System dynamics and power

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Abstract

System dynamics projects in organizational contexts are impacted by power and politics. Case studies show how decision makers' interests influence both the modelling process as well as the implementation of recommendations. The system dynamics literature offers little in terms of conceptual understanding or empirical research focused on the impact of power. This paper discusses definitions of power, and its interaction with rationality and consensus. This is contrasted with system dynamics based organisational interventions. System dynamicists are encouraged to speak truth to power. They place themselves in the role of scientists, building decision makers' conceptual understanding and helping to identify policies that improve overall system functioning. An alternative theoretical perspective emphasizes the wide availability and accessibility of model-based decision support. The motivated information processing approach adds that sharing and processing information is motivated not only by finding the best solution for the group or organisation, but also by self interest. System dynamics lacks an understanding of the competent proself motivated decision maker. The focus on overall system functioning places individual interests and stakeholder relations in the background. To more directly capture these elements of power, a range of intervention methods complementary to system dynamics is described. This paper may help to ground system dynamics interventions in relevant literature and rethink practice.

Introduction

System dynamics is an analytic methodology that helps to understand complex problems and identify leverages for change. The field has a long tradition in modelling organisational problems and intervening to improve decision making. It is part of a broader set of Operational Research/ Management Science (OR/ MS) approaches, which share an emphasis on constructing models of the situation of interest. What sets system dynamics apart from most OR/ MS approaches is its emphasis on constructing a transparent, generic model of the structure giving rise to problematic behaviour. Involvement of decision makers, experts and other stakeholders is frequently sought, both for bringing in crucial data as well as to ensure model ownership and implementation of results. The literature offers many case studies that address the process of modelling and the resulting model, sometimes also addressing implementation of recommended policies. Several of these reports show how individuals or subgroups try to influence the modelling process so that is is more likely to support their goals, or work towards certain desired outcomes. Perhaps the best illustration of this is the line of publications on using system dynamics modelling in legal disputes (e.g. Stephens et al., 2005), starting from the Ingalls Shipbuilding case in the late 1970s. Ingalls experienced cost and schedule overruns in a large project for the US Navy and used modelling to show how changes in the contract had cascading effects (Cooper, 1980). The legal claim was supported by detailed modelling work, involving an Ingalls team working closely with consultants and drawing on dozens of interviews across the organisation. Stephens et al. (2005) observed a number of ways in which the opposing party defended itself and attacked the application of modelling: for instance by discrediting the method ('for this particular case, system dynamics is not an appropriate analysis method') or its application to the situation at hand ('it is not possible to build a reliable model of all the factors the analyst claims to have included in the analysis'). Overall, model-supported legal cases seem to have a beneficial outcome in terms of the settlement reached and ending the detrimental relation between the parties. An example with a less positive ending is provided below.

Box 1

Many countries in sub-Saharan Africa are rich in metal ores and copper mining is a major industry. In 2014 an African mining company decides to start a group model building project, seeking to increase cost efficiency. The modelling team meets with management and organises a first workshop. The workshop starts from an initial model showing how copper ore is mined, refined in a series of stages and finally shipped to the customer. It turns out that an important bottleneck is the equipment used for transporting ore. The rock containing ore is transported from the pit to the surface by trucks. If a truck breaks down this interrupts the workflow immediately. If the number of available company-owned trucks is not sufficient, trucks are rented from a nearby supplier. The number of trucks breaking down and the duration of the maintenance process seem higher than typical for the copper mining industry. This leads some managers in the client company to suspect that not all breakdowns are due to accidents or equipment wearing out. If a truck driver intentionally hits a rock wall and the truck is no longer functional, it needs to be replaced which creates additional revenue for the rental company. The modelling project may help to reveal evidence of such cases of corruption. However, after a successful start, members of the management team inquire about the content expertise of the modelling team. Since the team has no knowledge or previous experience in the mining industry, they lack content expertise. The argument that the team has been involved in modelling a range of other complex workflows and has extensive experience in applying system dynamics and working with stakeholders is not sufficient. After a few meetings the project is cancelled (confidential personal communication, 2015).

The example in box 1 raises a number of questions. Why is the modelling project prematurely ended? Why is the domain expertise of the modelling team used as a argument for stopping the project? One interpretation – an interpretation not checked by the participants in the case! – is the following. A fraction or subgroup in the client organisation profits from the way maintenance is currently organised. The modelling process may point to excessive costs of the current maintenance process. The subgroup therefore may seek to end the modelling project but can hardly use their profits as an argument for doing so. Referring to a lack of domain expertise is a pretext that hides their real reason but is effective in ending the modellers' involvement.

The current research on effects of system dynamics modelling provides little help in answering these questions or checking this interpretation. Controlled studies on the impact of modelling or gaming typically focuses on participant understanding of system structure or performance in steering behaviour in a desired direction. As mentioned, case studies on organisational interventions are available. However, these typically offer in-depth descriptions of single cases or seek to generalise over problem domains (similar to Stephens et al.'s paper covering litigation cases). System dynamics has a blind spot for power (De Gooyert et al., 2016). Sterman (2000) advises system dynamicists to speak truth to power, which calls for following scientific standards in modelling work. However, the fact that crucial data for constructing system dynamics models exist only in the mental models of decision makers, experts and other stakeholders (Forrester, 1992) means that information can be withheld, partially disclosed or spun to support a particular agenda. Speaking truth to power can also refer to the expectation that even powerholders will change their minds after seeing the truth, perhaps because even they have an incomplete understanding of their situation and a model-based analysis point them to new and relevant information. Alternatively, it could be taken to mean that powerholders provide rational arguments for their course of action and modelling may be able to reveal that these are less strong than hoped for. In other words, power plays a role in system dynamics based organisational interventions and the intervention in turn is expected to mitigate some of the effects of power. Looking more closely at the role of power is relevant as it builds the field's understanding of what happens in organisational interventions. Consideration of the role of power in analytical interventions in organisations is likely to become even more important in the future, given that societal challenges such as sustainability, loss of biodiversity and inequality involve stakeholder groups with diverging interests and different access to power sources.

This paper aims to answer the following questions: 1. How does power impact system dynamics based organisational interventions? 2. How do system dynamics based organisational interventions mitigate the impact of power, and which complementary tools may increase intervention effectiveness? To answer these questions the following section goes into different conceptualisations of power. A narrow definition is chosen, which focuses on power stemming from an actor's place in the organisational hierarchy, informal organisation and access to information. This allows us to separate power from two other constructs often discussed in relation to organisational decision making: consensus and rationality. The next two sections describe system dynamics practice and research and the way the field has addressed power. System dynamics is positioned as a scientific modelling approach. Research in the field focuses on cognitive deficiencies in decision making, and the major route for alleviating these is increasing insight into how problematic behavior is caused by the underlying system structure. The next section describes theoretical implications by looking into a an alternative perspective on supporting rational decision making and into motives for decision making. While system dynamics has highlighted the epistemic motivation, social motivation (ranging from proself to prosocial) also drives information exchange and processing. The section on practical implications suggests other intervention methods are suggested that complement current system dynamics practice and more directly capture elements of power, as well as aspects of rationality and consensus. The paper ends with conclusions, limitations and suggestions for further research.

Throughout the paper, boxed text segments provide examples of how power influenced system dynamics based interventions. With 'actor' we refer to an individual or subgroup in an organisation. With 'stakeholder' we refer to decision makers, experts and others who influence or are influenced by a decision.

Conceptualisations of power

This section describes different conceptualisations of power in organizational decision making. Starting from a broad definition by Weber, later authors such as Thompson, Pettigrew and Lukes have highlighted specific ways in which power manifests itself in organisational life. The tendency to bring more and more of what happens in organisations within the scope of power seems to culminate in the work of Foucault. In this paper we choose a narrow definition of power which allows us to contrast it with consensus and rationality. This in turn enables a more precise description of how these three elements influence one another.

