

# Agent-based modeling: a new tool for legal requirements engineering --- introduction and use case (KEI)

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## Abstract

Foundational assumptions under legal systems come adrift with innovation in non-law disciplines. In an effort towards improved understanding of what is going on (and what can be done) we turn to agent-based modeling as a tool. We use the KEI project for our use case, apply Holland's ECHO framework as legal requirements engineering tool and use NetLogo as platform for implementation (resulting in an application we call *Epiframer*). We study parameter-change induced behavioral dynamics in the resulting artificial society. Findings are in two tiers: (i) on the role of the law in a multi-force field and (ii) on the role of institutions (also: sibling disciplines) for informing specialist legal professionals. We submit *epiframer*'s assumptions for diverse-disciplinary scrutiny as a closure.

We have not yet reached a level that warrants the deployment of statistical learning methods onto data provided by simulation runs and are aware that such an approach has — where legal requirements engineering events tend to be sparsely punctuated — limited added value for legal-requirements engineering situations anyway. With De Marchi (2005) our claim is that under such conditions computational, mathematical and, indeed, qualitative methods have complementary uses.

**Keywords:** Agent-based modeling, ECHO, Innovating legal practice, KEI, Legal requirements engineering, Disciplinary consultation.

## Preamble

We belong to the law discipline. The law field is experiencing baffling times. Its anchor is the assumption that humans are capable of deciding consciously and autonomously and that they muster sufficient comprehension of causality to be held responsible for the consequences. But current dynamics in political, economic and cultural divides combined with spectacular advances in, say, neuroscience, social media, big-data analysis and behavioral profiling seriously challenge our discipline's foundation. We suspect that we need outside help to find a bridge over these troubled waters. Yet inviting other disciplines in may add insult to injury.

To domesticate this risk we adopt a two-tier approach: the first concerns modeling how the law works in an artificial jurisdiction on a specific issue (we chose the Dutch KEI project for digitization of professional legal communication as our use case) and the second concerns modeling how artificial institutions (including several different disciplines) can have impact on the legal practice that is modeled in the first.

We adopt the expectation (as for instance expressed in Holland (2006), Bleda & Shackley (2012) and Gilbert et al. (2018), and substantiated by De Marchi (2005)) that agent-based modeling of complex adaptive social systems (cass) will on the fly improve our understanding of them. This, we submit, will be useful to legal requirements engineering<sup>1</sup> and to multi-disciplinary consultations.

Our framework is ECHO, our platform is NetLogo, our use case is KEI (a project to completely digitize communication in Dutch legal practice – begun in 2012, called off in 2018,

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two months before its planned and prepared comprehensive launch as a mandatory service). Our aim is to understand forces and mechanisms like those behind the KEI project's orbit.

## KEI

KEI (Dutch acronym for "Quality And Innovation," so "KEI" would translate into "QAI") is a project for and by the Dutch judiciary. It aims to offer a mandatory platform for communication between professionals in Dutch legal practice, an interoperability layer even – with gateways and semantic ambitions and all (e.g., Boston Consulting Group (2013)). The service is not operational, not adequate, not delivered on time and not within budget. In short: as of April 10, 2018, two months before it was to be launched as a comprehensive operational service, the project failed and was withdrawn for a "reset". Apart from stature loss to the Dutch judiciary as independent self-organizing institution, estimated waste of public funds is €200 million (Review Board TRConsult (2018), Raad voor de Rechtspraak (2018)).

In the Netherlands, successful ICT projects for public services (governmental and judiciary) are rare indeed. A decennia-long stream of documented failures, including failures to mend project design and management procedures, suggests that ICT projects for the Dutch public services produce sticky situations by default (e.g., Algemene Rekenkamer (2008), Schmidt & Corvers (2009), Algemene Rekenkamer (2013), Elias et al. (2015)). Considering recent Dutch history, a successful KEI project would have constituted a miracle.

But why? By now the state of the art in information technology is surely sufficient for adequate digital communication of legal stuff between courts (e.g., judges), professionals (e.g., lawyers, paralegals) and civil servants without getting too excited? And does not KEI aim to do exactly that? So if KEI success would have been achieved, why consider such to constitute a miracle?

We harvest a candidate answer from evolutionary psychology (Cosmides & Tooby (2013), Sloan Wilson (ed.) (2013)). As a result of our culturally nursed evolutionary predispositions for neat forms of categorization and analysis we all crave to understand things with straight sweeps of our mental brooms. The two capabilities release forces so powerful, that forms of specialization emerge (Smith (1776), Durkheim (1893), Krugman (1996)). Specialization evokes tunnel vision. Framing the KEI project as an ICT project makes the miracle involved invisible.

This invisibility is fed by the popular idea that computer programs and the services that use them are *manageable*. This is often felt to be a useful perspective, even when the world and the agents that a program serves are dynamic, have variable preferences and are hardly ever rational (Akerlof (1984), Gazzaniga (2011), Kahneman (2011)). To survive, such a service will need to co-evolve with its user base. ICT services for governments and judiciaries live uncertain, adaptive lives in complex, policy-wise and versatile systems and domains.<sup>2</sup> A lens that focuses on such aspects is likely to give better access to KEI's success-as-a-miracle.

How is that? As a Dutch service for digital communication for justice, across institutional jurisdictions, KEI will need to serve one supreme court, five courts of appeal, eleven courts of first instance, and, in all, several hundreds of municipal, provincial and national agencies with public function and, on top of that, several thousand different legal and paralegal firms and -professionals. These have all diverging institutional ideas on, say, security, cooperation, autonomy, efficiency and efficacy and are all organized around public functions like adjudication, legislation, administration, policing and enforcement. KEI's user interfaces and back offices will have to deal with these differences and their dynamics. Although infrastructural communication services with low-level semantic ambitions like HTTP (the web) and SMTP (e-mail) can handle such dynamics quite well, such dealings become more difficult to coherently manage for services with increased semantic ambitions.

One side-effect targeted by the Dutch government (which funds the service's development, maintenance and provision) and by the Council for the judiciary (which manages the judiciary

– further: the Council) is that the judiciary will work more efficiently and will be managed more effectively with the digitization of its communication (Boston Consulting Group (2013)). With forms and apps, implementation of semantic ambitions (also for administration and efficiency) becomes within reach. Thus we identify an administrative force that autonomously works towards increasing the service’s semantic level.

KEI was envisaged as mandatory by procedural law. By April 2018 the law is in place. KEI is not. Because a few procedural arrangements were considered a success during pilot projects, they have been implemented notwithstanding the overall withdrawal. One of these successes, the arrangement around digital supervision of bankruptcy administration becomes our target use case.

KEI works *in abstracto* as follows. A message initiating from KEI participant institution X is formulated in its proper language (often a form) and offered to the local service provider, which translates the message into the interoperability-platform dialect and routes it to the local service provider of the intended receiver’s institution, which translates it into the proper language of- and presents it to the receiver in participant institution Y. (See Figure 6.) We submit that, when such a service would operate effectively in the long run for the complete Dutch judiciary (happily adopting it), this would constitute a miracle considering the dynamics, the autonomies, the competencies and the complexities involved.

Our reason for selecting KEI bankruptcy administration supervision as a use case relates to the fact that adoption of the service by authorized professionals (judges, trustees) is less complete than hoped for. A similar effect has been observed around a miraculously successful European Large Scale Pilot (e-CODEX) with similar architecture, function and ambition for connecting the legal systems of the member states. The Dutch representative in the e-CODEX Consortium recognized the complexities involved (Velicogna & Steigenga (2016)) and initiated a project to find out why the e-CODEX service is under-used. This contribution is largely based on information gained while participating in the latter project.

As the current article aims to support comprehension of the KEI project through modeling it as part of an artificial society in action, legal professionals and practice-oriented civil servants are in our target audience. Therefore we have ordered technical elaborations to be content with finding themselves exposed in endnotes.

