, solution oriented managers of a fast and customized procedures (Intern Documents KEI, 2016). The process becomes more linear and more according to one format. Most of the cases will be hearing, where it is established what is the quickest way to settle the case. Another change the court of Utrecht implements, is that the day of the *Rol,* which was first instance every Wednesday 10:00, disappears. With KEI, when a case comes in to be processed by the AM, they will process the case as soon as possible. People do not have until a Wednesday to hand in their files, but this day might be every day. On an online portal it will be clear which files need to be handed in on which date.

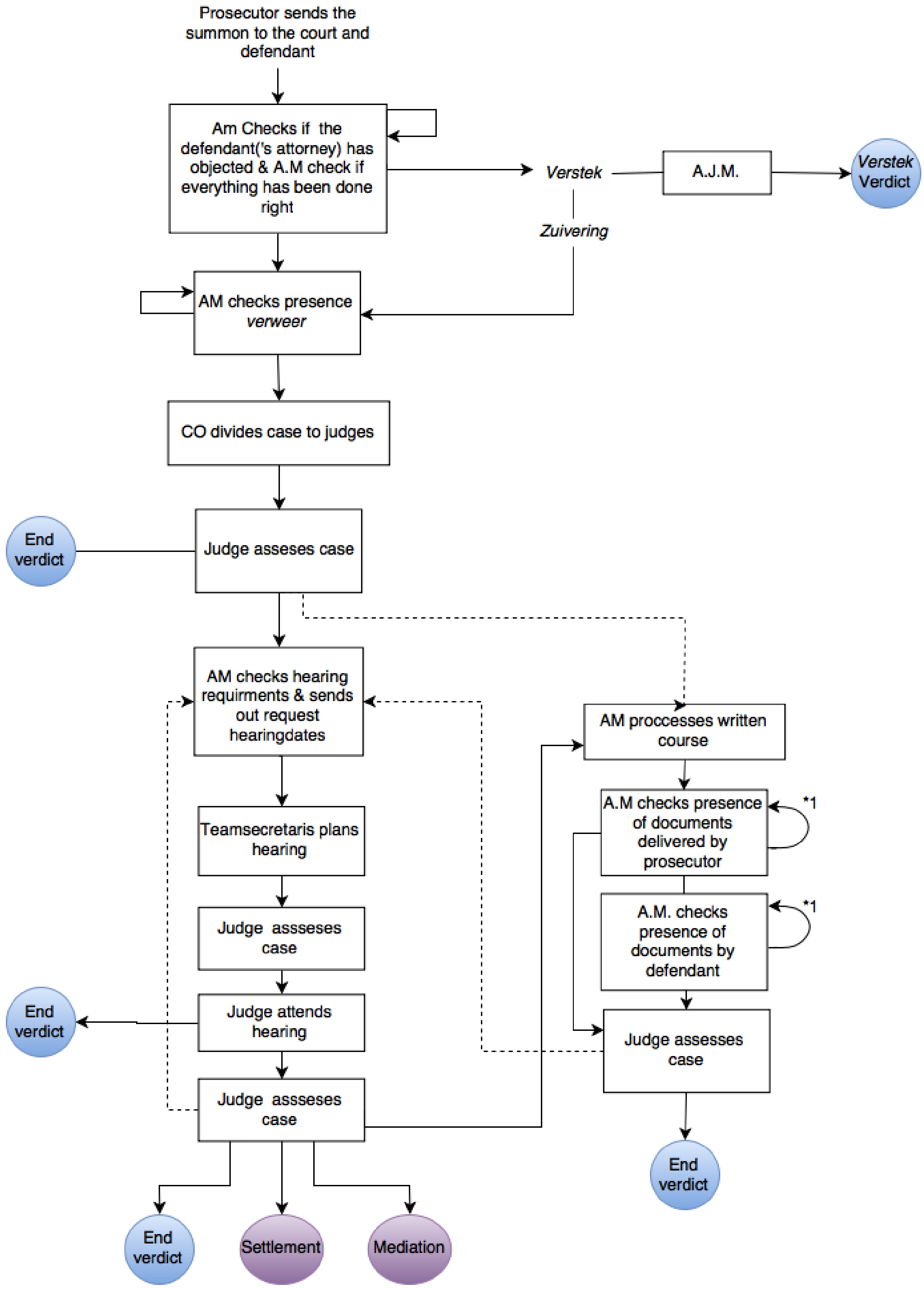
The simplification, digitalisation, and standardisation, change the process of the trade law system. Figure five presents the new flowchart. The terms *dagvaarding,* is replaced by the term *proces inleiding.* The prosecutor goes online and register a case through a digital portal at ′mijnzaak.nl'. After paying the *griffier* costs, he can either choose for the informal or formal way. In case of an informal way, the prosecutor personally takes care of letting the defendant party know they are sued. However, if this party does not respond within four weeks, there is no case of *verstek*. This only can be the case when the formal way is chosen. With the formal way the court bailiff will notify the defending party. If after the informal way, the defendant does not respond, and the prosecutor does not use the formal way, the case is closed without verdict. If however the prosecutor does decide to go with the formal procedure. Within four weeks the defendant has to appear at court. When the defendant does not appear at court after the formal notification, the case goes into *verstek.*

After this appearing in court the defendant gets six weeks to reply by letter. In the old system this was called *conclusie van antwoord,* this changes to *verweer* (Intern Documents KEI, 2016). Next, a hearing is planned as soon as possible. Before the hearing, the judge is able to see the case, and inform the parties what is discussed during the hearing. He or she can, in advance of the hearing, manage the case and look for a solution of the conflict. This can lead to a verdict or a solution without a hearing. During the hearing both parties can bring witnesses or experts. It can also be the case that the judge gives his final verdict during the hearing.

After the hearing the judge decides what to do next. In case of a final verdict, this is reported to both parties within six weeks after the hearing (Intern Documents KEI, 2016). If this is not the case, another hearing or a written round can be set into progress.

To sum up, the changes in the system come down to having a simple basic procedure, but provide room if cases turn out to be more complex. With the judge having a more governmental task in the case, the throughput time of the cases should decrease, since he or she determines what procedure is needed. Using a digital system will become mandatory for professionals and results in decreasing service times for AM.

The justice system and its changes in processes is according to us a logistic management change. Logistic is about the flow of goods and managing this flow. In this case de flow of goods are court cases, which are tried to be managed due to the changes with KEI. The digitalisation and change in process has to meaning to shorten the process time.



*1: The Defendanct / prosequtor can ask for postponement for the Rolzitting, Repliek, Dupliek, Akte and Akte van antwoord.

Figure 5 Flow chart KEI

4. Methodology

In the previous parts we have seen why simulation and the associated experiments are useful for optimizing systems, and how this can also be applied to public organisations. This quantitative experimental method of simulation modelling, consist out of two phases.

In the first phase, the systems needs to be explored, for which data out of the current system is gathered. This data is analysed, to make sure the right values and distributions are used when setting up the model. Based on this information two models are made with its corresponding state and occurring events, and is programmed in an editor. This research makes use of an editor called 'visual studio', with the use of the programming language 'C#'. By using the software, a program is written where events influence the state of the system. The process, as presented in the flowchart of figures four and five, is recreated in visual studio.

In the second phase we create data by experimenting with the system created in the program. Since we have made two systems we experiment with both of them and compare the results. During this phase data is gathered by running the program, and generating output from the system. This output differs if the system has different settings. These different settings are compared to one another and statistically analysed. In the next sections we discuss the gathering of the data to establish the systems, the validation of the research and the experiments which are conducted.

Input data gathering

To determine the state of the court, two meetings were planned with a judge and an administrative employee, to discuss the process of trade law in the current system. Based on these two meetings, email conversations, and the national process law document, the state and process are established. During a third meeting with the administrative office the current process and the process of KEI were checked and revised, making sure the system programmed corresponded as close as possible with the actual system.

From the court's data system, data is gathered on the amount of cases each year, the time from planning of the hearing until the actual time of the hearings, the amount of cases postponed, the amount of cases going to *verstek,* and the amount of cases being *gezuiverd*. The gathered data includes the period of 2012 till 2016. This data is inspected in the input analyse in the next chapter.

Besides the quantitative data out of the court system, another part of data is self-measured. This includes the service time of the judge, the Coordinating supervisor (CO), the team-secretary, the administrative employee, and the Administrative juridical employee (AJM). We asked the administrative employee of the court of Utrecht to check how many cases they averagely process in half an hour. The other employees are asked how much time they needed for one case, since their task can take more time than a couple of minutes. They reported the minimum amount of minutes (or hours in case of a judge), the maximum amount of minutes or hours, and the most common amount of minutes or hours.

Validation & reliability

Since the existing situation is modelled, the model should be as close to reality as possible. To ensure the internal validity, a meeting was held with the administrative office, during which both models were checked. If any programming choices had to be made, this was done by consulting the administrative office and discussing how this works in the actual system.

Still, there are some differences between the program and the real system, since a model always is a representation of the real system. However, these differences are present in both the current and the new model. Our goal for this research is to compare both systems. Due to this, the assumptions we made in our following chapter, have an influence between reality and the model, but the effect between the two models still is the same. For example, if in both models we do not take withdrawn cases into account, we can still say something about the system. Our objective is to show what the effect of the process innovation is. For this we can look at the basic process, and say something about the differences in the two processes.

This means that the output of the research data might not correspond as close with real situation as we would like. Another source for this problem is that we take the trade law system as a separate system from the other law systems. However, there are not 29 trade law judges, but there are 29 judges which can deal with many types of cases. We separate the system to really show the effect of logistic changes, to see what it would do with a system. Due to this the actual throughput times might be higher. This research can show the effect of the system, making it valuable for process change evaluation.

Since the output data is based on (multiple) stochastic variables, multiple runs are needed. There is always a variance when dealing with a stochastic model. By doing multiple runs we can establish the distribution an see whether this is normal, and how high the variance is. With less variation, a lower amount of runs is sufficient. Also when we increase the amount of cases in the system, the amount of events increase as well. This results in more event and a slower program. In experiments with a higher amount of cases, we lower the repetition rate of the simulation. When the amount of runs decreased, an extra test run is performed to see check whether the means of the two runs were equal. The two runs were compared with a t-test. For all performed extra runs, the t-test showed the output were the same. Showing that our measured values are reliable.

What is important to check, is if the state of the system over time becomes steady. If this is not the case, court cases may be stuck in a loop in the system or cases get stuck in a queue in the system. This means the amount of cases in the system enlarges till infinity over time. The system cannot deal with the amount of cases over time, and becomes more and more inefficient. For each of the systems we check every experiment, if there is a steady state over time. If not stated, this was the case.

In the program there are several random generators. A random generator in the editor often makes use of the seed based on time, but to increase the reliability of the research, we chose to make use of a set seed. To make sure the experiments can be reproduced, we used seed 666. Also the reliability of the research is guaranteed because the program is created based on a set process. Reproducing this research means that the same process has to be created, for which there is not much room to deviate. For choices during the programming, we accounted during the following chapter, and explained why these choices are made.

Experiments

To answer the question: '**How do the KEI interventions to improve logistic handling, affect the throughput time of trade law court cases?'**, both the situation as it used to be and the situation with the new process influenced by KEI are modelled.

Once the input analysis and programming of the events are established, five experiments are conducted. These experiments are set up to examine the difference between the two models. The idea of KEI is to have the judge involved in a case in an earlier phase, so he or she can determine what is needed to solve a case quickly and effectively. A judge is able to inquire what the problem is and guide towards a solution. The second change is that the *rol*-Wednesday disappears. This means that a case is dealt with the moment it returns from (both) the defendant and prosecutor. The last change is that because of the digital system, cases take less or no time to be processed by the administrative office anymore.

For the current situation, we unfortunately do not know the division of the cases over the different possibilities. There is no information available on how many of the cases will go to the written round, and how many of them are going to a hearing round. It is the CO which makes the decision what is best for the case. With the changes of KEI it is the intention to have more cases going straight to the hearing procedure. The judge gets a governing function earlier on in the process. It is not the CO anymore which decides if a written round or a hearing is needed, but the judge. They will be active, solution oriented managers (Intern documents KEI, 2016). The judge can make the decision to start a hearing, give an end verdict or start a written round. In the current situation no cases go directly to a verdict. So what happens if all cases go to a hearing or if a percentage goes to a written round? We check this for both the current system and the system based on KEI. The first experiment question therefor is:

1. *What is the effect of having more cases towards the hearing procedure on the total throughput time and the productivity?*

In the real court system, a judge is not only busy with trade law cases, but also with other cases. The second experiment looks for the boundaries of the trade law system. Our model can deal with more cases than in real life, since it is separated from the other law systems. By increasing the amount of cases arriving in the system, we see what happens with the throughput time, which servers struggles the most, and at what server the delay starts to increase. This leads to the experiment question:

2. *What is the effect of the arrival rate on the throughput time and productivity of the servers?*

Not only can we increase the amount of cases arriving to look for the boundaries of the system, it is also possible to find the minimum amount of servers needed without causing any large delays. For a start, we optimize the current system for the amount of judges. When the amount of judges becomes too low, this does not only cause large delays, but also make the system unstable. If the amount of judges cannot handle the cases anymore, the amount of cases present in the system will only increase. This means that the amount of cases entering the system is larger than the amount of cases leaving the system. The amount of cases will never stabilize and grow to infinity over time. For each type of server there is an optimal amount, before destabilising the system, leading to the third research question:

3. *What is the optimal amount of servers without causing the system to become unstable?*

A large advantage over the current system, is that in the situation of KEI the reply time of the defendant and prosecutors can have a large effect on the throughput time. In the current system a case will be looked at if the set reply time is over, but in the new system a case is dealt with from the moment it is returned by the parties. This results in the question:

4. *What is the effect of the reply/postponement/zuivering time on the throughput time?*

Since in the current system, the times are set, we will only look at KEI for fourth research question.

In the four experiments we will look at stochastic variables independently, to show the effect of the changes. In the experiment 5 we look at the model with all stochastic variables turned on. Since there is more ‘randomness’ in the model, due to the more stochastic variables, we need to run the simulation for a high amount of runs, in order to guaranty the validity of the data. To show the overall effect of the changes, four different settings are compared. The current system with two different settings, one with the optimal settings found during the experiments and one with the settings which are realistic to KEI. For KEI we will look at a realistic setting, which can be compared to the current system with KEI settings, and an optimized settings. These can be compared to each other to see what the effects are on the throughput time, showing if the 40 percent decrease can be made. The fifth experimental question therefor is:

5. *What is the difference between the two systems, both realistically and in a best case scenario?*

For these models the event model, the state, the output measures, the input analyse, assumptions, and the experiments with the model are explored and explained in the next paragraphs.

