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From Hardware to Hardcore:
Formalizing Systems with Form Theory

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ABSTRACT

The state and relevance of Systems as a field of research and a specific form of scientific inquiry into complex real-world problem situations, can be enhanced significantly by developing and applying more formalized and coherent tools: a new 'hardware' enabling to build a new 'hardcore' for systems science. The basis of this new hardware stems from a line of thought emanating from George Spencer-Brown and the 'Laws of Form', running through the work of Francisco Varela and his calculus for self-reference, being radicalized by Niklas Luhmann and his views on 'Social Systems', and continued by Dirk Baecker with the application of form theory to management and organizations. In this contribution, the author develops an understanding and appreciation of the potentials of a form-theoretical approach to formalizing systems (real-world phenomena) as well as Systems (field of research). Central aspects will be the power of the form-theoretical hardware as regards systems storytelling, systems diagnostics and abductive reasoning.

KEYWORDS

Form Theory, Laws of Form, Second-Order Cybernetics, Systems

1. POINTS OF DEPARTURE

Some years ago at an UK System Society meeting in Oxford, Peter Checkland was arguing that systems theory just about struggles on. Surely, he added, the field of Systems (with a capital S) had been institutionalized within university departments and courses are taught dedicated to systems theory and practice; but in Checkland's view there appeared to be a certain stagnation both within Systems and with its acceptance across disciplines. In listening to his remarks, one could not help but feel a certain resignation in his voice. By remembering Checkland, we did a quick Google Ngram search on the terms 'system' and 'systems' in order to check for any signs of 'peak system' and a potential decline in references in published books. The results are sobering. You do actually notice a peak of both terms at around 1990 and a slow but steady decline afterwards. The term 'systems theory' peaked at around 1980 and remained somewhat on a plateau until the mid-1990s. Since then it fell back in its prominence to mid-1970s levels. For 'soft systems methodology', Checkland's own creation (Checkland, 1999), the peak occurred in the late 1990s followed by continued decline ever since. Quite interestingly, the hard system approach of 'system dynamics' remains on a high plateau as regards references since the 1990s and even shows some increase since the mid-2000s. Needless to say that all of these terms are dwarfed by more common managerial concepts like 'strategy' or 'marketing'. By these admittedly crude and quantitative measures, but substantiated by the observation of one of the most eminent researchers within the Systems community, Systems as a field and its associated notion of systems theory is increasingly looking like a niche product for connoisseur scholars.

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The peaking of concepts and ideas is not the end of the world and a normal process in the evolution of science. However, the initial promise of systems research, providing a unique conceptual lens for addressing complex real-world problems, is probably more in demand in our age than ever before. Messy and intertwined problems like climate change mitigation and adaptation, managing the digital transformation of economy and society, as well as finding a new global governance framework in a time of resurgent nationalism and authoritarianism, defy classical predict-and-control approaches in the fields of economics or political sciences. Systems understood as a post-classical approach i.e. not bound to a single discipline (e.g. economics) and a single rationality (e.g. rational choice), must not be abandoned in the light of these challenges. In this contribution, we will argue for the need for more formalization within systems research and more rigour – yet also for increased playfulness within a formal framework we call the 'hardware' of systems research. We propose a certain tradition of system thought emanating from Francisco Varela's work on a calculus of self-reference (Varela, 1975) that was based on George Spencer-Brown and his 'Laws of Form' (Spencer-Brown, 1969). This tradition continued with Niklas Luhmann in his theory of social systems that he based firmly on the grounds of second-order cybernetics (Luhmann, 1995) and culminated in the form-theoretical reconstruction of management and organization by Dirk Baecker in his 'Form of the Firm' (Baecker, 2006). Some insights from our own work (Reichel, 2011, 2017) will be re-evaluated in the light of what we call an emerging form-theoretical approach to systems storytelling, constituting a new 'hardcore' of systems theory and research.

