

CONSEQUENCES OF INSTITUTIONAL RESTRUCTURING IN THE ELECTRICITY SECTOR - A REVIEW OF EXISTING RESEARCH AND SOME DIRECTIONS FOR FURTHER WORK

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Abstract: The generation, transmission and distribution of energy are among the most vital prerequisites for the functioning of modern societies. Since the early 1990s, the energy sectors of Western societies have been through a process of institutional restructuring, where large state-owned monopolies have been divided into several independent organizations. Also, the organizations responsible for providing energy, like most other industrial organizations today, have made increasing use of outsourcing strategies. Taken together, this development represents a significant change in the framework conditions for the energy sector. How this development affects the reliability of energy supply and the capacity for effective crisis management is an important question from both a research perspective, as well as from a societal point of view. This paper reviews the current literature on these issues, and specifies several topics for future research.

Keywords: Electricity, reliability, institutional restructuring, crisis management

1 Introduction

The generation, transmission and distribution of electricity constitute the veins and arteries of Western societies. Moreover, these societies seem to become increasingly dependent on electricity as different critical infrastructures become increasingly intertwined. Parallel with the development towards increasing societal dependency on electricity, the electricity industries in Western countries have been subjected to a massive institutional restructuring from around 1990 and onwards. The large, state-owned organizations have been divided into several smaller units, which are increasingly exposed to competition. Also, the use of outsourcing strategies has increased rapidly. Together these changes represent a significant institutional restructuring of the industry.

Recently, some governmental bodies have started to question how this restructuring has affected the reliability and capacity for crisis management in the energy sector. In Norway,

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for instance, both the Norwegian Water Resources and Energy Administration and the Directorate for Civil Protection and Emergency Planning have voiced concerns that the fragmentation of the industry has left society more vulnerable towards energy-related crises (DSB 2005; NVE, 2008).

This serves to illustrate that the restructuring of the energy sector was largely initiated without a clear view on how the restructuring processes affect the reliability of the industry. As de Bruijne and van Eeten (2007: 19) have noted, “these infrastructures might be critical to our societies, but that hasn’t stopped us from subjecting them to the great experiments of privatization, liberalization and deregulation”. This paradox is the starting point of this paper. The paper assesses the current scientific knowledge regarding the effects of restructuring on the operational reliability and emergency handling capacities in the energy sector. As well as recounting the most important literature, we will seek to draw an outline of a few key questions that should be explored empirically in future research.

Before addressing the literature on the consequences of institutional restructuring of the electricity sector, it is necessary to give a brief account on the logic and context of these processes in general, as well as the theoretical perspectives that form the basis of the paper.

1.1 The logic of institutional restructuring

All countries in Western Europe have to various degrees taken steps towards liberalization of their electricity industries. The organizations responsible for the production and transmission of electrical energy have to a large extent gone from being bodies regulated by governments, to being organized more like private companies subjected to more indirect regulations. This development is part of a general trend of public sector restructuring which is heavily influenced by the ideals of new public management (NPM). These ideals, often associated with the political regimes of Thatcher in the UK and Reagan in the US, involve the transformation of public monopolies into several decentralized, competition-exposed or privatized organizations (see for example Hood, 1995; Johnsen, 2005). These organizational changes span from internal reorganization, like internal transfer-price systems or benchmarking, to full blown outsourcing of the public service. There is a myriad of organizational variants, but the drift towards management by market mechanisms and a modularization and commoditization⁴ of services is common denominator. Two arguments are usually associated with this development: It explicates the quality demanded and the cost of all individual parts of the public services, and hence makes the service more manageable. Also, it is argued that the introduction of competition makes it more cost efficient.