5. Simulation of trade law in Utrecht

System Description & Event models

We earlier described the flow of cases through the system, both for the current situation, as for the system with the changes due to KEI. Here we will describe the system without the flow, and follow with the occurring events when the flow is going. To describe the system, we answer questions like: ‘How many employees of each type of service are present in the system?’ and ‘How does a case goes through the system and which servers does he passes?’. Events in the program change the state of the system. For example the start of the service done by a judge will make him busy, whereas his state first was idle.

The court system, independent of the process, is presented in table 1. At the department of AM there are four regular employees and one intern. Four of them work four days a week and one of them works three days a week. This would mean that four times a week there are four persons at the office, and one time a week there are only three persons available. For this research we assume that every day there are four people available in the starting state. Later on we experimented with the amount of servers to see what happed if fewer AM are present.

At the court of Utrecht there are three teams of judges, which deal with trade law cases. For each of these teams there is a coordinating employee (CO) which distributes the cases over the judges. Also for each team there is one team planner. There are 29 judges in total, however they do not all work fulltime. A fulltime job as a judge means working 36 hours a week. In the simulation of this research, there is an effective worktime of 40 hours a week. We use the amount of servers which are effectively present during these 40 hours. For the judges, this means that instead of the 29 judges working 26,17 fulltime-equivalent (1fte = 36) in total, see appendix 1, table 16, we will take 23 judges in the model all working one fulltime-equivalent with one fte of 40 hour.

The last server, the Administrative paralegal (AJM) consist out of two employees working fulltime (36 hour) and two employees working 32 hour. This means that for the use of the program the AJM work 3.4 fte, with one fte being 40 hours. We continue with three AJM. Later on we experiment with, how changing the amount of servers affects our model. These servers all work together in the court system, as described flowchart in figure four and five.

Table 1. Facts on the Court of Utrecht, department trade law	
Opening times	8:30 – 17:00
Opening days	5
Effective work time (exc. ½ hour break a day) a week	40 hours
Runtime model	5 years
Number of AM available each day	4
Number of judges available each day	23
Number of CO's	3
Number of AJM's	3
Number of Team-planner	3

This process can be translated to an event model. An event model represents how events are scheduled from other events and from themselves. The simulation starts by a single "push" of the arrival of one case. From that moment on the event 'arrival case' reschedules itself, and schedules the end service of the AM (or place the case in a queue if all the AM's are busy). From that moment on, an external drive is no longer needed. What is needed is an event called 'End Simulation', since the model does not terminate from itself. A new cases always arrives from the first push on, and only manually we can stop the simulation. This is done by determining a runtime for which the program will keep continuing, until this pre-set time.

In figure six the event model of situation one is given. It represents the flow of the cases through the system, as seen in events happening. Each colour represents a different server; AM is yellow, CO is red, the Judges are green, the TS is blue, and the AJM is purple. The arrows show how the end of a service on a case starts a new event to happen. It can start or schedule the service of a new server on the same case, or it can show how the same server schedules or start the service on another case. We start with the arrival of a case, based on the distribution a new arrival is scheduled. If an AM server is empty, the time of the end of the service is scheduled. We do not explicitly account for the customers entering service, this could be done, however an event may be removed if: 'the event is scheduled by other events and without any intervening time' (Law & Kelton, 2000, p.58). This is the case for 'start service AM', since it is always directly scheduled after a previous event without any delay. This means that if there is no queue the case could be handled right away. However, this is not the case for a *rolzitting* since this only takes place every Wednesday at 10 a.m.. Here there is a delay, and the event is not directly scheduled after the finishing of an AM service. The end of a *rolzitting* however can schedule the start of the new *rolzitting* if there is a queue. A hearing is also an event which needs to be an event on its own, since it does not start directly after the finish of the team-secretaries service, but is scheduled in the future.

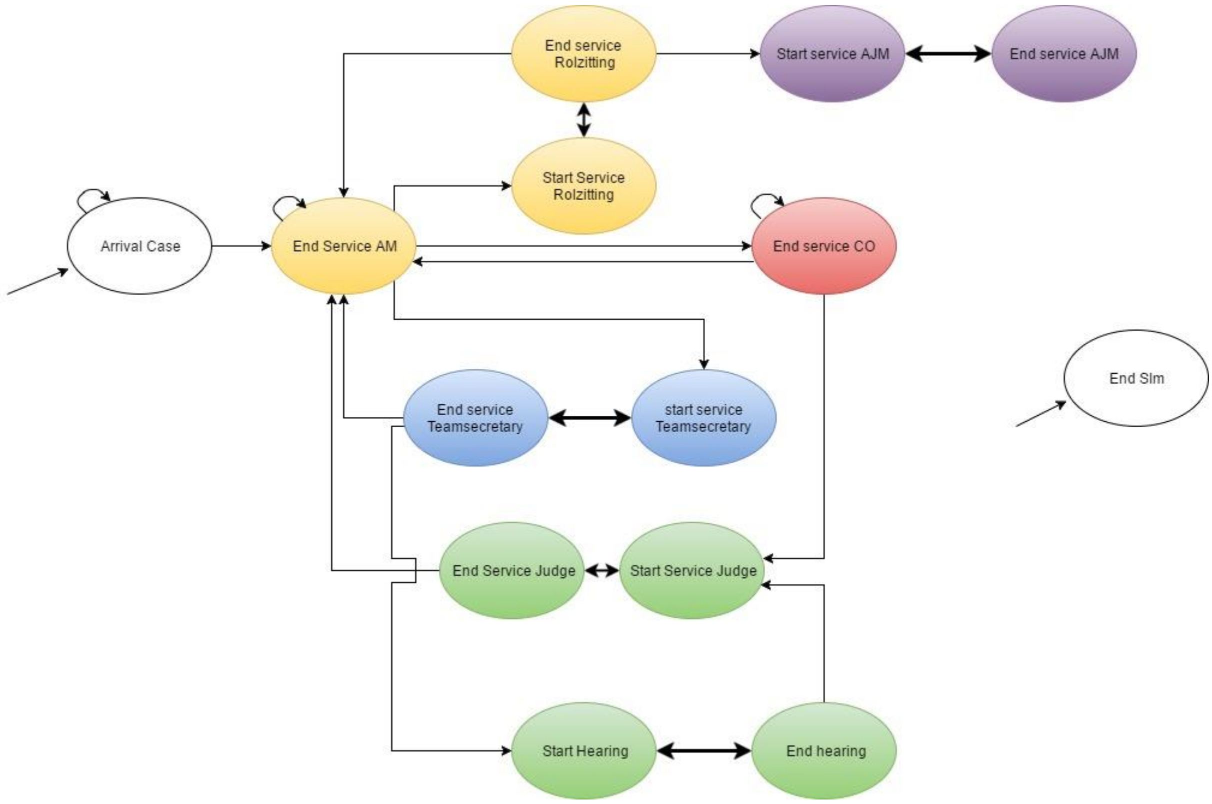


Figure 6 Event model current situation

With the changes of KEI the event of 'Start Service *rolzitting'* will no longer be needed. The case is entered by the prosecutor and only after response of the defendant or after four weeks of no response by the defendant the case will arrive at the Administrative Employee. There is no *rolzitting* weekly anymore, where documents will be checked. The start service *rolzitting* has been replaced by Start Service AM, which is used to start the check for *verweer*. In figure seven the new event model is presented.

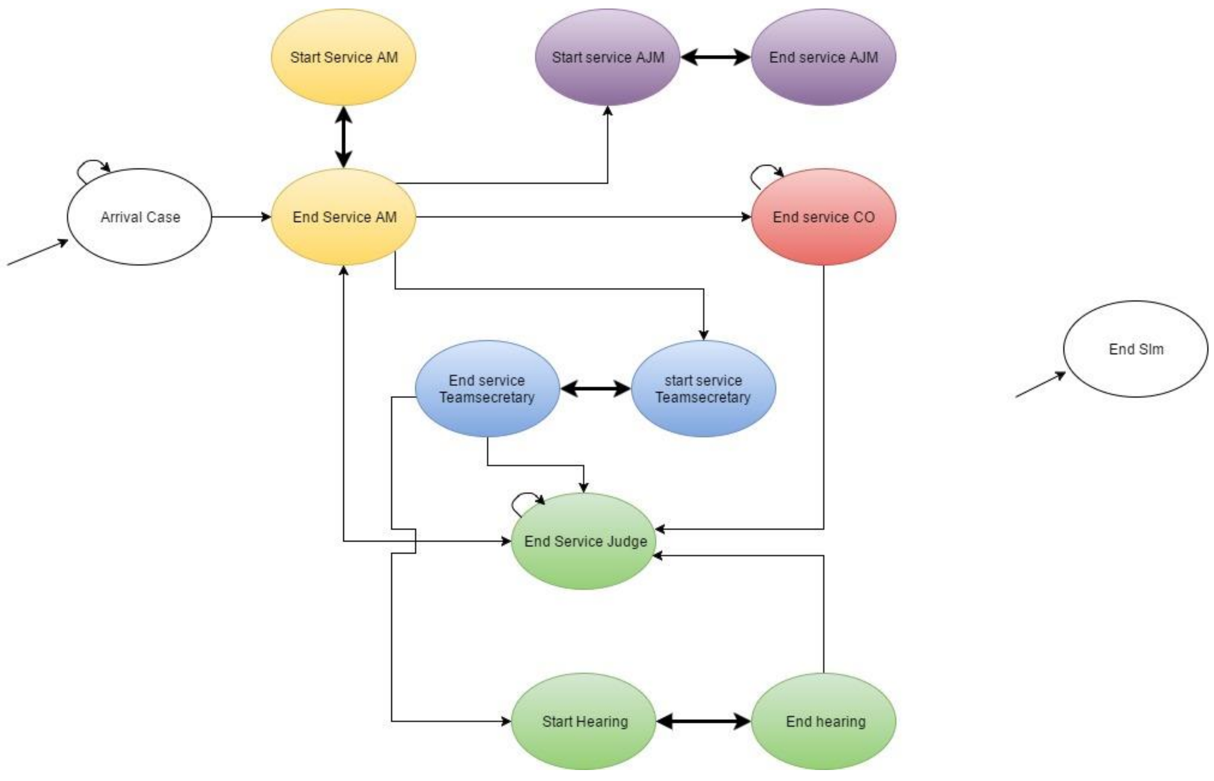


Figure 7 Event model KEI

Performance measures

The intention of the simplification, standardisation, and digitalisation changes made by KEI are to decrease the throughput time with 40 per cent. This research will elaborate what happens to the different processes and their corresponding times.

We start by looking into the average throughput time of cases. In both models we use Little's law to calculate the average throughput time. This formula states that the long-term average number of object in a stable system (L) is equal to the long-term average effective arrival rate (λ), multiplied by the average time the object spends in the system (W). This formula can be used since our arrival is Poisson distributed, as we see during the analysis of the input data. So to calculate the average time of a case in a system we will apply the formula:

$$W = \frac{L}{\lambda}$$

Based on this outcome we compare the two models and determine what happens with the average throughput time due to the changes of KEI.

Next we analyse which percentage of this time is waiting time, reply time, service time, postponement time, time till hearing, and delay, compared to the total throughput time.

The waiting time is the time between the response of the parties and the moment the case goes on the *Rol*. This time therefor only is present at the first model, where there is a *Rol* date present. The time till hearing, is the waiting time between the day of planning and the actual hearing. We also compare this to the actual data to validate the research. The reply time is the amount of time in total of waiting for the defendant or prosecutor to reply. Either by handing in the documents or the hearing dates. The total postponement time, it the time lost, due to the permitted postponement of cases. Service time includes the actual time the servers combined are busy with a case. Every time a server handles a case this time is added to the total service time. Last but not least is the delay. This variable keeps track on how long cases are in a queue, which means the moment a case arrives at a server, but cannot be dealt with since the server is already busy with another case.

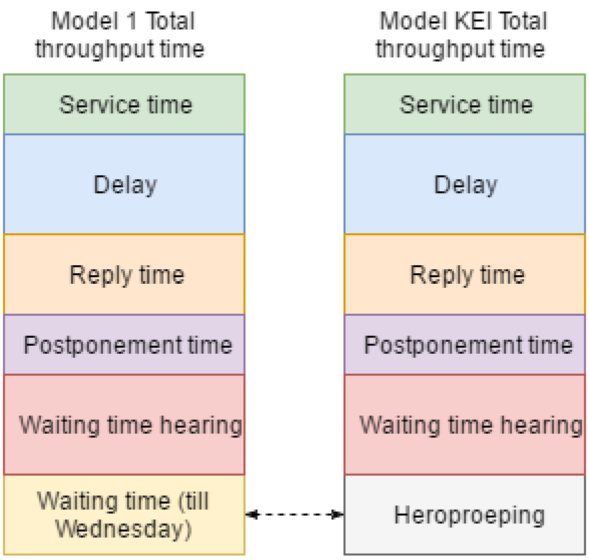


Figure 8 Composition of the total throughput time

Based on the changes of KEI we see if the composition of the throughput time changes, and if the total throughput time will decrease with 40 percent as hoped, and how the distribution of the throughput time is divided over the different categories.

The last performance measure for this study is the time servers are busy. For each server type we check if there are abnormalities in their activities. Since the trade law is only part of the functions for the servers, a to high productivity would indicate the system is works to efficient compared to reality. However a low productivity indicated that a server in this case would be superfluous. We cannot make any claims on the needed employees for the whole system, only for the trade law part of the system. Also we have to keep in mind there are times in which a server has to wait for the next case to arrive. This is due to the shape of the model. There are reply times which can influence the being idle of a server. Therefore we look for a high productivity, without changing the throughput time.

System analysis.

To know how well the system performs we can already calculate (or estimate) the minimum performing times. If we know some of the outcomes in the ideal situation, we are able to compare these to the outcomes of the model. This both gives the reinsurance that the model (if put in the best conditions) resembles reality, and gives us an idea how far the system at this point is off of the ideal situation. We start with the delay of the Rolzitting and with the total throughput time of the first situation. Then the situation of the KEI model is discussed.

The delay of a case till the Rolzitting is an average of 2,5 workdays, or 20 hours. Since, the maximum waiting time is when a case comes in on Wednesday at 10 am, this means it is dealt with the following Wednesday, five working days waiting time. The minimal waiting time is when a case comes in Wednesday before 10, and this is processed the same morning. This would make the waiting time 0 days.