The starting point for many discussions of power is Weber's (1978) early definition: power is the ability to get others to do what you want them to, if necessary against their will. In Weber's view all organizational members have some creativity, discretion and agency to use power. A person for instance has a degree of discretion over how to use her labour in an organisation, in line with or opposed to managerial directives. Management in turn is seeking to increase control and continuously looks for strategies to bring labour in line with directives, be it in the form of self-discipline or by creating organisational bureaucracies. Later conceptualisations show how the access of different subgroups in the organisation to sources of power shapes their room for manoeuvre. Thompson (1956) studied airforce operations and showed that the aircrew, while having a higher formal authority, depended on the ground crew's expertise for safety and survival. His conclusion was that the technical design of tasks and their interdependencies offer a better explanation for the distribution of power than the organization's formal design. Crozier (1964) and Crozier and Friedberg (1977) extend this understanding to include uncertainty: power is held by those who control the remaining sources of uncertainty. Examples that come to mind are the specialised staff departments in many organisations addressing personnel, IT or legal affairs. Routines throughout the organisation such as contracting with clients, processing information around products or services, or hiring personnel depend on advise from these staff departments. At the same time their special expertise (in labour or contracting laws, or software) means that their arguments and decisions can only be checked by persons with similar expertise. Box 2 illustrates how access to information operates as a source of power.

Box 2

A large German service provider experiences problems in workforce planning. The company needs highly skilled operators to ensure timely and effective provision of service. But selecting and training operators is a long and complicated process, and in the past was managed in a sub-optimal way. Periods of staff shortages were followed by periods of staff surpluses, with negative consequences for service quality, workforce costs and productivity. The company management decides to bring in consultants experienced in using system dynamics. The consultants work with stakeholders in the company to construct a model that captures the training process and reveals why the number of operators oscillates over time. An unexpected result of the modelling process is that a sensitive management decision is now made more transparent. Some managers see this as a problem, as personnel policies involve negotiations with department heads and employees and the model may reveal information that was formerly only known to managers, undermining the management's position in the negotiations. Further use of the model was foreseen, but scheduling additional meetings with stakeholders proves to be difficult. After several planning delays and cancelled meetings the project is finally stopped (personal communication Gröβler, 2017).

Uncertainty plays a role in intra-organisational life as well as in dealing with the organisational context. Depending on the context, different sources of power become relevant. According to Hardy and Clegg (1996) the list of potential sources of power is virtually endless. Depending on the circumstances, anything can be used as a power base: information, expertise, credibility, formal position, access to members at other hierchical levels or control over money, rewards and sanctions. The actual use of any of these bases of power brings politics into the discussion. Pettigrew (1973) and later Hickson et al. (1986) understand politics as the process of mobilizing power. If the mobilising is done by those outside of a position in the organisational hierarchy, it can be viewed as illegitimate and disfunctional. Legitimacy, according to Hardy and Clegg (1996: 761) '*is usually defined in terms of the 'organization', when writers really mean organizational elites: that is, senior management or top management teams.'* The organisational elites may seek to convince others of their views. Lukes' (1974) and Pettigrew (1977) show how power can influence ideas and desires, legitimising certain views and not others, and so prevent conflict from emerging out in the open. As an extension, and going back the idea of surveillance described earlier, Foucault (1977) analyses the micro-processes of power and disciplinary practices. These constitute ways in which norms become routinised and normalised. Hardy and Clegg (1996: 763): *'Surveillance is not only accomplished through direct control. It may happen as a result of cultural practices of moral endorsement, enablement and persuasion, or as a result of more formalized technical knowledge, such as the computer monitoring of keyboard output or low cost drug-testing systems.'* The prevalence of norms means that all actors operate within a web of power relations.

Foucault's (1977) analysis is wide ranging and makes tangible that power pervades organisational life. It shows how seemingly different aspects of organisational life are interlinked and in combination form the basis for decision making. Such an all-encompassing view has the drawback that it does not clearly seperate dimensions of power and may hide how different dimensions pull in different directions. The Competing Values Approach (Quinn & Rohrbaugh, 1983; Reagan & Rohrbaugh, 1990) clarifies which demands drive decision making and how these may conflict. Four perspectives can be contrasted based on their internal versus external focus and emphasis on control versus flexibility. Each perspective can be characterised in terms of means and aims.

Perspective	*Focus*	*Means*	*Aims*
Political	External, flexibility	Adaptivity, creativity	Finding solutions that are in line with a changing situation, uphold the standing of the group and are legitimate in the eyes of external stakeholders
Consensual	Internal, flexibility	Open expression, sharing opinions and sentiments	Reaching a collective agreement and a mutually satisfactory solution
Rational	External, control	Planning, setting objectives, evaluation	Achieving organisational goals and objectives
Empirical	Internal, control	Information management, coordination	Achieving full documentation and accountability

Table 1. Competing Values Approach (cf. Quinn & Rohrbaugh, 1983; Reagan & Rohrbaugh, 1990)

The Competing Values Approach adds to the previous discussion on power in a number of ways. Whereas politics was defined earlier as mobilising power (Hickson et al., 1986; Pettigrew, 1973), the Competing Values Approach clarifies this further by specifying goals: adapt to changing circumstances and maintain legitimacy. The framework also shows how the differing values underlying perspectives create tensions. Take for instance the political perspective which thrives in a flexible and creative context. Insisting on using concrete data (empirical perspective), on following a plan (rational perspective) or keeping in line with the consensus view (consensual perspective) places boundaries around flexibility and creativeness. In this paper we build on the idea of tensions between perspectives, but since we are concerned with the use of an analytic approach separating the empirical and rational perspective is considered a too fine grained distinction. We group the rational and empirical perspective together under rationality, leading to the framework depicted in Figure 1.

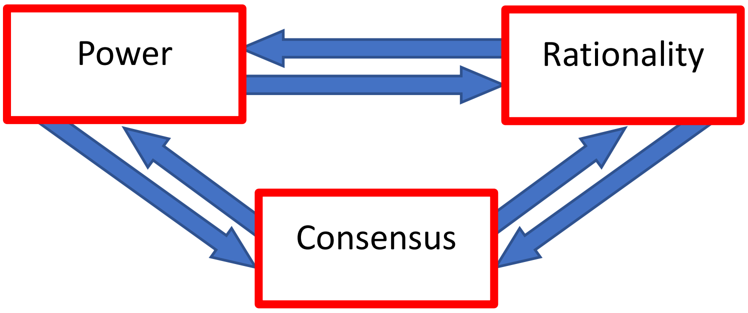

Figure 1. Central constructs driving organisational decision making

Below we define each of the three concepts and describe their mutual influences. We choose a narrow definition of power to separate it from rationality and consensus. The definition builds on Weber's and focuses on the organisational network and access to information. In this paper, we define power as the ability to get others to do what you want them to, on the basis of the formal or informal position in the organisation and access to information.

Rationality refers to an analytic, systematic, rule-based, and explicit mechanism for decision making. A rational approach to decision making starts by structuring a problem and defining a set of alternative decisions. Second, for each alternative, the decision maker chooses a measure that reflects her preferences (subjective utility) and evaluates the likelihood (probability) of each alternative occurring. Third, the decision maker compares alternatives, selects the one with the highest expected value, and implements it (Cabantous & Gond, 2011; Janis & Mann, 1977). Because using a rational approach critically depends on access to information, we combine the empirical and rational perspectives in the Competing Values Approach. The interaction of rationality and power can be understood in at least two different ways: rationality can be used both to legitimise decisions which are in fact driven by considerations of power, or rationality and power jointly shape decisions. Pettigrew (1985: 443) describes the legitimising role of rationality as follows: *'The content of strategic change is thus ultimately a product of a legitimization process shaped by political/cultural considerations, though often expressed in rational/analytical terms'*. Quinn (1981) sees strategic decision making as a combination of rational analysis to assess the suitability of strategy content, and of political activity to make the strategy acceptable to senior management. Following a rational decision-making process implies bringing together relevant information and analysing its implications for choosing between decision alternatives. However, power and organisational politics may hamper the unrestricted flow of information. If a policy endorsed by top management is legitimised on the basis of rationality, this means arguments are brought forward that show the policy supports organisational goals (Nutt, 2002). Information that puts these arguments in doubt is likely not to receive a warm welcome. In a newspaper article for The Guardian, Wintour (2021) describes how deficiencies in gathering and processing military intelligence contributed to an inaccurate estimation of the Afghan and Taliban military forces, with grave consequences for the withdrawal of NATO troops in 2021. An observer who spent a year in Afghanistan speaking with US and Afghan military personnel, wrote that his conclusions *"bore no resemblance to rosy official statements by US military leaders about conditions on the ground". There is a "natural desire for good news to pass on up the chain of command". In the words of one former senior military official: 'As intelligence makes its way up higher, it gets consolidated and watered down; it gets politicised. (…) Operational commanders,* *state department policymakers and Department of Defense policymakers are going to be inherently rosy in their assessments. They will be unaccepting of hard-hitting intelligence.'* Janis and Mann (1977) provide a general description of how information is disregarded in situations.