From the perspective of societal safety, the processes of restructuring have at least two possible effect scenarios. As institutional restructuring is often accompanied by new audit regimes, one possible consequence is that it leads to a clarification of existing regulations and demands regarding safety and emergency preparedness. The combination of explicit demands and strong governmental control might lead to an increased focus on safety and emergency preparedness, and thus a reduction in societal vulnerability. Another possible scenario is that being exposed to competition will lead to increased vulnerability because it imposes a financial logic upon organizations maintaining critical infrastructures: While public organizations have the provision of public services as their main objective, private organizations’ ultimate goal is to generate profit.

The discussion as to which of these possible outcomes is the most likely result is highly politicized. Most market liberalists would probably find the first outcome most plausible whereas those on the left side of the political-ideological scale would tend to find the latter outcome the most likely. What in seems certain is that this development has changed the way

⁴ Here commoditization refers to the process towards regarding a part of the service, as a discrete standardized product that can be bought in a market. It implies standardizing the requirement for quality and leaving only price as the significant variable. Modularization implies the same interchangeability of parts without necessarily implying a market.

the reliability of society-critical services is maintained. Rather than weighing in to the politicized debate, we believe it is important to study how reliability is maintained when the organizations are fragmented into interchangeable modules held together by contractual and economic relations.

1.2 Institutional restructuring in the electricity industry

The trend towards liberalization reached the electricity sector in the late 1980s and early 1990s. Traditionally, both the generation, transmission and distribution was assembled in vertical integrated utilities, often state owned. Some general aspects about are outlined in (IEA, 2005b:12):

“Electricity market reform has also brought unbundling and independent, decentralised decision-making. As a result, decisions affecting network operation and performance that were once made in a centrally coordinated way within vertically integrated utilities are now made by many independent market participants. [...] In this more integrated and dynamic operating environment, an event affecting a relatively distant part of a transmission system may have greater potential to spread and severely disrupt the supply and operation of electricity markets.”

The first launch of an open electricity market came in England and Wales in 1990. Prior to the electricity reform, the entire electricity industry in these countries was state owned, but with the reform came unbundling of generation and transmission, reorganization and eventually privatization.

Norway began restructuring the electricity industry in 1991, with unbundling of activities and the establishment of an open market, the latter which other Nordic countries joined during the second half of the 1990s. The entire sector was reorganized, creating a distinction between monopoly (network) and competitive business. Nevertheless many network companies were included in larger company groups, practicing both monopoly and competitive activities. Most electricity companies are still owned by the state or local authorities.

The electricity sector in the US has undergone similar changes as outlined above, the historic picture here being more complex due to differences in state regulation. The latest milestones are the federal energy acts of 1992 and 2005, the first triggering the unbundling of transmission and generation business and the latter promoting further development towards open and competitive markets.

The International Energy Agency (IEA) concludes that the liberalization process in the electricity sector has delivered considerable economic benefits. Competition has led to a focus on cost-reductions and a more efficiently use of assets. However low investment levels, loss-of-supply incidents and the society’s increasing dependability on electricity has shifted the focus towards quality and security of supply in many western countries (IEA, 2005a).

2 Theoretical perspectives on restructuring and reliability

There are two main theoretical schools within the theory on safety and reliability, Normal Accident Theory (NAT) and High Reliability Theory (HRT). These schools to a great extent represent competing frameworks, although HRT to some extent recognizes the insights of NAT. These two frameworks offer insights into understanding the consequences of institutional restructuring. Surprisingly, despite their theoretical differences, they come to the same conclusion regarding the consequences of institutional restructuring.

2.1 Normal Accident Theory

Normal Accident Theory is inextricably connected to the works of Charles Perrow (1984, 1999) and Scott Sagan (1994). NAT to a large extent hinges on the concepts of “coupling” and “complexity”. The concept of coupling refers to the degree of interconnectedness in technological systems, i.e. the extent to which failures are escalate rapidly and spread to other parts of the system, or even into other technological systems. The concept of complexity refers to the degree of predictability and linearity in a system’s processes. If a system (either a

technological system or an organization) is characterized by low complexity, i.e. linear processes, it will be largely transparent, predictable and follow familiar sequences. If it, on the other hand is a system of interactive complexity, its processes will be characterized by “unfamiliar sequences, unplanned and unexpected sequences, and either not visible or immediately comprehensible” (Perrow 1984: 78).