In the old system once a case would enter the system it would be possible to submit a case Tuesday and have the *rolzitting* Wednesday. If a case goes to *verstek*, a verdict is possible 21 days later. If a case does not go to *verstek*, the defendant has 6 weeks to respond with their conclusion. The CO can judge the case and distribute it within the same day. So overall this would mean about 31 working days until the case is divided over the written course and the hearing course.

For the written course, the time of the response of the defendant and the prosecutors, the CO service time, and judges service time add up to the throughput time. Which is a minimum 61 days. For the hearing the service times of the AM, TS and the judge's assessment and hearing need to be taken into account. Together with the reply of both parties for their hearing times of 2 weeks and the time till the planned hearing takes place. According to the data as discussed in the next chapter 60 days is the best average to take. In total this would be around the 72 days.

In case of a continued written course another 41 days is added due to the response time of the both parties for the *akte* and *akte van antwoord*, and the time of the judge to assess the case.

In the best case scenario a case can be done in 2 days if it goes to *verstek*. However every time a case enters another round the amount of days gets higher. With the difficulty of the cases increasing, so does the throughput time of the cases. Also postponement increases the throughput time. In figure nine the minimum times are presented of each round. These do not include postponements. For the KEI model the documents will no longer be only checked on the due date, but can be processed the moment they are handed in. This

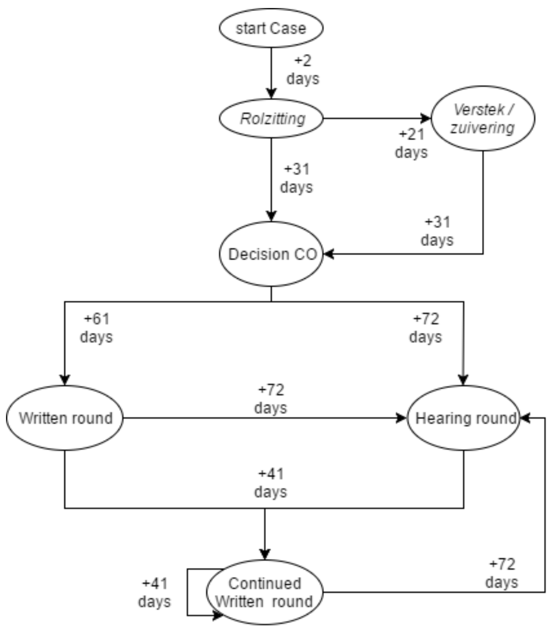


Figure 9 Minimum throughput days for different rounds

means a case can be quicker if the parties hand in their documents faster. When there are no postponements a case can be dealt within a couple of days. In this system it depends on the response time how long (or short) the throughput time will be.

Assumptions

Assumptions are the points on which the model will not represent reality totally, however these choices are made to keep the model, programmable and simple enough.

- No cases are withdrawn
- Hearings are not running late and are not rescheduled.
- The team secretary will always plan a hearing.
- Except for during the rolzitting, there will always be a reply of the prosecutor / defendant.
- The amount of people working each day is a set variable.
- People do not multitask, they can only deal with one case in a time.
- Every task that is not finished at night, will be the first thing to be continued in the morning

Input analyse

For the input analysis we make a distinction between two types of input data. The first data is obtained by the court of Utrecht out of their data server. It consists out of the following datasets:

- the amount of cases arriving each week,
- the time between the planning of a hearing and the actual hearing, and
- the amount of cases going for *verstek* and being postponed.

The other data is less accurate and more artificial input obtained during contact with the employees of the Court in Utrecht. This data is about the service times of employees. For two places in the program there is no data available, in the first model this is the distribution of cases over the different possible paths. This means how many cases will go through the written course, a hearing, and the continued written course. For the second model this also includes the response time of the parties involved. For these factors we experiment with these factors to show the different impacts. For now we continue with the input analysis of the current situation, in order to create a realistic input model.

Arriving cases

The first data set contains the amount of cases arriving in each week, for the years 2012 till 2016. Since 2012 there is a small decline in the total amount of cases, and the weekly average. In Appendix one more details can be found on the statistics. For the arrival of cases we use a discrete distribution, based on the distribution found in the data. The amount of cases were plotted in a bar chart to determine the distribution of the frequencies of arriving cases each week. By using a paired samples statistics we found there is no significant difference between the different years. All the data is used together, in order to have a better and extended information of the arrival rate.

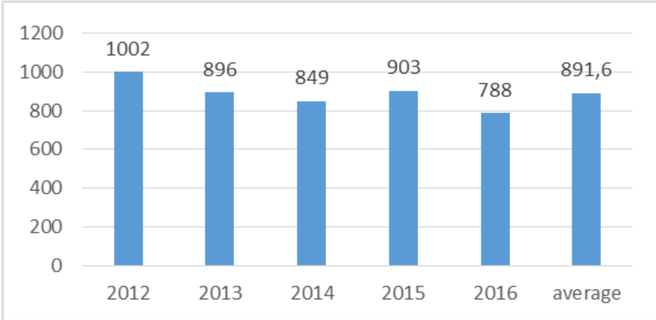


Figure 10 Total amount of cases trade law

The data is checked on correlation between week numbers, or the time of year, and the amount of cases arriving weekly. The fluctuation, however, is constant, with no significant correlation. Therefore we take the mean of the years as the premise of the distribution.

We compare the distribution of the arriving amount of cases each week of the different years. They all are similar to the one presented in figure eleven. This figure indicates that a binomial or Poisson distribution would be fit to use in the program. With the range and the mean of the data we can estimate the variance and standard deviation of binomial and Poisson distribution. We compared these two to the real standard deviation and variance of the data, see appendix one. We estimate that a Poisson distribution fits best to our model, with a mean of 17,14. This means that the amount of cases arriving each week can be determined by this distribution. Still, we do not have the arriving of the cases for each hour.

Year	Mean
2012	19,27
2013	17,23
2014	16,33
2015	17,04
2016	15,76
2012-2016	17,14

Table 2 Average cases arriving weekly

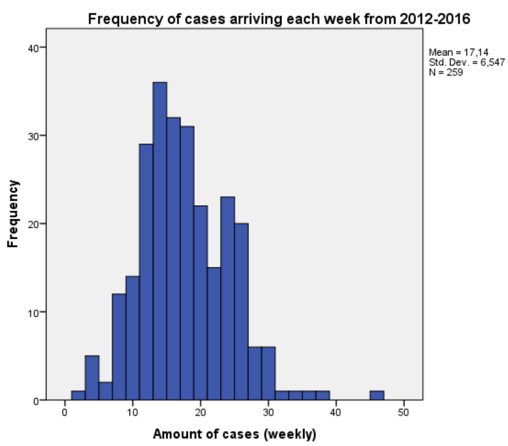


Figure 11 Frequency of cases arriving 2012-2016

The theory of input probability distributions shows that in case of a distribution needed for the arrival of events, a Poisson distribution provides a arrival distribution for which the interarrival time is independent and identically distributed (IID) exponential random variables (Law & Kelton, 2000, p389). This is the most commonly used model for the arrival of customers, cases or products in the DSM. Since our model deals with the arrival of cases for each hour, this distribution fits the description. Averagely 17,12 cases arrive each week. Since a week contains 40 hours this means that on an average every 2.333 hour a case arrives. The frequency of arriving cases becomes: $\lambda = \frac{1}{2.333}$

We do not want the chance of an arrival, but we want to estimate the inter arrival time. The theory tells us a Poisson distribution of arriving can be transposed to the inter arrival. Using the Poisson distribution for the interarrival time with IID exponential random variables means that the more time passes, the more likely it is that a case will occur. This translates to the exponential distribution of probability and can be used to estimate the chances of a case arriving after a certain amount of time.. To calculate time between now and the next arrival we can use the inverse of the exponential function: $Interarrival\ time = \frac{-\ln U}{\lambda} = (-\ln U) * 2.333$. In this case the U is a random number generated by the program. Lambda is the average inter arrival time. With the exponential distribution, the random number, and the average inter arrival time, we can calculate for every new arrival, with a new random U, a new inter arrival time.

Verstek & Postponement times

The next input needed in the simulation is the amount of cases which meet the criteria for v*erstek*. For this input we would like to know how many percentage of the cases are without any reply by the defendant and therefor go to for *verstek*. We also need to know how many of these cases will eventually be replied to and be *gezuiverd*, since these cases will continue with the process.

For the distribution of this probability we will use the uniform distribution, and the percentage of the cases which go to *verstek* as the demarcation. The average percentage of the cases going to verstek is 39,68 percent. However 29,47 percent of the 39,68 percent will be *gezuiverd*, so these cases will continue the normal procedure again after the four weeks a case can be held in verstek without a verdict.

The same method works for the amount of times cases are postponed at the *conclusie, dupliek, repliek, akte* and *akte van antwoord*. Here too we start with an uniform distribution and take the average percentage as the margin of cases going either for postponement or not. The percentages are based upon the data from 2012 till 2015. In table 3 the percentages of the amount of cases which were postponed are presented.

Conclusie	26,1
Dupliek	34,7
Repliek	43,4
Akte	17,7
Akte van Antwoord	26,5

Table 3. Average percentage cases postponed (2012-2015)

<u>Planning hearing</u>

For the time between the planning of the hearing and the hearing itself data is gathered at the courthouse in Utrecht. This data contains the amount of days between the day the date was determined and the actual hearing. This hearing can be a *comparitie* (appearance), *comparitie na antwoord* (appearance after continued written round), *pleidooi* (pleading), *mondelinge behandeling* (hearing), and *descente* (viewing at location). These cases are not taken separately since the model does not take them separately either. Since we do take all the data into account we also take the different planning times into account. The data contains information on the planning times from 2012 till 2016. To establish the distribution for the input in the model all the data is placed in a bar chart, as seen in figure twelve

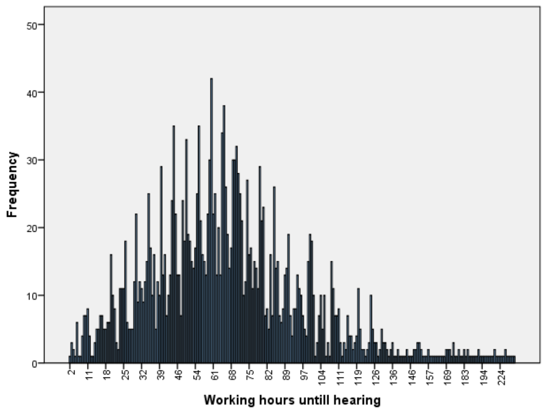


Figure 12 Time till hearing

The mode of this figure is 60 days which appeared for 42 times between 2012 and 2016. We need to take the mode of this data, since we have to deal with the tail at the right. There are some extreme cases of waiting over a year. In this research we want to include the possibility of having a longer time before a hearing can take place. However a waiting time over a year seems to us as a possibility there is something else going on than finding a date to have a hearing. For this reason we do not take the cases over 365 days into account.

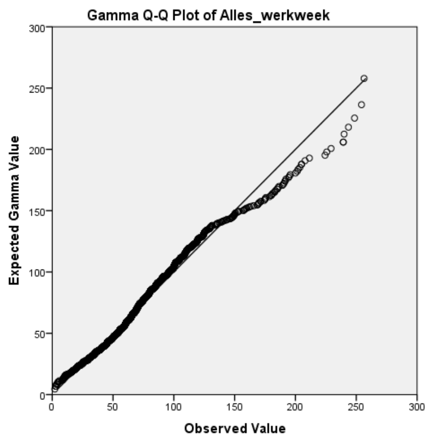


Figure 13 Q-Q plot gamma distribution

Based on the figure, we estimate that a Lognormal, a Weibull or a Gamma distribution would best fit our model. By taking a closer look to the Q-Q plots of the data with the lognormal, Weibull and gamma distribution. We have made the decision to use a gamma distribution in the model. There is a degree of skewing, which can be seen in figure thirteen. This is due to the long tail at the right of the histogram in figure twelve. Still this is the best fitting distribution for this data. This results in an α of 3,733 and an β of 146.

Service times

Based on contact with employees of the service times are estimated, since there is no factual data available on the actual time of completing a task. In table 4, the minimum, maximum, and most common service times are presented. Since the most common amount of minutes for the AM and the team planner, AJM, and CO lies close to the minimum we use the exponential distribution for calculating the service time of these servers. We calculate the exponential variation and add this to the minimum service time. Since the exponential distribution has a higher chance of being close to zero, the distribution of the service time peaks at the minimum service times and declines to larger service times. The only thing we need to take into account is that an exponential distribution can once in a while have extreme values. For these values we decided to make them the mode of the service times, since these are the most common values, and this gives us no extreme values or peaks at other values.

For the judge’s prepare time we use the triangular distribution, since the most common does not lie at the minimum, but in the middle of the range. We have no information on the distribution, and it is common to then use this distribution.

	Min	Max	Mode	Distribution in hours.
AM handling request	15	30	15	1/4+Exp(12)
AM handling documents	7,5	30	7,5	1/8+Exp(4)
Team planner	15	30	15	1/4+Exp(12)
Coordinating Employee (CO)	20	120	30	1/3+Exp(1,2)
AJM	10	75	25	1/6+Exp(1,846)
Judge prepare time hearing.	360 (6h)	480 (8h)	420 (7h)	triangular
Judge assessment case	120 (2h)	240 (4h)	240 (4h)	2+Exp(1)

Table 4. Service times estimated in minutes.

The AM has two types of service times. The first is the processing of an arriving case, handling the request of a hearing and the handling the written and continued written course which from now on we will discuss as handling a request. The second service time is the process of checking

the *conclusie, repliek, dupliek, akte, akte van antwoord* and in case of the second model, checking the *verweer*. This is seen as handling documents.
For a judge there are also two types of service times. The time before a case, to prepare for the hearing, and the assessment after a written round or after a hearing. Most of the times the preparation takes six to eight hours. A case needs to be assessed before the hearing, otherwise the program will show a default.

<u>KEI input: Reply Defendant / Prosecutor</u>

For the second situation, the process based on the process changed by KEI, it is not possible to determine the probabilities based on real situations. We use the distributions as found in the 'old' situation for the interarrival rate of cases, the reply time for hearing and postponement rates. For the postponement, we use the *conclusie* postponement for the *verweer*, and the *repliek/dupliek* for the written course. For the service times everything stays the same, except for the AM. For them, all service times become equal to the lowest service time of the old system, since their task will change to only checking the digital files.
For model two, though, the reply time of the defendants and prosecutors becomes important. In the first model, a case is dealt with if the set reply time is over. So handing a document in earlier does not decrease the total throughput time. With the changes of KEI, this affects the throughput time, since a case is dealt with the moment a document is handed in and the server is free.
There is no data available on how the respondents behave towards handing in their documents. There are three possible options. Either they want the case to be solved as quickly as possible, in which case they tend to hand in their documents as quick as possible. At the other side of the extreme, they want to stall the process as long as possible and take all their time to reply with their documents. The third option is they do not reply as quick or as slow as possible, but averagely. These three options are looked at during the analyse of the system.

