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Abstract

The commodified transaction is a key element of Transaction Cost Economics and has become one of the building blocks for management information systems, enabling increased scale, scope, and speed for business operations. The logic of simplification and closure underpinning this model of organizational activity is exemplified by Enterprise Resource Planning. As the popularity and expansion of ERP shows, there is a push to encapsulate yet more areas of organizational activity such as supply chain and contract management cumulating into smart networks. We present empirical material to highlight the complexities associated with this expansion with a particular focus on the consequences of the move toward commodified transactions as a model of contract. Our contribution lies in theorizing functional simplification and closure as it applies to contract, in the course of which we develop the concept of transactionalizing technologies and apply it to describe the processes of economization and marketization revealed by the breakdown of contract innovations during the financial crisis.

Keywords: Networked markets, information infrastructure, IS success/failure, transaction cost economics, risk, innovation

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Introduction and Overview

Recent literature has focused on how interorganizational information systems and alliances can be transformed into smart networks "to harness the power of business networks, embedded with intelligence, to coordinate business processes running on diverse platforms" (Crawford 2007). This has been part of a general trend in which the term "network" has featured prominently in a wide-ranging discourse (see Castells 1996; Gottinger 2006; Shapiro and Varian 1998; Vervest et al. 2008). The field of information systems has produced a body of work examining the various facets of network phenomena: end-devices, platforms and telecom services (Martikainen et al. 2002); forms of collaboration (Montazemi and Siam 2006; Tan et al. 2007; Xu and Chau 2006); security (Onieva et al. 2008); structural properties of networks (Oestreicher-Singer and Sundararajan 2006); and management challenges associated with emerging smart networks (Vervest et al. 2004).

Our research question has two inter-related parts. Firstly, since many authors make reference to the dynamic and unpredictable characteristics of smart networks, what is the contribution of information technology to this potential instability? Second, how is contract involved or implicated in this potential instability? Drawing on original empirical material and surveying other relevant information systems (IS) research, we consider the lessons that can be learned from the financial sector where business is dependent upon a dense network of smart networks.

In our first section, we examine the theoretical origin and logical models characterizing management information systems. We draw attention to the reciprocal relationship between smart networks and a transaction-cost inspired program of functional simplification and closure. Illustrations are provided from the world of enterprise resource planning (ERP) which we maintain exemplifies this transaction-centric approach to management. We note the recent interest in extending the ERP model to manage contracts and consider the implications of drawing them into the internally focused reality of functional simplification and closure in which, for example, relationships are converted into transactions. We use the notion of performativity to highlight the difference between what is written in contract documents and how the contracts work in practice (do things), overflowing the boundaries of their templates. Building on these conceptual foundations, we develop the term "transactionalizing technologies" to describe sociomaterial phenomena whose usefulness lies in producing forms of instrumental calculability regarded as essential to contemporary accountability. We then we trace the two key characteristics of transactionalizing technologies, information-hiding and self-referentiality, through the features of information systems that frequently form part of smart networks.

Motivated by an interest in making IS research matter, the second part of our paper applies this framework of analysis to the financial sector, and in particular we explore these issues in the context of contract innovations at AIG (an institution that played a key role in the recent economic crisis). Rather than separating out technology and practices, we consider the complexity that accumulates in smart networks as a consequence of their propensity to comprise multiple transactionalizing technologies, including contract, and thus their capacity to embed a mutually dependent sociomaterial entanglement. We conclude by noting that these issues raise both practical and ethical issues for IS designers whose work sums up to smart networks and the management challenge of governing smart network phenomena.

Smart Networks as Reciprocally Related to Functional Simplification and Closure within the Organization

Functional simplification and closure are essential characteristics for the system-ness of particular kinds of technology according to systems theorist Nicholas Luhmann (1993). In this paper, we explore Kallinikos' (2005, 2006) extension of this proposition in which he maintains that a program of functional simplification and closure marks the transformation of the organization into a saturated Information and Communication Technology (ICT)-enabled information habitat. We use this as a basis for understanding the conditions that create dynamic and unpredictable characteristics within the information habitat of smart networks in the financial sector. Following Kallinikos, we will argue that the roots of potential instability lie, somewhat ironically, in the faithful reproduction of logical models that ensure technological systems function reliably over time and across contexts. This is achieved through a strategy that begins with the logical process of functional simplification which demarcates an "operational domain within which the complexity of the world is reconstructed as a simplified set of causal or instrumental relations" (Kallinikos 2005). In this way, the complexity of specific life-worlds (air traffic control, manufacturing systems, financial trading) is rendered "inspectable and controllable" (Kallinikos 2005) by its reduction to a set of rules or scheme of classification. Next, the principle of functional closure is applied to set boundaries that serve as a "protective cocoon…around the selected causal sequences or processes to safeguard undesired interference and ensure their recurrent unfolding" (Kallinikos 2005).

In many ways, functional simplification and closure can be seen as the leifmotif of management information systems. As processes within organizations become more defined, bounded and enclosed, they are more liable to be defined as candidates for systems solutions. It could be argued that outsourcing through contract is the strategic partner to this kind of systems thinking. Outsourcing may involve another organization or involve internal outsourcing (for example to a shared services function). More, both operationally and in terms of risk, is being pushed into the contract space, with contract increasingly viewed not only as a tool or technique of exchange with a market but more generally as a way to blackbox processes and risk. Contract becomes a functional element in a self-consciously "object-oriented" composition of an organization, featuring (ideally) "plug and play" modularity and encapsulation. Put another way, contract is a technology enabling functional simplification and closure. The de-composition of the organization through contract corresponds to the model of the firm defined by transaction cost economics (TCE), where the boundary of the firm is negatively defined to include within the firm those activities that cannot be efficiently contracted to others (Madhok 2002). At the same time, we would expect contracting itself to become a key competency for organizations (Argyres and Mayer 2007), although it too can be outsourced, in a kind of regression.

The smart network can be seen as a reciprocal development. Van Heck and Vervest (2007) envision an ICT platform that supports the rapid formation of networks for trading of goods and services, including goods and services that are relatively complex and bundled. Ciborra (2007) notes the "overall trends in formalization of transactions" and described "grid technologies" like smart networks as "contract-enabling". He argues that this creates conditions where "buy" (for example, through outsourcing) would crowd out "make", and risk would be optimally dispersed in a more perfect market. In his 2003 book, *The New Financial Order*, the economist Robert Shiller envisions a "smart computer network" that would keep track of [individuals'] contracts "so that the system ensures that contracts do not conflict with one another. …[such a network] will make possible more effective and more extensive contracts." ICT-enabled contract is in turn envisioned as a technology for the re-design, or re-placement, of work, organizations and risk. Ciborra (2007) cautions, however, that these grid technologies might create risks that would be "new and surprising".