Although the energy sector has become increasingly interconnected with different critical infrastructures, the technology involved in production and transmission of electricity itself may not have become more complex as a result of institutional restructuring. However, according to NAT, the institutional restructuring in the energy sector will have led to an increased complexity in the energy system as a whole. Splitting up the large monopolies into independent organizations increases the number of organizational interfaces. In addition to posing challenges for cooperation and coordination, the restructuring can also be expected to increase the emphasis on cost efficiency, something which is also seen as problematic according to NAT. Together these factors would lead NAT theorists to predict that the institutional restructuring of the energy sector would lead to increased vulnerability.

2.2 High Reliability Theory

While NAT theorists are predominately interested in the system properties that cause systems to fail, proponents of High Reliability Theory (HRT) are searching to find the properties that *prevent* failure. Among these properties are a high degree of structural flexibility and redundancy, as well as a strong organizational commitment to reliability and organizational learning (La Porte 2006). Both of these properties are likely to be under attack in processes of institutional restructuring. Restructuring usually means increasing efficiency by reducing the number of employees. Such principles of lean organizing aim at reducing the redundancy of the organization, and are therefore problematic according to HRT. Also, the drift towards market principles may pose challenges for the prioritization of reliability. A greater emphasis on cost efficiency may also come at the expense of continuous improvement

Both proponents of NAT and HRT would find the institutional restructuring of the energy sector problematic in terms of reliability. This is why de Bruijne and van Eeten (2007: 18) classify restructured energy systems as “systems that should have failed”. Moreover, both proponents of NAT and HRT would agree that processes of institutional restructuring create a need for increased cooperation and coordination between the organizations involved in the production and transmission of energy. Importantly, the issues raised by the two theoretical schools relate to both the reliability of normal operations, but not least to the capacity for effective emergency handling and crisis management, since cooperation and coordination are the two key properties of effective crisis management. The question that remains is how the challenges described here are met by the industry. In the following we will review the existing literature on this topic, in order to assess the “state-of-the-art” on this area.

3 **Some relevant literature**

As this is an interdisciplinary field with somewhat unclear boundaries, it is hard to provide a definitive literature review. In order to assess the current knowledge on the effects of institutional restructuring on reliability and capacity for crisis management, we performed literature searches in the following journals:

- Journal of Infrastructure Systems
- Journal of Contingencies and Crisis Management
- Safety Science
- Accident Analysis and Prevention
- Risk Analysis
- Journal of Risk and Uncertainty
- Reliability Engineering and Systems Safety
- Energy Policy
- IEEE Transactions on Power Systems
- Electricity Journal
- International Journal of Critical Infrastructures

In addition to surveying these journals, we also performed literature searches in library databases, contacted researchers who had previously published research on the topic, and searched the internet for relevant governmental reports. As is reflected in the selection of journals, the scope of the literature search was not confined to finding research on restructuring of the energy sector. Since many other industries have been through similar restructuring processes, we also reviewed research related to other industries, since this research provides insight on general aspects of deregulation and restructuring. In particular, the deregulation of the British and American transport sectors has spawned some research on the consequences for reliability. Some contributions are delineated in the following section.

3.1 Experiences from transport deregulation

The transport sector is by far the sector in which most studies have been conducted to analyze the relationship between deregulation and safety, particularly in the UK and US. In the UK, the railway transport has received the most attention, after experiencing several serious accidents, such as the Hatfield crash in 2000. Though the number of casualties at Hatfield was not extremely high (4 killed and 70 injured), the subsequent restrictions on the rail system lead to severe problems for train operators in Britain in the time after the accident. The accident exposed flaws in the systems for control of the railway infrastructure:

“The underlying causes identified by the HSE investigation were that the maintenance contractor at the time, Balfour Beatty Rail Maintenance Ltd (BBRML) failed to manage effectively the inspection and maintenance of the rail at the site of the accident. [...] The investigation also found that Railtrack PLC, the infrastructure controller at the time, failed to manage effectively the work of BBRML.” (Office of Rail Regulation, 2006:4)

The exposed systematic failures lead to a speed reduction on the rails (since one could not guarantee their condition) which in turn crippled much of the British railway system.