	Minimum	Maximum	Mode	Mean	Distribution
Quick response	8	240	8	85,33	Exponential
Average response	8	240	120	122,67	Triangle
Slow response	8	240	240	162,67	Exponential

Table 5. Response time estimated in hours.

Warmup period

Since the system starts without any cases in it, we first need to have a warm up period for which the program runs, before we start measuring the output. The systems start with a state where all servers are empty, but after the warm up period, the servers can be either idle or busy, depending on the amount of cases in their queues. In the warm up period, the system will fill itself with cases and come to a "steady state". We do three runs, for five years, in order to see at what time the system will have the average amount of cases in its system. Figure fourteen presents the output of the three runs for model one, and figure fifteen presents the output for the three runs for model two, KEI. For the both models a warm up period of 2000 hours is needed, before we start measuring the output. After the warm up period we run the simulation for five years, 12400 hours, to make sure the period is long enough to measure fluctuations. Since the simulation does not terminate itself, we need to end the simulation manually. In cases of many random variables in the system we will repeat the simulation for 500 times, to make sure the output is valid.

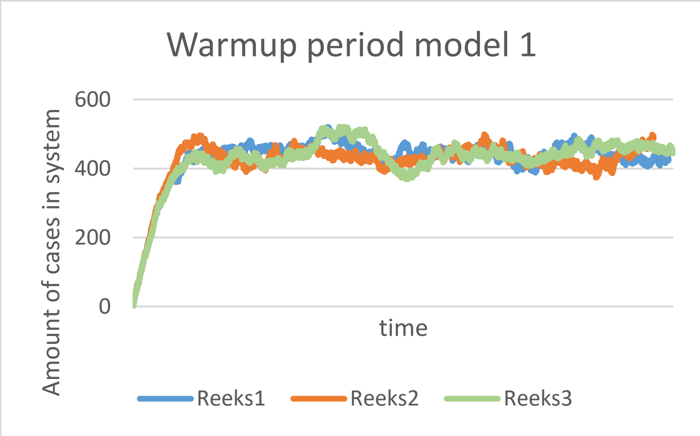


Figure 14

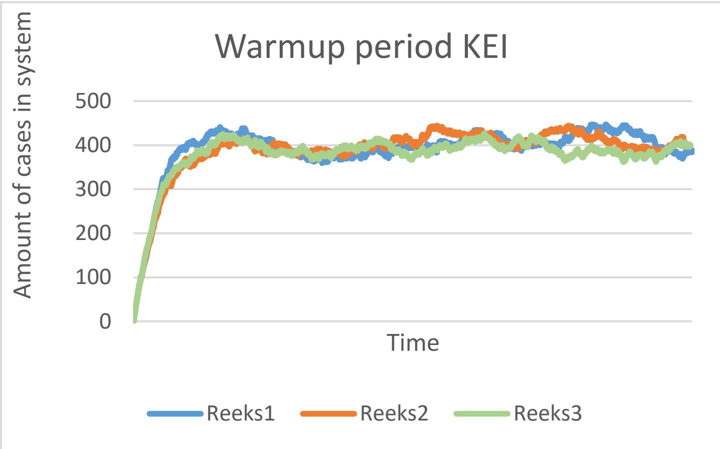


Figure 15

6. Results

Experiment 1

For the first experiment question: *What is the effect of having more cases towards the hearing procedure on the total throughput time and the productivity?*, five different combinations are tested in both models. Hearing 0 % - Written course 100% (H0), Hearing 25 % - Written course 75% (H25), Hearing 50 % - Written course 50%(H50), Hearing 75 % - Written course 25% (H75) and finally Hearing 100% - Written course 0%(H100). The settings after the assessment of a judge of a written round and hearing are kept the same throughout this experiment. Fifty percent of the cases go to the continued written round and 50 percent get an end verdict. For the first model, after the *akte* a case gets an end verdict automatically, to prevent having looping cases in the system. In the second model, of KEI, we did not take the incorrect notice in the first stadium into account, but postponement is possible. No cases are settled during the hearings, and after the hearing 50 percent of the cases go to a written round. The other cases get an end verdict. The average throughput time (W) of the cases within the same models are compared by doing a one-way repeated measures ANOVA. The data has been explored for outliers, normality and homogeneity. This can be found in appendix 2. All the output was normally distributed, and met the criteria for homogeneity.

First, we look at model one: The current situation. Here the assumption of sphericity was violated, since the mauchly's test turned out to be significant[2]. The variance of H100 was significant different from the other simulations. The Greenhouse-Geisser corrected test are reported[3] and the results show that throughput time of cases is significantly affected by the percentage of cases going to either the hearing round or written round[4]. The other data, H0 – H75, did comply with the mauchly's test[5], and also showed a significant difference between the different settings[6]. In the first data set the F is large which show us that the differences between the means are larger, and we can discriminate between the cases of the different settings. The effect of the omega squared shows that the impact of the percentage of the cases going to a hearing between the scenario's H0 and H75 is relatively low, however data set including the H100 has a higher impact. This is probably due to the fact that the mean of the H100 is relatively higher compare to the other settings, as shown in figure sixteen.

[2] $\chi^2 = 31.83$, $p < .05$

[3] $\varepsilon = .967$

[4] $F(3.87, 1930.46) = 840.74$, $p = 0.00$, $\omega^2 = .243$

[5] $\chi^2 = 5.6$, $p = .347$

[6] $F(2.98, 1486.03) = 84.368$, $p = 0.00$, $\omega^2 = .0367$

	H100	H75	H50	H25	H0
Mean	1015,74	949,94	936,88	941,34	958,63
Std. Error of Mean	1,31	1,08	0,98	1,05	1,03
Std. Deviation	29,32	24,12	21,96	23,55	23,11
Variance	859,89	581,75	482,22	554,74	533,89
Range	197,88	140,98	123,48	146,92	133,65

Table 6. Descriptive statistics model one.

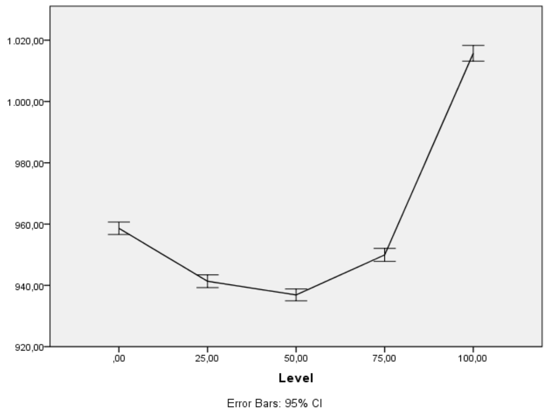


Figure 16 Throughput time for different H's (model1)

We see a significant difference between the different combinations. When more cases go to a hearing the throughput time of the cases increases, but also when all cases go towards a written round the throughput time increases. The optimal situation according to the simulation would be a 50/50 division. We also see that the variance increases when all cases are going through the hearing round. The explanation for the increasing throughput time from the 50/50 division towards the H100 or H0 is that it is a trade of between on the one hand postponement and reply time and on the other hand the waiting time till the hearing and the delay. With a written round the reply time and the postponements are together averagely 86.11 percent of the total throughput time, while with a hearing this is 35.72 percent. With a hearing we see that the service time increases significantly ($p<0.00$), however this is a small amount of time of the process.

When the amount of cases to a hearing increases the time till a hearing can be planned increases. This means that the time till a hearing is much higher than the 60 days as stated in the input analyse. Also, the delay increases, which the time a case is in a queue for a server. In a written round the AM has higher delays, however with a hearing the delay for the assessment by a judge increases. The service time with a hearing for judges is much higher, and this has an effect on how many cases a judge can deal with in a certain amount of time.

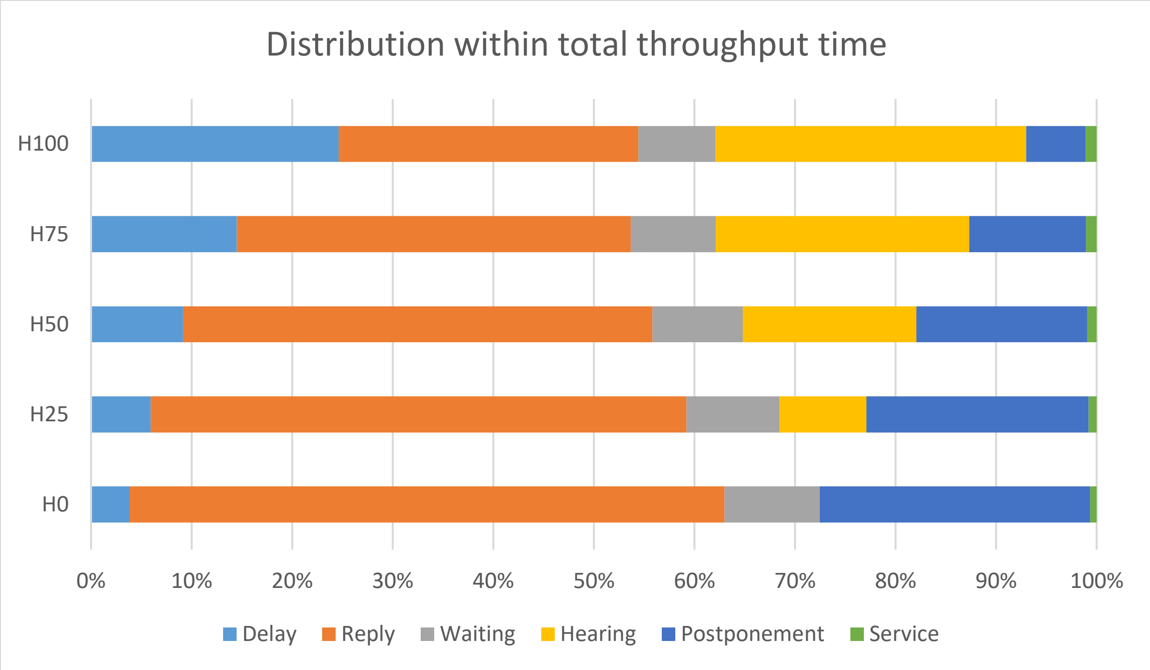


Figure 17 Model one

In the new situation the idea is to abolish the *Rol*-Wednesday and deal with documents and cases as soon as they are returned by the prosecutor or defendants. According to the results above this would shorten the throughput time enormously for the written round. However, when more cases are a hearing the gains of this change diminishes.

Now if we look at model 2: KEI. In table 7 the descriptive statistics is presented. In this model the throughput time in hours increases when the amount of cases to a hearing increases. However this data too, does not comply with the assumption of spericity, since the mauchly's test turned out to be significant[7]. The Greenhouse-Geisser corrected test are reported [8]and the results show that throughput time of cases is significantly affected by the percentage of cases going to either the hearing round or written round[9]. The large F indicates that the difference between the means are large, and the omega squared shows that the impact of the percentage of the cases going to a hearing has a large effect.

7 $\chi^2 = 111.59$, $p < .05$

8 $\varepsilon = .901$

9 $F(3.60, 1797.83) = 28823.57$, $p = 0.00$, $\omega^2 = 0.916$

Statistics Model 2.

	H0	H25	H50	H75	H100
N	500	500	500	500	500
Mean	746,34	818,99	900,31	992,61	1082,43
Std. Error of Mean	,62	,63	,79	,92	,94
Median	746,07	818,55	901,30	993,18	1082,65
Mode	730,94	801,98	882,37	978,83	1055,15
Std. Deviation	13,93	14,14	17,59	20,57	21,00
Variance	193,99	199,88	309,47	423,10	440,856

Table 7. Descriptive statistics model KEI

In the first model there is a large trade-off between reply and postponement time and the waiting time of a hearing. Going to an all written round system, would also increase the throughput time. In the model of KEI this is not the case. The relationship between the dividing cases and through put time is linear. When the amount of hearings increases, but the agenda of the judges stay the same, it takes longer before a hearing can take place. In this model the service time is just a small percentage of the total throughput time. When more cases go to a hearing, the service time increases. More servers are involved and the judge, with the highest service time, is more involved in a case. Therefore, the average delay therefor also increases when more cases go to a hearing. Since the judge has a higher service time, cases need to wait longer before a judge can handle the next case.

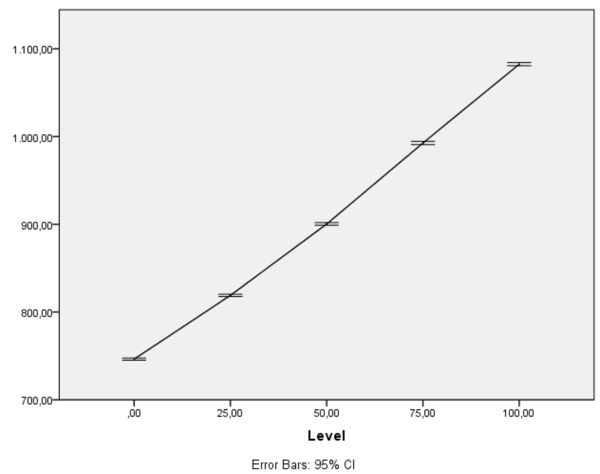


Figure 18 Throughput time for different H's (KEI)

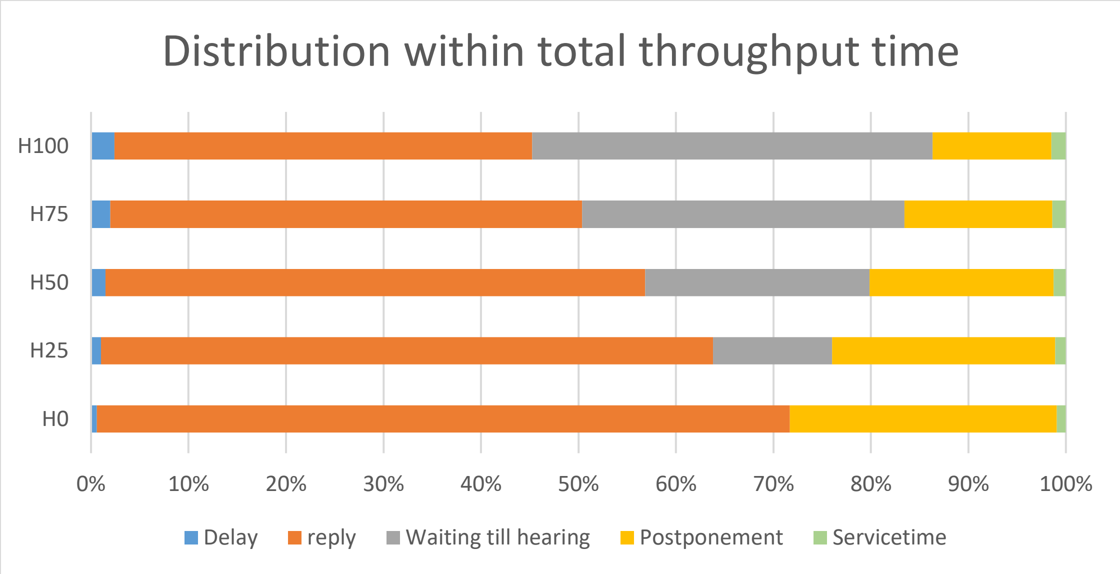


Figure 19 KEI

In table 8 the productivity rates are presented. In both systems, with the current amount of servers, the productivity rate is low. In the current system the productivity of a judge is 20 percent, and in the model of KEI only 24 percent of the time judges are busy dealing with cases. This time decreases when more cases will go to a written round. For the Administrative office the productivity rate increases when more cases go to a written round.