The Role of Transactionalizing Technologies in Functional Simplification and Closure

The program of functional simplification and closure described above is enacted through the operationalization of discrete datapoints according to explicit rules. In this way, business processes are mapped to the capabilities of computers (Dreyfus 1992) and correlated with computer "effectiveness" (Winograd and Flores 1986). The outcome is a commodified transaction – a bounded and discrete standard process running on standardized datapoints – which becomes the basic unit of organizational activity, underpinning calculability (Power 2007). ERP (enterprise resource planning) systems are representative of this approach: elements of organizational activity are defined so that they can have a virtual existence in a database (that is, resolved to database-quality discrete datapoints), which is then put to work, to automate and monitor processes. An ERP system also serves as a calculation machine that enables aggregation and multi-function analysis, purported to support enterprise strategy formation or "whole house thinking".

However, things and activities do not themselves directly transform or resolve to machine-ready data and rules. Instead transactionalizing technologies have to be designed to give substance to the scheme of classification required and implied by (constitutive of) functional simplification . By transactionalizing technology, we mean a technology that enacts an information systems design that is predicated upon functional simplication and closure affording it specific materiality. The transactionalizing technology sustains the reduction or simplification of information and either encapsulates complexity or removes uncertainty. The particular contribution of transactionalizing technologies is to convert what remains into a discrete variable for the purpose of generating or resolving to instrumental calculability. Transactionalizing technologies employ two principal strategies: information-reduction through the stripping away of context, and modular, encapsulating construction. In the first case, informational complexity that would distract from ease of calculability is simply deemed irrelevant, and discarded; in the second, informational complexity is encapsulated within calculative processes or managed away. One of the ways in which informational complexity can be managed away is to disperse it with a strategy of isolating distantiation or put simply through "detachment" (Millo et al. 2005). It is through this propensity for encapsulation and detachment that transactionalizing technologies acquire a key characteristic of layered interdependency. For example, we can regard ERP as a multilayered transactionalizing technology incorporating classification schemes, analytic models, and modularity each of which involves information reduction (stripping away context to generate the inputs) and calculative encapsulation based on simplifying (context-ignoring) assumptions.

Transactionalizing technologies present potential issues well understood in the IS research community. Resolving information to discrete datapoints requires the creation and maintenance of classification systems (Bowker and Star 1999), and entails loss of meaning through decontextualization (Dreyfus 1992). Errors in calculation subroutines produce errors in the larger operations from which they are called. Modularization is instrumental fragmentation, or isolating distantiation, by design. In the case of ERP, modularization, particularly if it corresponds to functional divisions, may cut against the apparently monolithic nature of ERP that would support the "enterprise view", or organizational knowledge: the "enterprise" in "enterprise resource planning" can be illusory, or at least elusive.

There is an assumption that a relatively straightforward (additive) aggregation of transactional data in a pyramid or hierarchical structure will produce organizational knowledge that supports central decision-making and control (e.g. Laudon and Laudon 2000, pp. 37-46). However, as March and Simon (1993) suggest, this "absorption of uncertainty" is far from straightforward; the reification of classification schemes within the organization provide us with "inferences rather than evidence" which can severely limit our ability to make informed judgments.

We extend this notion to say that the reduction or encapsulation of information, complexity and uncertainty through processes and strategies that cannot be easily interrogated generate opacity, that is, become information-hiding. When information reduction leaves out too much or encapsulation hides but does not actually contain and suppress complexity, the information system may fail. Failure can include successful operation within a limited, self-referential domain where that domain is decoupled from the pertinent reality. Surveying the history of artificial intelligence, Winograd and Flores (1986) and Dreyfus (1992) concluded that success in solving problems that feature discrete data and explicit rule sets could not be simply extrapolated to predict success with more complex, context-dependent problems – a kind of "principle of non-extendibility".

Despite strong evidence documenting the ineffectiveness of these information strategies for complex environments, an almost gravitational "pull" to believe in computer "effectiveness", or calculability, through functional simplification and closure has developed. Pollock and Williams (2008) recount the success of SAP, against expectations, across multiple, diverse organizations. To bring ever more of the organization within their reach, ERP systems have refined, redefined and extended the modules on offer, gathering more information into the structured database environment where it can become instrumental or "effective". For example, in a list of SAP functions as of 1997, "human resources time accounting" consisted of payroll, personnel planning and travel expenses; in 2007, "human capital management" consisted of "talent management" and "workforce process management" (Pollock and Williams 2008, pp. 23-24). The model of "enterprise" level management through calculability has extended its reach vertically within the organization, for example in "enterprise risk management" (Power 2007).

Transactionalizing Technologies for Contract

When we consider the potentially significant effects of ICT on contract, as a consequence of the purportedly well-known insights in our field discussed above, it is surprising to find relatively little effort to expressly examine and theorize contract as artifact and technology (Suchman 2003) from an IS perspective. Our discussion in this paper can be regarded as an important step in this direction and to this end we focus on two key implications arising from the program of functional simplification and closure for contract. First, as noted above, contract becomes an increasingly important organizational competency and a vital component of the smart network model. The second, related implication is that contract will generally be seen through the lens of ERP – in other words, the ideal of the commodified, data-discrete transaction as the internal unit of operation will migrate outward. Thus, in functional areas such as procurement, supply chain management, and strategic sourcing, transactions shift into a calculation environment. This treatment of contract makes it appear directly operable and renders its components available for compliance monitoring in support of ERP and accounting integration.

In about 2000, software vendors developed and brought to market contract management software (CMS) applications, in a corporate information environment increasingly defined by ERP. A CMS package features workflow, automated document assembly, and a document repository, together with alerts, reporting and analytics capabilities. It was designed to support the entire contract lifecycle, from bidding, though negotiation and approvals, until the finalized contract is filed in an electronic document repository, with the key contract terms constituting the document metadata for the document within the repository. These key terms can then be used to feed or test against other IT (information technology) systems internally and possibly external (counterparty) systems as well. In 2008, one of the authors carried out a review of CMS sales literature and a series of interviews with industry participants and concluded that the full range of CMS capabilities is likely to map most directly to contracts in domains such as commodity procurement featuring high level of both standardization and what we term "data discreteness" (meaning the extent to which the meaning of the contract can be appropriately resolved to database-quality datapoints).

