The applicability of an integrated framework of the capability approach and complex adaptive systems for exploring complex problems

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Abstract

The capability approach (CA) in its current form, albeit considered promising for assessing ethical value fulfillment, has several limitations for the evaluation of complex adaptive systems (CAS). In this paper, an attempt is made to develop an integrated framework of the CA and CAS theory. In doing so, several key elements within CAS theory – dynamics, adaptivity, internal states, system environment, and performance mechanisms – have been implemented in the CA. After which a practical application of the framework is assessed and reflected on. It was found that albeit several limitations with respect to the well-being of individuals, problems with dynamics, and distanciation of ethical values, the framework proved useful for assessing value fulfillment and performance metrics of complex adaptive systems.

Keywords: Capability approach, Complex adaptive systems, integrated framework, approach synthesis, system evaluation

I. Introduction

This paper serves as a practical step in determining the applicability of an integrated framework which includes two research approaches: Complex adaptive systems and the capability approach. Before assessing the applicability, an integration attempt of both research approaches is discussed, after which a synthesis of both approaches is described.

Complex adaptive systems (CAS) are systems that inherit an *evolving structure* (Holland, 1992). These systems change and reorganise their system components to adapt to changes in their surrounding environment.

The capability approach (CA) helps in determining personal well-being by evaluating it concerning the ability to achieve various valuable funtionings (Sen, 1993). The CA puts focus on human agency and freedom.

The integration effort is intended to fill a set of limitations of the CA in its current form. Furthermore, the practical applicability and usability of such an integrated framework remains relatively unexplored. It's quite Peculiar as Sen envisioned his approach as a modular approach. Therefore, the approach should be well suited to be combined with other theoretical approaches (Kleine, 2010). Robeyns (2005) already hinted towards the integration of other evaluative methods within the CA. The integrated framework should prove useful for exploring systems characterised by elements common to complex adaptive systems.

This paper identifies key elements from both the CA and CAS theory. An attempt is made to link the elements of both approaches and establish an integrated research framework. The work of Robeyns (2006) and Holland (1992) are used as the main articles for theoretical background.

The structure of this paper is as follows. Section two elaborates on the main limitations of the CA. Section three describes the key elements of both complex adaptive systems and the capability approach. Section four elaborates on the differences in both approaches and how these differences could potentially pose a problem for integrating both approaches. Section five elaborates on a synthesis of the different elements. Section six describes how this integrated framework should be viewed and how it is structured. Section seven describes a practical application of the integrated framework. Section eight concludes this paper.

II. Limitations of the CA

The CA in its current form has several limitations when using it for evaluating the ethical impacts of complex systems.

The notion of *agency* is not specifically embraced by all versions of the capability approach. (Robeyns, 2011). Individual agency is however critical in assessing individual decision-making. When assessing systems where individual-decision making takes place, such as complex adaptive systems, agency has to be made explicit or else autonomous choices are not possible (Deneulin, 2008). With regards to complex adaptive systems, human agency is needed for people to interpret who they are and what they can do (Deneulin, 2008). These aspects of self-determination and self-evaluation remain unclear in the current CA (Bellanca, Biggeri, & Marchetta, 2011). Robeyns (2011) stated that due to the aforementioned lack of a clear description, the CA is less prevalent for individual decision-making or evaluation. Furthermore, according to the CA all sorts of social interactions have an effect on the beings and doings of individuals. Robeyns (2003) stresses that including quality and quantity to these social relations is needed, but that this requires further argument and defense.

Originally the CA is considered as a normative framework. It helps evaluating and conceptualising problems rather than explain them. though, functionings and capabilities can themselves be explanatory elements, there is a need for an overarching explanatory framework or concept. Both Sen (1993) and Robeyns (2005) mention the need for integrating explanatory concepts.