## ECHO-ing KEI

Imagine you are (like one of us) in the Netherlands, back home from a vacation in France. You get mail. Apparently you have been driving too fast near Toulouse, have been photographed in the act and are fined €45 as a result. The letter contains three complicated forms with instructions how to pay or to protest. Why a letter?

Communication channels available are letter, e-mail and web-forms/apps. All these services are communication platforms. All provide interoperability layers with multiple points of access and semantic-gateway supported architectures. They all work. So why do French civil servants on speeding tickets choose the channel they choose?

To understand the environment in which the choices under scrutiny are made, we model it. We create an operational, artificial society to help us find mechanisms that simulate how to realize (or thwart) an artificial goal. We use agent-based models when the rules and roles of players and conditions lead to complexities that we no longer can domesticate intellectually without computer support.

Why all these efforts for such a simple problem? Because the environment where French civil servants on speeding tickets are operational is a complex adaptive social system, just like the environments where Dutch legal professionals communicate are. And because unhampered communication between legal professionals is an elementary requirement for any legal system’s vitality. And because communication channels and their user communities are currently in

transition. We submit that the KEI-project failure is a symptom of a quite serious real-world situation which we apparently do not yet comprehend sufficiently.

ECHO<sup>3</sup> provides a platform to design agent-based models for studying how to design and domesticate artificial societies. We make building and studying them part of our legal requirements-engineering efforts.

## A few elements in our artificial society

Our artificial society has several types of agents (individuals, institutions, registries). Each has brands. *Individuals* can be judges (we have 8), bankrupts (20), trustees (8), creditors (80) and civilians (908). *Institutions* are a government, the council, courts, the bar, parliament, the KEI-team, ICT-firms, consultancy firms and the press. *Registries* are registries of messages and traffic data (messages can be laws, norms, contracts, track records, ... any *information*).

The artificial society has a “world.” Agents are located in it on *patches* (or plots). Agents can connect directly (as neighbors) or via *links* (which, like patches and registries, are specialized agents; patches for locating agents, links for connecting agents and registries for storing addressed information). Trustees are linked to bankrupts, judges and creditors. The links between judges and trustees support the full set of communication channels, the remaining links support letters and e-mails only. Figure 1 shows a screenshot that reports on an artificial society representing the KEI bankruptcy supervision niche.

Agents spend resources in transactions with other agents that provide resources. Agents handle communications via specific channels, chosen by the sender agent. In our artificial society all transactions revolve around communication-channel selection. Strategies available are letters, e-mails and forms/apps.

Spending and acquiring resources are explicitly modeled for agent types in communication patterns. Agent types relate to two sorts of characteristics, *tags* which produce (physical) phenotypes and *conditionals* which produce (cultural) convictions.<sup>4</sup> Both are dynamic, be it with different adaptation mechanisms and cycle times. Our artificial society (we will also call it *epiframer*) has a very limited set of tags. These can urge an agent to select strategies for maximizing *security*, *community*, *efficiency* and/or *independence*.

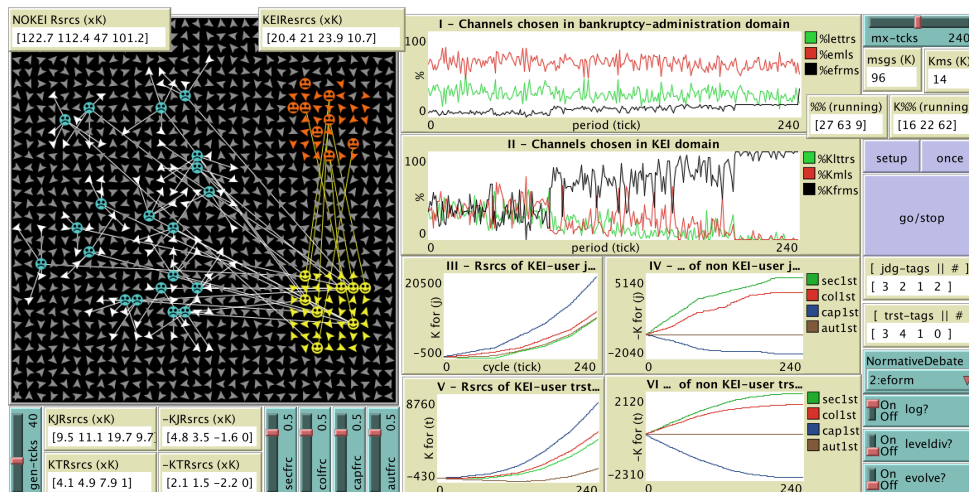


Figure 1: An early screenshot reporting on an artificial society

We use *patterns* to model regularities.<sup>5</sup> For instance for communicating messages: (i) sender creates an addressed message and offers it to the service provider; (ii) depending on the laws, contracts and the values attached, the service provider will contribute (or not contribute) to one or more collections of “Big Data” for better security, social-media, (fake) news and/or

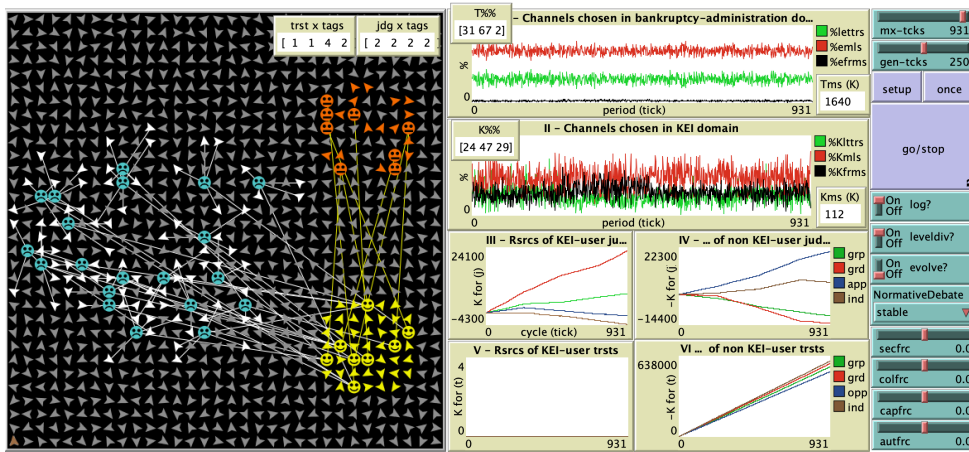


Figure 2: Another screenshot (Epiframer has been updated)

marketing services; (iii) the service provider transports (and transforms if digital) the message (via other service providers when necessary) to the addressee. This pattern is applicable to all three channels in the model.

The main pattern we use for the artificial bankruptcy administration works as follows: (i) judge appoints trustee; (ii) trustee calls creditors to register; (iii) creditors request registration; (iv) trustee decides on registration; (v) trustee calls for comments on plan; (vi) creditors comment (judge) on plan; (vii) trustee calls for the supervising judge's support; (viii) judge gives decision (in this pattern, the links with service providers and big data repositories remained implicit as we consider them to be ubiquitous).

Dynamics in our artificial KEI world are mimicked by processes, for instance pseudo-evolutionary processes as induced by "deaths" of agents whose resource-levels get below a threshold value, that are concurrently replaced by "newborn" agents (resulting from single-offspring Mendelian inheritance that follows "mating" of two randomly selected "living" agents and that collects from both parents half of their resources on the fly). Consequently, in this mechanism individual resource levels are proxies for individual survival and evolutionary fitness values. Another possibility to induce dynamics is via the infusion of cultural climate changes by the operator of the artificial society as discussed below.

In our artificial society, behavioral choices always relate to a foursome of resource values. *We all tend to be subject in a jurisdiction **and** to be member of several communities **and** to be operating on markets **and** to be free creative and autonomous agents in several networks.* So with any behavioral choice we assume that an agent in our artificial society takes into account what foursome of gains and/or losses are involved – qua security, community, economy **and** independence.<sup>6</sup>

## Setting up and reading a simulation run

To setup a simulation run we setup the artificial society's world and its agents. Each agent will get randomly assigned a tag (defining its type) and a value table resulting from processing a theory (like the one in Table 4) provided by whom operates the model. Setup will then assign 8 judge-roles to individuals in a part of the world that is made ready for them, 8 trustee-roles to individuals in another similarly prepared part of the world, 20 bankrupt-roles with each 4 creditors. Setup is completed by translating patterns into a network that can guide how agents meet and communicate – marking who will be the sender (and has to choose the communication channel) and who will be the recipient.