Model one.	H0	H25	H50	H75	H1005
AM	20,32	18,82	17,36	15,88	14,37
CO	17,56	15,38	13,24	11,06	8,79
AJM	2,09	2,09	2,08	2,08	2,08
TS	0	0,83	1,66	2,49	3,36
judge	6,95	10,28	13,54	16,85	20,43
Model KEI					
AM	13,3	12,69	12,07	11,37	10,74
CO	8,72	8,71	8,72	8,71	8,72
AJM	3,87	3,92	3,87	3,84	3,89
TS	0	1,13	1,83	2,62	3,43
Judge	8,4	12,18	16,12	20,33	24,23

Table 8. Productivity of the servers for the different hearing percentages

Experiment 2

The servers are idle for most of the time, which means that the system can deal with the amount of trade law cases ‘easily’. The second experiment looks at question: *What is the effect of the arrival rate on the throughput time and productivity of the servers?*. For the first model we continue with a 50H division and no postponements (to decrease the amount of random variables). For KEI we continue for H50, H75, and H100, since this is the new model and the idea is to have more cases going to a hearing. The tested amount of cases arriving are between 20 and 120 cases a week. We again start with model one, the current situation. The descriptive statistics are presented in table 9.

	AC = 20	AC = 40	AC = 60	AC = 80	AC=100	AC = 120
N	500	500	100	100	50	50
Mean	824,93	820,28	1030,94	1041,88	1047,41	1849,32
Std. Error of Mean	,57	,43	1,13	,950	1,68	14,43
Std. Deviation	12,69	9,52	11,29	9,50	11,91	102,06
Variance	160,94	90,60	127,41	90,20	141,85	10416,05

Table 9. Statistics Model one for different arriving cases

We see that for the first model the difference between 25 cases arriving each week or 40 makes no real difference. However when 60, 80 or 100 cases arrive, the average throughput time increases with 200 hour. When we increase the amount of cases arriving even further to 120 cases, the throughput time will double compared to the current situation.

The situation of 120 cases arriving is the first situation in which one of the servers is 100% busy, the administrative employees (AM). But also the CO and the Judges have a high productivity rate. This also explains the increased throughput time. In the AS=120 situation, there is a large delay at the AM, and they cannot deal with the amount of cases flowing in the system.

	AS=17	AS=25	AS=40	AS=60	AS=80	AS = 100	AS = 120
AM	15,27	22,32	35,72	53,46	71,35	89,15	100,00
CO	13,17	19,28	30,81	46,16	61,60	76,90	92,51
AJM	2,08	3,05	4,84	7,25	9,68	12,14	14,58
TS	1,66	2,42	3,89	5,80	7,74	9,66	11,60
Judge	13,50	19,67	31,55	42,83	62,56	77,67	87,85

Table 10. Productivity model one

In the model of KEI we see a similar situation. In appendix 2 (table 31, 32, and 3), the descriptive statistics of the three simulation are presented. At a certain arrival rate it is not possible to schedule all the hearings in time, and the amount of cases entering the system is higher than the amount of cases leaving over time. This is why the amount of cases in the system will only increase over time, and the system jams. For each of the settings, H100, H75 and H25 this point is different. A system with more hearings, can deal with less cases before it becomes unstable. The amount of cases going to a hearing, therefore influences the resilience of the system. When more cases go to hearing, the system has more trouble with increasing weekly arriving cases.

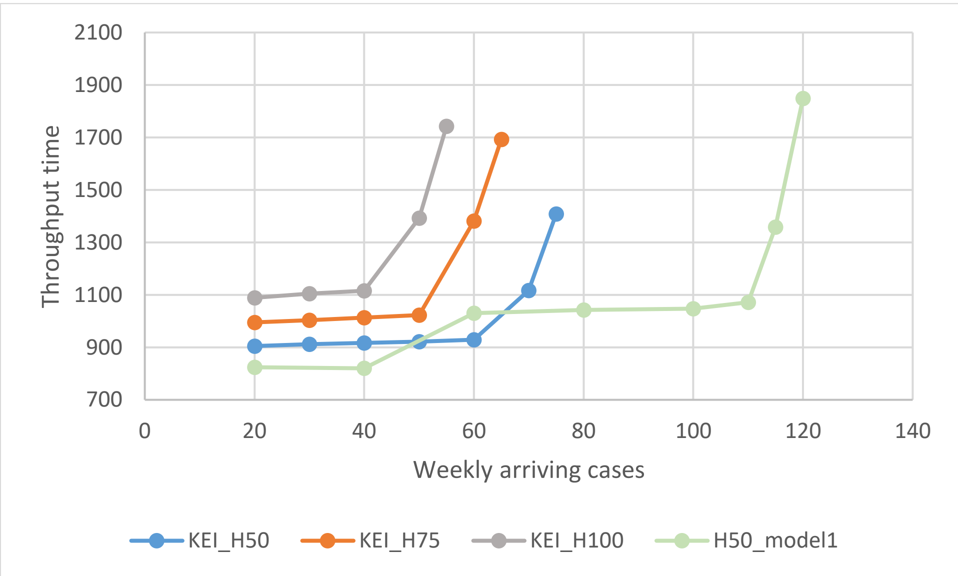


Figure 20 throughput time for different arrival rates, both models

When compared to the old system, we can state that the new system is even lower in resilience, as seen in figure twenty. In the model of KEI there is an optimization process. Since judges have their own cases from the beginning, a new case may not be taken by the judge with the most cases. This could mean that some judges may be free, but have too many cases compared to other. For this research we take this optimization, however in a following research we can also look into the effect of distribution of cases over judges. Due to process, it is impossible to obtain a 100% productivity of the judge. The productivity of the judge in this model does not reach above the 79 percent. Increasing the amount of cases gives large delays at the judge. The judge has more service time in the second model and deals with a case earlier in the process. This also explains the larger delays and may explain the differences between the process of KEI and the current system. In appendix two (table 34) the productivity rates of the different servers are presented for the three KEI situations, H100, H75, and H50.

Experiment 3

In the current situation, with the arrival rate of 17.14 cases a week, the productivity is on the low side. In experiment three we will look at the question: W*hat is the optimal amount of servers without causing the system to become unstable?*. To start, we optimize the current system for the amount of judges. For the judges the system becomes unstable when there are less than four judges. When we go from four to three judges, the throughput time doubles. The productivity with four judges is 76 percent, with three judges the productivity is averagely 90.3 percent. There are two reasons why the productivity of the judges is not reaching 100 percent. First, judges have their own cases, part of the time they are waiting until the defendants and prosecutors reply. Secondly, are hearings planned and they have to wait before this hearing takes place. If there is no other case to judge, the server is empty. For the other servers, AM, CO, AJM, and TS, one server is sufficient. With this setting the system does not become instable. We compare the original system with all servers and the optimized system with four judges, one AM, one TS, one CO, and one AJM. As seen in table 11 the difference between the two means is significant, however compared to the other output, it does not increase critically.

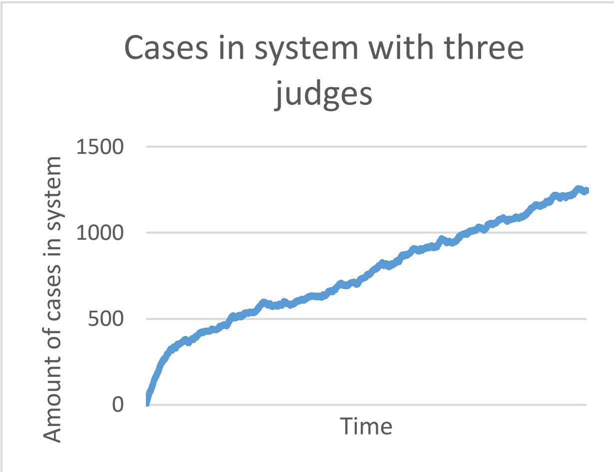


Figure 21 An unstable system

Paired Samples Statistics Model1

	Mean	N	Std. Deviation	Std. Error Mean
Optimized	1053,79	500	20,84	,932
Original	1042,80	500	19,13	,855

Paired Samples Correlations Model1

		N	Correlation	Sig.
Pair 1	Optimized & Original	500	,042	,348

Paired Samples Test, Model1

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Optimized - Original	10,99	27,69	1,24	8,56	13,43	8,877	499	,000

Table 11. Paired samples T-test between Model one optimized and original.

When we look at the new situation of KEI, we can also optimize the system and determine how many servers are needed to run the current situation of 17.14 cases arriving each week. To show more variation in the process we will look at it for the situations of H100, H75 and H50. In graph twenty the average throughput times are plotted against the amount of judges, for all three situations. In this model too, the system will become unstable, and the amount of cases going into the system will be higher than the amount of cases flowing out of the system, which causes a high throughput time. Large delays occur if too few judges are available. For H100, eight judges are necessary, for H75, seven judges, and for H50, six judges.

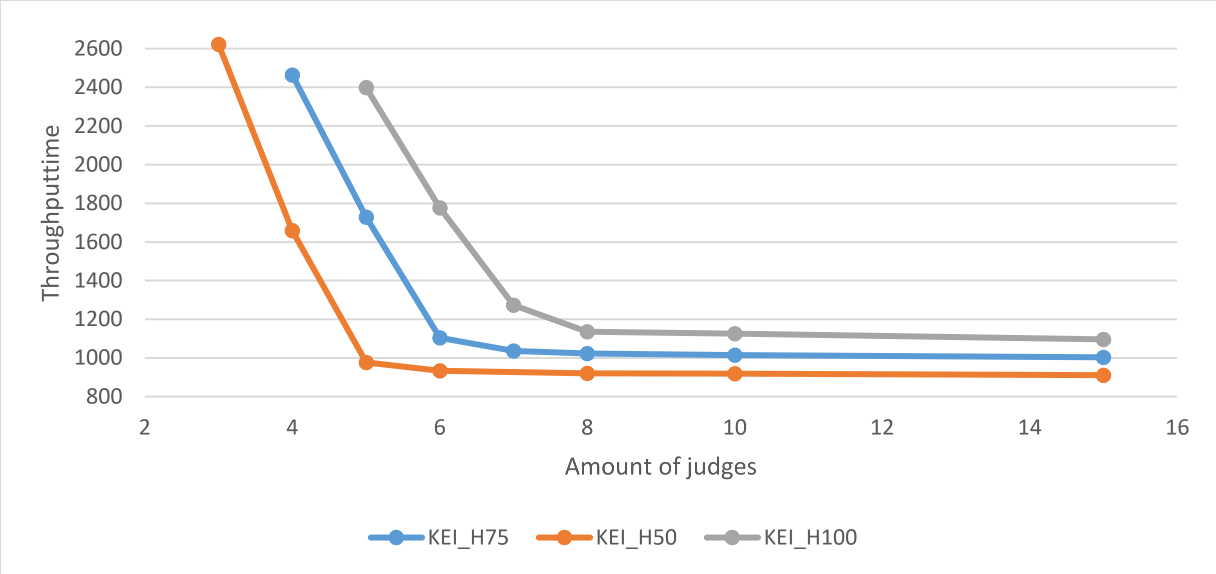


Figure 22 Throughput time as function of amount of judges

The throughput time increases due to optimizing the system. The time increases for a H50 system with 28 hour, for a H75 system with 44,6 hours, and for a H100 system with 56 hour. All of the systems were stable. Again we see that the KEI system is more susceptible to changes, then the current system.

	Mean	N	Std. Deviation	Std. Error Mean
Original KEI H100	1079,15	50	2,82	2,82
Optimized KEI H100	1135,67	50	3,55	3,55
Original KEI H50	905,18	50	2,33	2,33
Optimized KEI H50	933,92	50	2,93	2,93
Original KEI H75	993,38	100	1,81	1,81
Optimized KEI H75	1036,88	100	1,91	1,91

Table 12. Descriptive statistics KEI

Experiment 4

A large advantage over the current system is that in the situation of KEI, the reply time of the defendant and prosecutors have a large effect on the throughput time. In the current system a case will be looked at if the total reply time is over, but in the new system a case is dealt with from the moment it is returned by the parties. In experiment 4 we look into the question : *What is the effect of the reply/postponement/zuivering time on the throughput time?*

We continue with the setting of everything goes to hearing (H100) and we run the simulation for three possible scenarios. In the first scenario, both parties respond as soon as possible. This means that the reply is exponentially distributed with a peak at a day the lowest response rate. In the second scenario, the average response time lies in the centre of the available reply time. The peak there lies in the middle and a triangle distribution is used. In the last scenario the respondents reply as late as possible. Here too, an exponential distribution is used, however the peak here lies at the other end, at the maximum reply time. The times for which these distributions are used are the *zuivering* time, the reply times for documents and the reply for hearing dates.

	Mean	Std. Deviation	N
Slow	925,43	18,90	500
Med	871,09	17,18	500
Quick	845,32	18,15	500

Table 13. Descriptive Statistics

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Reply	1,000	,017	2	,992	1,000	1,000	,500

Table 14. Mauchly's Test of Sphericity

As seen in table 14, the Mauchly's test of sphericity is not significant, so we can assume that the variances of the differences are roughly equal and the assumptions is met. There is a significant effect of the reply time of the parties on the average throughput time of a case[10].

In figure 23 we can see the difference between the three scenario's and the standard errors. As expected the error bars are not overlapping. Now if we look to the difference between the three scenarios we see that between the Slow and medium scenario the throughput time decreases with 54 hours. Between the medium and quick scenario the throughput time decreases another 26 hours.