Notwithstanding the implications of functional simplification and closure for contract that we outline above, research suggests that a wholesale transposition of contract to a transactionalized ICT environment presents two IS issues. The first involves the feasibility of information reduction through decontextualization: Contract is already closely bound up with an essential, first-order technology, namely, documents written in a version of natural (or some would say non-natural) language that has meaning within a rich and specialized knowledge environment and that does not, except in commodified domains, easily resolve to discrete datapoints (cf. Wakayama et al. 1998 with respect to documents generally). Some contract domains feature implicit (Campbell and Collins 2003) and relational (Macneil 1985, 2003) dimensions (Bernstein 1992, 1996; Macauley 2003). Mithas et al. (2008) discuss dimensions of "non-contractability" (quality, supplier technological investments, information exchange, responsiveness, trust, and flexibility) and their effect on participation in reverse auctions. The second challenge relates to the possible futility or counterproductivity of encapsulation or isolating distantiation as a goal and strategy: Malhotra et al. (2005) noted that: "The need for continual value innovation is driving supply chains to evolve from a pure transactional focus to leveraging interorganizational partnerships for sharing information and, ultimately, market knowledge creation." This tendency prompted Pollock and Williams to remind us that: "The most profound criticism of TCE [transaction cost economics] concerns its exclusive attention to reducing transaction costs and its consequent failure to address processes of inter-organizational learning" (2008: 68). Lastly, we note that contracts are performative in Austin's (1962) original sense; that is, they *do* things or, in another version, may be said to be artifacts that have significant material agency.

These caveats suggest that it could be difficult to design transactionalizing technologies for complex and context-heavy contract domains. However these concerns would seem at first glance to be mostly irrelevant to the financial markets. In the financial sector, contracts are about the payment of money, and significant effort is made to decontextualize contract in order to promote liquidity (reducing friction in business flows to encourage trading between willing buyers and sellers). To test this assumption that transactionalizing technologies will be relatively straightforward and transparent in the financial sector, we consider some examples.

Transactionalizing Technologies in Financial Markets

The financial markets have been especially subject to ICT transformation (Lucas et al. 2009, Weber 2006). ICT-enabled financial markets can be thought of as the leading example of a smart network, or the ultimate contract management system. They enable execution of highly data discrete contracts, usually featuring extensive standardization or in the case of exchange trading complete standardization. A "grid technology" comprising networks of trading nodes, executing contracts for the exchange of money, risk and other contracts, the financial markets run on calculability and fungibility (the counting and valuation of identical items). Reduction to discrete datapoints is essential. There is no time to "look behind" the flat information display, and complexity should be not only hidden but actually, substantively, suppressed.

But the "flat" view of ICT-enabled financial trading as a seamless flow of fungible commodity units itself suppresses the existence of embedded transactionalizing technologies. Financial markets rely on these transactionalizing technologies, such as credit rating, to simplify or reduce information, to wrap or encapsulate complexity, to remove uncertainty or convert it into calculation variables, and reward these technologies with increased liquidity. This is summed up in the following quote from a prominent financier: "Triple-A has almost a religious connotation in finance. If you call it a Triple-A, you don't have to analyze it – that is why it's a Triple-A." (Stephen Schwarzman, head of private equity firm Blackstone, quoted in *The Wall Street Journal*, March 10, 2009).

These transactionalizing technologies act as points of uncertainty absorption as described above but are also instrumentally enabling, to a powerful degree. They are among "the institutional and technical arrangements that enhance the capacities of human agents for action and cognition" and thus agents in economization processes. They are, in effect, key to what Caliskan and Callon (2009a) call processes of "marketization". These technologies are enlisted to "pacify" things in order to value them and bring them to market, one of the five types of framing in marketization (Caliskan and Callon 2009b). Things thus pacified are "passive" in that they can be transferred as property, but more fundamentally because they become "incapable of expressing novelty or unexpected characteristics", in other words, inert. It is these "inert" packets (of goods and services) that trade and travel most easily across the network. Making things market-ready by making them inert is thus the goal of "pacification", as conceived by Caliskon and Callon.

We present examples of transactionalizing technologies in financial markets to illustrate the operation of various information-reduction strategies both successful and unsuccessful. We also show how transactionalizing technologies can be information-hiding, and create self-referential, but performative domains, thus giving rise to "new and surprising" risks.

Decontextualization and Encapsulation Using Models: The Case of Lending Advisor

As the UK emerged from the last mortgage crisis (1991-1992), one of the authors conducted a longitudinal case study (1993-1998) following the design and implementation of a decision support system called Lending Advisor into the credit risk function of a major retail bank ("UK Bank"). Having sustained the highest losses in the sector (£2.6 bn), UK Bank needed to reassure regulators and shareholders that they were overcoming flaws in their risk management. The Lending Advisor project marked the first time that a major UK bank had attempted to use a decision support system in their lending function. Previously lending was a manual practice, dependent upon the individual trained expertise of bank managers and paper-based information cards held in filing cabinets in local branches.

This was also a 'first' for the software company involved, as they were learning how to adapt the inference engine that they had developed for oil prospecting to credit risk assessment in the banking sector. The model had to be extensively customized through a program of knowledge engineering in order to establish domain specific classification schemes, rules, and relations. The parameters of the system were worked out by seconding lending experts from the branch network and asking them to vote on weightings, giving them a score out of 100 to reflect what they felt were the most pertinent criteria in the loans process. When the design team asked lenders to define "quality" in lending practices they were told that there were no strict rules to define quality: "Lending is a gut feeling, part art, part science". Then, a project member recalled: "I would say to them, 'So you can't define for me what a quality portfolio is?' 'Yes!', they would say, 'You can'. So, I would sit them down and say, 'Well, OK, how do you define it?' I had to cajole them and...over time they broke down the structure of how they went about lending" (Director, Design and Development Team, 1996). Through processes such as this, information relating to the art of lending was reduced and a decontextualized model of lending was developed.

Where lending could be assessed by an effective proxy or against a large pool operating according to standard procedures, it successfully achieved the status of a commoditized transaction. Not only were considerable efficiencies achieved but new levels of calculability were realized enabling comparison of credit applications to a network-wide global database. Lending Advisor enhanced strategic understanding of exposure in different market segments which in turn informed lending policy. However, a proportion of cases continued to resist commoditization and expensive workarounds had to be developed. For example, for many years one of UK Bank's logos had been "The Small Business Bank" and they specialized in identifying promising small businesses to whom they could sell banking products as the businesses grew larger. Many small businesses didn't fit the Lending Advisor classification scheme because they were innovative which meant there was little or no relevant historic data. Lending managers who had either retired or been made redundant were hired as consultants to overcome this until specialist business centers could be established.