The third concept in Figure 1 is consensus, which is defined as the collective agreement on what the organisation stands for, in terms of values, aspirations, and past. Lukes (1974), Pettigrew (1977) and Foucault (1977) show how power can be used to shape collective orientations: influencing perceptions and preferences, creating legitimacy for ideas and values, shaping knowledge and accepted discourse. We may add that power forms the organisation's understanding of quality and standards for practice. Drawing on the Competing Values Approach, once a consensus view has been established, it limits what is politically possible. Eden (1992) separates the negotiated *social order* (relationships between actors) from the socially *negotiated order* (definition of reality). Relationships between actors are part of the order in an organisation and form an element of our definition of power. These form the basis for the social negotiation that accompanies discussion of complex problems. Maitlis and Lawrence (2003) describe the interplay between discourse and political in a case on a major organisational change process. Consensus is influenced by rationality in the sense that information on changed external conditions may change ways of working and aspirations. This may for instance take place in the case of a routinised way of working of which hampers timely updating of mental models (cognitive inertia) and a reduced fit with the organisational environment (Hodgkinson, 1997). New information may bring this mismatch to light and inspire changes in the consensus view.

So far the discussion has centered on intraorganisational factors. It is worth considering that power, rationality and consensus are embedded and constrained by wider society. Power, whether wielded by those high in the organisational hierarchy or staff with specialised knowledge, is constrained by organisational regulation, policies on for instance HRM, and labour laws. If an organisational member feels boundaries are trangressed, there is often an ombudsman to go to, the case can be made public using press or social media or a court case can be filed. Rationality was defined as an analytic and systematic mechanism that gathers and processes information according to specific rules, embedded in scientific methodology. Likewise, consensus is also shaped by the background and culture of organisational members. Some authors posit that fairness and justice are general principles that are universal drivers of people's behavior (Cropanzano et al., 2007; Habermas, 1984). Others (Flyvbjerg, 2001) point out that people are also driven by self-interest. A safe conclusion is probably that as an espoused reason for behaviour, fairness and justice have a wider appeal than egotism.

This section has argued that conceptualisations of power have progressively come to embrace more and more of organisational life. The choice has been made to use a more restrictied definition of power in this paper, which relates an actor's power to his or her posion in formal and informal posision in the organisation and access to information. This alllows for separating power from rationality and consensus and places their interrelations into the foreground. Even this more restricted definition of power shows that most actors in organisations have access to one form of power or another. Power is not a resource managers at the top of the organisational hierarchy have in abundance, and people lower in the hierarchy progressively less. Power also follows from relations and information. The balance of power may operate largely behind the scenes, until an event impacts core interests of one or more actors. To protect their interests, actors mobilise their power sources and may legitimise their actions by using rational arguments or by appealing to a consensus view on what the organisation does or stands for. In this view organisational decision making is the outcome of competing perspectives or values: use of power to protect actor's interests, rationality to select courses of action that help to achieve (organisational or subgroup) goals and consensus to reach collectively accepted solutions.

System dynamics based organisational interventions

This section describes the specific contribution system dynamics makes to organisational decision making. System dynamics is a methodology that helps to make better decisions in complex problems. It starts from behaviour of key problem indicators over time. A model is then constructed which offers an endogenous explanation for observed dynamic behaviour, showing how the behaviour of interest is caused by a set of interlocked feedback loops. Information for constructing the model comes from quantative data sources, written data and most importantly from the mental database (Forrester, 1992). The mental database refers to the views and understanding of decision makers and others knowledgeable about the issue. It is often the only source for explanations of how the processes studied work, making the mental database a crucial source of information for model building. Bringing these different sources of information together allows for checking their consistency, in a process similar to data triangulation as used in empirical social sciences research (Yin, 1984). The ability of system dynamics to combine different types of data creates the advantage that all assumptions (on causes for observed behaviour) can be brought together in one place (Homer, 1996) . It is recognised that discovering especially sensitive parts of the problem or new data, can lead the modelling process to take an unexpected turn and – slightly or more substantially – change the focus question (Campbell, 2001).

Models are transparent and fostering model users' understanding of how structure creates behavior is a key goal in system dynamics. Vennix (1996: 185) points out the ability of a model to restructure *'exisiting, but scattered, knowledge by putting it in a systemic perspective. It thus revealed relationships between various elements and in that way created new knowledge for the group'*. The iterative process of model construction leads to counterintuitive insights which change problem understanding (Thompson et al., 2016). Learning about the problem at hand may be a necessary condition for changing behaviour and implementing conclusions, but it is not sufficient. System dynamicists have long seen implementation as pervading all phases of modelling, from problem definition to policy analysis (Weil, 1980). Selection of a problem important to the client (Roberts, 1978) and involvement in the modelling process have emerged as two additional factors driving implementation. The field has a long tradition in actively involving decision makers, experts and other stakeholders in facilitated model construction and use, leading to group model building and related facilitated approaches (Hovmand, 2013; Richardson & Andersen, 1995; Vennix, 1996). However, the majority of system dynamics applications proceed in an expert-driven mode, with client involvement limited to interviews for data gathering, iterative presentations of model structure and resulting behaviour and involvement in gaming simulation of the final model. Not surprisingly, in testing the impact of system dynamics modelling, most attention goes to cognitive limitations (Sterman, 1994; Vennix, 1999), for instance showing how decision makers have difficulties in understanding the relation to behaviour of even simple model structures (Cronin et al., 2009) and how improved structural understanding improves decision making and performance (Gary et al., 2012).

The context in which system dynamics is used is often described as a complex, messy or wicked problem. It is worthwhile to zoom out and determine more specifically which elements of these problems system dynamics concentrates on, and which receive less attention. A general definition of a problem is a difference between the actual situation (as is) and the desired situation (should be).

The mismatch between the two is the basis for defining actions, which serve to change the situation as is and hopefully bring it closer to the desired situation. Definitions of complex problems add a number of factors, most importantly the presence of multiple stakeholders and the different definitions of the actual and desired situation they bring with them (Vennix, 1999). System dynamics clearly departs from the actual situation. Time series capturing past behaviour of problem indicators and data on model structure are the main input. Most time in the modelling process goes to building model structure that is both consistent and generates simulation output matching observed data. Elements of the desired situation appear throughout the model as they drive policies (e.g. desired inventory, desired number of employees) that generate realistic model behaviour. Nevertheless, the overall desired situation, or the change in behaviour aimed for, is typically posited without extensive discussion. Forrester (1971) gives examples of problems faced by many companies such as falling market share, low profitability, or instability of employment which initiated modelling engagements. Which exact level of market share, profitability or employment is desirable is not made explicit. System dynamicists first aim to build a model that is fit for purpose: a structure that endogenously creates the behaviour of interest and is valid in relation to the defined goal of the modelling effort (Barlas, 1996; Forrester & Senge, 1980). The model is then used to test policies to improve behaviour. Since the relation between structure and behaviour is at the core of system dynamics, the field offers a sophisticated understanding of the dynamic impact of structural changes, for instance looking at differences in short versus long term impacts and shifting loop dominance. Policies are connected to the sensitive parameters in the model, which are often found in places least expected by decision makers (Forrester, 1971). Policy experimentation spans the full spectrum from to a one time change in a single model variable, to changing sets of variables at different points in time, to adding new feedback relations and additional model structure representing new policies. Approaches for comprehensive analysis of uncertain parameters and deducing policies under uncertainty are available (Kwakkel & Pruyt, 2013) but are not the mainstream in the field. Wheat (2010) analyses system dynamics publications on policy analysis (focusing on the public sector) and finds that out of 150 relevant papers, 51 report on policy analysis and only 14 of these include new policy structures and decision rules. Wheat concludes that although policy experimentation and the broader topic of implementation have been extensively discussed in the system dynamics literature, in actual practice policy analysis receives limited attention. In other words, analysis of the current situation is clearly the point of departure as well as the forte of system dynamics, and although these offer an excellent basis for testing effects of actions (policies) the latter receives relatively little attention. Likewise, the desired situation is often left impl.