As a part of the Norwegian research program *Risk and safety in the transport sector* (RISIT), Johnsen et al (2002) produced a knowledge survey on the safety consequences of deregulation. The authors emphasized the need for scientific knowledge on the topic, and identified several negative issues related to deregulation:

- Increased competition coupled with decreasing profitability could lead to reduced maintenance and quality, which in turn could lead to lower safety levels
- The entrance of new and inexperienced market actors could involve increased risk
- Outsourcing can lead to a fragmentation of responsibility

Despite identifying these negative factors, much of the research concludes that deregulation has not adversely affected transport safety. Many of the studies reviewed come from the American aviation industry (e.g. Oster & Zorn 1989; Rose 1992). However, these studies have been criticized for relying on too limited post-deregulation data. When extending the analysis to include more recent accident data, results show a reversal of the declining trends in accident rates (Raghavan & Rhoades 2005). This suggests that there might be differences between long-term and short-term effects of deregulation.

There are of course differences between transport and the production and distribution of electrical energy. Nevertheless, the issues emphasized by Johnsen and colleagues (2002) are general challenges related to deregulation. As such, there is little reason to believe that these challenges will not be relevant in the energy sector.

3.2 Public reports after major blackouts

Typically, much research on safety is event driven, following at the heels of major accidents and events. Several countries have experienced major electrical blackouts in the past years, and these has highlighted the society's vulnerability and contributed to rising further questions about the regulation and organization of the electricity sector. Often, major work is done by public organizations and regulating bodies.

One event raising some fundamental questions regarding the security of electricity supply was the California crisis in 1999. The rolling black-outs, skyrocketing prices and lasting under-supply of electrical power exposed how vulnerable the society had become. Simultaneously the cause analyses of it tend to point to flaws in the deregulation of the energy sector as one key condition making the breakdown possible. The crisis has later been regarded as a consequence of the deregulation of the energy market or as a consequence of a flawed deregulation. The official FERC-report states that “supply-demand imbalance, flawed market design and inconsistent rules made possible significant market manipulation”. Hence, the market for taking care of the critical infrastructural function of providing energy to California was rendered vulnerable to manipulation. When a situation with supply-demand imbalance occurred, the design of the market was such that manipulation (both legal and illegal) was possible (FERC, 2003; Borenstein, 2002).

Though the California blackouts brought much attention to the restructuring as a possible contributor, the publications written in the aftermath of most large blackouts focus more on the technical aspects, i.e. the “physical” chain of causes and consequences, and not so much on the organizational and institutional framework of the system.

The Task Force after the blackouts in the US and Canada in 2003, which affected 50 million people, concluded that lack of system understanding, poor communication and non-compliance with voluntary standards created the ground for the cascading events. The need for clarifying responsibilities and accountabilities in the deregulated energy sector were addressed (IEA, 2005b). It has been stated that the regulator (FERC) lacked both technical expertise on reliability issues and the necessary jurisdiction to ensure the security of supply (Young, 2006). The Energy Policy Act of 2005 made it possible to answer some of these challenges, introducing mandatory reliability standards and broader jurisdiction regarding enforcement.

UK experienced two large loss-of-supply incidents in 2003, affecting London and Birmingham. In both cases the supply was restored to all costumers within an hour. However, the incidents caused significant disruptions of activities, particularly for the transport systems, e.g. the London Underground. Both incidents were triggered by the malfunctioning of protection equipment in combination with ongoing maintenance work causing the system to have less redundancy than normal. The incident reports focus on the protection systems, but also address issues such as communication, competence and recruitment as well as the need for more rigid and formalized procedures (OFGEM, 2004). After the incidents the regulator (OFGEM) decided to introduce an incentive scheme to promote a high level over reliability.