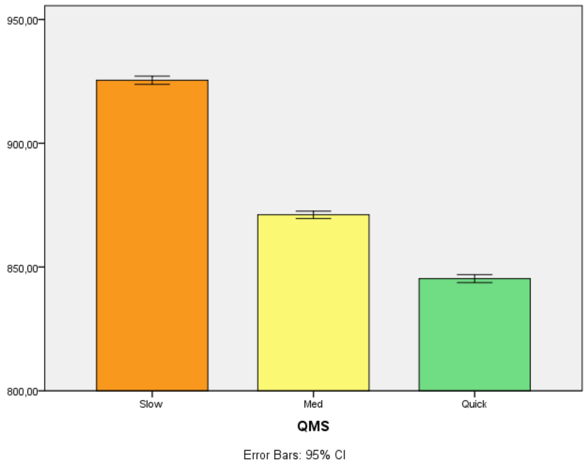


Figure 23 Throughput time against different response speed

[10] $F(2,998) = 2759.513$, $p = .000$, $\omega^2 = 0,604$

In total this is a gain of two weeks. This number is not as high, since the amount of times a prosecutor or defendant has to reply in the new process has decreased. In model one, a reply was needed at the *conclusie*, *zuivering*, *repliek*, *dupliek*, hearing date request, *akte*, and *akte van antwoord*. In the new process the round of *repliek* and *dupliek* is cancelled, which has an influence on the effect of the reply time. Most of the cases are assigned to be a hearing, and a in an easy case a judge can decide if a written round is needed. In case of an easy case the chance of having another hearing or written round after the first written round will decrease. In table 15, the percentile changes between the three groups are presented for each category; delay-, reply-, waiting till hearing- , postponement- , and service time. The only group changing is the reply time. The reply time decreases with 39,92 percent from a slow to a quick system.

	Delay	Reply	Waiting till hearing	Postponement	Service time
Slow-Med	0,08	+19,25	-0,06	-0,13	-0,01
Med-Quick	0,00	+11,49	0,02	0,08	-0,06
Slow-Quick	0,08	39,92	-0,04	-0,06	-0,07

Table 15. Percentile change of the times compared between the 3 categories

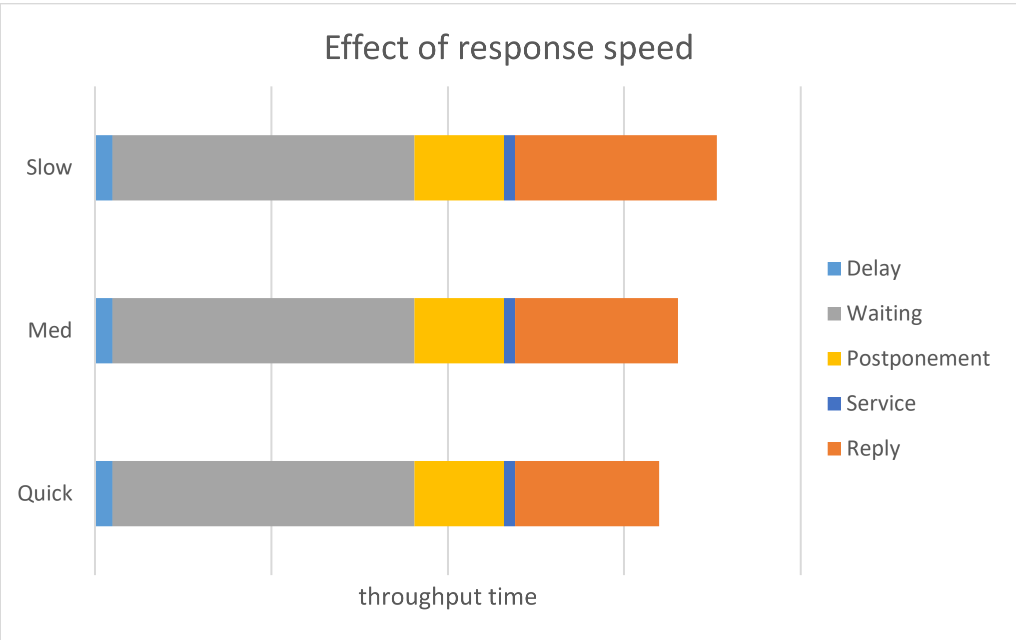


Figure 24 Model KEI, compilation of total throughput time

Experiment 5

So far we have tested the different scenarios more independent from other stochastic variables to show the effects of that change in setting. In the next part we look at the model with all stochastic variables turned on and explore the question: *What is the difference between the two systems, both realistically and in a best case scenario?.*

We compare four different situations to each other. For model one, two runs are performed. Once with H50 and once with H80. In the earlier experiments we already saw that this leads to a difference in the composition of the throughput time. The H50 feels more like the actual system at this point, but the H80 can be compared to the new situation of KEI. For KEI also two simulations are run. Both have the setting H80, however the first run has the same other settings as the one of Model1 H80. The second run will be a more optimized and have the possibility of cases getting an end verdict (or settlement) during a hearing. In appendix three the settings of all four runs are presented. Also in the second simulation the reply time of the respondents will be as quick as possible. Since the system is seen separately from the other law systems, we cannot say something in compared to the actual throughput times. However, we can compare the two different settings for each model and compare the output between the two models. In table 16 the descriptive statistics of throughput time of the four situations are presented.

	N	Min	Max	Mean		Std. Deviation	Variance
				Statistic	Std. Error	Statistic	Statistic
Model1 H50	500	1272,87	1396,91	1337,38	1,05	23,40	547,38
Model1 H80	500	1271,40	1416,59	1336,78	1,11	24,89	619,60
KEI Real	500	854,03	972,38	911,51	,83	18,45	340,57
KEI optimized	500	668,49	761,28	713,57	,69	15,54	241,38

Table 16. Descriptive Statistics of four complete scenarios.

Model one H50 and Model one H80 are not significantly different from one another ($p = .696$). However in figure 25 is presented how the throughput time is composed by the different times, like delay and reply. The main difference is in the delay, reply, postponement, and waiting time till a hearing. As we saw in experiment 1, there is a trade-off between the administrative round and its associated times and the hearing round with its associated times. When more cases go

to a written round, the amount of reply time and the amount of postponements increase. Whereas a scenario with more cases to a hearing round deals with longer waiting times for a hearing, more service time from the judge and therefor larger delays.
Model one H80, KEI optimized, and KEI real are significantly different (p =.000). The waiting time till a hearing between Model one H80 and KEI real H80, are about the same, which makes sense because the same amount of cases have to be planned to a hearing. With the new system the reply time decreases. This is due to the logistic change of the process. Since a judge is involved in the beginning of the process he or she can decide whether a case is easy or more difficult. Only in case of an easy case a written round is chosen, and the chances of having another round afterwards decreases. However if a case turns out to be more difficult, a hearing will be the first option, and only is a case cannot be settled during this period a written round may be necessary. This means that in an earlier phase and at an earlier time cases can be settled, and less written rounds take place.
The productivity of the judges between the two models increases. during these simulations we have taken 23 judges into account. On average, a judge in model 1 H50 is 15,9 percent of the time busy with a case. In the new system of KEI real this increases to 21,2 percent per server. Since the judge is earlier and more involved his service time increases. This means that the workload for the judged will increase. Depending on the existing workload, included with the other types of law cases they deal with, this can lead to delays and extra pressure.
For the administrative office we see a decline in the time their busy. In model 1 H50 , with four servers, each servers is approximatly 18 percent of the time busy. In the KEI real model, this decreases to 11,8 percent. Also the service time of the CO declines. From 13,6 percent in model 1 H50 to 8,2 percent in KEI real. In appendix 2 table 51 all productivity rates are presented.

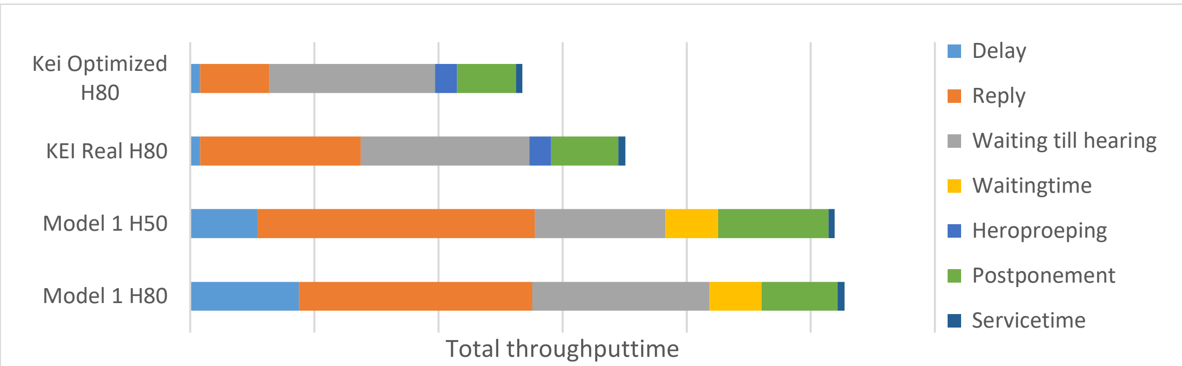


Figure 25 different times within total throughput time

The second time gains is the waiting time till the Rol- Wednesday. In the first model, cases were only dealt with on Wednesday, So if a case was handed in on a Tuesday, the time till the next Wednesday was additional waiting time. This time will no longer be there in the second model of KEI. However the time of *heroproeping* will replace this time. However, these two times have no large effect on the total throughput time.

What does have a large effect is the delay of cases at a server. Because of the less rounds a case can and will make, the amount of times a case goes to a server decreases. This results in a decrease in the total delay time. The service time does not stay the same, since the service time of judges increases, whereas the time of the AM and the amount of times an AM deals with cases decreases.

Another effect on the delay is the disappearance of the *rolzittingen* and due dates for documents. In the first model, having due dates and *rolzittingen* makes that the cases are sent in bundles through the system. This has two main effects. First the system can deal with more cases since they are going clustered through the system, and no harmonica effect occurs at servers for a large amount of cases. On the other hand, since they are going more clustered through the system, the average delay at the server turns out higher. The new system can therefor deal with cases quicker, but is less resilient than the old system.

The last comparison made is between KEI real and KEI optimized. The verdict during the hearing and the quick reply time result in an overall decrease of the throughput time of 21,7 percent. This is mostly is due to the quick response, leading to a decline of the reply time of 56,8 percent.

One of the objectives of KEI was to decrease the throughput time with 40 percent. Looking at the difference between Model1 H50 and KEI real a decrease is noticeable of 31,84 percent. Which would not meet the criteria of 40 percent. KEI real does not take a quicker reply into account. When we only look at the times due to the process of the court (all the time, excluding reply, *heroproeping*, and postponement time) there is a decrease of 46,25 percent. Which does comply with the set goal. The only extra time to be gained then is when the parties respond earlier than their document due date. So when we look at the throughput time of Model one H50 vs KEI optimize we see the goal will be met.

7. Analysis

The main findings from our first experiment is how both systems react to changes in the division of cases over hearing or a written procedure. Due to the change of choice of procedure from the CO, in model one, to a Judge, in KEI, not only the throughput time of the cases changes, but also the relation between the division and the throughput time. In the first model a curved relation was found, due to the trade of between the time parties need for cases, reply time and postponements, and the waiting time till a hearing and delay. In the first model, there is a large trade-off between lager throughput time due to the defendant and prosecutor, and longer process time due to the court system.

In the second model, KEI, this relationship is linear. The throughput time no longer has a large effect when more cases go to a written round. The explanation for this 'missing' effect is the assumption that is more cases go to a written round, a judge thinks this case can be dealt with without a hearing, and the case is easy enough to solve without a hearing. This means extra procedures after the written round are not necessary, and if so this is only a small percentage. The main effect of the shift towards more hearings is that the waiting time till a hearing increases, and people have to wait longer until a hearing can be scheduled.

In the second and third experiment we tested both systems on resilience. In the second experiment we tested the amount of cases a system can deal with without becoming unstable, and in the third experiment we tested how many servers a system needs before becoming unstable.

The main findings for these experiments are that the current system, model one, is more resilient than the new system, KEI. The first model is able to cope with more cases and needs less judges before becoming unstable. This can be explained by a combination of factors. First of all in the new system the process has changed toward a system where a judge is involved in an earlier phase. In both systems we divide the cases over the judges though an optimization process, where a judge can take a case, as long as he does not have the most amount of cases. Throughout the process he deals with his own cases. In the first model, the judge is involved later on in the process, which makes this optimization works efficiently. However, if a judge is involved earlier and a case gets delayed, a judge cannot take a case in the meantime. This results in longer delays for cases and a lower productivity rate. For further research it will be interesting to explore this optimisation process.

The second factor is the disappearance of the *rol*- Wednesday. In the first model the *rolzitting* acts as a gate sending cases through the system in batches. This has two effects. First, a larger amount of cases arrive at a server at about the same time, but on the other hand there is a larger time between these groups. So we both have a harmonica effect in the groups of cases, but have an opposite effect between these groups of cases. The rol-Wednesday leads to larger delays of the cases, since they are longer in a queue for a server, however it does make the system more resilient to larger amount of cases, and can therefor deal with cases with less servers.

In experiment four and five the effect of the reply speed of the prosecutors and defendants on the throughput time of their case becomes clear. Due to the process change the amount of cases going to a written round declines, which already result in a declining reply percentage. With the change from a slow response rate to a quick response rate, the total throughput time will declines even further. The effect of a quick response has a larger effect in model one, but still leads to a decline of 20 percent of the total throughput time in the model of KEI.

The main objective of this research is to see what happens with the throughput time due to all the changes. Experiment 5 shows that the overall throughput time will not meet the criteria of 40% when we go from a H50 system in model one to an H80 system with KEI, without a quick response rate, but meets the criteria when people speed their reply's. Looking only at the total throughput time, the process needs quick replies. What needs to be said is that when we only look at the times the court room can influence, their side of the throughput time decreases with more than 40%. The process changes do speed things up at the side of the court. Even though the throughput time declines, the service time increases. This means that more time is spent on a case, which leads to more workload in the system, and especially for the judges. Depending on the situation of the court at this moment, this might lead to a problem. If there are large delays in the present system, having extra service time might only increase the problem.

So looking back on the original research question "**How do the KEI interventions to improve logistic handling, affect the throughput time of trade law court cases?**", the answer is twofold. First, the system does reduce the throughput time of a trade law court case significantly. On average, a case will flow 32 percent quicker through the trade law system due to the process optimization, and 46 percent quicker when respondents improve their reply speed. On the other hand the system has become less resilient and will sooner cope with large delays and queues, when put under pressure. This can partly be traced back to the increase of service time for the judges. The earlier assignment of cases to a judge will lead to less flexible system.