The CA offers a more holistic view on development (Kleine, 2010). Although this has its advantages, scholars struggle to find balance between its conceptual usefulness and operationalisation. One of the main problems scholars experience regarding the CA is that Sen (1993) did not prescribe a fixed list of capabilities, but rather stated that the process of choosing capabilities should be done by the individual. As a result it is hard to approach a specific problem with specific capabilities, while retain enough freedom for individuals to choose from. In other words, preselecting a limited set of capabilities, limits the actual freedom that people have. This crosses swords with the very essence of the CA, which is to focus on these freedoms.

III. Key elements

Key elements in the CAS approach - Holland (1992) describes four key elements of a complex adaptive system: (1) Evolution, (2) aggregate behaviour, (3) anticipation, and (4) non-optimality. The following descriptions of the key elements are derived from the work of (Holland, 1992).

Evolution entails the ongoing urge of system elements to improve according to changes in their surrounding environment. A nice example is that of a chameleon adapting its skin colour to the colour of its surroundings in order to blend in and increase its chance to catch and eat insects. This adaptation increases the survival chances of the chameleon. The adaptive processes within complex adaptive systems are *complex* as they involve many parts of unique individual criteria determining a good outcome.

Aggregate behaviour describes the phenomenon that system behaviour cannot be understood by looking at the system as a whole but that this behaviour emerges from the behaviour of individual parts of the system. It relies on the notion that the whole is more than the sum of the parts. The behaviour of the system can't be explained or understood by looking at the system as a whole.

Anticipation underlines the possibility of individual system parts to assess the consequences of certain responses. The individual anticipation of system elements can cause massive changes in aggregate behaviour of the system.

Non-optimality details that due to the continuously evolving structure of complex adaptive systems, they never reach an optimal point. Therefore, standard theories in physics, economics, and elsewhere pose little help in understanding complex adaptive systems as they all concentrate on optimal outcomes.

Complementing the four key elements is the notion of individuality. Each part of the system has its own decision rules and its own states which determine the outcome of a decision. These individual decision rules and states may influence other parts as well, creating a rule-based structure.

Key elements in the CA – Giving a clear overview of key elements in the CA is somewhat less straight forward, which is probably due to the normative character of the approach. The elements are arguably better presented in a narrativised fashion.

The CA is a normative framework useful for evaluating and assessing individual well-being (Robeyns, 2005). A distinctive property of the CA is the focus on what a person is able to do and to be. This is referred to as their capabilities. A