2. THE ARGUMENT FOR FORMALIZATION OF SYSTEMS

Systems as a field of science apparently knows no singular form, neither in its own name nor in the term 'systems theory'. Actually, we should probably call it systems theories instead when we talk about the conceptual foundations of Systems. For some this plurality within Systems can be seen as both a strength and vital sign for its further development, creating new insights and understanding in the complexity of the phenomenon of systems. Given the notion of peak system above, you could also rightfully argue that plurality might now be a major hindrance to any future development within Systems and to the relevance of the field to the great societal challenges around us. We are not yet ready to argue for turning Systems into a monochromatic discipline, but we do believe that the continuing rise of e.g. system dynamics gives us a hint what to look out for. There can be many criticisms about the method of system dynamics and its rather under-complex conceptualization of systems as first-order feedback systems, but its methodological rigor, its 'hardness' is most likely to blame for its ongoing success (Featherston, Doolan, & others, 2012). We are not proposing to become system dynamicists or trying to apply computer simulation to our own systems theories; rather we follow the insights from Stephan Fuchs that there is no hard distinction between 'hard' and 'soft', between the methods of the natural and the social sciences because there is no *Ding an sich*: "The choice of methods, stances and approaches is… not governed by intrinsic differences between things social and things natural. Rather, 'social' and 'natural' are consequences of processes of attribution that vary from observer to observer, across time and space." (Fuchs, 2001, p. 109) Moreover, Fuchs is arguing that what "makes a [science] culture 'hard' and realist, rather than 'soft' and constructivist, is hardware, among other things." (ibid., p. 306) Hardware means tools, not just physical tools like a telescope but conceptual tools like mathematics and others. System dynamics' success rests on its hardware and the mindset of those who do system dynamics for a living. Again, we neither advocate the hardware nor the mindset of system dynamicists, but the insights we can gain from their particular culture. Without the proper conceptual hardware and an appropriate mindset, the field of Systems cannot progress. The mindset we deem appropriate here is that of formalization, not necessarily quantification: developing and applying formalized languages, tools and descriptions for systemic problems.

This argument is inspired by research originally carried out by Francisco Varela more than 40 years ago in his seminal article on 'A Calculus for Self-Reference' (Varela, 1975). Varela's lifelong

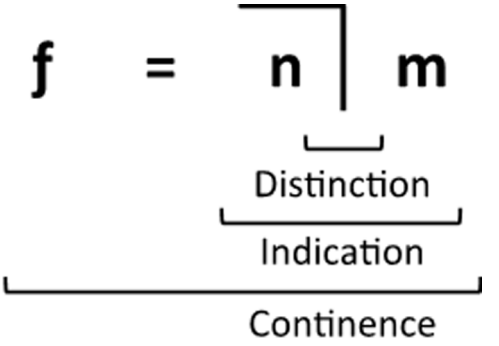
journey to finding an answer to Erwin Schrödinger's question 'What is life?' lead him to the insight that in order to understand life you have to understand several intertwined notions: autopoiesis i.e. the self-production of complex system-wholes, requiring closure against their environment, thus stating autonomy from their environments. Only then a system can interact with its environment without loss of identity (Varela, 1981, pp. 15–17). Autonomy as self-rule through closure and self-production leads to the insight that "the rules of operation are all self-contained, there is no possibility of referring to the outside from inside the system." (Varela, 1997, p. 73) The conceptual and real-world hardships with self-reference have all the same root: the distinction between actor or operand, and that which is acted or operated upon, collapses. All complex systems and all those messy real-world problems we can perceive as such are self-referential in their nature. Varela framed the problem like this: the peculiarity of such systems "lies in being self-indicative in a given domain, in standing out of a background by their own means, in being autonomous as the strict meaning of the word enounces." (Varela, 1975, p. 5; emphasis added) In order to understand such self-referential systems, any conceptual foundation has to be placed firmly within their self-referential grounds. In his quest to creating his own science, Varela went on looking for a formal foundation not only for the problem of life but in fact for all situations – and all systems – that exhibit self-reference as their central feature. We are arguing that Varela actually came up with the required hardware so desperately needed for Systems. Before we can show some applications of this hardware, we have to briefly rehash its foundations: the 'Laws of Form' by George Spencer-Brown (Spencer-Brown, 1969).