After setup, time starts ticking.<sup>7</sup>

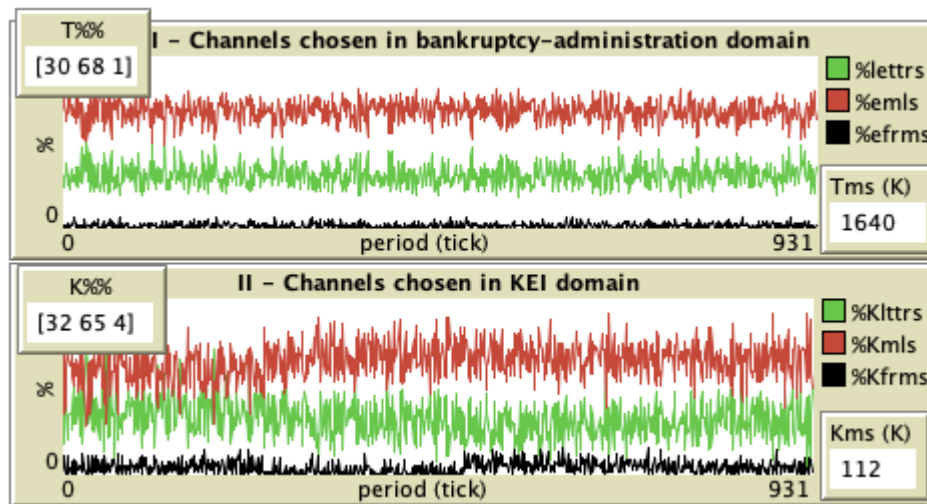


Figure 3: Reading Graphs I and II

In general terms the left-hand square is the fantasy world with bankrupts (blue, sad faces), creditors (white, faceless), trustees (yellow, glad) and judges (red, neutral). There are links between bankrupts and creditors, bankrupts and trustees and trustees and judges. Only the latter are open to the KEI service. Top right in the “world” are the current distributions of types over judges and trustees. In the middle band of Figure 2 we see the graphs representing the developments in channel choices (I and II) and those that represent incremental developments in resource acquisition (III - VI). The six graphs in Figure 2 all map their x-scores in ticks. Consequently, these graphs make the dynamics of their y-scores visible over ticks.

The right-hand side of Figure 2 is devoted to buttons and parameters that can be set for each run.

## Reading a simulation run

Graph I (the top graph in Figure 3) gives channel choices in the overall bankruptcy administration domain as modeled in our fantasy KRI system. It is apparent that under the current parameter settings and theory approximations the percentage of eform channel choices is low. Actually amounting to 1% of over 1.047 K messages sent. This shows how tiny a fraction of the overall messaging in the bankruptcy supervision domain is served by KEI.

Of course we can focus on the subset of messages that are allowed to use the KEI service (those between judges and trustees). In Graph II we see the percentage of KEI eform choices within that subset reach 2 % of over 71 K messages that could have used the KEI service. That the use of KEI's eforms is so low, is the result of our modeling the channel choice as optional (and not mandatory) and our modeling the qualities of the eforms as rather low based on personal inspection of the forms involved.

An interesting phenomenon every now and then occurred during the exploration phase: often periods do occur with KEI channel choices dropping to zero. This is a result of the small numbers of active judges and trustees. In such small numbers, the distribution of tags may vary wildly from the standard.<sup>8</sup>

## Turning to Resources

The Graphs numbered III - VI are on resource accumulation per tick. Resources are directly derived from the theory.<sup>9</sup>



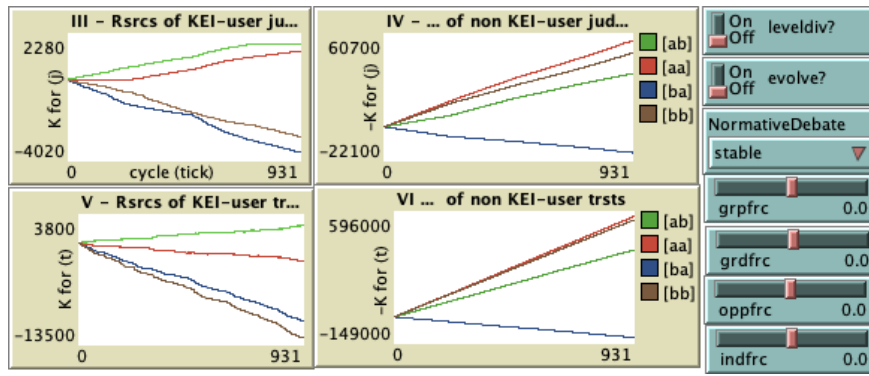


Figure 4: Reading Graphs III - VI: resources within the KEI domain

Graph III shows the dynamics in resource accumulation of judges that use the KEI service. For these, [ab] and [aa] resources steadily rise, while [ba] and [bb] resources steadily drop. I would be inclined to interpret this as an indication that using the KEI service is welcome to [aa] and [ab] type judges while it is unwelcome to [ba] and [bb] type judges. It seems worth while to investigate further whether this can usefully be interpreted as a trend that will guide the distribution of types over judges to get skewed in the long run and as how this trend would fit in current ideas on the separation of powers.

Graph IV shows the dynamics in resource accumulation of judges that use the KEI service. For these, [aa], [ab] and [bb] resources steadily rise, while [ba] resources steadily drop. Similar investigation options are inviting for who is interested in the state of the separation of powers.

Graphs V and VI show the dynamics in resource accumulation of trustees that use the KEI service and those that do not. The trends are analogous to those in Graphs III-IV with the exception of the [aa] type trustees, who seem to suffer in comparison with [aa] type judges.

For these, [ab] and [aa] resources steadily rise, while [ba] and [bb] resources steadily drop. I would be inclined to interpret this as an indication that using the KEI service is welcome to [aa] and [ab] type judges while it is unwelcome to [ba] and [bb] type judges. It seems worth while to investigate further whether this can usefully be interpreted as a trend that will guide the distribution of types over judges to get skewed in the long run and as how this trend would fit in current ideas on the separation of powers.

Graph IV shows the dynamics in resource accumulation of judges that use the KEI service. For these, [aa], [ab] and [bb] resources steadily rise, while [ba] resources steadily drop. Similar investigation options as for Graph III are inviting for whom are interested in the state of the separation of powers in the toy world.

## Harvesting Insights on KEI/e-CODEX using *epiframer*

Modeling bottom-up behaviors in artificial societies requires theories and assumptions about generalities in individual's characteristics in order to domesticate multitudes of individual choices. Consequently, whatever insight we harvest from behaviors in such societies is predicated on such theories and assumptions.<sup>10</sup> *Epiframer* can show us how our models and assumptions make an artificial society behave. These behaviors can in turn be translated into hypotheses that are open to falsification. In this manner, artificial societies, empirical data and qualitative reasoning can combine towards new insights/knowledge on the behaviors of complex adaptive social systems.

*Epiframer* makes such a theory operational. We can use it to harvest a few hypotheses related to the questions behind the model's origin: Why is the successful KEI-service under-used? Why did the KEI project begin with high expectations in 2012? Why did it fail in 2018?