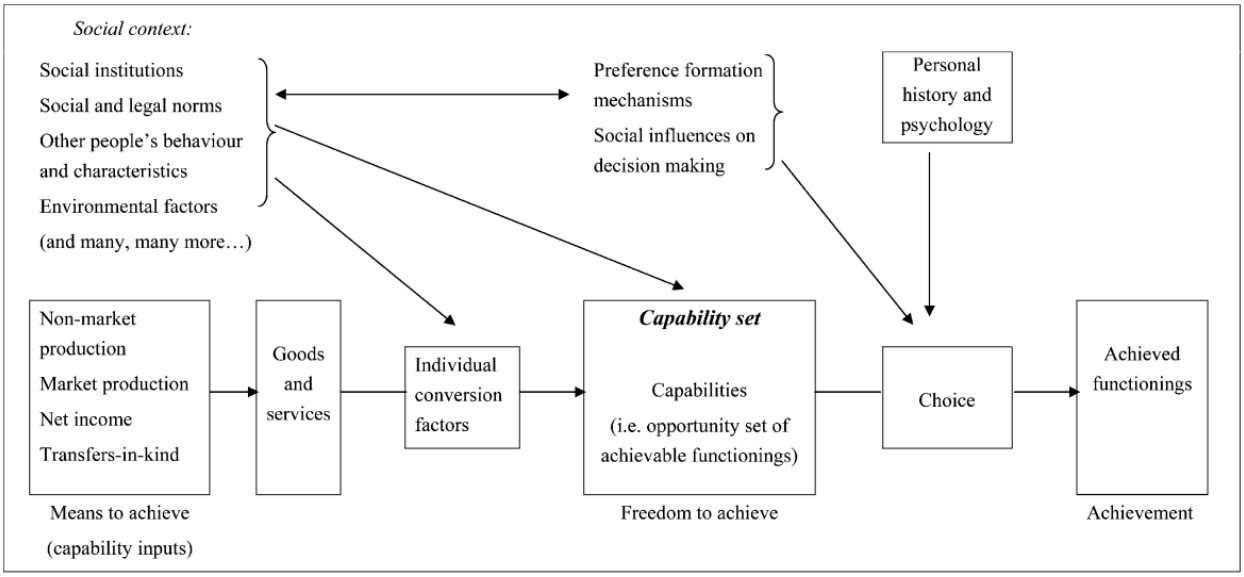

Figure 1 non-dynamic representation of CA process

clear distinction is made between the opportunities people have, and the opportunities people want to undertake. The opportunities people undertake are referred to as achieved functionings. People should be free to decide which opportunities they undertake. Within the CA, means are the instrumental things that help people to reach their goal of increased well-being. Whether a means will aid in achieving a functioning depends on the following four elements: (1) conversion factors, (2) social context, (3) preference formation, and (4) choice.

Conversion factors are separated in three groups: personal, environmental, and social. Whether a person can use a good or a service in achieving a functioning depends on its personal conversion factors. For example, a disabled person has limited use of a bicycle in achieving mobility (Robeyns, 2005). Personal conversion factors are linked to the mental and physical state of a person. They create individuality between different persons. Environmental conversion factors are factors not related to the mental and physical state of a person but rather to the environmental aspects a person cannot change. An example could be a particular law that forbids people to ride a bicycle. Social conversion factors are those that for instance originate from social norms, which state that women are for instance not expected to ride a bicycle.

Social context concerns the arrangement of all factors contributing or limiting the possibilities of a person to achieve a functioning. The effects work through in the personal conversion factors, the preference formation mechanism (and therefore the choice) of a person, and the capability set of a person. It can consist of a wide variety of norms (social and legal), the behaviour and attributes of others, environmental factors, and more.

Preference formation resembles the individual criteria weighting mechanism that leads to a person making a choice. The arrangement of factors originating from the social context contribute to this preference formation mechanism. In simpler terms, the preference formation is the decision making process of a person.

Choice as a concept is quite simple. It entails the decision of a person to choose a capability from its capability set. The underlying processes leading to the choice are more complex in nature.

Robeyns (2005) tried to capture these four elements within a non-dynamic representation. This representation is visualised in Figure 1. It details the whole process of a person from a good and service towards an achieved functioning.

IV. Complications for an integrated approach

The possibilities and implications for an integrated approach are elaborated on by assessing four key elements: (1) individuality of people, (2) decision making mechanisms, (3) adaptivity, and (4) social and environmental surroundings.

Both the CA and the theory of CAS mention the individuality of people. Within the CA it resembles the different mental and physical characteristics a person has which determine the usability of a good or a service (Robeyns, 2005, 2006; Sen, 1993). Within CAS theory individuality resembles the individual states which determine the outcomes of an action (Holland, 1992). CAS theory also mentions that the individual states of people can have an effect on others, either directly or indirectly. This implies that individuality exceeds individual decision-making. This decision-making structure is dynamic due to the reactive nature of a system. A similar process

exists within the CA, however this process is displayed as non-dynamic. The decision-making processes of an individual are influenced by a social context, which incorporates the behaviour and characteristics of other people. The capability approach doesn't mention that persons change their mental and physical states according to these influences. Something that is, according to the CA, to be expected in a real-life situation.

The decision-making mechanisms in CAS theory prescribe that a decision is based on internal states and action rules, environmental changes, and states and action rules of others. When a decision is executed, this decision in turn affects the latter, resulting in a dynamic process. The main difference in the CA is that a decision doesn't have an ongoing effect. The decision, referred to as choice, results in an achieved functioning which is useful in assessing personal well-being. However, this achieved functioning is the end-point (Kleine, 2010). Therefore, the dynamic effects of the decision itself are non existent. Alsop and Heinsohn (2005) made an effort to operationalise the link between choice of an individual and the desired actions and outcomes. They assume that the rationale behind effective choices can be measured. Two sets of factors primarily influence effective choice: agency and opportunity. Agency resembles the ability of an individual to make meaningful choices, thus assessing options and comparing them. Agency is continuously recognised by the CA. Opportunity resembles the formal and informal contexts within the individual operates. Compared to CAS theory, the definition of these intrinsic possibilities of individuals to make their own weighted decisions based on own opportunities seem alike. It is however questionable to which extent the adaptive character of a person as described by CAS theory is applicable to the CA and whether such an extension is justified.