3. ON THE 'LAWS OF FORM' AND THE FORM-THEORETICAL HARDWARE

Much has been written about George Spencer-Brown and the laws of form. Louis Kauffman sees them as "a lucid exposition of the foundations of mathematics. It embodies a movement from creativity, to creation, to symbol, to system and language and thought and self." (Kauffman, 2002, p. 50) In one sentence, 'Laws of Form' can be described as a conceptual inquiry into the origins of mathematics as well as a mathematical inquiry into the origins of concepts – summarized in the form of a question: how to inquire? The answer Spencer-Brown gave was simple: draw a distinction and create a universe. Drawing a distinction is a threefold operation consisting of the distinction itself, that separates a previous unmarked space *n* (no-thing) into two distinct sides thus creating that space through indication i.e. by distinguishing this side from that side the space becomes marked as *m* (some-thing) and, finally, the continence of all aspects of distinction/indication that are bound together by itself into the form of distinction. The symbol of this indicational notation of Spencer-Brown is called 'the cross' or 'token'. Two basic laws of the form, the laws of calling (condensing several sequential indications into one) and law of crossing (cancelling out so-called nested indications), give rise to both a simple arithmetic, a system of rules how to operate with the cross and turn markedness into unmarkedness and vice versa, as well as to an algebraic system denoted as Brownian algebra that allows calculating with unknown variables according to the rules derived from the ideas of distinction, indication, continence and the two basic laws of form. It is one of the simplest origins of mathematics that starts with no-thing, the void, and then adds a distinction to create some-thing (Robertson, 1999). We will call the ideas and tools developed in 'Laws of Form' form theory. Figure 1 depicts the basic notation with the form of distinction.

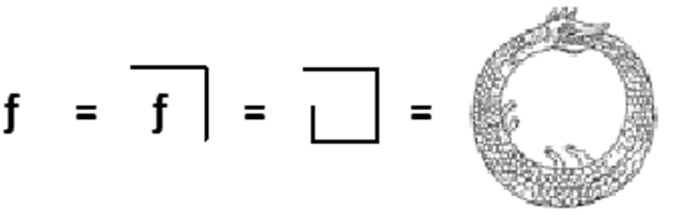
Spencer-Brown stopped his work when self-reference was encountered. Chapters 11 and 12 of the Laws of Form are dealing with what he calls 're-entry'. This is a situation in which a distinction is inserted into itself i.e. when it becomes self-indicational or self-referential. Then something curious happens: some-thing is equal to no-thing in time. Indication gives rise to space, turning the void into the form while self-indication gives rise to time and an oscillation between opposing states. Whenever self-reference is called, temporal oscillations occur. This is important insofar as all complex systems we observe as such today exhibit a self-referential nature, i.e. they recur on themselves in order to evolve and change. In the course of their evolution they become what they are not – yet: a system can

Figure 1. The form of distinction (Reichel, 2017, p. 91)



change from a present state A to a future state ¬A. While Spencer-Brown finished his work at the moment when self-reference becomes an issue, Varela decided to start his journey right here with his calculus for self-reference as an extension of the calculus of indication: "I have taken the Calculus of Indications as a starting point in an attempt to produce adequate tools to deal with self-referential situations. Self-reference is, of course, of great historical importance; it was responsible for a major crisis in mathematical thinking at the turn of the century. More recently, with the development of cybernetics and systems theory, other aspects of self-referential situations have become apparent, namely, the fact that many highly relevant systems have a self-referential organization." (Varela, 1979, p. 141) The key problem when dealing with systems that produce themselves autonomously through the production of a boundary is that of self-reference. In developing a rich body of formal foundations for self-reference, Varela provided the grounds on which any systems theory can stand and his work is a prime example of how Spencer-Brown's 'Laws of Form' can be applied in the field of Systems. The emphasis on and embracing of self-reference, driven by Varela's motive of finding a conceptual foundation for the autonomous systems he was dealing with as a researcher, changed the indicational perspective insofar as self-reference is now as constitutional for it as the primary distinction Spencer-Brown made. Robertson noted that this "is ... an explicit creation of a new calculus in which self-reference will be the core." (Robertson, 1999, p. 53) The form of re-entry is depicted in Figure 2 and resembles the mythological creature of the Uroboros, the serpent eating its own tail. As abstract as it all might seem, this form-theoretical hardware of the calculus of self-reference has been applied within the broader field of Systems. First and foremost, we have to mention Niklas Luhmann and his works on a theory of 'Social Systems' (Luhmann, 1995).