The reliance of expert systems on historic data has the potential to create other "new and surprising risks" as a consequence of their self-referentiality. The back-loading of data on the Lending Advisor project had proved laborious. Managers struggled to back-load business sensitive data from branch filing cabinets. Many of the banks that implemented similar systems regarded this as too time-consuming and limited the amount of data back-loaded. Furthermore, since many of these later projects began in the mid- to late-1990s, well after the negative equity characterizing the mortgage crisis that had motivated Lending Advisor, databases were populated by predominantly positive values.

As transactionalizing technologies become standard in a sector, it is tempting to make further compounding short-cuts to achieve higher levels of efficiency. To gain acceptance among its lending managers, UK Bank had presented Lending Advisor as decision support designed to augment rather than replace the decision process. However, Lending Advisor analyses were regarded as complicated and time-consuming. New entrants in the banking sector chose to implement a less-sophisticated form of credit scoring which would give customers that walked in off the street instant answers (see Poon 2007 on credit scoring).

Although the Lending Advisor case study points to potential management challenges relating to information-hiding, encapsulation, and self-referentiality, these qualities are an integral part of highly effective organizational strategies. Indeed, one could say that the capacity to detach is essential to the flow of business in financial markets.

"Detachment": Isolating Distantiation through Clearinghouses

Millo et al. (2005) describe the clearinghouse function as an organizing technology for "detachment", in this case of trading from settlement. It enables parties to a trade to assume execution (*fin*alization, as in *fin*ance) and go on to make further trades without concerning themselves with the technicalities of settlement. The authors describe how, notwithstanding the apparently mechanical nature of settlement, information analysis, in the form of counterparty risk assessment, has become part of the clearinghouse function. So counterparty risk was not eliminated from the system, it was essentially *displaced* to an organization that was in a position to scale risk assessment, to design and implement control parameters, and to coordinate response to failure.

Securitization: Decontextualization, Encapsulation and Detachment Using Models and Contract

Securitization is a second example of detachment, in this case of financial investors from the credit analysis of real economy lending transactions, for example loans to homeowners, students and consumers. In securitization, both information and contract technologies are deployed to encapsulate or wrap complexity. Statistical models applied to an aggregation of debt instruments (contracts to pay money) are used to structure a tiered package of derived securities, representing horizontally layered, as opposed to vertically defined, rights to payments from the debtors. Legal entities consisting solely of contract rights and obligations issue these securities. Investors generally do not concern themselves with the underlying debt instruments, but instead rely on a few key datapoints such as tenor and credit rating. Credit analysis is *displaced* to mortgage originators, securitization sponsors and credit rating agencies.

The technology of securitization has been used successfully for decades in the United States to provide liquidity for standard, conservatively underwritten 30-year fixed rate mortgages and other relatively homogeneous, conservatively underwritten loan pools. On an aggregated basis, and using historical data going back years for statistical analysis, these loans could be treated as if they were commodified transactions, and they were then processed, through securitization, to manufacture market-ready securities. More recently, the mortgage securitization industry (technology) *extended* to accommodate new style mortgages (subprime and Alt-A), about which little was known other than that they were not as conservatively underwritten. Securitization also extended to include commercial mortgages, which are not standard and cannot be made approximately standard through aggregation.

So-called CDOs (collateralized debt obligations), reportedly first created in 1998 (O'Harrow and Brady 2008a), were bundles of various debt instruments, including prior securitizations, that might otherwise not be too liquid. The assumption was that any group of financial assets could, based on statistical modeling and without knowing (having to know) the particulars of the underlying assets, be sufficiently homogenized to produce another generation of market-ready financial assets. The sponsors of and investors in these late generation securitizations relied on the strategies of information reduction – decontextualization, encapsulation and detachment – that had served well enough in the past, *extending* the technology of securitization with its attendant information reduction strategies into ever more complex domains. Importantly for what was later to transpire in terms of liquidity dynamics, multi-tiered securitizations (securitizations of securitizations) enabled a particular underlying financial asset to appear in multiple places, potentially borrowed against by the investors at each level. The CDO market grew fast, from $157 billion issued in 2004 to $551 billion issued in 2006 (O'Harrow and Brady 2008b), alongside growth in the US subprime mortgage market.

The World of the Traders

A different type of "detachment" is created by the affective environment of traders working at a computer terminal, where the screen comes to *become*, not merely represent, the market (Bruegger and Knorr Cetina 2002). The computer that could as easily host gaming or a movie blurs the boundary between the virtual and the real. The computer console as trans-portable artifact (Latour's "immutable mobile" as cited in Mol and Law 1994) may carry over a quality of make-believe from one application to the next, and the "detachment" is of the operator from the consequences of his [sic] operations. Introna (2002) invoked Baudrillard's "hyperreality" to describe this effect in the experience of Nick Leeson at Barings in 1995, and the "rogue trader" Jerome Kerviel from the 2008 Societe Generale trading scandal described the "dematerialized" trading environment (Caldwell 2008). An atmosphere of at least unreality is reflected in the apparent distinction made at Societe Generale between "virtual trades", which were tolerated, and illegal fake trades (Daneshkhu 2008).

There is a second level of "detachment", separating the organization's self-awareness from its ICT-enabled instrumentality. The lack of awareness has two dimensions, the first is practical: the speed and volume of trading execution not only exceed the scale of human comprehension but outrun automated control systems despite the capture of relevant transaction data. The second is the self-referentiality that Kallinikos (2007) has identified as a potential risk associated with ICT. The trading technology creates a self-referential, apparently virtual, domain with substantial (non-virtual) consequentiality, or performativity. This quality of self-referentiality not only affects the individual trader but characterizes the information habitat of the organization.

Price Arbitrage, and Perverse Performativity in the Case of Long Term Capital Management

Arbitrage is the exploitation of simultaneous "commensurability and disjuncture" (Caliskan and Callon 2009a, citing Guyer 2004) whereby differences in valuation open up opportunities for profit across trading zones. The strategy of *price* arbitrage (MacKenzie 2007) requires an information infrastructure that supports opportunistic price discovery and very fast trade execution capabilities. The hedge fund industry was originally conceived as a way to profit on price arbitrage across financial markets, using leverage (borrowed money) to amplify returns. As such, its business model is positioned (a self-referential business within the financial sector) to sit "on top of" the financial markets, as it were, not to move them.

However, the well known case of the hedge fund Long Term Capital Management (LTCM) illustrated that hedge funds were no longer actors standing "outside" the markets. In 1998, LTCM faced a liquidity problem so severe, and entailing so much risk for the financial system, that US federal regulators orchestrated a bailout. MacKenzie (2005) has analyzed the events leading up to this as the "creation of a superportfolio", where a relatively small group of hedge fund arbitrageurs, using similar risk models, ended up with similar positions on macro-economic events.