Both approaches identify an environmental and social environment which affects the decision-making of an individual. Within CAS theory this interaction with the environment is two directional, meaning that both the individual and the environment interact among each other. The CA presents a one directional relation in which the individual's conversion factors and capability set are only directly affected by the environment and not vise versa (Robeyns, 2005).

V. Synthesis

According to the structural differences between the CA and CAS theory, conducting a preliminary synthesis of both research approach requires several steps. First, a form of *dynamics* is added to the existing structure of the CA. These dynamics should not interfere with the existing line of reasoning of the CA. Secondly, an *adaptive* elements is to be incorporated within the new framework. This adaptive element should be related to both the individual and the (social) environment. Thirdly, a link is identified between personal conversion factors as presented by the CA and internal states as presented by CAS theory. Fourthly, The social environment as described within the CA is transposed to an overarching system environment in which all elements of the CA are interpreted as CAS elements. Lastly, the personal preference formation mechanism is operationalised building upon the notions of Alsop and Heinsohn (2005) regarding agency and opportunity.

Dynamics are integrated in both the interaction between an individual and its social environment and the effect of the achieved functioning on the social environment. The addition of dynamics is best described an example. Imagine for instance a person named Herman. Herman is capable of taking a boat to work as a means of transport. He values taking this boat to work as it increases his well-being. However, the boat will only sail when

it is fully loaded. The decision of other people to take the boat has an effect on the capability of Herman to take the boat to work. On the other hand, the decision of Herman to take the boat to work affects the capabilities of others as well. Furthermore, the decision of Herman to take the boat to work has an indirect effect on the well-being of others. The latter is a clear addition to the material and non-material circumstances that determine the opportunities that people have and the capabilities that people choose from. Robeyns (2011) Already identified cases in which capabilities are available to multiple people and in which the choices of people depend on the choices of others, implying the justification of adding dynamics to the CA.

Adaptivity can be directly linked to the aforementioned example of Herman taking the boat to work. If no people make use of the available boat, Herman has no choice but to take the train to work, despite Herman less valuing this alternative. If, over time, more people start using the boat, Herman can decide to abandon his daily train routine and start going to work by boat. With respect to the CA, adaptivity could be a decisional change invoked by a change in preference as well as a change in possibilities.

CAS prescribes that heterogeneity; i.e. variation between individuals, is needed to enable adaptation (Levin et al., 1998). Therefore, adaptivity requires that *personal conversion factors* are looked upon *as internal states* that differ among people. The CA itself already identifies that these personal conversion factors indeed differ between persons. Robeyns (2005) states that human diversity is represented by focusing on personal and socio-environmental conversion factors. It is assumed that a quite substantial overlap of interpretation of both the concepts *conversion factors* and *internal states* is present within the CA and CAS theory.

The concept of *system environment* in CAS theory is quite flexible, given that the environment depends on the chosen scale of analysis and is therefore more easily scoped (Choi, Dooley, & Rungtusanatham, 2001). One should however consider the separation of person from system. The CA is concerned with the well-being of an individual. The number of influencing environmental factors is therefore automatically scoped to those that directly and indirectly affect the concerned individual.