In conclusion, system dynamics has a long tradition of working on complex organisational problems. Decision makers, experts and other stakeholders are often engaged in the modelling process, both as a source of crucial information on the issue modelled and to foster implementation of results. Modelling is expected to help overcome cognitive limitations to decision making. In terms of the aspects of the problem attended to, system dynamics focuses most on capturing the actual situation in a generic model. The desired situation and policy experimentation in practice receive less attention. In the next section we look in more depth at how the focus and practice of system dynamics turns attention to some aspects of power but neglects others.

System dynamics and power

What is the consequence of system dynamics' in-depth consideration of the current situation and relative lack of attention to other aspects, for addressing power? This question can be answered on two levels: with regard to the role system dynamicists take in supporting organisational decision making, and with regard to the content of models built. System dynamicists position themselves toward decision makers in a similar way as most scientists would. Their job is to analyse the available data and decisions are left to managers or politicians. Sterman (2000: 85) encourages the field to 'speak truth to power' and explains in great detail how to construct a valid model that help to answer client questions. In working directly with clients, Vennix (1996: 144) concludes that power games are not helpful and the facilitator can best avoid them: '*The best thing to do is to concentrate more on the group task or problem. By doing this the facilitator helps the group to surpass politicking behavior in the group'.* Vennix highlights the ability of careful analysis of the current situation to defuse power struggles: *'what seemed to be a difference of interests, often turned out to be a difference of interpretation'* (personal communication). This goes back to the ability of models discussed in the previous section, to bring dispersed elements of the problem together and thereby construct new insights. If new insights connect to goals that are important enough, learning may lead to change in decisions and to action. The case in box 3 provides an illustration of this process.

Box 3

In the early 1990s managers at the Dutch Ministry of Infrastructure and Maritime Affairs are worried about the declining number of ships flying the Dutch flag. Ship owners increasingly register their fleet in other countries as this reduces costs. The Ministry has to decide on whether or not to continue subsidising the Dutch fleet. Managers from the department most closely concerned with shipping invite a system dynamics modeller to help create more insight into this issue. In the first session it becomes clear that two other departments, responsible for shipping movements in the North Sea and for the harbours respectively, do not share this concern. Some participants feel that the Dutch fleet is a thing of the past and future efforts should be directed to growing the ports, such as Rotterdam. The facilitator proposes to the participants to explore whether there are relations between the three strategic areas. If the number of ships flying the Dutch flag is indeed independent from fleet movements in the North Sea and from the size of the harbours, it is safe to stop paying attention to the size of the fleet. If not, that is a clear argument for continuing the subsidies to the fleet. The model that emerges over the course of the sessions shows strong interdependencies between the three areas. The project results in a qualitative model and all three departments support the continuation of subsidies to the fleet (Vennix, 1995). The intended further development into a simulation model does however not take place, as the client feels that important insights have already been reached.

This is still predominantly a cognitive view on decision making: decision makers change their understanding of the situation and accept that in order to reach goals *important to them* a new course of action is needed. There is however nothing in the model that indicates why the benefits of collaborating across departments outweigh the benefits of putting one's own department first. An alternative outcome of the reported case may have been that relations between the departments were recognised, but did not have enough impact on actor interests to cause a change in action. The models in both cases may have been identical. In other words, the value that particular stakeholders put on outcomes or actions is not represented in the model. De Gooyert et al. (2016: 144) conclude that system dynamics has a blind spot for power: *'A perfect perception of the system however, is not a sufficient condition to overcome policy resistance (…), other sources of policy resistance may (co-) exist. The power dimension of implementing policies can be seen as one of such sources. Policy makers may have a flawless understanding of the system they want to intervene in, but if individual* *stakes prevent them from coming to an agreement on implementing high leverage policies, such an understanding will not lead to improvements'*.

Some have gone further and concluded that system dynamic does not lend itself well to situations in which multiple goals or conflicts play a role. These authors see system dynamics as a 'hard' or deterministic operational research approach (Lane, 2000). Flood and Jackson (1991) posit that OR/ MS methods are best suited for unitary contexts, characterised by clear and agreed objectives. Lane (2000) disagrees as there is no requirement in system dynamics on what constitutes the best outcome from a model. The modelling effort should generate support and commitment from those stakeholders whose views are modelled. Richardson (2013) provides a fitting example when he discusses modelling a change in US welfare legislation with representatives of counties in New York State. A first version of the model showed what proponents of the changed legislation hoped for: limiting the number of years a family could receive welfare lowered the number of people on assistance, and increased the number of employed. Two model iterations later, the simulations no longer show more people at work, and while financial expenditures by the national government are reduced as expected, part of the financial burden is taken over by states and counties. Needless to say, in terms of interests of counties and states the legislation reform went from positive now suddenly to harmful. This is a special case as the future effects of a structural change are modelled, instead of what is more commonly done: a past situation that has not undergone any structural changes. However, it supports the point that system dynamics captures the situation as is (or here: as it will be) and the desired situation is not of primary importance. After a model has been built in which there is sufficient confidence, policies can be tested that serve different goals.

Another counterargument against the idea that system dynamics works best in situations of clear and agreed objectives, are modelling projects on conflicted situations that capture directly how power works. Bleijenbergh and Van Engen (2015) describe modelling studies at two universities in the Netherlands. The reference mode in both universities shows a declining percentage of women in each subsequent step of an academic career. In one university 8% and in the other 6% of full professors were women. Both models identified masculinity of norms as an influential factor in bringing this situation about and maintaining it. Norms among others led to insufficient corrections of publication targets for pregnancy and for working part-time, lowering perceived research output for women. This in turn negatively impacts promotion opportunities. An important input to norms are the proportion of women and men in the organisation. Here we have a clear example of a system dynamics model of a conflicted situation, offering a structural explanation for resulting behaviour which clearly benefits one group more than another. The model structure captures impacts of power, such as the ability to legitimise certain views and shape norms (Lukes, 1974; Pettigrew, 1977). Other examples of models on conflicted situations can be found in the work on social services of Hovmand and colleagues (e.g. Fowler et al., 2019) and on participation in environmental modelling by Stave (2002). It seems then that system dynamics' cognitive perspective on decision making does not preclude actor goals from being included in models, and models may even help to understand how power was used by one actor to gain an advantage over another. The modelling process helps to build a structural explanation for observed behaviour. Starting a modelling project to support a prefered course of action may be difficult however, since the modelling process may take unexpected turns, new information may be found and information may be combined in novel ways. In terms of Figure 1, we can conclude that system dynamics can function as a rational procedure that impacts power. Powerholders motivated their policy on the basis of rational arguments, by showing how it positively impacts organisational goals. As power may distort information exchange (Janis and Mann, 1977), it is unlikely that those in power have a complete and consistent picture of the existing situation. System dynamics modelling may show how the rational motivation for prefered policies is incomplete, inconsistent or faulty. System dynamics also has an impact on the third element in Figure 1, consensus. The case in box 3 is one example of how iterative construction of a model changes ideas of participants in the modelling process. Modelling has been shown to impact participants' ends models (Huz et al., 1997), perceptions of norms (Rouwette, Korzilius, et al., 2011) and consensus (De Gooyert et al., 2021). This is however limited to the participant group and not the same as influencing consensus across the organisation.