As the macro-portfolio played out, adverse events in Russia and Asia propagated and amplified across the holdings of many financial institutions, affecting asset prices and liquidity in many apparently unrelated (and supposedly uncorrelated) markets. In particular, the effect of leverage was significant; margin calls on losing positions forced the liquidation of "good" assets at distressed prices. The liquidity dynamics of mark-to-market accounting and leverage thus quickly transmitted distress across firms and markets. Aggregation across organizations was not linear but reflected the complexity and interdependence of a network comprised of many informational and contract technologies with interactional components. These included electronic execution technologies, but also information-reduction technologies such as ratings and risk models, and contract technologies which operationalize information inputs (e.g. ratings downgrades, asset prices), converting them into legal and financial effects that in turn trigger further consequences, in a chain or cascade of "deleveraging" (paying off debt by whatever means, including asset sales).

From Price Arbitrage to Classification Arbitrage: The Role of Contract

Recent financial activity (and financial contract innovation especially) has been to a significant degree self-consciously targeted toward the arbitrage of various classification schemes, such as accounting rules, tax rules, capital adequacy requirements, national regulatory jurisdictional rules, exchange listing requirements, and risk management schemes. For example, American International

Group Financial Products (AIGFP), a subsidiary of the global insurance company American International Group, Inc. (AIG), offered so-called 2a-7 puts on various CDOs, enabling these securities to be treated as short-term and thus qualifying for inclusion in money-market mutual funds. Off-balance-sheet arrangements are now so variable and complex that there are elaborate rules for disclosure of these in financial statement footnotes. Securitization itself is a (mostly) off-balance-sheet financial technology that supports the origination of loans in volumes that vastly exceed the capability of traditional banking institutions to carry them on their balance sheets. In all of these cases, contracts and related valuation technologies are designed to touch the appropriate bases within, or navigate the interstices between or within, various and often multiple classification schemes. In this way, contract is tightly bound up with information systems in the financial sector.

As an example, contractual risk transfer through hedging (using derivatives) has been enlisted to mitigate real business risks but also to exploit classification arbitrage opportunities, e.g. to achieve certain accounting or regulatory ends. Fully matched hedging – a perfect hedge – makes valuation moot as risk sums to 0, or "disappears" so far as accounting and risk management may be concerned. But a hedge always entails a new exposure, that is, exposure to the hedge counterparty, and, through that hedge counterparty, to *its* other counterparties. One result of the chaining of risk transfer means that risk can become concentrated without the participants, each looking at its own position vis-à-vis its named direct counterparties, being aware of the extended risk profile of its position.

Hedging is a mechanism that can enable taking on a risk that would otherwise be viewed as unacceptable. If not properly understood and considered, it can convert what was a negligible or manageable contingency into a significant real cost incurred on the hedge side, as was alleged in the spring of 2009 with respect to derivative contracts related to municipal bond offerings in the US and in Italy (*The New York Times*, April 7 and April 28, 2009). Lastly, hedging as a strategy depends on the availability in the market of appropriate hedging instruments and on market access. That is, a firm reliant on hedging is exposed to the risk of market disruption. In sum, a change in circumstances (such as downgrade of a key counterparty) can cause latent risk to suddenly appear in many places where it was previously, under relevant classification schemes and rules, suppressed. The sudden appearance of the risk may cause "surprise".

These technologies can be subject to abuse, as in the case of Enron. In the beginning, the structures built at Enron achieved the desired ends but they were effectively invisible; when circumstances changed, the latent qualities of those structures became operative, and the distance that had opened between Enron's accounting and its capacity to generate cash was revealed (Powers 2002). The story of Enron can be read as a story about people who lost their way in a self-referential world.

The [Financial] World is Not Flat

In moments of stress, such as that occasioned by LTCM, the systemic quality of the financial markets as made up of interdependent information and contract technologies is revealed as potentially problematic. But in fact, these technologies construct and produce financial markets (MacKenzie et al. 2007). ICT-enabled financial trading, far from being an aggregation of decontextualized market exchanges, overlays and generally masks a complex and layered network of transactionalizing technologies. These information and contract technologies have their own attributes (or agential qualities) that come variously into play but in the ordinary course may be latent, or at least non-obvious. Trading speed and volumes overwhelm comprehension; the computer is massively "effective" at execution, but this operationalization of discrete data does not directly translate to control. Discrete transactions can have non-linear cumulative and interactive effects not easily anticipated through simple aggregation but which look more like features of high-risk technologies as described by Perrow (1984).

Mackenzie concluded his 2005 paper on LTCM by describing a chastened hedge fund community that having experienced the phenomenon of high correlation adjusted its business model accordingly, and he noted that the shock of September 11, 2001 had failed "to ramify and amplify through the markets…testimony to the way in which market linkages driven by imitative arbitrage" had become weaker. However, ICT-enabled arbitrage remained a dominant model in finance, as evidenced by the high trading revenues enjoyed by banks during the last decade. We hypothesize that it had a performative "pull" effect on financial innovation, as transactionalizing technologies were *extended* into ever more complex, context-heavy domains. This is illustrated by the story of credit default swaps at AIG (the following account is, except as noted, drawn from AIG's 2007 and 2008 annual reports filed with the Securities and Exchange Commission).

Credit Default Swaps at AIG

Background

Credit default swaps are reported to have been invented by bankers at JPMorgan around 1997 (Tett 2006). Under a credit default swap (CDS), one party agrees to pay the other party if a payment default occurs on reference debt, by paying the amount of the reference debt or by purchasing the reference debt. Credit default swaps, as a self-standing obligation, need not map one-to-one to outstanding debt. That is, for a particular debt instrument, there could be multiple (multiplier?) CDSs, and purchasing or paying off the underlying debt instrument might or might not extinguish the related CDS obligation. A CDS can provide a way to hedge long (owned and funded) positions generally against a name. For example, an investor owning X Corp. securities might "hedge" its exposure to X Corp. by buying CDSs on X Corp. debt: if the price of X Corp. securities goes down the price of the CDS may be expected to go up. Importantly, CDSs have generally been traded "over the counter" (OTC), meaning that they have not been traded on exchanges and thus have not benefited from standardization and centralized clearing. The CDS market has grown exponentially in the last decade, and was reported to cover $62 trillion (notional amount) of underlying debt in 2008 (Morgenson 2008).