Regarding *Preference formation,* Alsop and Heinsohn (2005) presented their view on preference formation to be based on opportunity and agency. The proposed structure seems very alike to that of the CA. First it is assessed whether a person has the opportunity

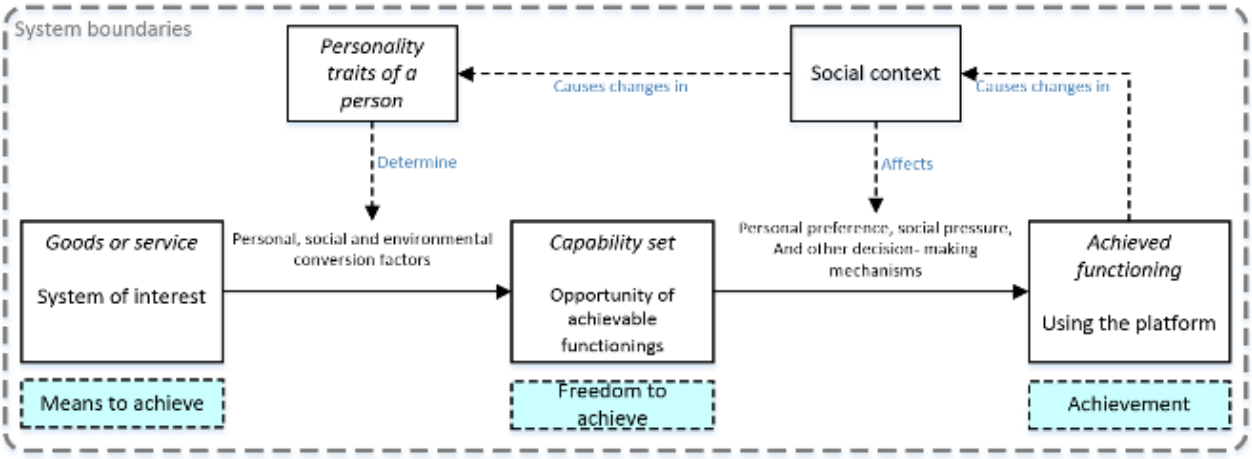

Figure 2 Stylised overview of integrated CA-CAS framework incorporating core elements

to choose (has the needed conversion factors), then it is decided whether this choice is made (Choice of capability), and finally it is evaluated whether it gave the desired outcome (achieved functioning) (Alsop & Heinsohn, 2005). It is also detailed that the notions of agency and opportunity can be structured in different ways, depending on the type of research.

VI. Integrated framework

Within this section an overview is presented with respect to how the integrated framework is envisioned. Figure 2 presents a conceptual overview of the integrated framework, with the addition of the integrated elements discussed in section five.

The most important change is the feedback from achieved functioning towards the social context. This feedback implies that practical experience with a technology has an effect on the preference and choice of the person. The social context also describes the social norms which pressure the user. When a system has more users, social norms can potentially shifts towards using this system. Furthermore, The overall level of experience of the group of users increases over time, the longer people use the system. This increased level of experience could for instance have an effect on the performance of the system and therefore the effect on the well-being of people.

The changes in the social context work through in the personality traits of a person. Taking the example of experience; experience is required to use the system, the level of experience will most likely increase over time, causing changes in the experience level of a particular person. Even when the system is not used, the experience of this individual can increase caused by the actions of others due to the structure of the relations within the integrated framework.

The personality traits are interpreted as conversion factors as presented in the CA. They determine whether the person is enabled to choose a certain capability. These capabilities are enabled by the system of interest.

VII. Experiences from a practical application

A practical application of the integrated framework has been executed in a master thesis. Within this thesis the CA combined with CAS was used to evaluate various performance metrics with respect to system-usage, transactions, and ethical value fulfillment of a smart electric vehicle charging system.

Within this project the unified theory of acceptance and use of technology (UTAUT) as presented by Venkatesh, Thong, and Xu (2012) was implemented to serve as an explanatory concept. Preference formation was largely based on the performance of the system as a whole, and the expected effort for the user. A social network structure was implemented.

The integration of CAS indeed provided a operationalised conceptual model. However the different numerical values for modeling still needed quantification. Combining the theory on performance-expectancy, effort-expectancy, and the relations between the users with data was considered both tricky and induced uncertainty. Due to this uncertainty, a more explorative approach was needed. Exploratory modeling and analysis as introduced by Kwakkel and Pruyt (2013) was used to deal with the uncertainty and provide usable model outcomes.