Figure 2. The form of re-entry (Reichel, 2011, p. 652)



4. NIKLAS LUHMANN AND THE FORM OF RE-ENTRY

Before getting into Luhmann's application of the hardware of form theory, some brief remarks about his own achievements might be necessary. Luhmann used the ideas of what Heinz von Foerster termed 'second-order cybernetics' to address the question of how to build a theory of society, especially modern society. The notion of 'second-order' denotes a situation where e.g. in the case of cybernetics, cybernetic reasoning is turned towards cybernetics itself i.e. thinking about feedback control in terms of feedback control (Foerster, 2003; Scott, 1996). The main question of first-order cybernetics is: how to control a system through feedback of its own past states in its present calculations? Observation of the system of interest from its outside was the road to answering this question. The main question of second-order cybernetics is: how are cyberneticians constructing feedback models of cybernetic systems? The attention is now turned towards the observer and the act of observing systems. Taken to its extreme, this line of reasoning sees systems as observers who are observing themselves. The theory of social systems is the result of what happens when a self-referential type of system theory is applied to the sociological problem of a theory of society. The theory is self-referential insofar as it takes into account the observer as the pivotal starting point of any observation, scientific or otherwise, and thus not only giving a theory of society observed as being made up of systems, but a theory of society that contains itself i.e. gives a coherent and complete description about how theories within society are created (Luhmann, 1992). In other words: it is an ontological conceptualization of society and social life without reference to ontology – that is the 'joke' behind Luhmann's theory. No other systems theory comes close to this and you might rightfully argue that Luhmann's theory is not just a systems theory but provides us with a glimpse to a unified System Theory (in capital letters).

His ontology without ontology starts with the premise, in his opening lines to 'Social Systems' that "the statement 'there are systems' says only that there are objects of research that exhibit features justifying the use of the concept of system, just as, conversely, this concept serves to abstract facts that from this viewpoint can be compared with each other and with other kinds of facts within the perspective of same/different." (Luhmann, 1995, p. 2) In this perspective, the divide between hard and soft systems approaches, between systems as real-world entities or mere epistemic devices, is resolved in an operational way: if there is a some-thing that can be observed as a system, it is systemic in its consequences. We hold such a de-mystified form of constructivism, an operational constructivism that is interested in getting better explanations for real phenomena, suitable as the epistemological standpoint of a system theory. In the words of Fuchs again: "Constructivism is adequate only if it can explain why some constructions appear unconstructed. Otherwise it is an arrogance and imposition." (Fuchs, 2001, p. 338). So, the starting point for our line of thinking about a new hardware for Systems, is the insight that any system can be observed as a process of drawing a distinction, a difference, between system and environment and the intra-systemic realization of that process: the system 'is' that process. Such an approach yields insight for a more general approach to systems theory, namely the clarification and conceptualization of a descriptive language for self-referential systems we briefly sketched above.

Luhmann used exactly one concept of the hardware the 'Laws of Form' and Varela are providing: the form of re-entry. Social systems operate with re-entries constantly. The creation and management of their own paradoxes is what defines and drives them. Luhmann starts his system theory not with the notion of unity, of a system-whole, but with the notion of difference. A system is first and foremost defined by what it is not: by what is excluded from it, by the fundamental distinction between the system and its environment. Drawing this distinction creates the system and the constant production of the distinction with intrasystemic means ensures the system's viability: without distinction no re-production. At the same time the system can observe this distinction operation and its outcomes. It re-enters the distinction between itself and its environment within the system through observing how it is drawing the boundary. Re-entry, in a social system perspective, is thus understood as a self-observation of the system within the system. This is the origin of reflexivity, of the ability of being

aware of oneself, what you are, what you become. All complex systems that we can observe as such today are of a self-referential nature, i.e. they recur on themselves in order to evolve and change. In other words: systems become, over time, what they are not. For Luhmann, the dominant task of management then does not follow a simple procedure of plan-do-check-act but revolves around a rather ambiguous balancing act of self-references within an organization and the provision of means for self-description for organizational members in order to cope with the paradoxes of the system (Luhmann, 2006, p. 433).

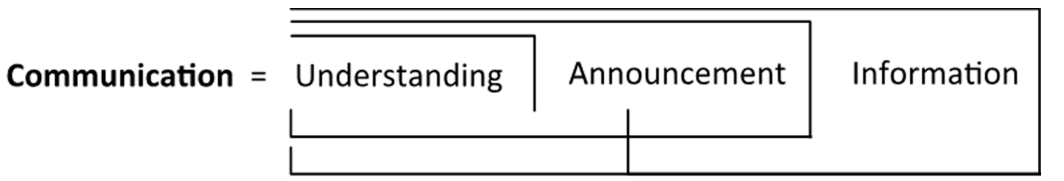
In applying the formal notation developed by Varela on the back of 'Laws of Form' on the central Luhmannian notion of communication as constitutive for social systems, we can draw the following form of communication in Figure 3.