## Why is the successful KEI-service under-used?

Our model suggests that all users that could choose the KEI channel would choose the KEI channel when this would result in superior combinations of resource values. In our use case these are inferred from the values in Table 4. The mechanics in our Tier-1 model are simple: each sender selects a value vector that relates to his tag and to the pattern at hand (the appropriate line in Table 4). With the help of this value vector sender selects the channel to be used (the channel with the highest value – when there are ties one-of, randomly). Then, sender collects the values from the vector as resources gained. If this mechanism leads to a channel being underused, an effort could be made to adapt the individualised Table 4 such, that a desired result is produced. Looking at Graph II in Figure 1, it appears that adding 2 value units (look at the results after four generations) to each value for the eform/apps channel will do the trick. So when we choose a simple mechanism-design approach and work from the desired goal back towards a mechanism that works in our Tier-1 use case, we get a first result (not necessarily the best or most efficient).

The result is – roughly – that all (all from the dedicated audience) will choose the KEI channel for communication when the choice will provide better resources for each and every type in the audience. This means we can conflate the expected four hypotheses into one: *the KEI channel will be chosen by all, when it delivers superior resources to users from all four tags*. In other words, for reaching this goal, resources should be adapted. Efforts must be made to make the KEI channel most resourceful – to whom tend to maximise security, *and* to whom tend to maximise community, *and* to whom tend to maximise economy *and* to whom tend to maximise individual independence. In short, a secure, social, free (as in free beer) and optional service.

For what we know about our use-case KEI service, not many of the tag-related resource requirements are met for the targeted users. When the service is only to be used in its eform-formatted form, it tends to rob the communicators that use it from all sense of interconnect-edness, and from all respect for professional expertise and initiative. Maybe under-use of both KEI and e-CODEX are symptoms, revealing that the service made available has at least some below-par tag-related resources. And, adding insult to injury, the economy-tagged users may be unhappy too, because e-forms as they are currently designed will be experienced by all as unnecessarily cumbersome and time consuming. Finally, the security-inclined in the targeted audience are uncertain because the whole service has not yet christallized in a stable and secure institutional form, while the innovations carried by the new service may prove to be a threat to their professional positions.

Finding answers to how the KEI service can gain the profile of a secure, social, free and optional service is tricky business. Certainly in a time where AI applications manage to know our preferences before we do, manage to present fake news as political weapons and manage to use generative AI to fake evidence by adapting footage – and especially when such innovative applications are consistently ahead of protective mechanisms. In this context it is appropriate to list a few ways how the Tier-1 model could be drummed into shape. One way is to improve the service such that its values become first overall. As an observable, not as in fake news. Lets call it *the path of competition and hard work*. Another way leading towards success could be through substantive reputation damage suffered by the other channels and/or reputation boost enjoyed by the eform/app channel. Lets call this *the path of cultural-climate change*. Yet another way would be when the different fitnesses of individuals would support an evolutionary orbit towards eform/app-choosing individuals getting a reproductive advance over individuals that do not. Lets call this *the path of evolution*. Finally, the use of targeted legislation annex enforcement measures may be used to stamp the KEI channel as mandatory and will, consequently, be used by all addressed (as judges and trustees do not have the leeway to ignore mandatory law). Lets call this *the path of mandatory law*. In all four approaches, institutions are conducive to realise adaptations in the critical value table (Table 5), or in de



distribution of agent types over judges and trustees.

## What About Tier-2?

A Tier-2 agent-based model of the KEI service is on the institutions that influence individual choice. We visualise institutions as networks of agents that can themselves decide and behave as single agents. Institutional networks have characteristic architectures: either hierarchy, community (preferential attachment), market (random) or lab-related (small-world).<sup>11</sup> Networked institutions have main targets: security, solidarity, efficiency, independence. For the Tier-2 analysis of our use case (KEI) we model eight institutional types. We list them by name with additional (network type – main target type): government (hierarchy–security), the council (hierarchy–independence), courts (lab-related–security), the bar (community–solidarity), parliament (community–security), the KEI-team (community–efficiency), ICT-firms (market–efficiency), consultancy firms and the press (market–independence) as institutions. (As we evaluate with four-value vectors, institutional types are not “pure”).

Before we can attempt to design value-code tables we need to identify what patterns of communicative behavior we are looking at. In Tier-1 we have individuals behaving in ticks that together make generations that create a run (era) in the life cycle of an artificial society. We have 20 bankruptcies per tick with 20 messages per bankruptcy; our example in Figure 1 shows 6 generations of 40 ticks each (we make a generation span one year) in an era of 260 ticks (6 years). In Tier-1 perspective, Figure 1 presents the dynamics in a system with something like 96.000 messages in six years. We domesticated this number with 5 patterns. Are there feasible patterns for analysing Tier-2?

We look at the four paths that induce changes in individual value bases : competition/innovation, cultural-climate change, evolution and mandatory law. Lets consider the institutions that could play a role in our use case (KEI). Competition/innovation is for ICT firms to operate; all Tier-2 institutions influence the cultural climate; evolution proper is phenomenological and (in our minds) not a path to meddle with outside the medical; mandatory law is for parliament and government to operate. When we accept that major innovation and major mandatory-law changes on telecommunications are sparsely punctuated through history and may occur as contingencies any time, we will not model them and refer to monitoring real world processes (of sufficient importance to warrant the effort) for incentives to adapt the basic value table and then reconsider *epiframer* behavior. Consequently, we focus further on cultural-climate change.

## Cultural-climate Change

Changes in cultural climate that can work to help the KEI service to dominance would be through a serious reputation boost enjoyed by the eform/app channel and/or through substantive reputation damage suffered by the other channels. For this, many diverse options are open, e.g., publication of real digital disasters/breakthroughs – and other Public-Relation campaigns. Even fake news campaigns via the press (social media included) could help do the trick. So we accept that the cultural climate is a result of a clash (or combination) of PR efforts by the different institutions involved. Here we encounter completely different time cycles and real complexity.

We draw a graph in Figure 5 in an attempt to discover Tier-2 communication patterns (in the manner explained at Figure 6). In drafting this Tier-2 model we are not focusing on the communication patterns to find out what channels have been chosen and why. Here we are interested in communication patterns that allow conditionals and institutions to influence the cultural climate that is conducive to changing an individual's Tier-1 value table on KEI

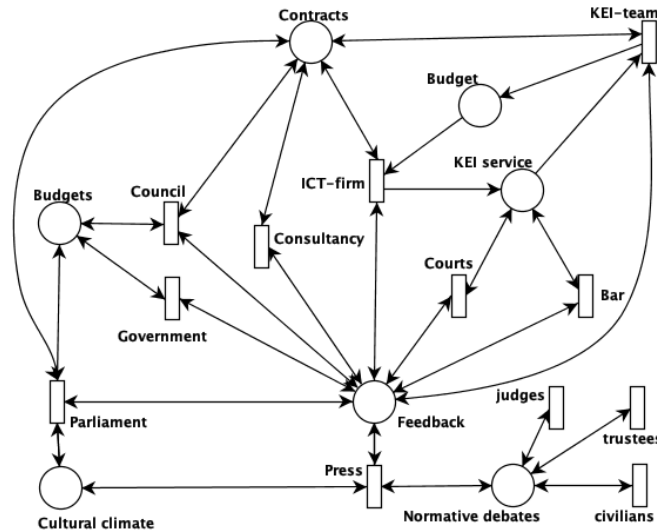


Figure 5: Discovering Tier-2 communication patterns

communication. At the heart of Figure 5 we see a registry with feedback information on the KEI project, information that our institutions make available to the public via the press. Any public Tier-1 project is subject to budgeting so the KEI project may begin with budgets being provided by Government under the blessing of Parliament. KEI is a project for the judiciary and managed by the judiciary (the Council). The judiciary is managed by the Council, which is manned by the judiciary, as the separation of powers has been reorganised in the Netherlands in 2000 (with computing becoming ubiquitous in administrations) by introducing the Council as a managing institution, internal to the judiciary (see Schmidt (2007)).

Considering our focus on how an individual's Tier-1 value table on KEI communication can be influenced by institutional behaviors, we modeled the press as a central intermediary. All institutions in Figure 5 have reciprocal links with the press. Consequently we can visualize that all institutions inform the press and that the press informs all institutions. [Judges and trustees are, like civilians, individuals, not institutions – they participate (like all, via the press) in the normative debate on behavioral choices that supports the whole system of Figure 5.]