We begin by noting an issue of classification: though called a "swap" or "derivative", a CDS is quite different from an interest rate or currency swap. An interest rate or currency swap on a "notional amount" of $100 involves variations that are usually a small percentage of the notional amount. A credit default swap, on the other hand, stands behind the entire amount of the debt and acts more like a guarantee. Indeed, the Financial Accounting Standards Board (FASB), which is responsible for setting accounting standards in the US, in 2008 issued FSP FAS 133-1 and FIN 45-4, which began to require some CDSs to be treated as guarantees for disclosure purposes. Some proponents say that a credit default swap is like insurance, but that term has a prudential (impliedly regulated) aspect that would make it misleading. Efforts in the late 1990s by some regulators to gain regulatory oversight over the credit default swap market were defeated (O'Harrow and Brady 2008a). There is a question, for example, whether the career of the credit default swap would have been the same had it been called a "debt put".

In 2004, the UK Financial Services Authority observed a sectoral transfer of credit risk from the banking sector to the insurance sector (FSA 2004, pp. 55-56). There seems to have been an idea that credit default swaps would disperse risk, presumably in a kind of engineering sense, as a net or grid absorbs and disperses a physical impact:

> While the growth of the market may have improved financial stability by allowing the wider dispersion of credit exposures, it is not without risks. The growth of the credit derivatives market has facilitated the transfer of risk between sectors and individual counterparties. For most market participants the intention is [to] diversify risk, but the ease with which risk can be transferred creates the possibility that some risks could become concentrated. …A survey published by Fitch in September 2003…found that the market remains relatively concentrated, with the ten largest global banks and broker-dealers accounting for 70% of the market. The [Fitch] report however concluded that the growth of the market is a positive development, as it assists the diversification of credit risk and results in improved liquidity in underlying credit markets.

With respect to portfolio credit default swaps (linked to a basket of credits), the FSA noted potential problems with valuation:

> The market in portfolio trades is still new and relatively illiquid, so banks usually rely on models to re-value and risk manage the transactions on a day-to-day basis. Valuing and risk-managing complex and illiquid structures like the portfolio trades described above presents challenges for even the largest and most sophisticated of banks.

AIGFP's Super Senior Credit Default Swap Portfolio, and the Events of 2008

AIGFP, the financial products unit of global insurance giant AIG, wrote credit default swaps to earn "revenue on credit exposure in an unfunded form". They focused on a "super senior" layer of exposure in CDOs and other securitizated debt, above other AAA-rated layers:

> AIGFP enters into credit derivative transactions in the ordinary course of its business. The majority of AIGFP's credit derivatives require AIGFP to provide credit protection on a designated portfolio of loans or debt securities. AIGFP provides such credit protection on a "second loss" basis, under which AIGFP's payment obligations arise only after credit losses in the designated portfolio exceed a specified threshold amount or level of "first losses." ***The threshold amount of credit losses that must be realized before AIGFP has any payment obligation is negotiated by AIGFP for each transaction to provide that the likelihood of any payment obligation by AIGFP under each transaction is remote, even in severe recessionary market scenarios. The underwriting process for these derivatives included assumptions of severely stressed recessionary market scenarios to minimize the likelihood of realized losses under these obligations.*** (AIG 2007 Annual Report, pp. 121-122, emphasis added)

Put in terms of price arbitrage, the premium AIGFP earned, even if it was very low, was more than its funding cost, which was 0, and the risk of payout was assessed as "remote". An AIG executive is reported to have said: "The models suggested that the risk was so remote that the fees were almost free money" (O'Harrow and Brady 2008a).

Of the $527 billion in notional exposure of the super senior credit default swap portfolio (SSCDSP) at the end of 2007, nearly $380 billion consisted of a "regulatory capital relief" portfolio written specifically for purposes of lowering capital charges for (mostly European) banks under Basel I capital adequacy rules, "rather than risk mitigation". This exposure was expected to run off without significant loss as banks adopted Basel II. About $78 billion notional amount (or just over half) of the remainder of the SSCDSP related to "multi-sector CDOs", of which approximately $61.4 billion included some exposure to US subprime mortgages. As of year end 2007, AIG booked $11.25 billion of unrealized market valuation loss on the multi-sector CDO portion of the SSCDSP, but "continue[d] to believe that the unrealized market valuation losses recorded on the AIGFP super senior credit default swap portfolio are not indicative of the losses AIGFP may realize over time". However, AIG's accountants identified a material weakness in internal control over financial reporting and oversight relating to the valuation of the SSCDSP. For 2008, AIG booked an additional $28.6 billion of unrealized market valuation loss on the SSCDSP, $25.7 billion of which related to the multi-sector CDO swaps.

Due to degradation of the underlying CDOs and AIG ratings downgrades, there were collateral calls on the SSCDSP portfolio that (together with collateral demands in AIG's securities lending program) precipitated a liquidity crisis by mid-September 2008. The US federal government, determining that a collapse of AIG threatened unacceptable systemic risk and having seen the consequences of the Lehman bankruptcy, rescued AIG with emergency loans. By the end of 2008, a majority of the multi-sector CDO swaps (face amount $62 billion) had been liquidated in a transaction whereby a vehicle funded by the US government (Maiden Lane III) acquired the underlying CDOs and the associated CDSs were terminated. The purchase price consisted of $32.5 billion of AIG's previously pledged cash collateral and an additional $26.8 billion. To put these figures in perspective, shareholders' equity at year end 2007 was $95.8 billion, net loss for 2008 was $99.3 billion, and shareholders' equity at year end 2008 was $52.7 billion (US government equity purchases amounting to over $60 billion).

In the initial SEC filings regarding the Maiden Lane III transaction, the identities of the counterparties to the CDSs were redacted but in March 2009 they were made public (AIG press release March 15, 2009). As widely reported, they included Societe Generale ($11 billion) and Goldman Sachs ($8.1 billion). Goldman Sachs' exposure under the securities lending program ($4.8) had also been paid off. When interviewed regarding the AIG transaction, Goldman responded that it was fully collateralized and hedged (with other counterparties in the credit default swap market) but acknowledged that its exposure to AIG is "a fraction of what it was at the time of the September bailout" (Reuters, March 17, 2009).

In retrospect, through credit default swaps, major financial institutions were exposed to AIG in an amount at least equal to the CDS payments it made to them in 2008. This effective risk-shifting was in addition to the capital support (for regulatory purposes) that AIG was providing to banks under its regulatory capital relief book. The exposures appear to be in some respects reciprocal. At year end 2008, AIG identified as a risk factor its continuing concentrated credit risk exposure not only to real estate and other securitizations but also to financial institutions, particularly money center/global banks (160% of shareholders' equity; 65.6% attributable to the top five).

AIG's 2008 annual report includes extensive discussion of its valuation methodologies, including detailed explication of their modified version of the BET (binomial expansion technique) model to value the SSCDSP. BET was developed by a rating agency in 1996 to generate expected loss estimates for CDO tranches.