In conclusion, in addressing power there are three areas in which system dynamics is limited. First, system dynamics models capture an issue at an aggregate level, while an analysis of power calls for a more fine-grained view that captures stakeholders, the relative value they attach to preferences and their resources. Second, system dynamics models capture the current state of the issue which includes specific stakeholder goals. However, the system-level goal, or what counts as a desirable future development, is not part of the methodology. Third, in line with the cognitive focuse discussed in the previous section, system dynamicists assume the major route to influencing decisions is to educate decision makers on structure – behaviour relations. What this leaves out is the motivational aspect: learning may also include a change in the value put on a particular goal, or finding new ways to reach personal goals.

Theoretical implications

This paper aims to create more clarity on the interaction between power in organisations and system dynamics based interventions. The previous section made clear that system dynamics sees itself an analytic, scientific methodology for addressing complex organisational problems. In this section we will adress the interaction between power and system dynamic first at at macro level, looking into the relation between science and practice, and into rationality as an organisational practice. We then turn to the micro level, broadening the cognitive view on decision making with a motivational perspective.

Vennix (1990) reviews early evaluation studies of model use for policy making. He points to various reasons for the lack of actual impact on decisions. Among the reasons most often mentioned are lack of relevance, given that many early models did not focus on a problem of interest to policy makers or did not deliver insights at the required level of detail. Lack of impact was also caused by the fact that early models were difficult to interpret due to their complexity and because limitations of modelling were not indicated to policy makers. The models' coverage of the issue at stake may also be questioned, as intangible, unmeasurable aspects tended to be left out, model structure contained hidden assumptions and models were prone to technical error. Finally, practical matters such as data 'hungriness' and high costs limited the impact of modelling. A general recommendation by many early modellers is to focus on a problem that is relevant to policymakers and to give ample attention to communication of results. Interestingly, while modellers expected that policy makers would possess expert knowledge and thus it would be easy to communicate results, it turned out policy makers' decisions were more often influenced by powerful constituencies than by expert knowledge. Many of these reasons can be recognised in a recent discussion on the lack of impact of mathematical models (Gilbert et al., 2018).

Underlying these discussions on impact, is the conceptualisation of model usefulness. What does model use actually mean? Vennix (1990) points to a number of different conceptualisations in the literature. Direct use refers to choosing among different policy options on the basis of model results. A more indirect use is education or enlightenment, which serves to clarify an issue and results in learning. A third way in which models can be useful is agenda setting, by focusing attention on and articulating policy issues. While most modellers are probably thinking of model use in terms of directly influencing the choice between policies, indirect influence by changing ideas is more prevalent. As mentioned, only a minority of applied studies address policy analysis (Wheat, 2010). On the other hand, a line of studies has shown the impact of system dynamics modelling on cognition and learning (see Rouwette, 2016 for an overview). Vennix (1990) places the debate on model use in the broader discussion on utilisation of scientific knowledge, departing from the so-called Two communities theory formulated by Caplan (1979). Here we find similar ideas on two approaches to using science: instrumental which is similar to direct model use, and conceptual which resembles educational model use. The third type of use of scientific knowledge is however different and relevant to the goal of this paper. Science can also be used symbolically, when research results are used selectively or distorted to serve a policymaker's purpose. This type of use is more likely in highly controversial problems. While research utilisation continues to develop as a scientific discipline and offers many relevant insights for modellers (see for instance Landry et al., 2001; Parkhurst, 2017; Wickert et al., 2021) we would like to turn to another perspective that offers a fundamentally different understanding of the roles of the modeller and decision maker.

The above ideas on the interaction between modelling and organisational decision making fit well with system dynamic's preference for 'telling truth to power', its scientific approach to modelling and emphasis on the cognitive dimension of organisational decision making. We could even say that guidelines for system dynamics modelling (e.g. Sterman, 2000; Vennix, 1996) serve to overcome many of the reasons for lack of impact in early modelling studies. Models are nowadays common tools for supporting decision making in public and private settings (Gilbert et al., 2018; Ranyard et al., 2015). This may mean that modelling is no longer a special occasion in which scientists interact with managers and policymakers, but a more routine endeavour undertaken regularly by consultants, in-house analysts or decision makers themselves. Cabantous and Gond's (2011) analysis of rationality in science and practice offers a new and interesting perspective. The authors seek to explain the paradox between rationality as a prescriptive ideal that science generally considers unreachable, and the everyday use of tools to support rationality in organisational practice. Cabantous and Gond conceptualize rational decision making as performative praxis. Praxis refers to the flow of activities by which rational decision making is accomplished. A theory is said to be performative when it influences social reality in such a way that its premises, or even its predictions, become true. Performative praxis rests on the presence and combination of three elements: theory, tools, and actors. Theory has contributed to making rationality conventional, via influencing business school curricula. These curricula emphasise the role of decisions in organisational life, and familiarise students with a range of concepts that help to navigate the phases of rationality mentioned earlier: defining alternatives, determining their subjective utility and probability, choosing and implementing the alternative with the highest expected value. Tools refer to rationality engineering. Research and surveys show that tools to support rational decision making featured in textbooks are used in organisation practice and *'can be seen as "prostheses" that enable managers to make rational decisions by overcoming limited cognitive capacities'* (Cabantous and Gond, 2011: 580). Actors such as academics and consultants have contributed to making rational decision making a commodity by selling it to managers and organisations in search of rationality. Management consultancy as a discipline has expanded tremendously, both in a general sense and for operational research spefically (Ormerod, 2021) and is influencing organisations beyond offering tools for rational decision making. Consultants play several symbolic roles, such as convincing clients of the worth and quality of their own work, providing external legitimacy, reinforcing the need to adopt a rational approach, marketing and selling tools, and overseeing implementation. Comparing the 'scientific view' of modelling to the view of rationality as performative praxis leads to a number of differences. One is that the modeller may no longer be an academic but is likely to be a consultant. This has consequences for the status of the resulting product. While the impact of scientific research may be supported by norms such as value neutrality, consultancy work may be seen to support client interests first and therefore perceived differently. Increased access to rationality tools may mean that different organisational units or sides of a debate are each supported by their own model (King & Kraemer, 1992). Finally, the modeller is less likely to be the only source of methodological expertise. Clients may also be familiar with modelling concepts and tools, and remain the main information source on the issue at stake.

What do these changes on the macro level mean for the interaction between modellers, decision makers and other stakeholders? De Dreu et al. (2008) notice that group decision making theories tend to take either a cognitive view (e.g. Hinsz et al., 1997) or motivational view (e.g. Johnston et al., 1997). A full account of generation, dissemination and integration of information in group decision making however needs to be based on an integrated theory. De Dreu et al. propose the motivated information processing in groups (MIP-G) model that posits two motivations driving group decision making: epistemic and social motivation. Epistemic motivation is defined as the willingness to spend effort to achieve a thorough, full, and accurate understanding of the issue at hand. Social motivation refers to the individual preference for outcome distributions between oneself and other group members and can vary from proself to prosocial. Groups high in epistemic motivation search for new information and use strategies for deep and deliberate information processing. Social motivation influences what type of information that someone looks for, generates and processes. Prosocial individuals tend to focus on information conducive to group goals and harmony, proself individuals focus on information that supports personal goals. Either type of motivation is influenced by a host of individual (e.g. need for cognition) and situational variables (e.g. accountability to process, time pressure). Consequences of combinations of motivations are shown in Figure 2 .