### Expert consultation

In Tier-2 we need value tables for the institutions in Figure 5. We again assume that the institutions have policies that relate to tags (respectively maximizing security/legitimacy [aa], fraternity/equality [ab], capability/efficiency [ba] and autonomy/independence from both hierarchy and group pressures [bb]). From each specialist discipline (law, sociology, economy, science) a single column in the value table is reserved. Values relate to willingness to invest in establishing, maintaining and running infrastructural communication services: for letters, e-mail and eforms/apps. Like in Table 1:

The idea is, that the experts provide informed estimations expressed in codes as provided in table 3.

### The normative debate

We will use Table 1 for simulations of Tier-2 processes and their influences on the Tier-1 value tables. It is possible to do agent-based Tier-2 simulations. For practical reasons we contend ourselves with modeling contingencies we do not think to be too eccentric for investigating how the Tier-1 processes would react.

We begin with a normal setting. The Council has secured the budget for the KEI project. It has drafted a set of contracts and agreements with a project team, an ICT-firm, consulting

	[aa]	[ab]	[ba]	[bb]
	lttr eml efrm	lttr eml efrm	lttr eml efrm	lttr eml efrm
Council				
KEI-team				
ICT-firm				
Bar				
Courts				
Consultants				
Government				
Parliament				
Press				

Table 1: Expert estimates of willingness to invest to be specified by diverse specialists

firms and even the Government and Parliament (as the KEI project included a concurrent effort to adapt procedural laws to its practices). When these contracts and agreements are in place and consultations urge to proceed, the ICT-service can be arranged by the KEI team and the KEI-providing ICT-firm around a budget and the service requirements. When accepted by the KEI-team, the resulting service can be made operational and provided to its target users, the courts, the members of the bar and the functionaries that operate under judiciary supervision (like trustees do). The feedback is collected and processed by the press, feeding normative debates and, with this, the cultural climate. Changes in the cultural climate may induce changes in individual value tables. We can simulate this proces in the manner described.

In the normal setting we found four patterns. One around budgetting. A second, around contract and agreement formation. A third, around ICT-service design, building and delivering. And a fourth, around feedback and the press. We submit that these patterns can have influence on the cultural climate and climate changes that influence individual value tables. We discuss how by addressing one questions and one contingency.

### Why did the KEI project begin with high expectations?

As we mentioned earlier, successful ICT projects for public services (governmental and judiciary) have, consistently, been rare indeed in the Netherlands for decennia. A long stream of documented failures of large projects, including failures to mend project design and management procedures for them, suggests that success of large, public, Dutch ICT projects is a contingency (e.g., Algemene Rekenkamer (2008)). In this context it is difficult to grasp why the Council designed the KEI project to support a cold-turkey transformation from paper to digital for all Dutch litigation in one go. Even more difficult is it to grasp how budgeting could be realized and how agreement with and commitment from the government, parliament, ICT-firms, the bar and the judiciary on such an approach could be acquired.

Yet this is what happened. Looking at things through a lab-conditioned lens would, when choosing *support*, lead to very low resources. For those who prefer independent judgment, that is. We guess that somehow the cultural climate for transforming Dutch legal practice from paper-based into digital must have been extremely strong, strong enough to make substantial and blatantly visible risks ignored or acceptable.

A significant clue can be found in Boston Consulting Group (2013), in which the KEI business case is presented as a means to reduce real-time consumption by litigation (up to 40%, without quality loss) and to reduce on personnel and paper-handling costs (a yearly reduction of €61 Million). Moreover, yearly cost reductions in the range of €210 Million are suggested to parties that depend on the courts efficacies.

It remains difficult to understand how the institutions involved could swallow such unlikely vistas, unless we accept that the cultural climate involved is not only dominated by neo-classical

economic adagia, but also and concurrently with rule-of-law adagia (like: the separation of powers), and with the unfathomable, AI propelled captivations of social-media emerging with Big-Data based nudging. This is complex. Modeling a Tier-2 value table as in Table 1 is useful here. This type of value table does not expect homogeneous institutions, but institutions that are coalitions of 4 groups with different tag-related preferences (see also Perri 6 (2003)). Thus our modeling approach implements the assumption that institutions are coalitions of four tag-related groups. Such groups have distinct identities yet cooperate in the support of their institution. This is a delicate balance (e.g., Asch (1951), Abrams & Levine (2012)). Such groups can be sensitive to diverging Big Stories (e.g., rules are rules, solidarity-, welfare-, objectivity-first) and succeed to back their group-identities while concurrently cooperating for their institution's viability. This, and the relative dominance of the Big Story of the moment in the Netherlands (economic growth first) helps explain why the KEI project was begun in 2012 with high expectations. An important corollary is that our approach apparently is able to model "rational choice" that is incoherent with "objective reasoning". Another is that intra-institutional cohesion and between-institutional competition are both important for institutional fitnesses, be it at different levels (see also: Sherif (1961), Perri 6 (2003), Schmidt (2009), Haidt (2012)).

### **Why did the KEI project fail in 2018?**

The KEI project began its orbit seriously in 2013. Project teams were established, management procedures and yearly reviews put in place, and when the time was there, pilots made operational. In May 2018 the whole system (mandatory digital litigation over the complete legal domain) would come live. The bar had prepared itself and so had the judiciary. Somewhere a problem must have emerged. On February 22 a review team was asked by the Council for a quick scan, which was provided on April 5, The main gist being that the whole legal system ran serious risks and that the project needed a reset as project governance was seriously unbalanced (Review Board TRConsult (2018)). A week later the project was brought to a temporary halt.

The first reason for concern is, according to the quick scan team, that management and commitment have been in serious disbalance, leading to risks that could derail the whole project. The central problem is the disfunction of the triangular network between the Council, the Courts and the ICT-services. This network is supposed to keep the project domesticated but did not function adequately. Addressing the issue is by no means a trivial affair, receptive to speedy solutions.

Of course there must have been more. We already found significant clues in Boston Consulting Group (2013), in which the KEI business case is presented as a means to reduce real-time litigation lengths (up to 40%, without quality loss) and to reduce on personnel and paper-handling costs significantly. We find it difficult to believe that court personnel is idle during the times that paper dossiers are being transported (as suggested by the presented shortening of procedures), otherwise a reduction of litigation length would imply a growth in adjudication staff. All in all we would not be surprised when the KEI project leaves the judiciary in a position of expected cutbacks, concurrently with a growing workload.

We found another clue in the e-forms designed for and used in KEI-supported bankruptcy administration. For sending a request to a judge the trustee is confronted with a form, accessible via drop-down lists – the first of a length with over 23 wildly diverging concepts. The trustee will have to process such in a task he could easily perform with a simple un-formatted letter or e-mail. Such ICT practices will reduce the resources a trustee acquires through the use of e-forms as a channel. We would not be surprised when many who are willing to use the service in principle will be discouraged by such semantically daunting demands.

Of course the reset of the KEI-project 2 months before its announced deployment has/had influence on the individual value tables of agents in the Tier-1 model. Presumably judges (and their trained personnel) lose confidence in the e-form/app channel. We can model this with

parameter settings as described in paragraph 5.4.

## Concluding Remarks

Our aim is to understand forces and mechanisms behind the KEI project's orbit by treating the project and its environment as a complex adaptive system and by using the platform that Holland designed for studying such systems (ECHO), employing a two-tier approach to agent-based modeling.

For modeling we address the notion of individual preferences as a compound and represent them in a neo-Durkheimian<sup>12</sup> four-value vector that is processed into a resource-value table and that is made operational in the Tier-1 model. This move is neither new nor eccentric (e.g., see e.g., Perri 6 (2003), Ingram et al. (2012), Olli (2012), Ingram & Bush (2013), Owadally et al. (2018)). It can help us calibrate the model's behavior to what we see in the outside world and that helps us understand what is going on because the model's mechanics are carefully mapped to natural-language reasoning. Parameters in the Tier-1 model also allow the use of the model to find manners for gaining a predefined goal (in an informal mechanism-design approach). Tier-1 modeling proved a veritable agent based issue, with some 96.000 transactions in a run.