> AIG modified the BET model to imply default probabilities from market prices for the underlying securities and not from rating agency assumptions….To generate the estimate, the model uses the price estimates for the securities comprising the portfolio of a CDO as an input and converts those estimates to credit spreads over

current LIBOR-based interest rates. These credit spreads are used to determine implied probabilities of default and expected losses on the underlying securities. This data is then aggregated and used to estimate the expected cash flows of the super senior tranche of the CDO.

> ***Prices for the individual securities held by a CDO are obtained in most cases from the CDO collateral managers, to the extent available. For the year ended December 31, 2008, CDO collateral managers provided market prices for 61.2 percent of the underlying securities. When a price for an individual security is not provided by a CDO collateral manager, AIGFP derives the price through a pricing matrix using prices from CDO collateral managers for similar securities.*** Matrix pricing is a mathematical technique used principally to value debt securities without relying exclusively on quoted prices for the specific securities, but rather on the relationship of the security to other benchmark quoted securities. (AIG 2008 Annual Report, p. 235, emphasis added)

AIG also described its use of VaR (Value at Risk calculations) in valuing its risk exposure but acknowledged that VaR has shortcomings "most evident during the current credit crisis". In addition, AIG relies on various indices and on external valuation providers. Its own credit spreads are relevant to some valuation techniques.

Both AIG and Goldman in their 2008 annual reports acknowledge disputes about valuation, the problems in reliance on historical data, the risk of unanticipated high correlations, concentration of risk and the possibility that loss of market access could prevent the execution of hedging strategies. In its annual report for 2008, AIG opened its risk factors discussion by noting: "Many of these risks are interrelated and occur under similar business and economic conditions, and the occurrence of certain of them may in turn cause the emergence, or exacerbate the effect, of others" (p. 21). They went on to say:

> AIG seeks to manage the risks to which it is exposed as a result of the insurance policies, derivatives and other obligations that it undertakes to customers and counterparties by monitoring the diversification of its exposures by exposure type, industry, geographic region, counterparty and otherwise and by using reinsurance, hedging and other arrangements to limit or offset exposures that exceed the limits it wishes to retain. In certain circumstances, or with respect to certain exposures, such risk management arrangements may not be available on acceptable terms, or AIG's exposure in absolute terms may be so large that even slightly adverse experience compared to AIG's expectations may cause a material adverse effect on AIG's consolidated financial condition or results of operations. (AIG 2008 Annual Report, p. 28)

A principal advisor on AIG's risk models commented on the effective tainting throughout the financial system caused by the "dispersion" of risk: "You have this very, very complicated chain of the movement of the risk, which made it very opaque about where the risk finally resided. And it ended up residing in many places. So the whole infrastructure of the financial market became kind of infected, because no one knew exactly where the risk was." (Gary Gorton, Yale University School of Management, transcript reported in *The Wall Street Journal*, October 31, 2008).

Subsequent Events

Over the course of 2008 and continuing into 2009, the FASB issued a series of releases relating to derivatives and securitizations (FSP FAS 133-1 and FIN 45-4 "Disclosures about Credit Derivatives and Certain Guarantees: An Amendment of FASB Statement No. 133 and FASB Interpretation No. 45"; FSP FAS 157-3, "Determining the Fair Value of a Financial Asset When the Market for That Asset Is Not Active"; FSP EITF 99-20-1, amending EITF 99-20, "Recognition of Interest Income and Impairment on Purchased Beneficial Interests and Beneficial Interests That Continue to Be Held by a Transferor in Securitized Financial Assets"; FAS 161, "Disclosures about Derivative Instruments and Hedging Activities — an Amendment of FASB Statement No. 133"). These recognized that valuation of many financial assets had become problematic and that disclosure has been inadequate. For example, FAS 161 requires disclosure stating *why* a particular derivative is being written.

As of April 2009, the US Department of Justice and the Securities Exchange Commission were reportedly investigating whether three AIG employers had made improper adjustments to the model for valuing credit default swaps at the end of 2007, using the value adjustment called "negative basis" (*The Wall Street Journal*, April 28, 2008). On May 1, 2009, *The Wall Street Journal* reported that the bond insurer MBIA had sued Merrill Lynch, "accusing the investment bank of deliberately offloading its deteriorating subprime mortgage exposures onto the insurer and misrepresenting them as high-quality assets back in 2006 and 2007. …MBIA says it was paid an average of less than 0.08% annually to insure $5.7 billion in collateralized debt obligations backed by mortgage assets, or less than $4.6 million a year." A software engineer who "wrote the software that turned mortgages into bonds" described his professional detachment from the consequences of his work, and "the complexity masked by thousands of unseen whirring widgets that beguiles people into a sense of power, a feeling of dominion over the future. …How to adjust and control these complexities, without stifling innovation, is the problem" (Osinski 2009).

Also as of April 2009, the International Swaps and Derivatives Association (ISDA) announced a "Big Bang Protocol" for auction settlement and dispute resolution mechanics for credit default swaps (ISDA press release April 8, 2009), dealers were agreeing to standard terms for certain credit default swaps, and a number of exchanges had set up or applied to set up clearing for credit default swaps. Dealers were also reported to be trying to identify and cancel offsetting trades, shrinking the overall market (Bullock et al. 2009). These developments evidence a further evolution of the transactionalizing technologies for credit default swaps, and probably began to mark a distinction between those forms of credit default swaps that would survive the financial crisis and those that, with rare exceptions, would not.

Discussion

Do the transactionalizing technologies of the financial markets, and the commodified transaction as a model of contract, exercise a performative "pull" effect on contract innovation? The story of CDSs at AIG suggests they do. The technology of the trading desk was *extended* through credit default swaps into a complex domain, that is, to accommodate credit underwriting. But as in the case of Lending Advisor, credit underwriting competence was not easily transposed to the calculating machine. Instead apparent *but only apparent* calculability was constructed using layers of new and relatively untested transactionalizing technologies, such as BET. These technologies were effectively information-hiding, both *inside* and across organizations, while contractual "detachment", or isolating distantiation (immunization), from the underlying risk and heterogeneity was imperfect. An intended risk-dispersing technology which had left too much information behind disabled ring-fencing or quarantine strategies; instead it spread contamination.