For Luhmann, communication is the basal operation of any social system and has an event-like character. It is, in his words, the unity of three selection processes: understanding, announcement and information. We depicted these selections as distinctions with different forms of re-entry i.e. observations within communication of information, announcement and understanding. Note that any distinction can be observed from any other distinction, depicted by the various hooks attached to different crosses. The re-entry from information into announcement means that announcing this particular information is weight against announcing that information that might also be relevant. Announcement re-entering understanding implies that this particular announcement is more relevant than that announcement. Information re-entering understanding then implies that this announced information is understood regarding its context of all other potentially announced information. All these re-entries have to be taken simultaneously in order to establish communication in a Luhmannian sense; they are context to each other without which no meaningful synthesis could be achieved. This is one particular way how to use our new hardware in systems research: to simplify complex phenomena of self-reference with a new descriptive language for telling a facet of a system in a different way, sensitizing researchers for re-entry relations and enabling them to ask new questions for gaining new insights. Using the form-theoretical hardware can be regarded as the first step in exploring a new hardcore of Systems as a field with a formal description language (Reichel, 2011, p. 662). The most advanced attempts in using form theory in systems research have to be credited to Dirk Baecker and his form-theoretical models of the economy and its firm (Baecker, 2006a).

5. THE FORMS OF DIRK BAECKER

We focus on two specific forms Dirk Baecker developed with the form-theoretical hardware that are based on key ideas of Luhmannian systems theory. The first form is that of the economy of modern society that Baecker describes as an empirical reconstruction. It starts with scarcity as the central problem of the economy and driver of any economic logic: to economize implies to accept the problem of scarcity and deal with it. In a Luhmannian perspective, the economy then observes scarcity and the activities connected to it and communicates about it via means of prices expressed in the medium of money and goods traded on markets (Baecker, 2006b, p. 45). In our very own attempt to deepen form-theoretical understanding of the economy as a system, we playfully adopted Baecker's form and included re-entry operations in order to tell a richer story about the economy while at the same time

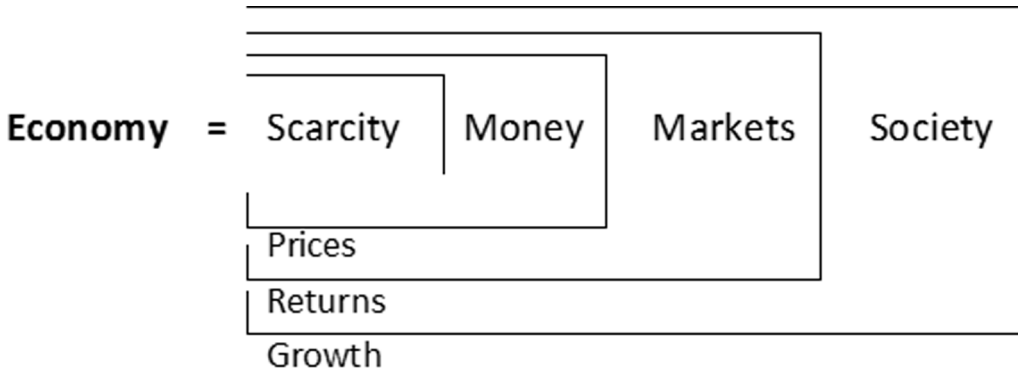
Figure 3. The form of communication (Reichel, 2011, p. 659)



increase our understanding of applying the form-theoretical hardware (see Figure 4). The distinction between scarcity and money can be read as money being the context against which scarcity can be evaluated. The re-entry between money and scarcity, the observation of the distinction between the two from the viewpoint of scarcity, is achieved by the formation of prices: the price relates money and scarcity. Prices tell market actors where scarcity is most pressing and economization is necessary. Next to the understanding of re-entry as the process of self-observation of the system within the system, we now have an additional reading: in-forming and relating what is distinct through (self) reference (Spencer Brown, 1969, p. 57). The relating aspect of the re-entry operation is an essential insight for understanding systems not in terms of causality but in terms of contextuality. Speaking of contexts, markets are then related to scarcity through monetary returns e.g. on investments or on expenditures when compare with utility gained. Returns are in-forming onto what markets money is to be directed. As markets are changing, flows of money and its returns are changing and driving the economy. Society is then containing context for the economy, its evolution, operations and their contexts. The final re-entry is then described as growth, expressed in the increase of the sum of all traded goods according to market prices over the long-term, and enables the observation of how scarcity is relevant to society. Economic growth, in this observational form of the economy, is the predominant means to overcome scarcity via investing in markets with optimal returns and trading monetized goods via the price mechanism. All of these re-entries can be empirically substantiated, especially when we look to the hegemonial position economic growth has acquired (Schmelzer, 2015).