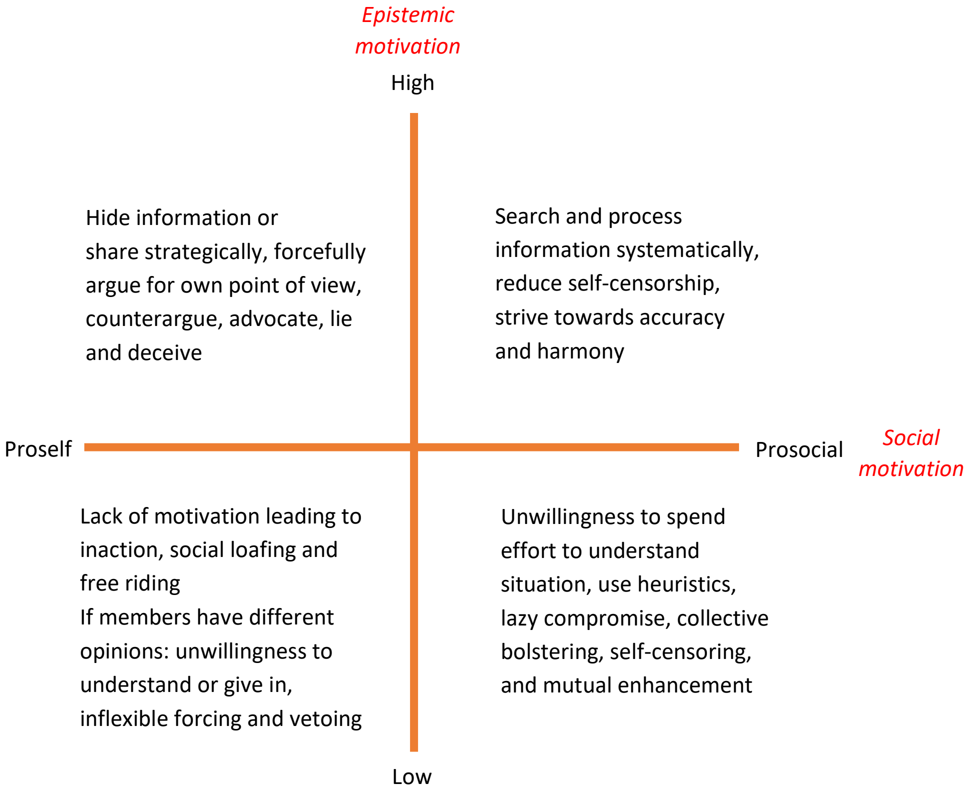

Figure 2. Expected effects of combinations of social and epistemic motivation (cf. De Dreu et al., 2008)

De Dreu et al. point out that many studies on groups as information processers depart from the implicit or explicit assumption that group members share the cooperative goal of reaching consensus on a high quality decision. This may not always be true, as in realistic tasks group members may be driven by a mix of cooperative and competitive goals (see also Frankfurt, 2005). Nor is the upper right hand corner (high social and high epistemic motivation) always desirable. Not every situation asks for deliberate, deep information processing. Often decision making involves a tradeoff between speed and effort. In urgent situations it is advisable to use heuristic processing, for instance by following well-learned routines that lead to a satisfactory result in most cases. Neither do all group decisions ask for a prosocial motivation. A proself orientation leads to more independent thinking and original ideas, which in divergent tasks contributes to group output. In convergent tasks, where participants need to build on each other's ideas and input needs to be combined, prosocial groups do better.

We can compare a situation in which a group of stakeholders is involved in constructing a system dynamics model to the four quadrants of the motivated information processing theory outlined above. Which motivations can be expected, and which are desirable? Concerning epistemic motivation, it seems modellers typically involve stakeholders who are willing to spend effort to understand the issue in full. Relevance or importance of the issue at hand may increase epistemic motivation. As mentioned, evaluations of early modelling studies encouraged modellers to focus on a problem that is relevant to decision makers. Rouwette et al. (2011) test problem importance in seven system dynamics applications with in total 42 participants, and find it to be high before and after the modelling intervention. Stakeholders are selected to represent all areas of expertise relevant to the issue as well as those organisational units involved in implementing recommendations (Vennix, 1996). As described earlier, over the course of the modelling project its orientation may shift and at times may be seen to threathen departmental or individual goals. It is therefore likely, as is also apparent in the cases in Box 1 to 3, that participants experience a mix of cooperative and competitive incentives. That means participants may have a proself or prosocial orientation. Which combination of motives is most likely to support a high quality modelling process? Most modelling projects are probably low in urgency, as the process of model construction and accompanying involvement of participants will take time. Participant input is needed to fully capture the situation of interest, meaning that member input is indispensible. The main part of the modelling process is clearly convergent, as information is combined and related to form the model. A line of studies (De Dreu et al., 2011) show that when there is the need as well as the opportunity to combine member inputs (low urgency, high input indispensibility, and a convergent task), high epistemic and high social motivation are needed to produce quality decisions. An important question for practice is then how to nudge participants that are predominantly proself to the prosocial quadrant.

This section departed from the idea that system dynamics aims to support organisational decision making by offering a scientific modelling approach. While 'support' may often be understood as helping to make a choice between policy options, other types of use such as education or learning (akin to conceptual use of science) are more prevalent. An alternative perspective on how modelling supports decision making is offered by viewing rational decision making as performative praxis. Rather than a decision maker interacting with a scientist and her scientific methodology, decision makers work with a consultant or academic modeller and both have access to relevant theory and tools. The MIP-G model helps to clarify how this plays out on the microlevel of interactions in a modelling project. A modeller is likely to work with a mix of proself and prosocial motivated participants, which is a challenge if improvement in overall functioning of the system is the goal – as it is in system dynamics. In the next section we turn to practical guidelines for modelling in the context of power.

Practical implications

This section addresses the interaction between system dynamics and power in organisations from a practical perspective. System dynamicists are trained in an analytic approach that helps to identify the structure responsible for problematic behaviour. We assume that the goal of the modeller is still to improve overall system functioning, rather than helping one particular actor advance his or her agenda. We agree with Sterman (2000: 85) that: '*The political context of modeling and the need to focus on the clients' problem does not mean modelers should be hired guns, willing to do whatever the clients want.'* When applying modelling with stakeholders that have different interests and will use different sources of power to foster their interests, which additional tools are helpful? We address this question by first going into the power bases of an organisational analyst. Next we identify several topics that need to be considered alongside traditional modelling phases: problem boundaries, stakeholders, stakeholder goals, evaluating options against goals and building a coalition to support proposed options. Organisational intervention methods that can be used in combination with system dynamics are described that support gathering information on these topics.

In considering how a modeller can support a decision making process in which power plays a role, it is worthwhile to first consider which power resources the modeller has access to. Typically a modeller or analyst is contacted by one person in an organisation, who seeks help on a complex issue. After the contact client communicates her personal understanding of the issue at stake, the client and analyst together work towards an agreed project goal and process outline. As it can be expected that each stakeholder may have his or her own understanding of a complex problem (Vennix, 1999) it may be that already in formulating the project goal several stakeholders are consulted. After an agreement on goal and process has been reached, the analyst can be said to have a degree of legitimate power, as a decision maker in the client organisation has 'sanctioned' him to conduct the work and involve other participants. Pettigrew (1975) suggests that the analyst's ability to influence clients rests on five power resources: expertise, control over information, political access and sensitivity, assessed stature and group support. While Pettigrew focuses on internal consultants, we will also consider how his observations apply to external consultants. Expertise refers to the services rendered by the analyst, which are in the main time and methods to produce detailed solutions to complex problems and access to certain kinds of information. To the extent that these services cannot be obtained elsewhere, the client is dependent on the analyst. The work of the analyst includes establishing contacts with stakeholders across organisational units, and in some cases external parties, which give him broad access to information. Pettigrew (1975: 198) notes that in the course of their work, analysts may uncover the *'inefficiencies and incompetences of others'*. This may be perceived as a power base by others in the organisation, even if the analyst does not reveal the information. Political access refers to the analyst's social network in the organisation, the degree of reciprocity involved and the closeness to the locus of power. It is likely that for an external analyst, the contact client is the starting point for building a network and depending on the scope or duration of the project the network may be small or large. Stature refers to the analyst's ability to anticipate what the client needs in terms of the task and interests. Client needs vary over time and therefore the timing and wording of a proposal have a crucial impact on the way it is received. Finally, group support refers to the time and energy of others in the organisation on which the analyst can make a claim. Pettigrew discusses how a department that is (perceived to be) encroaching upon the territory of another, may set in motion a conflict. Higher management may then have to intervene and reassign responsibilities. For internal and external consultants alike, the degree of authority and scope of the assignment determine how large a claim they can make on human resources.