The effort to model how the law works in an artificial society turned out to be a question that cannot be answered by the legal discipline alone. From the moment onwards that we accept that the law has value in a currency that is not identical to the \$ (€ £), we realised that modeling how the law works implies modeling how culture works, and how the economy works, and how science works. That modeling how the law works implies modeling these in concert. We find our results – showing that it can be done at all – exciting and are already planning sequels that focus on legal themata (privacy? the rule of law? global market power and competition?) while inviting sibling disciplines in for normative debates on compound models.

We find it really difficult to refrain from conclusions at this stage that go further than our having established that the compound ideas of rationality that have been around for some time can be effectively modeled in artificial societies for research purposes. And that such an approach can serve cross-disciplinary communication and political decision making. We are happy to notice that the approach is gathering momentum. This may well be a corollary of the general inability to explain recent observable phenomena (like for instance ISIS, the divides, energy consumption, the credit crisis, Trump and Brexit) with traditional forms of rationality as its vehicle.

Running the Tier-1 model left us with a calibrated theory in the form of a resource-value table. The Tier-2 model aims at understanding how such a tabel can be influenced by institutions. Applying the same ECHO approach we got results – not in numbers but in arguments. We conclude that applying the ECHO framework with a neo-Durkheimian flavour does seriously help reduce the parameter space while it helps us to comprehend what moved KEI, its institutions and its users, in the pluriform dance around arguments and collective decision making as is characteristic to all political platforms.

The type of comprehension gained includes forms of specialist disciplinary knowledge. It succeeds in doing so by distributing the neo-Durkheimian approach to model preferences/resource values over such specialist disciplines as are appropriate – e.g., law (hierarchies), anthropology/social psychology (norms), economy (contracts) and descriptive science (lab conditions).

In this approach we expect to win comprehension even in domains with exploding parameter spaces. Yet, comprehension cannot be complete. We study behaviors that result from individual and grouped actions, by whom are considered responsible and autonomous, so we cannot hope for accurate long-term prediction. Soit.<sup>13</sup>

## Notes

<sup>1</sup> We conceptualize legal requirements engineering as the effort to find and/or design legal mechanisms that support the realization of a predefined goal.

<sup>2</sup> Complex adaptive systems are systems that involve many diverse, networked components that adapt or learn as they interact. They are at the heart of important contemporary problems (Holland (2006)). All systems that governmental ICT services serve are such systems (Ruhl (1996), Zhang & Schmidt (2015)). To see and understand them (the KEI miracle included) requires adequate perspective and tools. Complexity theories provide such (Mitchell (2009), Holland (2014)). John Holland even provided a framework for studying complex adaptive systems (Holland (1995)). He named it ECHO. We use it to study KEI in the domain it serves.

<sup>3</sup> ECHO is designed by John Holland, whom we accept as an authority on complexity research. Its first use is in listing essential characteristics of complex adaptive systems, thus reducing our parameter space enormously. Holland mentions (Holland (2006) – what follows is our interpretation *ad hoc*): (i) diverse agents, (ii) agent connectedness (agent encounters via networks), (iii) agent “metabolism” (or agent resource-acquisition and resource-spending mechanisms), (iv) agent characteristics (visible (“tags”) and invisible (“conditionals”)), (v) if-then rules, (vi) patterns, (vii) evolutionary processes and (viii) emerging phenomena (Holland (1995, 2006)). We use all these elements for ECHO-ing KEI.

<sup>4</sup> With “evolution” we also refer to non-biological processes that can be modeled in terms of life cycles, reproductive success, variation and fitness. As far as such processes concern the dynamics in jurisdictions, cultures, markets and disciplines they are modeled as such (as pseudo-evolutionary mechanisms).

<sup>5</sup> We use simple *Petrinets* for pattern discovery (agents are Petrinet transformations, registries/registries are Petrinet places, links are Petrinet edges). Like Van Der Aalst (2011) we find them useful for their potential to distinguish actions from states while modeling. Patterns are there, we claim, when agents and registries can be substituted in a stable structure. An example is in Figure 6.

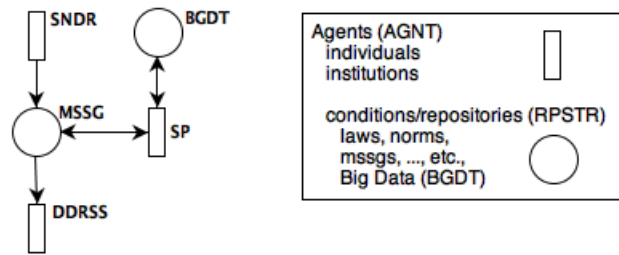


Figure 6: Communication infrastructure pattern

Figure 6 shows a pattern for communication infrastructures. Circles are repositories (places) and boxes are agents (transformations). The pattern is supported by the idea that any communication channel can be represented in it. A sender (SNDR) creates an addressed message (MSSG) and offers it to the service provider (SP). The service provider transports (and transforms if digital) the message (via other service providers when necessary) to the addressee (DDRSS). Depending on the laws, contracts and the values attached, the service provider will contribute (or not contribute) to one or more collections of “Big Data” for better security, social-media, (fake) news and/or marketing services. The pattern is applicable to all three channels in the model.

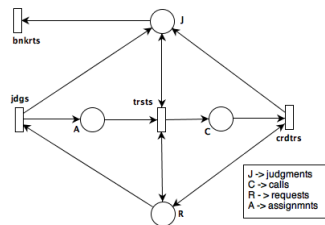


Figure 7: Main pattern for the KEI use case

Figure 7 shows the main pattern we use for the artificial bankruptcy administration. It works as follows: judge appoints trustee; trustee calls creditors to register; creditors request registration; trustee decides on registration; trustee calls for comments on plan; creditors comment (judge) on plan; trustee calls for the supervising judge’s support; judge gives decision. (In Figure 7 the links with service providers and big data repositories from Figure 3 are implicit as we consider them to be ubiquitous. Making them explicit in the graph would clutter it.)

<sup>6</sup> *Note on the adoption of the four-value frame.* We mentioned that our roots are in the law discipline. We also and concurrently have roots in different cultures, European and Chinese. These cultures show differences in collective attitudes towards social, legal, economic and individual interests. Despite these differences, Europe and China share a single socio-political universe. When our modeling platform is to serve our cooperative research it needs the capability to respectfully handle cultural differences. We do not find that the powerful assumptions on rationality, preference stability and equilibrium dynamics as widely adopted in neo-classical economics provide sufficient analytic potential for whom it makes sense to differentiate between values like security, fraternity, welfare and liberty. (Kaplow & Shavell (2001) can be read as defending the opposite). To us, the differentiation is essential. We do not think that adopting neo-classical economics as the social theory of everything can deliver it. Although we undoubtedly need it for understanding the role of economics, we do not think that it could provide a comprehensive descriptive model that usefully explains any substantial period of socio-political dynamics in terms of welfare economics alone. (Our point in case would be the socio-political orbit of any jurisdiction in 1921-2020. E.g., Europe? China? USA?) No specialist discipline can, we submit.

We consequently have looked elsewhere for guidance. We need a social-scientific cosmology that does include economics, yet does not strive to reduce human behavior to market behavior alone. We found much in work by Mary Douglas *cum suis* that serves our purpose (Douglas (1978), Douglas & Wildavsky (1982), Wildavsky (1987), Thompson (2018), Douglas (1992), Verweij & Thompson (2006), Ney & Verweij (2015)) and adopt it for the guidance we needed for implementing our brand of Holland's ECHOing framework.