In using our form-theoretical hardware we can formalize, in one picture, very precisely what is happening in such a complex system like the economy, without having to explain the whole story in detail in sequential sentences. Baecker went on to apply this hardware to construct a new hardcore for a form-theoretical theory of the firm. His 'Form of the Firm' works with simple re-entries as we have chosen above i.e. relating different contexts of the firm with its basal operation. While the basal operation of the economy was scarcity, the basal operation of the firm is its product. This defines the firm more than anything else. In Stafford Beer's words: "The purpose of the system is what it does" (Beer, 2002). The story of the firm can be told from different perspectives, depending on our interests for inquiry. For example, we focus on issues of how products are actually produced: with technology being organized through work to create the product. This is the story of operations management and it is all about the relation of product and technology i.e. the re-entry of technology via work against the context of the organization. It enables us to inquire critically about the conditions of work, the kind of technologies employed and the organizational structures and hierarchies in which this takes place. Given that re-entry is not about causality but contextuality, it also sensitizes us to the fact that changes in the contexts, e.g. new organizational structures like new arrangements of the value chain or new decision rules like organizational democracy, will force the re-entry to change as well and

Figure 4. The form of the economy (Baecker, 2006b, p. 45)



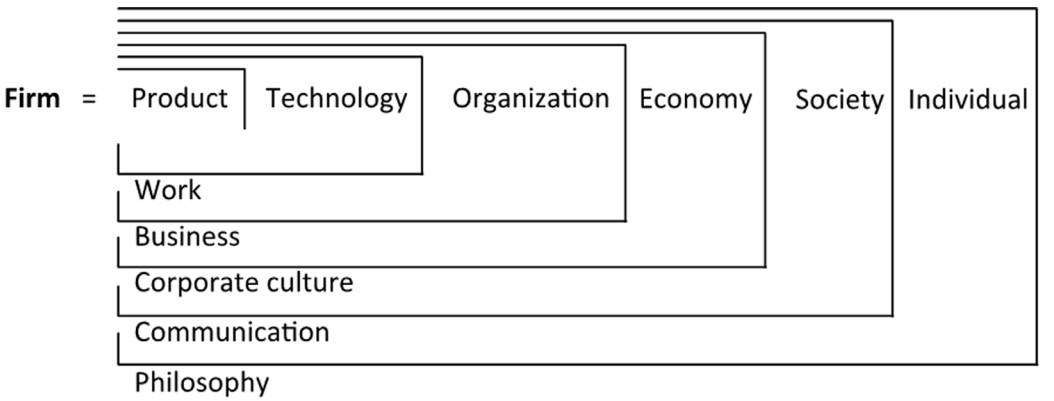
relate product and technology different. If we chose to tell the story of the firm from a more strategic perspective, we focus on the relation of the product with its organization against an economic context through business. Strategic management then becomes that activity within the firm that is not so much concerned with work or technology, but with the whole lot we described above in the form of the economy: how to turn scarcity in the economic contexts of the firm into a business case. Baecker's original form of the firm is depicted in Figure 5.

It is exactly here where we ventured further with our own form-theoretical enterprise. We remain firmly on the basic premises set-up by the hardware as developed by Varela out of the 'Laws of Form', the system-theoretical perspective of Luhmann on systems as differences and paradoxes, and the empirical work of Baecker when it comes to the forms of the economy and the firm. What we have chosen to do, is to expand the rules of using the form-theoretical hardware in order to understand the potential of its application better. In short, we developed our own form of the firm by applying a 'mathematical trick', thus creating a more flexible systems tool that can deal with the societal challenges we briefly touched upon as one of the points of departure of this contribution.