What this research shows is that the change with KEI is definitely a change in the throughput time. However, it is important to see that this is at the expanse of the resilience of the system, and increasing the service time of the judges. Since this is not a closed system, but part of a larger law system, there might be more pressure on the procedure then arising during the simulation. This can be internal pressure of decreasing amount of judges or employees, or already existing delays. It can also be from external pressures like the increasing amount of cases both in trade law and in other types of law. Unravelling the new system, one could say more lawyers, an optimal dividing of the cases over the judges, or more hearing blocks might be necessary. Also, the choice of a judge in how to solve a case becomes crucial. These results show which aspects during the implementation of KEI could be important focus points, and what can be researched in order to optimize the system.

As with every research, there are some critical notes which need to be made. Some of these notes are due to the characteristics of using simulation modelling, as is the first. In this research, we have looked at this system as if it is a closed system of other court cases, but in reality this is not the case. This means that the throughput times are based upon a system where the servers are not busy with other cases. In real life the throughput time of court cases will be higher. In using simulation modelling it is common to research the system as if it is a closed system. Also, we are interested in the effect of the interventions on the throughput time of trade law cases. The effect remains the same whether we include other law cases or not, since we keep the conditions equal in every test. The actual total throughput time of cases will therefore be higher than measured in the program, still the effects of the innovations do become clear. Also we took into account the schedule of a judge for planning the hearings, which results in a more accurate comparison with reality.

Another critical note on our model is that we deal with humans in our system. Quantifying services of machines is always easier than quantifying humans. Humans are rational beings, who can make a decision to change the process. A machine is only able to do as told, whereas humans can either use an efficient way, make mistakes, or make choices which are less efficient. Self-measured performance tends to be optimistic measurements. People take breaks, are distracted and do not work efficiently 100 percent of the time. The stochasticity of the service times, and corresponding distribution, deal with the possibility of having a longer service time. Still, it is logic that the service time turns out to be higher in reality, also because these tasks are not the only part of their job. On the other hand we also do not take into account that humans can multitask, and in our simulation we assume that a server can only deal with one case at a time. These objections might influence our actual throughput time, but since we compare systems for which this both is the case, the effect of this imperfection does not influence our research. We are still able to show the difference between the two models, since this is the case for both models.

A model is always a simplified representation of a real system, and therefore can never exactly give the same results. What we did show with this research is how useful simulation modelling can be for testing systems, also in the public sector. The models are a close representation of the real situation and still show how certain decisions effect the system. In this research we single out specific variables to test, and kept the other variables constant.

The beauty and problem of this method and this program is that everything is possible to test. First, this is great because it gives so much flexibility and use of only one program. It gives us an endless amount of variation to test, since there are many stochastic variables and setting possibilities. If more variables become stochastic, the variance of the output increases. For other, continued, research with more variation, one should keep in mind that more variation, will require longer and more runs, to have valid data.

Not everything possible to test with this program has been tested, and further research is definitely possible and recommended. The court might have to cope in the future with difficulties due to a system which is less resilient. This study gave insight in how KEI changes the system and what effects it have. The next step is to optimize the system, within the new rules and guidelines of KEI. This research shows, for example, that the distribution of cases over the judges can have large influence on the resilience of the system. It can be useful for a Coordination Employee to have more insight in which distribution method would optimize the system, in terms of delay, throughput time and productivity of the judges.

Another possibility to make the system more resilient is to optimize the division of time between hearing time and assessment time for a judge. With the new system, a judge would be able to assess cases during a hearing, which means that more time could be available for hearings. An optimum can be found when testing this with discrete simulation modelling.

We have looked in this research especially to the system of Utrecht. For this system we have showed what the effects are due to the changes of KEI. The flow chart of the current system is based on the system of Utrecht, and there for our findings relate only to the court of Utrecht. We have not looked into the other court systems. However other court systems can also learn from this study. Other court systems apply to the same legislation and process changes due to KEI. This study shows the possible effect of implementing a judge in an earlier phase, abolishing a *rol*-date, and making the process more linear.

8. Conclusion

This study commenced by stating how a new, logistic, perspective on the public sector provides new methodological opportunities to research policy decisions. Since public organisations affect so many lives of citizens, it is worth to pursue an optimal and efficient system. These values can be traced back to the shift toward the new public administration, where the citizen is a customer of public organisations, and these organisations serve rather than steer. Applying private sector ideas like efficiency to the public sector, lets us think in terms of resource and process optimisation. Having an efficient system can save both the public sector and citizens time and other resources, which can be used elsewhere.

Optimizing the public sector requires policy changes, and many of these can be found in process optimisation. The effect of the policy changes can often only be determined a long time after the implementation. Insecurity about the effect of a policy, complicates creating support. However, we have shown that implementing a business-like idea of the public sector also provides us with a new research method: simulation modelling. Simulation modelling makes it possible to show the ‘what if’ question of policy decisions. It is possible, with this method, to do ex ante research to create legitimacy and support for a policy change. So far, ex ante research in the public sector remained underexposed, but this study shows that it is definitely effective, with an example of the changes in the law system.

Due to the bureaucratic characteristic of the public sector, simulation modelling can be used for studying the effect of a policy decision without interfering in the real system. With the example of the court in Utrecht we showed how simulation modelling gives insight in the process change upfront. We now know that the objectives of the court to decrease the total throughput time with 40 per cent can be reached, but with the condition that the prosecutor and defendant reply sooner within the official reply time. It also showed that changing the procedure leads to a less resilient system and increases the service time of a judge. With this knowledge upfront, more informed decisions can be made during the implementation of the process. Without having to interfere with the system, experiment with real people, and saving a lot of time and money, we have given insights in the policy decisions upfront.

Simulation modelling is a research method especially studied in the private sector field by the IT departments. Public Administration is a field that especially uses qualitative research techniques and surveys. Combining these two fields can open up a large discipline for studying the public sector from a different perspective. Having multiple perspectives on the public sector widens and deepens our knowledge, and provides practitioners with more knowledge, so they can make more informed decisions. More public organisations should look into this design before setting up a new process or optimizing an existing process.

Process optimization to ensure efficiency is important, especially for public organisations. Simulation modelling will be the key to ensure the right policy decisions.

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Appendix 1. Input Analysis. Graphs and tables

	Amount of judges	Total hours working	Total fte
team 1	10	319,48	8,87
team 2	9	284,4	7,9
team 3	10	338,4	9,4
total (Fte =36)	29	942,28	26,17

Table 16. working hours judges

	2012	2013	2014	2015	2016	Total
N (weeks)	52	52	52	53	50	259
Mean	19,27	17,23	16,33	17,04	15,76	17,14
Total amount of cases	1002	896	849	903	788	4438
Std. Error of Mean	1,08	,84	,82	,90	,84	,41
Mode	17,00	12,00	13,00	11,00[a]	16,00	14,00
Std. Deviation	7,77	6,04	5,93	6,55	5,93	6,55
Variance	60,44	36,50	35,21	42,92	35,17	42,87
Minimum	2,00	4,00	4,00	3,00	3,00	2,00
Maximum	45,00	30,00	34,00	29,00	28,00	45,00

Table 17. Descriptive statistics arriving cases

	Data	Binomial	Poisson
Mean	17,14	17,14	17,14
Std Deviation	6,55	3,13	4,12
variance	42,87	9,80	17
Skewness	0,51	0,05	0,24
Kurosis	0,79	2,95	3,05

Table 18. distributions for arriving cases

Q-Q plots arriving cases

Estimated Distribution Parameters

		Arriving cases 2012-2016
Gamma Distribution	Shape	3,733
	Scale	,055

Table 19.

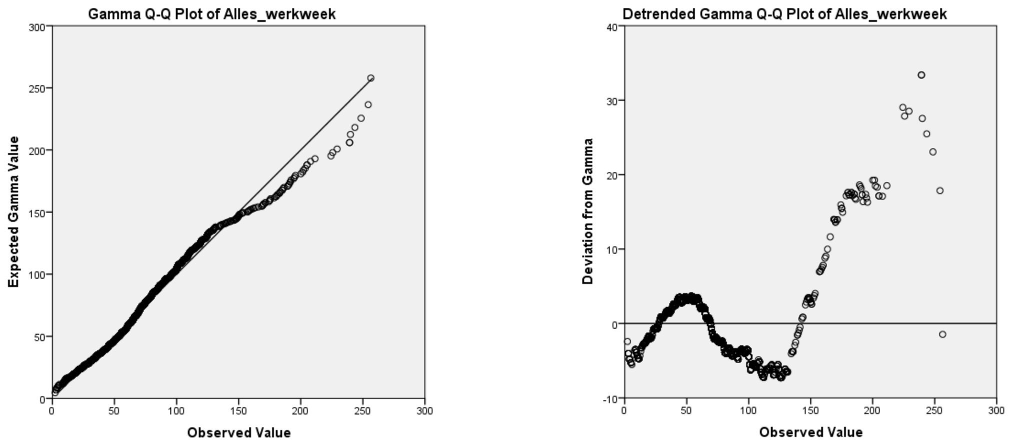

Figure 26 Q-Q plot Gamma distribution

Estimated Distribution Parameters

		Arriving cases 2012-2016
Weibull	Scale	76,877
Distribution	Shape	2,184

Table 20.

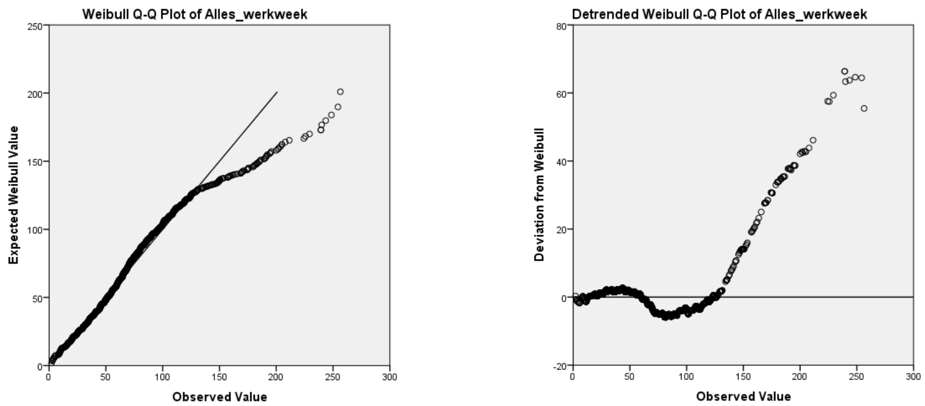

Figure 27 Q-Q plot Weibull

Estimated Distribution Parameters

		Arriving cases 2012-2016
Lognormal	Scale	59,042
Distribution	Shape	,582

Table 21.

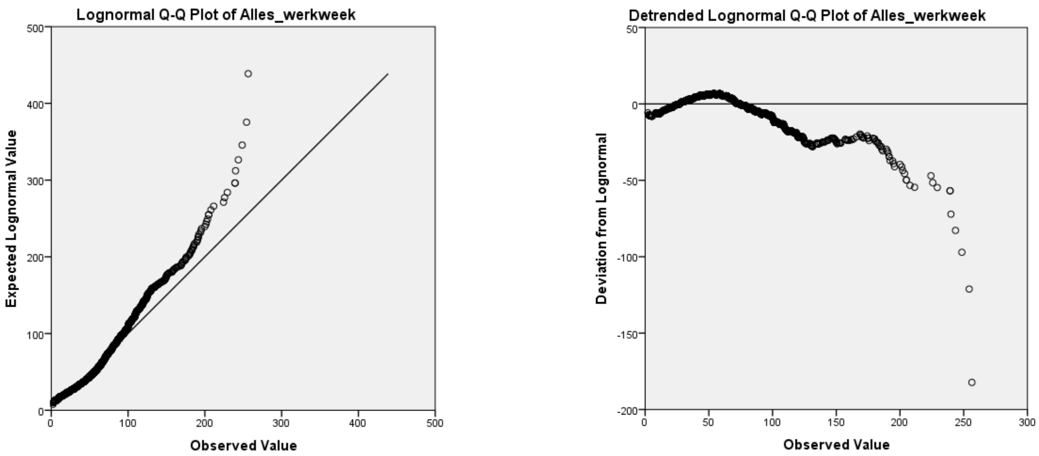

Figure 28 Q-Q plot Lognormal

Appendix 2. Simulation Analysis. Graphs and Tables

Experiment 1, model one:

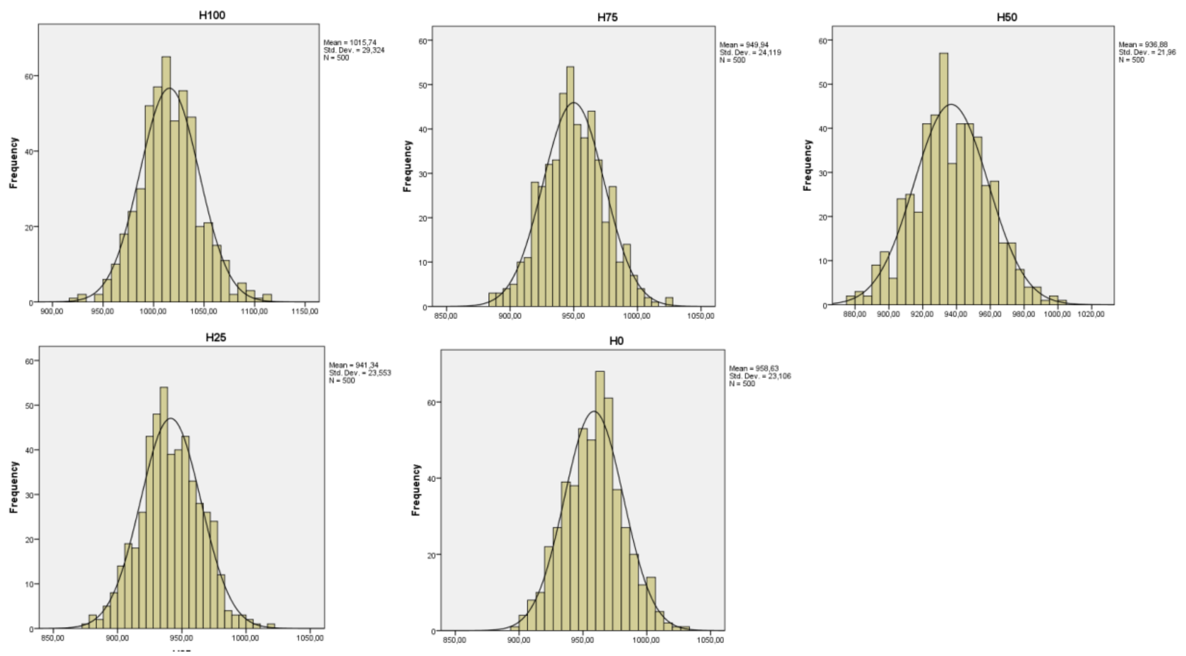

Figure 29 Histograms Model one H0 - H100

Table 22. Test of Homogeneity of Variance

	Levene Statistic	df1	df2	Sig.
Based on Mean	9,100	4	2495	,000
Based on Median	8,982	4	2495	,000
Based on Median and with adjusted df	8,982	4	2335,165	,000
Based on trimmed mean	9,042	4	2495	,000