As in predecessor cases discussed above, the technologies produced a self-referential domain. Up to the point of collapse the structure was highly productive, in its own terms, i.e. in generating revenues for AIG and achieving various results for its counterparties. As well as being highly profitable, the transactionalizing technologies involved in the AIG CDS case could also be said to have shown "effective performativity" in MacKenzie's (2006, p. 18) sense since as a concept, a set of interacting models, and economic contract they made this area of business possible, thus "making a difference". Risk management at AIG exhibited what MacKenzie refers to as Barnesian performativity constituted by "self-validating feedback loops" that can give the impression that reality is conforming to its economic model. However, if this was ever achieved it was disrupted when the composition of the CDSs broke down. Breakdown occurred when their artificial domain became increasingly decoupled from the relevant real domain at which point latent mechanisms in the the contracts became operational and there was "overflow" (Caliskan and Callon 2009b). Ironically, the transactionalizing technologies distributed through expertised layers across multiple organizations resisted interrogation and betrayed the promise of information systems. The capacity to manage interconnectivity and its consequences for the composition of value was lost. In this regard, we argue (for sake of discussion and taking the case of credit default swaps at AIG as indicative) that the financial crisis has been in large part an information systems failure. It is also a classic story of technology failure, as new technologies were uncritically adopted without an understanding of their affordances (Hutchby 2001, citing Gibson).

The story of credit default swaps at AIG also prompts a new perspective on contract. CDOs and CDSs, and their associated information technologies, were not merely instrumentally enabling in an impliedly objective or neutral sense of "creating liquidity" for the underlying assets. Nor can they be understood solely or principally by reference to valuation. The CDS book at AIG was managed, or located, only from a quite unstable internal valuation standpoint, mostly by reference to the market for the underlying reference debt, which became increasingly dysfunctional. Counterparty disputes on valuation of the underlying CDOs were common. While the location of the CDSs proved to be indeterminate along the dimension of valuation (calculability), they also existed, and assumed different forms, along other dimensions. Critically, contract as the technology of connectedness created extended interdependencies, producing and transmitting adverse events through latent contract mechanisms.

Mol and Law (1994) proposed the concept of "social topology", by analogy to the branch of mathematics which "articulates *different rules for localizing* in a *variety of coordinate systems*", and they described "mutable mobiles" (defined in contrast to Latour's "immutable mobiles") that transform as they change location, while maintaining continuity of existence. A credit default swap may be said to have the character of a mutable mobile in topological space; it "morphs" (may to some degree be designed to "morph") as it traverses the universes of financial accounting and disclosure, regulatory oversight and management controls within and across organizations. The credit default swap performs various turns as a risk-shifting mechanism, a regulatory hedge or capital substitute, a way to bet on a company, a tradeable asset in its own right, or an index of company risk (informational tool).

It seemed to have operated as a transactionalizing technology with respect to at least some CDOs (O'Harrow and Brady 2008a, Tett 2006). The CDO technology, incorporating models, ratings and contracts, in turn brought various (relatively) illiquid "goods" to market. And a CDS book aggregates to more than the simple sum of its parts when provisions in the contracts trigger a liquidity crisis. Credit default swaps on a particular name may have an effect on stock price, which in turn may affect ratings. Like (and together with) CDOs, credit default swaps enabled some potential risks to be more or less invisible during a period or conditions of latency but then appear in many places at once, spreading contagion.

As a general purpose risk-shifting but also risk-measuring technology, the credit default swap exhibits significant “material agency”, generating remote interdependencies, cascading effects and feedback loops, and contributing to the reflexivity and performativity of financial markets. We observe in CDSs a fluid quality (Mol and Law 1994) that has differential “hydraulic” effects in multiple systems; they are hardly the “pacified” or inert things deemed market-ready by Caliskan and Callon (2009b). They illustrate that contracts and the associated information mechanisms can trigger, delay, block, transmit or transport, replicate, divert, distort, interfere with, amplify, buffer or mask conditions or effects. Significantly, these effects are not described *per se* in the contract documents but are effects of how the contracts work (*do* things) in a larger social and material environment, and are thus performative, not only in Austin’s (1962) original sense but in the extended sense as applied with respect to the financial markets MacKenzie et al. (2007) or more generally (Barad 2003).

Implications and Conclusion

We return now to our research question: What is the contribution of information technology to the potential instability of smart networks? Second, how is contract involved or implicated in this potential instability? We have shown that smart networks will likely incorporate transactionalizing technologies, comprising both information and contract technologies. Transactionalizing technologies by definition are information-hiding, and they can create self-referential but performative structures, which can have substantial (non-virtual) consequences. Because of their instrumental power, there is a tendency for transactionalizing technologies to *extend* their reach into complex, context heavy domains, and thus a possibility that they will become decoupled from the pertinent underlying reality. Contract, for its part, can be a technology of exchange but it can also constitute a tradeable “good” or (part of) a transactionalizing technology. Contract enacts the connectedness within the network, and is performative. It can be differentially performative in multiple simultaneous dimensions, and can exhibit latent and transmissive performativity. These features of smart networks together can give rise to unanticipated instability

We draw our specific conclusions with respect to the financial markets, which may be in the advance guard of smart networks or instead be *sui generis* (a question that could be the subject of future empirical research). In either case, there are several implications with broader applicability. The program of functional simplification and closure appears to be extending to contract, consistent with TCE but not with broader, and richer, perspectives on contract. At the same time, enabling technologies such as smart networks extend the effective boundaries of the organization in terms of both instrumental reach and extended risk exposure. We have shown that the “marketization” process can involve transactionalizing technologies that are instrumentally enabling to a powerful degree but that can also be (quite) effectively information-hiding and create self-referential but performative domains. We have made some first steps into analyzing the emergence of different forms of performativity but this important area demands further research.

A further important question is raised regarding our capacity to use information systems to manage contract. Can IS be designed to be both instrumentally enabling as well as providing support for the kind of inquiry and awareness needed to extend understanding around or past points of “uncertainty absorption”? We note this as a challenge for IS design of smart networks but also for participating organizations and other stakeholders, and suggest that it has both practical and ethical dimensions. It may require new design and management methods that have a more integrative orientation, and that reward critical awareness of the role of transactionalizing technologies, and of the fragmented and detached nature of the corresponding professional expert domains, in the adoption of ICT-based innovation.

We suggest that part of our strategy for understanding should include a more direct examination of "the part played by materialities", and of the "careers" of things, that support or construct markets or more broadly economies (Caliskan and Callon 2009a), such as contract. Further we argue that such things do not only have careers but may potentially be located simultaneously in multiple dimensions, in the topological sense as suggested by Mol and Law (1994). Rather than separating out technology and practices, we consider the complexity that accumulates in smart networks as a consequence of their propensity to comprise multiple transactionalizing technologies, including contract, and thus their capacity to embed a mutually dependent sociomaterial entanglement. .

We make a contribution by theorizing the program of "functional simplification and closure" as it applies contract, in the course of which we develop the concept of transactionalizing technologies and apply it to describe the processes of economization and marketization (Caliskan and Callon 2009a) revealed by the breakdown of contract innovations during the financial crisis.

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