6. FROM HARDWARE TO HARDCORE

Issues like climate change and the greater ecological crisis, the aftermath of the financial crisis, the changes brought about by the digital transformation are all contextual changes in the form-theoretical view presented here. Having a background of managerial and organizational research ourselves, we chose to reconstruct the form of the firm by placing more emphasis on the economic contexts detailed in the form of the economy. In doing so we hitherto enable the form of the economy to change along the lines of other contextual changes in business, technology, the natural environment and society, revealing the nature of a new economy we call the 'next economy'. By doing so we follow Baecker who actually followed Peter Drucker and the idea of a 'next society' succeeding modern society (Baecker, 2007; Drucker, 2007). These rough remarks should caution you that what we have attempted here is using the form-theoretical hardware on some weak empirical signals, manifest in changes in the real world, in order to make an abductive guess about the future. More bluntly: we are going to tell a speculative system story – and that is exactly what the form-theoretical hardware is good for. The 'mathematical trick' needed to do that is rather simple. Think of Baecker's form of the firm as a mathematical equation in which 'economy' is a variable X that has its own underlying equation given with the form of the economy. We substitute that X by its own underlying equation thus changing the equation for the form of the firm. So, we zoom into the form of the firm and replace 'economy' with the contexts of 'scarcity', 'money' and 'markets'. We further introduce a new context between

Figure 5. Baecker's form of the firm (adapted from Baecker, 2006a, p. 128)



'society' and 'individual': 'nature', thus enabling us to take into account ecological considerations absent from Baecker's original form. This gives rise to the revised form of the firm depicted in Figure 6.

We then start looking closer at some changes coming from new contexts like digital technologies and their influence on work and product creation as well as organizing the firm; from changes in the re-entry operations between these new contexts that, again, act on the contexts thus further changing them; finally how a new form of the firm can give us insights into a new form of the economy and how this affects a new hardcore of management and organizations from the perspective of both systems theory and form theory. The story has already been told elsewhere (Reichel, 2017) and is depicted in its final form in Figure 7, so we will focus on some crucial insights gained from this application of the form-theoretical hardware.

First of all, the re-entry operation is truly central to any understanding of complex system-wholes and their evolution. Its multiple meanings, both as self-observation as well as relation to and in-formation by a context, orients systems research as an empirical science. What are contexts to each other? What changes can be observed in the context and in their relations? How are these connected? These are empirical questions revealed by applying the form-theoretical hardware to systems of inquiry. In our case this has revealed the incompatibility of scarcity as basal operation for any future economy. Scarcity is only driving the economy off its cliff and might easily stimulate

Figure 6. Revised form of the firm (author's description)

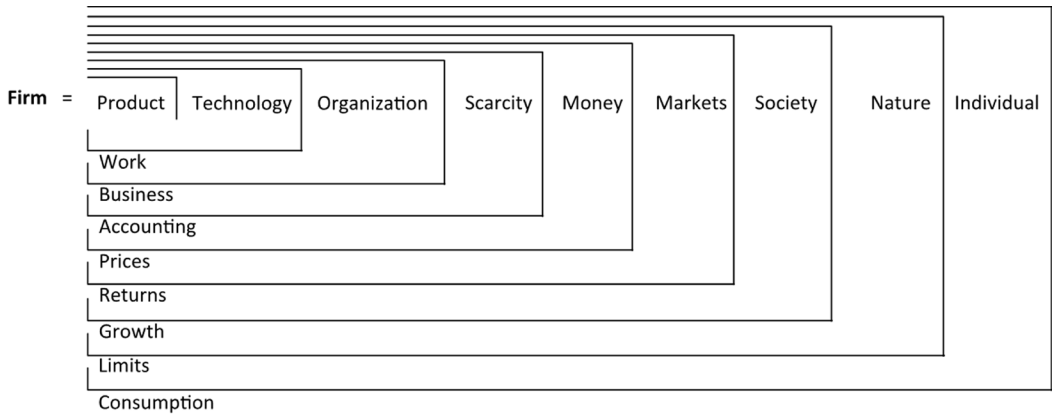
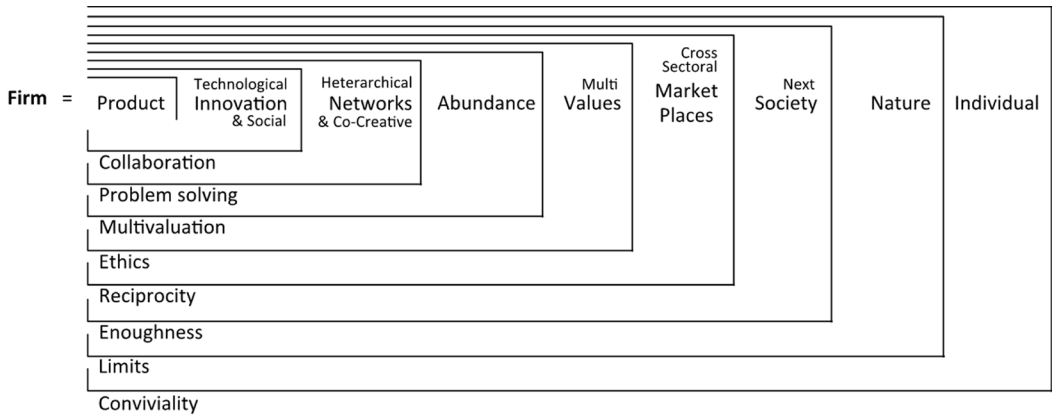