We address the issue of how agents choose. We adopt description in a rule-based, algorithmic manner. We already hinted at the type of inclusive rationality we aim for. Then, like now, we reduce Douglas' work to a few modeling assumptions. Table 2 shows an example of the universal structure we offer for the specification of values that guide the choices of agents. The table relates agent-types with behavioral options. In our artificial world we have four agent types (respectively maximizing security/legitimacy [aa], fraternity/equality [ab], capability/efficiency [ba] and autonomy/independence from both hierarchy and group pressures [bb]) and three behavioral options (communication channels: respectively mail, email and eform).

situation/pattern	letter	email	eform
security/order [aa]	p	p	?
equality/collective [ab]	n	p	?
capability/efficiency [ba]	u	n	p
autonomy/rights [bb]	n	n	n

Table 2: tags × strategies: per situation

Table 2 is actually our kick-off theory on the resource values of a judge who supervises a bankruptcy administration and must communicate an appointment to a trustee. The table reflects the following: [aa] when the judge cares for security, letters and e-mails are preferred (p) and it is unclear (?) what eforms will bring since they have been introduced recently and their efficacies, as part of the KEI project being reset recently, are dicey; [ab] when the judge is keen on behaving in a manner that fits in with his peers, using a letter will be indifferent (n), e-mails will tally with what most of his colleagues will be inclined to do (and thus be preferred) and eforms are again unknown; [ba] when the judge likes innovation and efficiency, letters are old-fashioned (unfavored (u)), email is indifferent and forms are preferred; [bb] when the judge is protective of judge independence (autonomy) all channels will be considered indifferent as they all have risks of traffic data being harvested by service providers and of them being used for applying commercial, cultural and hierarchical pressures.

?	(don't know)	random 3 - 1
m	(mandatory)	2
p	(preferred)	random 2 + 1
n	(neutral)	0
u	(unfavored)	random 2 - 2
f	(forbidden)	-2

Table 3: Code conversion rules

We name the contents of Table 2 a kick-off theory because we do not claim it to be valid as a description of how things work in the real system that our artificial system mimics – what we claim is that it is an initial formulation of the machinery that works in our artificial world and that we can manipulate in a manner that allows us to reason about falsifying or adapting it based on comparison and interpretation of empirical observations in the artificial and the real world. And that such will enhance our understanding. For implementing value-processing based choice algorithms we need to convert the codes used for modeling resource values into numerical values. For KEI we adopt a simple table with code conversion rules. It is in Table 3. Application of these rules lead to a numerical version of Table 2.

Table 4 contains a complete theory for KEI in a condensed form (as we used it for our simulation runs).

An important caveat is the use of randomization here (random 2 yields 0 | 1). It is a simple approach to model basic forms of autonomy (and, with this, a modeler's uncertainty).

An important issue then becomes how to apply the randomization (at preparing the initial state of a run, at new generations, at new periods or at new bankruptcies. We choose to apply the randomization with the initiation of individuals at the setup of the run. Thus, each individual gets its own resource-value table.

These Tables illustrate our frame for specifying resource values. It suggests that any value involved in a behavioral choice can be situated in one of four categories. Douglas (1992):178 uses quadrants for identifying these categories in a way that tallies with four natural but incompatible organizational forms – hierarchies, collectives, markets and

```

resource codes (pttrns x tags x strtgs)
jdg-trst -> [[p p ?] [n p ?] [u n p] [n n n]]
trst-prs -> [[p n f] [u p f] [u p f] [n p f]]
crdtr-trst -> [[p p f] [n p f] [u p f] [p p f]]
trst-crdtr -> [[p p f] [p p f] [u p f] [n p f]]
trst-jdg -> [[p n ?] [n p ?] [u n p] [n n u]]

```

Table 4: KEI resource codes



isolates. These organizational forms have different mechanisms that regulate their resource values: laws, norms, price mechanisms and individual ethics respectively. And these organizational forms generate value in different currencies in what they provide to the agents that constitute, invest in and enjoy their institutions, like public order, solidarity, wealth and access to information. One may feel a bit ill at ease with a four-currency vector, embedding specialist atomic evaluative concepts that are respected and at home in specialist disciplinary debates, yet seldom considered in concert.

Such concert would be the answer to Douglas (1992)'s appeal for normative debates. It would be served by a multiple value-factor approach such as we suggest. We will show what added values and costs an appeal to inclusive rationality bring to our further understanding of complex adaptive social systems. It may be useful to mention that the cultural-theory based assumption on four behavioral types has been widely tested empirically and has yielded a complete social-scientific sub discipline that some call "neo-Durkheimian theory" (Perri 6 & Swedlow (2016)).

<sup>7</sup>In the KEI model each single tick is a time slice that contains 20 bankruptcy-handling processes. Each bankruptcy is modeled to generate 20 messages. So one tick/period means 400 messages which in turn mean 400 channel choices. At the end of each period old bankruptcies will be resolved and new bankruptcies will be initiated with newly selected trustees (the yellow, laughing faces, from the pool prepared for them). The slider top-right allows the user to set the amount of periods - 931 in Figure 2. The six graphs in Figure 2 all map their x-scores on ticks. Consequently, these graphs make the dynamics of their y-scores visible over ticks. This is, however, no steady process: breaks happen periodically. These are related to "generations."

The periods between breaks are set with another parameter. It is the slider, bottom-left in Figure 1 (which moved to almost top right in Figure 2), allowing the model operator to set a number of periods that will together define the length of a generation. At each generation switch two things happen. First the set of active judges is renewed. Second, adaptive processes that relate to what I call cultural climate changes are activated too. The judge-renewal process may have influence because it may change the distribution of tags over active judges. Because there are few of them, such may have genetic-drift like effects. The adaptive processes that are sensitive to cultural climate changes have influence, because they have influence on the individual value tables as applied by individuals to make their choices. The four sliders bottom-right below the black square of the world can be set to indicate how the cultural climate on security, solidarity, economy and autonomy has changed (positive or negative). During each generation change such adaptations are effectuated on the individual value tables, but only for the tag-values as indicated with the chooser named "normative debate". This mechanism for incorporation cultural-climate change into the model's dynamics may be useful to the researcher/user of the model.

<sup>8</sup>This results from the mechanism that under different circumstances would generate genetic drift in niche worlds.

<sup>9</sup>How does a sender agent choose a channel and what resources will sender and receiver gain/lose by it? The nodes network that has been prepared will identify the pattern, the sender and the receiver. The model will relate individual tags, resource-scores, resource reservoirs and track records to these. The sender identifies the channel with the best sender-tag resource score (one-of when there are ties) and makes his choice accordingly, with accompanying adaptations of track record and resource reservoir. The receiver gets the resources belonging to the channel that has been chosen for him by the sender. The receiver's track-record and resource reservoir are also adapted, but with resources as-if the sender had been of the receiver's tag-induced type.

<sup>10</sup>In Tier-1 such assumptions are specified in inclusive resource-value models (in the form of  $pattern \times tag \times strategy$  tables for each individual. These tables are derived from a main table that has been provided by the researcher. An example for the KEI bankruptcy administration model is in Table 4.

<sup>11</sup>The "lab" organization is our answer to the apparent paradox of individuals that denounce rules and norms yet do form groups and networks. In many cultural-theory results, this group of "fatalists" (as these are often named) are left out of the analysis. We feel that heeding law neither norm neither money in presenting findings represents a high value for scientists and journalists and judges, for whom cherish independence, individual responsibility and descriptive truth. Lab conditions try to suppress the disturbing forces. The underlying network has, we assume, the small-world architecture as described in Watts & Strogatz (1998), Barabási & Albert (1999) and Van Der Hofstad (2016), because those who congregate around a principled target tend in general to form cultural groups with norms and small-world architectures. Academic disciplines do so too.

<sup>12</sup>We have to face the problem that what Douglas so brilliantly analyzed has become known as "Cultural Theory". The in-crowd calls it "CT", as cultural theory has quite different meanings in natural discourse. Yet "CT" does not make sense to the law scholars we hope to address too. Perri 6 uses "neo-Durkheimian theory" as a tribute to whom inspired Douglas. We use both, until the problem solves itself.