At the basis of these power sources is an understanding of the different actor groups in the organisation, their interests and means. *'The analysis of organizational power requires some attempt to map out the distribution and use of resources and the ability of actors to produce outcomes consonant with their perceived interests'* (Pettigrew, 1975: 195). The analyst enters into an organisational constellation and starts work based on an initial problem formulation and proposed process. Following up on the discussion in the previous sections, we see these areas in which the system dynamics approach can be complemented in order to better address situations in which power plays a role:

- check boundaries around problem
- identify stakeholders
- identify goals of stakeholders
- assess proposed options against goals of stakeholders
- build a coalition to support proposed options

Table 2 below gives an overview of approaches that help to address one or more of these areas. Most approaches have been used in combination with system dynamics before.

Methodology	*Aim*	*Core references*	*Combinations with SD*
Critical Systems Heuristics	To check boundaries around problem	Ulrich (2003); Ulrich and Reynolds (2010)	
SODA for issue management	To identify relations between options, issues of concern and goals	Eden (2004); Ackermann and Eden (2011a)	Eden (1994); Howick et al. (2006); Ackermann et al. (2011)
SODA for stakeholder analysis	To identify relations between stakeholders and between stakeholders and issues	Ackermann and Eden (2011b); Eden and Ackermann (2021)	
MCDA	To rank order options based on their scores against criteria	Belton and Stewart (2002); Salo and Hämäläinen (2010); Phillips (2007)	Reagan-Cirincione et al. (1991); Santos et al. (2004; 2002); Brans et al. (1998)

Table 2. Methods that may complement system dynamics in addressing power (SODA: Strategic Options Development and Analysis; MCDA: multicriteria decision analysis)

As mentioned, after getting into contact with a client, one of the first tasks of the analyst is to agree on a goal and outline of the process. There is a danger here that the initial problem formulation of the contact client restrict the goal of the modelling project. At least two aspects of system dynamics modelling work against a narrow problem definition. First, as mentioned, the field is well aware that complex problems are likely to be perceived differently by different people and therefore it is wise to talk to to several people in the organisation before agreeing on a project goal. Second, in the process of modelling, a generic picture of the issue at stake is built. However, these are broad guidelines and the field does not offer directions on whose views should be taken into account when defining the model purpose or who to involve in modelling sessions (Vriens & Achterbergh, 2006). Involving those with relevant expertise and the power to implement conclusions seems to be the general advice. While some authors such as Hovmand (2013) have explitly focused on involving other groups, also those who bear the consequences of decisions made, there is room for more careful consideration of deciding on the purpose of the modelling process and who to involve. Critical Systems Heuristics (Ulrich, 2003; Ulrich and Reynolds, 2010) offers a general framework on important choices in an organisational intervention, that helps to clarify and reflect on underlying values. At its core, Critical Systems Heuristics proposes four clusters of questions, around sources of motivation, control, knowledge and legitimacy. Each question adresses the current situation (is) as well as the desired situation (ought). Some examples of questions are the following: Who ought to be/ is the intended beneficiary of the system of interest? What conditions of success ought to be/ are under the control of the system of interest? Who ought to be/ is providing relevant knowledge and skills? Who ought to be/ is representing the interests of those negatively affected by but not involved with the system of interest? Ulrich offers a practical approach to consider boundaries placed around the problem, stakeholders to involve and expertise to bring in, among others. The section on conceptualisation of power addressed the foundation of power, consensus and rationality in societal norms. Critical Systems Heuristics helps in reflecting on how an organisation is embedded in society and as such is part of broader discussion on operational research and ethics (Ormerod & Ulrich, 2013).

The next approach that complements system dynamics in addressing issues related to power, is Strategic Options Development and Analysis or SODA (Eden, 2004; Ackermann and Eden, 2011a). SODA is a qualitative modelling approach that has been used in combination with system dynamics extensively, for instance in project litigation (Ackermann et al., 1997). Several compare SODA and system dynamics in the group model building mode: in terms of approach and effectiveness (Herrera et al., 2016; Rouwette, Bastings, et al., 2011), detailed steps in the modelling process (Ackermann et al., 2011) and the translation of one type of model into the other (Howick et al., 2006). SODA is a facilitated modelling approach that captures the subjective understanding of a problematic situation in terms of means-ends relations. In the issue management mode, it can be used to work with individuals construct cognitive maps, but also in a group mode. Dedicated software helps to capture individual and group models, the latter allowing for anonymous input of concepts and relations. While system dynamics typically departs from a reference mode (although other options are possible, see Scriptapedia cf. Hovmand et al., 2012), construction of a SODA model can start from a broader question. One option is to start from ‘what keeps you awake at night concerning problem X?’ This would usually lead to the identification of a set of issues, and form the middle layer of a model. From there laddering up leads to the identification of goals. Laddering down identifies actions that help to solve issues. The participants in a SODA modelling session jointly construct a goal network and identify resources to achieve goals. Together they articulate the purpose of the organisation and build an understanding of their goals as an interconnected system. It is likely that in the case reported in Box 3, SODA would also shown how the three departments involved share a set of goals and depend on one another to create desired outcomes. By departing from the desired situation and by including actions, it complements the system dynamics approach that concentrates on the current situation.

A recent adaptation of SODA is tailored to stakeholder analysis (Ackermann and Eden, 2011b; Eden and Ackermann, 2021). It starts with listing stakeholders, using for instance a power – interest grid (Bryson, 2004). Goals of stakeholders are then surfaced and interactions between goals identified. Strategies for reaching important goals can then be tested, by identifying reactions by other stakeholders (and reactions to reactions). The model helps to create an integrated strategic plan that helps to achieve goals, building on strategies supported by other stakeholders while migitating their adverse reactions. Thereby SODA helps to build a coalition around preferred policies (see Bryson, 2004 for additional techniques).

Multicriteria (decision) analysis or MCDA, also has a history of combined use with system dynamics (e.g. Reagan-Cirincione et al., 1991; Brans et al., 1998). MCDA starts from policy options and the goals they are expected to achieve. Goals are translated into specific criteria that measure to which extent a desired outcome has been achieved. A matrix can then be constructed, showing the score of each option on each criteria. Criteria can be weighted to indicate their importance to a stakeholder. By aggregating weighted scores on all criteria, the overall score of an option can be determined. The result is a rank order of policy options in terms of preference. The rank order can then be tested for its sensitivity to changes in scores, weights or aggregation method. Santos et al. (2004; 2002) compare MCDA and system dynamics. One obvious difference is that the first offers a static view and the latter a dynamic perspective. MCDA creates a detailed comparison of policy options without going into depth on the causal relations between underlying elements of the situation. System dynamics does offer a causal understanding of the situation at hand. However, to assess whether a change in a model variable is beneficial is not straightforward. The central reference mode of behaviour points to the leading performance indicator that can be used to determine whether a change in simulation output is beneficial. But in principle further analysis can involve all variables in the model. A system dynamics model will show how all variables in the model respond to a change in a policy, but there is little to go on to determine which variables are more important than others, or whether changes early in time need to be weighted more than later impacts. In short, what MCDA can add is an integration of the main impacts of a policy option into a single value scale.

The methods sketched above help to address power issues both directly and via their effect on rationality and consensus. They complement system dynamics in addressing power in the following way. The section on system dynamics and power concluded with a number of elements missing from most system dynamics interventions: stakeholders, the relative value they attach to preferences, stakeholder resources, the desirable future development, and means to reach personal goals. The methods above also add elements of rationality which receive less attention in system dynamics. Rationality was described as structuring a problem and defining options, defining subjective utility and probability of each option, and comparing alternatives and implementing. It is clear that the first element is a strong point of system dynamics while the latter two can be supported by the above methods. With regard to consensus, we discussed in the previous sections how a line of studies show the effect of system dynamics on learning, cognition, and shared cognition. The four methods described above may complement system dynamics because they start from a different perspective and capture different elements of problem situations. Literature on group-level sensemaking (Kaplan & Orlikowski, 2013; Stigliani & Ravasi, 2012) shows how artefacts can help to create a joint interpretation of an organisation's past, present and future, resolving discrepancies between a current and expected state of the world or reducing ambiguity. It is plausible that the storytelling mode, in which a system dynamics model is built up layer by layer, as well as the the ability to experiment with models and see the impact on behaviour offer a form of group-level sensemaking and thereby help to create consensus. This is however in the main limited to the participants in the sessions (not the wider organisation) and concerns cognitions rather than goals.