Figure 7. The new form of the firm in the next economy (Reichel, 2017, p. 109)



future crises. The nascent ideas on enoughness, on plenitude and a commons economy fit the story told in the form-theoretical language much more consistent than scarcity.

Thus, a second insight became clear by applying our new hardware: it is a tool for uncovering system pathologies and inconsistencies in the light of environmental i.e. contextual change. This places form theory in the tradition of some aspects of management cybernetics, most notably Stafford Beer's Viable System Model (Beer, 1995; Schwaninger, 2006). But while the VSM rested on a more rigid form of structural-functionalism and first-order cybernetics, form theory is based on self-reference and can be seen as one possible way of formalizing second-order cybernetics for systems research.

Third, with this form-theoretical hardware, the logical inference of abduction is turned into an epistemological method for systems research with technological results. What we mean by technological results are concrete abductive guesses in the form of practical guidelines for dealing with changing systems and their changing environments. In our research on the new form of the firm in the next economy, this resulted in some clear implications for management, namely that control over the firm has to be dispersed across its contexts, enriched with diverse values from the firms internal and external environment, and guided by a managerial ethics enabling collaborative evaluations of what kind of value is created, why this particular value should be created, and who benefits in what form from it. Highlighting collaboration points towards the shortcomings of a lot of supply chain and other partnerships that fail to take into account the systemic nature of collaboration (Neumann, 2012). Change can be traced and focused with the form, but it also provides a sensemaking device for management (Weick, Sutcliffe, & Obstfeld, 2005; Weick, 1995) and a tool for telling self-referential stories dealing with the many paradoxes of change.

Taken together, the empirical orientation through applying form theory, its diagnostic power rooted within the reality of self-referential systems, and its abductive epistemology enabled by the form-theoretical approach constitutes a new form of systems storytelling, both retrospective (understanding and analyzing current conditions) as well as prospective (perceiving and managing change). This storytelling through form theory, in our perspective, forms the new hardcore for systems theory, research and practice.

7. POINTS OF ARRIVAL

What we tried to show in this contribution is a glimpse into new territories for systems research and the entire field of Systems. We believe that form theory as hardware enables systems research to tell formalized system narratives by (1) formalizing systems and their workings i.e. depict their stories in an economic and condensed manner, as well as (2) enable understanding of systems i.e. enable to tell their stories in the first place through form-theoretical storytelling. At the same time, our new hardware can give rise to a new hardcore for Systems in general. The route of formalization of systems theory with the help of a form-theoretical hardware has been sketched and illustrated by examples resting on a tradition of systems thinking based on second-order cybernetics, the 'Laws of Form', and formal notations for self-referential systems – from Spencer-Brown (1969) to Varela (1975) to Luhmann (1995) to Baecker (2006) to Reichel (2011, 2017). This tradition as it is continued in here rests on the firm assumption that only with an appropriate way of formalizing systems (the phenomena) can the promise of Systems (the field) be realized. The points of arrival are thereby multifold, yet if using our new form-theoretical hardware both rigorously and playfully – as a formal structure of understanding systems and connecting them to empirical reality as well as in the spirit of the 'Laws of Form' and the creation of endless worlds and possibilities – we are convinced that this will reinvigorated discourse within Systems and about Systems.

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