<sup>13</sup>Such does not tally with our addiction to completeness: to know it for once and for all and, as a corollary, feel in control. Demsetz coined it the "nirvana fallacy." The subject keeps recurring in discussions about complex adaptive systems, often referred to as non-linearity, because the hope to understand a complex adaptive system once and for all is a nirvana fallacy. Monitoring them and finding mechanisms that support short-term predictions is – like weather forecasting – what we are currently able of.

## References

Abrams, D. & Levine, J. M. (2012). The formation of social norms: Revisiting Sherif's autokinetic illusion study. *Social psychology: Revisiting the classic studies*, (pp. 57–75)

- Akerlof, G. A. (1984). *An economic theorist's book of tales: essays that entertain the consequences of new assumptions in economic theory*. Cambridge University Press,
- Algemene Rekenkamer (2008). *Lessen uit ICT-projecten bij de overheid; Deel B. Tweede Kamer nr 26643*, (100)
- Algemene Rekenkamer (Ed.) (2013). *Aanpak van ICT door het Rijk 2012*, Vergaderjaar 2012–2013 33 584 Nr. 1. Tweede Kamer der Staten-Generaal
- Asch, S. (1951). *Effects of group pressure upon the modification and distortion of judgment*, (pp. 177–190). Carnegie Press, Pittsburgh, Pa
- Barabási, A.-L. & Albert, R. (1999). Emergence of scaling in random networks. *Science*, 286(5439), 509–512
- Bleda, M. & Shackley, S. (2012). Simulation modelling as a theory building tool: the formation of risk perceptions. *Journal of Artificial Societies and Social Simulation*, 15(2), 2
- Boston Consulting Group (2013). *Programma Kwaliteit en Innovatie, Eindrapportage Validatie en Advies (Dutch) [ Program Quality and Innovation – Final Report, Validation and Recommendation]*. Tech. rep., de Rechtspraak [The Council for the Judiciary]
- Cosmides, L. & Tooby, J. (2013). Evolutionary psychology: New perspectives on cognition and motivation. *Annual Review of Psychology*, 64, 201–29
- De Marchi, S. (2005). *Computational and mathematical modeling in the social sciences*. Cambridge University Press
- Douglas, M. (1978). *Natural Symbols: Explorations in Cosmology*. Penguin Books
- Douglas, M. (1992). *Risk and Blame: Essays in Cultural Theory*. Routledge
- Douglas, M. & Wildavsky, A. (1982). *Risk and Culture: an Essay on the Selection of Technological and Environmental Dangers*. University of California Press
- Durkheim, E. (1893). *The Division of Labor in Society*, translated by George Simpson 1965. Free Press
- Elias, T., Ulenbelt, P., Fokke, M., Bruins Slot, H. & Meenen, P. v. (2015). *Parlementair onderzoek naar ICT-projecten bij de overheid*
- Gazzaniga, M. (2011). *Who's in Charge?: Free Will and the Science of the Brain*. HarperCollins
- Gilbert, N., Ahrweiler, P., Barbrook-Johnson, P., Narasimhan, K. P. & Wilkinson, H. (2018). Computational modelling of public policy: Reflections on practice. *Journal of Artificial Societies and Social Simulation* 21(1) 14, 2018, 21(1)
- Haidt, J. (2012). *The righteous mind: Why good people are divided by politics and religion*. Allen Lane
- Holland, J. H. (1995). *Hidden order: How adaptation builds complexity*. Basic Books
- Holland, J. H. (2006). Studying complex adaptive systems. *Journal of Systems Science and Complexity*, 19(1), 1–8
- Holland, J. H. (2014). *Complexity: A very short introduction*. OUP Oxford
- Ingram, D. & Bush, E. (2013). Collective approaches to risk in business: An introduction to plural rationality theory. *North American Actuarial Journal*, 17(4), 297–305

- Ingram, D., Tayler, P. & Thompson, M. (2012). Surprise, surprise. from neoclassical economics to e-life. *ASTIN Bulletin*, 42, 389–411
- Kahneman, D. (2011). *Thinking, Fast and Slow*. Farrar Straus & Giroux
- Kaplow, L. & Shavell, S. (2001). Fairness versus welfare. *Harvard Law Review*, vol. 114, 961–1388
- Krugman, P. R. (1996). Ricardo's difficult idea. <http://web.mit.edu/krugman/www/ricardo.htm>
- Mitchell, M. (2009). *Complexity: a guided tour*. Oxford University Press, USA
- Ney, S. & Verweij, M. (2015). Messy institutions for wicked problems: How to generate clumsy solutions? *Environment and Planning C: Government and Policy*, 33(6), 1679–1696
- Olli, E. (2012). *Rejected cultural biases shape our political views: a migrant household study and two large-scale surveys*. Ph.D. thesis, BORA
- Owadally, M., Zhou, F. & Wright, I. (2018). The insurance industry as a complex social system: Competition, cycles, and crises. *Journal of Artificial Societies and Social Simulation*
- Perri 6 (2003). Institutional viability; a neo-Durkheimian theory. *Innovation: the European journal of social science research*, 16(4), 395–416
- Perri 6 & Swedlow, B. (2016). Introduction to the symposium: An institutional theory of cultural biases, public administration and public policy. *Public Administration*, 4(94), 867–880
- Raad voor de Rechtspraak (2018). Reset digitaliserig van de rechtspraak. Tweede Kamer
- Review Board TRConsult (2018). Quick scan Review KEI. Review op risicobeheersing en basis-succescondities voor grote ICT-trajecten, Raad voor de Rechtspraak and TRConsult
- Ruhl, J. B. (1996). The fitness of law: Using complexity theory to describe the evolution of law and society and its practical meaning for democracy. *Vanderbilt Law Review*, 49
- Schmidt, A. (2007). IT and the Judiciary in the Netherlands – A State of Affairs. *Computer Law & Security Review*, 23(5), 453–460
- Schmidt, A. (2009). Radbruch in Cyberspace: About law-system quality and ICT innovation. *Masaryk UJL & Tech.*, 3, 195
- Schmidt, A. & Corvers, S. (2009). *Aanbesteding en innovatie - Juridisch handboek functioneel specificeren van aanbestedingen*. Sdu uitgevers
- Sherif, M. (1961). *The Robbers Cave experiment: Intergroup conflict and cooperation*. Wesleyan (available at <http://psychclassics.yorku.ca/Sherif/>)
- Sloan Wilson (ed.), D. (2013). What's wrong (and right) about evolutionary psychology?
- Smith, A. (1776). *An Inquiry into the Nature and Causes of the Wealth of Nations*. Project Gutenberg  
URL <http://www.gutenberg.org/etext/3300>
- Thompson, M. (2018). *Cultural theory*. Routledge
- Van Der Aalst, W. (2011). *Process mining: discovery, conformance and enhancement of business processes*. Springer Science & Business Media

- Van Der Hofstad, R. (2016). *Random graphs and complex networks*, vol. 1. Cambridge university press
- Velicogna, M. & Steigenga, E. (2016). Can complexity theory help understanding tomorrow e-justice? available at ssrn: <https://ssrn.com/abstract=2914362> or <http://dx.doi.org/10.2139/ssrn.2914362>. Paper presented at the Conference on Complex Systems, Law and Complexity session, Amsterdam 20-23 September 2016.
- Verweij, M. & Thompson, M. (2006). *Clumsy solutions for a complex world: Governance, politics and plural perceptions*. Springer
- Watts, D. J. & Strogatz, S. H. (1998). Collective dynamics of small-world networks. *Nature*, 393(6684), 440–442
- Wildavsky, A. (1987). Choosing preferences by constructing institutions: A cultural theory of preference formation. *American Political Science Review*, 81(1), 3–21
- Zhang, K. & Schmidt, A. H. J. (2015). Thinking of data protection law's subject matter as a complex adaptive system: A heuristic display. *Computer Law & Security Review*, 31(2), 201–220

## **Appendix - *epiframer* source code**

The source code is available at <https://github.com/dotlegal/Epiframer>