We would like to emphasise again that in our view the above approaches complement system dynamics in situation in which power plays a role. As described in earlier sections, a system dynamics based analysis is likely to reveal counterintuitive insights (Forrester, 1971; Thompson et al., 2016). It is very improbable that a decision maker faced with a messy, wicked problem can make an accurate assessment on which policy will best serve her agenda. *'Individuals continually commit errors because of misperception through lack of information or miscalculation'* (Pettigrew, 1975: 199). System dynamics has a strong track record in showing structural determinants of problematic behaviour. What we suggest here is that other approaches offer other kinds of information, on stakeholders, goals and values, that are equally likely to surprise decision makers.

Conclusions, limitations and suggestions for further research

This paper set out to answer the following questions: 1. How does power impact system dynamics based organisational interventions? 2. How do system dynamics based organisational interventions mitigate the impact of power, and which complementary tools may increase intervention effectiveness?

Case reports on system dynamics projects in private and public organisations document the impact of power. Power affects the process of system dynamics interventions as well as the implementation of recommendations. In these situations system dynamicists seem to see their primary task as speaking truth to power. The field's research agenda is dominated by a cognitive approach, explaining suboptimal decision making in terms of inadequate data gathering and processing. From the central assumption of the field, that problematic behavior can be explained on the basis of problem structure, it is a small step to the expectation that improved understanding will lead decision makers to change their behavior. This has inspired extensive research into for instance stock-flow reasoning, pointing to predictable and consistent shortcomings in decision making. Similarly, case studies have shown examples of decision makers in complex and urgent real world issues who, on the basis of a comprehensive model of their situation which allowed them to test proposed policies, change decisions and improve their sitation. This approach fits well with the idea that rationality is the 'currency' of organisations (Bryson, 2004; Cabantous and Gond, 2011) in the sense that decision makers tend to adopt decisions that follow from a rational analysis.

However valuable the cognitive perspective on organisational decision making is, it does not completely explain the actions of a knowledgeable and competent decision maker who distinguishes his own interests from that of the overall organisation. System dynamics, with its emphasis on capturing all causally relevant factors into the model, is primarily concerned with creating an understanding of past, generic behavior. This aligns well with an organisation-level understanding, capturing how policies driving actors' behaviour interact to give rise to overall problematic behaviour. A competent self-motivated decision maker may however be more interested in individual rather than organisational goals, and more driven by options to improve future gains rather than understanding the past.

This paper argues that in striving after their interests, powerholders use resources such as hierarchical, network and informational power. In this perspective on organisational decision making, individual or subgroup interests are in the foreground. Policies backed up by a powerful coalition of actors drive decisions. Powerholders may use rationality to determine how to best reach their goals and to back up their prefered policies with rational arguments. They may also seek to influence organisational consensus, for instance by shaping what is considered relevant and by setting norms. How this setting shapes system dynamics interventions and vice versa is summarised in Table 3.

	Impact **of** *system dynamics*	*Impact* **on** *system dynamics*
Power	- 'Mythbusting' by triangulation of data, which may reveal a weakness in argumentation for preferred policy - *But* aggregate model leaves out stakeholders, their relations, values and resources	- Powerholders may use rational arguments to stop project, divert resources or access to participants - Actors may limit access to data bases - Participants may lie or spin information in line with own agenda
Consensus	- Increases transparency and information sharing, which appeals to informational justice - 'Storytelling' leads to convergence in understanding of participants - *But* not necessarily for organisation as a whole - The effect on convergence in goals is not clear	- Consensus determines which questions are found relevant - Strong consensus may lead to shared bias among participants in modelling project
Rationality	- Supports problem structuring and policy analysis - *But* problem structure is limited by not specifying system-level goal - Policy analysis is not frequently used in practice	- Rationality includes defining preference for and likelihood of impacts of policies - System dynamics does not include a single value scale to integrate policy impacts - As rationality support is known and accessible, actors may propose alternative methods that do include preferences and likelihoods

Table 3. Relation between system dynamics and power, consensus and rationality ('but' refers to limitations or open question with regard to the impact of system dynamics)

The second column in Table 3 summarises the answer to the first research question. It also clarifies how speaking truth may have an impact on power. A system dynamics analysis may point out that rational arguments given for a prefered policy are not as strong as previously thought. Data gathering for the modelling effort may bring new information to light, and the consistent incorporation of (mental, document and numerical) data into a model may point out unexpected and undesired consequences or prefered policies. Organisational members are likely to welcome increased transparancy on causes of major organisational issues (Cropanzano et al., 2007). If some of these consequences are not in line with what the organisations stands for, this may drive action to correct for these consequences. The case on gender diversity reported by Bleijenbergh and Van Engen (2015) provides an example. We may assume that academics see promotion in their organisation as based on merit. When the system dynamics analysis shows gender is also a determinant in promotion, this is not consistent with the self-image of organisational members who will then support corrective policies.

The third column of Table 3 summarises insights from the sections on conceptualisation of power and theoretical implications, as well as the examples in Box 1 to 3. The main theoretical contributions are 1. to broaden the perspective of system dynamics as scientific modelling with the view of rationality as performative praxis (Cabantous and Gond, 2011) and 2. to broaden the perspective on group decision making to include epistemic and social motivation, following the motivated information processing approach (De Dreu et al., 2008). The first makes posits that a decision maker has knowledge on and access to rationality support, enabling her to provide alternatives for and counterargue conclusions from system dynamics interventions. The second makes clear how personal goals influence information sharing and processing. A competent proself motivated decision maker may seek to influence the information that forms the basis for modelling. In addition, she may make good use of the new insights achieved through a system dynamics intervention, but not to support system-wide goals but rather to advance personal interests.

The practical contribution of this paper is to highlight a set of intervention methods that put considerations on boundaries (for instance concerning the problem and who to involve), individual interests, stakeholder relations, and criteria for choosing policies centre stage. Each of these methods has a track record of published cases and a clear outline of phases. Some of these methods, notably SODA in issue analysis mode and MCDA have extensively been used in combination with system dynamics. Hopefully by pointing the reader to these methods and their complementarity with system dynamics, practitioners have a way to work with and address power in a broader sense than with a single methods used in isolation. This can be accomplished by focusing on elements of power directly, or indirectly via consensus and rationality. The second column in Table 3 shows elements of all three concepts in which system dynamics can be complemented.

This paper is a conceptual discussion and contrasts ideas on power with assumptions of and practices in the system dynamics field. Its empirical base consists of examples known to the author and no attempt was made at a more systematic collection of data. It is meant as the start of a wider exploration. Four topics to address in future research come to mind.

First, a central aim of system dynamics is to increase system understanding, a claim which has been tested in a line of studies discussed previously. Since at the base of power issues there is a difference in actor goals, it is relevant to assess to which extent system dynamics modelling leads not only to alignment of cognition but also to alignment in goals. Several studies into mental model alignment measure evalation of goals (Huz et al., 1997; Rouwette, Korzilius, et al., 2011; De Gooyert et al., 2021). However, it is an open question whether model-based analysis lowers importance attached to individual goals and increases importance of system-wide goals, in particular in situations in which these are opposed. This is all the more relevant as today’s societal challenges often involve tradeoffs between personal and collective goals.

Second, does a multmethod approach add benefit over using system dynamics alone, in particular in power issues?

Third, the section on practical implications described for which elements of power, rationality and consensus system dynamics could be supported. The complementary methods seemed to be a good match for limitations in power and rationality. For consensus there is evidence that system dynamics heps to create (cognitive) consensus within the group of participants in the modelling project. The impact on the wider organisation deserves attention. Literature on group-level sensemaking (Kaplan & Orlikowski, 2013; Stigliani & Ravasi, 2012) can serve as a starting point here.

Fourth, in order to increase the usefulness of multimethod approaches, can we translate the four methods proposed here as complementary to system dynamics (CSH, SODA for issue management, SODA for stakeholder analysis, MCDA) into scripts? A starting point here is the combined use of SODA for issue analysis and system dynamics (Ackermann et al., 2011).

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