Several limitations and implications of using the framework were derived from the research. First of all, the line of reasoning of the CA poses a problem for the inclusion of dynamics. As Kleine (2010) earlier stated in his research, achieved functionings are considered the end-point of

evaluation within the CA. However, viewing the smart charging system from a CAS perspective implied the existence of feedback between the achieved functioning and social contextual factors such as the internal states of other users. This feedback essentially creates a dynamic setting. It remains unclear how to conceptualise the CA to properly deal with this.

VIII. Conclusion and reflection

Within this paper, an attempt was made at integrating CAS theory within the CA of Sen (1993). A reflection on the limitations of the CA in its current form identified the need to include five key elements from CAS theory. These elements are: dynamics, adaptivity, internal states, system environment, and preference mechanism. They were added to the conceptualised overview of the CA as presented by Robeyns (2005).

To a large extent this integrated framework seems plausible for assessing complex adaptive systems and complex technologies. Research on the short and long-term system usage and ethical value fulfillment of a smart EV charging system pointed out that new usable insights can be obtained by using this approach.

However, the approach has some sizeable limitations which definitely deserve mentioning. First, the combined framework is seemingly more distanced from the concept of well-being. Secondly, the unfoundedness of dynamics causes choices by the modeler which might not be ethically justified. Thirdly, ethical values are distanced from users due to the increased focus on the enabled capabilities by a certain technology.

The focus on technology rather than the user, results in a decreased focus on well-being. To effectively use the CA for the evaluation of well-being, a focus is placed on the well-being freedom and agency freedom. Sen (1993) has stated that for this evaluation, no limits should be enforced on these freedoms. The research on smart charging pointed out that scoping on a certain technology or system naturally induces forced decisions regarding available capabilities and relevant conversion factors. This raises serious concerns whether this is ethically justified as focus shifts from well-being of people towards the effects of a technology. The CA was not originally intended for this kind of evaluation.

References

Alsop, R., & Heinsohn, N. (2005). *Measuring empowerment in practice: Structuring analysis and framing indicators* (Vol. 3510): World Bank Publications.

Bellanca, N., Biggeri, M., & Marchetta, F. (2011). An extension of the capability approach: Towards a theory of dis-capability. *ALTER-European Journal of Disability Research/Revue Européenne de Recherche sur le Handicap, 5*(3), 158-176.

Choi, T. Y., Dooley, K. J., & Rungtusanatham, M. (2001). Supply networks and complex adaptive systems: control versus emergence. *Journal of operations management, 19*(3), 351-366.

Deneulin, S. (2008). Beyond individual freedom and agency: Structures of living together in Sen's capability approach to development.

Holland, J. H. (1992). Complex adaptive systems. *Daedalus*, 17-30.

Kleine, D. (2010). ICT4WHAT?—Using the choice framework to operationalise the capability approach to development. *Journal of International Development, 22*(5), 674-692.

Kwakkel, J. H., & Pruyt, E. (2013). Exploratory Modeling and Analysis, an approach for model-based foresight under deep uncertainty. *Technological Forecasting and Social Change, 80*(3), 419-431.

Levin, S. A., Barrett, S., Aniyar, S., Baumol, W., Bliss, C., Bolin, B., . . . Gren, I.-M. (1998). Resilience in natural and socioeconomic systems. *Environment and development economics, 3*(2), 221-262.

Robeyns, I. (2003). Sen's capability approach and gender inequality: selecting relevant capabilities. *Feminist economics, 9*(2-3), 61-92.

Robeyns, I. (2005). The capability approach: a theoretical survey. *Journal of human development, 6*(1), 93-117.

Robeyns, I. (2006). The capability approach in practice. *Journal of Political Philosophy, 14*(3), 351-376.

Robeyns, I. (2011). The capability approach. *Handbook of economics and ethics, 39*.

Sen, A. (1993). Capability and well-being73. *The quality of life, 30*.

Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. *MIS quarterly*, 157-178.