Table 23. Mauchly's Test of Sphericity[a] H0-H100

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
H	,938	31,827	9	,000	,967	,976	,250

Table 24. Mauchly's Test of Sphericity[a] H0-H75

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
H	,989	5,601	5	,347	,993	,999	,333

Table 25. Tests of Within-Subjects Effects H0-H100

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
H	Sphericity Assumed	2045610,90	4	511402,73	840,74	,000
	Greenhouse-Geisser	2045610,90	3,87	528764,73	840,74	,000
	Huynh-Feldt	2045610,90	3,90	524157,93	840,74	,000
	Lower-bound	2045610,90	1,00	2045610,90	840,74	,000
Error H	Sphericity Assumed	1214121,87	1996	608,28		
	Greenhouse-Geisser	1214121,87	1930,46	628,93		
	Huynh-Feldt	1214121,87	1947,43	623,45		
	Lower-bound	1214121,87	499,00	2433,11		

Table 26. Tests of Within-Subjects Effects H0-H75

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
H	Sphericity Assumed	138959,97	3	46319,99	84,37	,000
	Greenhouse-Geisser	138959,97	2,98	46661,80	84,37	,000
	Huynh-Feldt	138959,97	3,00	46352,82	84,37	,000
	Lower-bound	138959,97	1,00	138959,97	84,37	,000
Error(H)	Sphericity Assumed	821888,50	1497	549,02		
	Greenhouse-Geisser	821888,50	1486,03	553,08		
	Huynh-Feldt	821888,50	1495,94	549,41		
	Lower-bound	821888,50	499,00	1647,07		

	Delay	Reply	Time till Rol-Wednesdays	Time till Hearing	Postponement	Service
W100	3,82	59,18	9,44	0,00	26,93	0,63
W75	5,94	53,26	9,28	8,63	22,10	0,78
W50	9,14	46,69	8,99	17,26	17,00	0,92
W25	14,50	39,15	8,50	25,19	11,62	1,04
W0	24,63	29,82	7,66	30,91	5,90	1,09

Table 27. Percentages of the different time within total throughput time

Experiment 1, KEI:

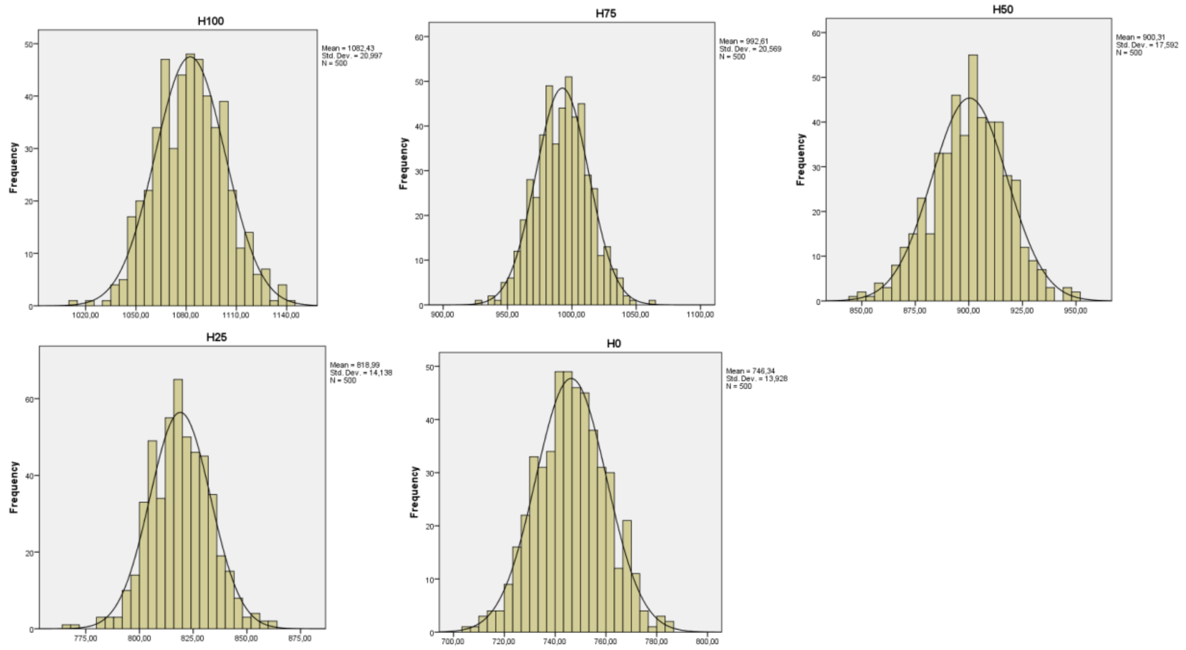

Figure 30 Histograms KEI H100-H0

Table 28. Test of Homogeneity of Variance

	Levene Statistic	df1	df2	Sig.
Based on Mean	34,12	4	2495	,000
Based on Median	33,94	4	2495	,000
Based on Median and with adjusted df	33,94	4	2264,94	,000
Based on trimmed mean	34,14	4	2495	,000

Table 29. Mauchly's Test of Sphericity[a] H0-H100

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
H	,799	111,585	9	,000	,901	,908	,250

Table 30. Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
H	Sphericity Assumed	35849944,18	4	8962486,05	28823,57	,000	,983
	Greenhouse-Geisser	35849944,18	3,60	9950412,98	28823,57	,000	,983
	Huynh-Feldt	35849944,18	3,63	9869769,98	28823,57	,000	,983
	Lower-bound	35849944,18	1,00	35849944,18	28823,57	,000	,983
Error(H)	Sphericity Assumed	620642,14	1996	310,94			
	Greenhouse-Geisser	620642,14	1797,83	345,22			
	Huynh-Feldt	620642,14	1812,52	342,42			
	Lower-bound	620642,14	499,00	1243,77			

Experiment 2, KEI:

Table 31. Statistics KEI H100 for weekly arriving cases (AC)

	AC20	AC30	AC40	AC50	AC55
N Valid	50	50	50	50	50
Mean	1088,90	1104,16	1115,46	1392,48	1742,47
Std. Error of Mean	3,09	2,61	2,25	11,65	12,015
Std. Deviation	21,82	18,47	15,88	82,35	84,96
Variance	475,98	341,26	252,05	6780,89	7217,75

Table 32. Statistics KEI H75 for weekly arriving cases (AC)

	AC20	AC30	AC40	AC50	AC60	AC65
N	100	100	50	50	50	50
Mean	996,39	1004,57	1012,71	1023,14	1381,33	1693,06
Std. Error of Mean	1,79	1,51	2,02	2,04	13,09	12,83
Std. Deviation	17,90	15,09	14,27	14,41	92,58	90,72
Variance	320,32	227,73	203,70	207,52	8570,44	8229,95

Table 33. Statistics KEI H50 for weekly arriving cases (AC)

	AC20	AC30	AC40	AC50	AC60	AC70	AC75
N	50	50	50	50	50	50	50
Mean	904,86	912,12	916,24	922,23	928,91	1116,87	1408,56
Std. Error of Mean	2,37	2,13	1,53	1,44	1,52	15,66	13,76
Std. Deviation	16,75	15,09	10,81	10,21	10,78	110,75	97,30
Variance	280,53	227,72	116,80	104,24	116,23	12264,72	9467,45

H50	AC20	AC30	AC40	AC50	AC60	AC70	AS75
AM	13,96	20,97	27,91	34,99	41,94	48,16	49,31
CO	10,10	15,21	20,25	25,25	30,39	35,65	37,96
AJM	4,19	5,01	5,86	7,19	8,48	9,83	10,44
TS	2,13	3,06	4,03	5,03	6,02	6,84	6,81
Judge	19,19	28,56	37,73	46,94	55,49	67,34	74,91
H75	**AC20**	**AC30**	**AC40**	**AC50**	**AC60**	**AC65**	
AM	13,24	19,87	26,42	33,03	38,08	39,44	
CO	3,04	15,19	20,21	25,29	30,37	32,87	
AJM	4,12	4,94	6,00	7,06	8,44	9,13	
TS	10,11	4,49	5,98	7,46	8,37	8,35	
Judge	23,77	35,31	46,72	57,47	68,99	77,34	
H100	**AC20**	**AC30**	**AC40**	**AC50**	**AC55**		
AM	12,52	18,77	24,98	30,28	31,69		
CO	10,16	15,20	20,21	25,32	27,73		
AJM	4,10	5,01	5,93	7,10	7,77		
TS	4,00	5,96	7,93	9,43	9,45		
Judge	28,31	42,17	55,53	63,88	79,32		

Table 34. productivity rate servers for different Arrival rates

Experiment 3, KEI:

T-test between (W) Optimized and original system for servers

Table 35. Paired Samples Correlations KEI

		N	Correlation	Sig.
Pair 1	Original H100 & Optimized H100	50	-,125	,385
Pair 2	Original H50 & Optimized H50	50	-,038	,795
Pair 3	Original H75 & Optimized H75	100	-,099	,326

Table 36. Paired Samples Test KEI

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Original H100 – Optimized H100	-56,52	33,98	4,81	-66,18	-46,87	-11,76	49	,000
Original H50 – Optimized H50	-28,75	26,96	3,81	-36,41	-21,09	-7,54	49	,000
Original H75 - OptimizedH75	-43,50	27,59	2,76	-48,98	-38,03	-15,78	99	,000

Experiment 4 KEI H100

Table 37. Within-Subjects Factors

Reply	Dependent Variable
1	Slow
2	Med
3	Quick

Table 38. Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Reply	Sphericity Assumed	1672601,94	2	836300,97	2759,51	,000	,847
	Greenhouse-Geisser	1672601,94	2,00	836329,59	2759,51	,000	,847
	Huynh-Feldt	1672601,94	2,00	836300,97	2759,51	,000	,847
	Lower-bound	1672601,94	1,00	1672601,94	2759,51	,000	,847
Error (Reply)	Sphericity Assumed	302454,99	998	303,06			
	Greenhouse-Geisser	302454,99	997,97	303,07			
	Huynh-Feldt	302454,99	998,00	303,06			
	Lower-bound	302454,99	499,00	606,12			

Table 39. Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	387739054,993	1	387739054,993	3094100,875	,000	1,000
Error	62532,476	499	125,316			

Table 40. Estimates

Reply	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	925,431	,845	923,770	927,092
2	871,090	,768	869,580	872,600
3	845,316	,812	843,721	846,911

Experiment 5

T-test model one (paired)

Table 41. Paired Samples Statistics

	Mean	N	Std. Deviation	Std. Error Mean
Model1_H50	1337,38	500	23,40	1,05
Model1_H80	1336,78	500	24,89	1,11

Table 42. Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Model1_h50 & Model1_h80	500	,009	,846

Table 43. Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Model1_h50 - Model1_h80	,59432	34,01235	1,52108	-2,39419	3,58282	,391	499	,696

Independent t-test model one H80 & KEI

Table 44. Group Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Model one H80	500	1336,78	24,89	1,11
KEI real	500	911,51	18,45	,83

Table 45. Independent Samples Test

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	28,627	,000	306,89	998	,000	425,28	1,39	422,56	428,00
Equal variances not assumed			306,89	920,28	,000	425,28	1,39	422,56	428,00

Table 46. Group Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Model1 H80	500	1336,78	24,89	1,11
KEI Optimized	500	713,57	15,54	,69

Table 47. Independent Samples Test

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	73,813	,000	474,93	998	,000	623,21	1,31	620,64	625,79
Equal variances not assumed			474,93	836,56	,000	623,21	1,31	620,64	625,79

KEI situation real & situation optimized

Table 48. Paired Samples Statistics

	Mean	N	Std. Deviation	Std. Error Mean
KEI Real	911,51	500	18,45	,83
KEI Optimized	713,57	500	15,54	,69

Table 49. Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
KEI Real- KEI Optimized	197,94	23,967	1,07	195,83	200,04	184,66	499	,000

	W (%)
Model 1 H50 - M1 H80	-0,04
Model 1 H50 - KEI real	-31,84
Model 1 H50 - KEI optimized	-46,64
Model 1 H80 - KEI real	-31,81
Model 1 H80 - KEI optimized	-46,6
KEI Real - KEI optimized	-21,7

Table 50. Change in average throughput time between models

	Judge	AM	TS	AJM	CO
Model1 H50	15,91	18,08	2,14	2,15	13,64
Model 1 H80	18,86	16,35	2,92	2,14	10,95
KEI real	21,23	11,81	2,79	3,06	8,17
KEI Optimized	19,64	10,89	2,74	3,06	8,15

Table 51. Productivity rate in percentage per server for each model.

Appendix 3: Settings during fifth simulation.

Model one H80:

- 80% of the cases after the CO towards a hearing
- Reply set variable
- After *repliek* 50 % of the cases done, 25 % towards a hearing, 25% towards *akte*
- One after *akte*
- Postponement as presented in input analyse

Model one H50

- 50% of the cases after the CO towards a hearing
- Reply speed set variable.
- After *repliek* 50 % of the cases done, 25 % towards a hearing, 25% towards *akte*
- One after *akte*
- Postponement as presented in input analyse

KEI real;

- 20 % *heroproeping (*recall at the first phase)
- *Verstek* & postponement percentages are as model one
- No end verdict during 1st assessment
- 80% of the cases after the CO towards a hearing
- Slow reply speed.
- 50 % of cases after hearing goes to a written round.
- After WR, 10% can go towards another hearing, only of the cases which never had a hearing before.
- No cases are finished during a hearing.

KEI optimized.

- 20 % *heroproeping (*recall at the first phase)
- *Verstek* & postponement percentages are as model one
- No end verdict during 1st assessment
- 80% of the cases after the CO towards a hearing
- Slow reply speed.
- 50 % of cases after hearing goes to a written round.
- After WR, 10% can go towards another hearing, only of the cases which never had a hearing before.
- 25 % of the cases are finished during a hearing.
- Quick reply speed.