As in other countries, the electricity sector in Norway has experienced an increased focus on profitability stemming from the deregulation in 1991. The blackout in Steigen in 2007, where a small municipality was affected for 6 days, and other loss-of-supply incidents act as wake-up calls for the government and the power network companies. Maintenance practice, investment level, the organization of activities and the interface between governmental bodies are among the discussion topics in Norway today. It has been questioned if restructuring and outsourcing have led to deterioration of the network companies’ competence to maintain a reliable system. It is regarded as vital that the network companies have the competence necessary to for fulfill their roles as service buyers, including high-quality specifications and control routines, and not least to be able to coordinate efforts during major break downs. Reduced local knowledge and man power, in combination with an aging infrastructure have been identified as areas of concerns.

After the hurricane Gudrun, which caused severe damage to electricity lines in southern Sweden in 2005, organization and access to man power, and materials as well as information to the citizens were recognized as areas in need of improvement. Centralized information centers and lack of local knowledge were identified as sources of misunderstandings and misinformation (SE, 2005). Gudrun also caused massive forest destruction and severe damage to other infrastructure in southern Sweden, hence exposing the interdependency of

infrastructures. The blackout was caused by extreme weather which the electrical distributions lines in general are not expected to withstand. Important lessons were, however, learned from the restoration process, especially in terms of communication, coordination and the dependency of other infrastructures such as telecommunication and transport.

The reports on major blackout events, all underline the integrated nature of power supply: in the causal chain (e.g. in the case of cascading effects) leading up to the events, or in the restoration of supply as in the Gudrun event. Not surprisingly, organizational factors, though they are not always discussed explicitly as such, play a role in all the events. And though it is clear that institutional restructuring has had *some* influence in both the generation and management of these crises, one would be hard pressed to make general conclusions from these reports regarding whether institutional restructuring is “good or bad”. The available investigation reports on major incidents do not provide grounds for making any conclusions regarding the effects of the institutional restructuring of the energy sector.

3.3 Research on institutional restructuring in the electricity sector

The literature search revealed that there has been done very little research on the way institutional restructuring affects the reliability and capacity for crisis management in the electricity sector. In the first years after the British (and other) electricity sector was deregulated, much of the research efforts were directed towards evaluating the functioning of the competitive electricity markets. The earlier literature in this field did not discuss the potential effects for reliability. The more recent economic literature, while, still predominately occupied with economic aspects of the deregulation, has started to pay attention to issues of reliability of the industry’s service provision. An example of this line of research is a study by Xin (2005), which discusses the role of regulation in the electricity supply business and the importance of a clear institutional framework are studied:

“With the unbundling along the supply chain of electricity, the integrated responsibility paradigm for security was broken up.” (ibid: 3)

“No one can be given the entire responsibility for security in the new environment. How to rebuild the responsibility chain for security of supply is now a main concern both for US and Europe governments.” (ibid: 4)

The author draws a link between large loss-of-supply incidents and institutional shortcomings. She argues that deregulation and insufficient investment incentives has resulted in a leaner system. Secondly the opening of markets has increased long-distance transmission creating a more complex and interconnected system, and both these trends make ensuring the security of supply a greater challenge. The importance of governmental involvement is also stressed by the IEA who states that even if the governments’ and regulators’ roles have changes, they are still vital in order to secure a competitive market and a reliable system. (IEA, 2005a).

In addition to the research on the economic research, there is a great deal of research on the technical robustness or vulnerability of energy systems, such as the special issue on critical electricity infrastructures in the *International Journal of Critical Infrastructures* (2007)⁵. While this research analyses the security of electrical power systems, its main emphasis remains on the technological properties of the system. The institutional restructuring of the organizational context of the system, is not discussed.

A third line of research is mainly published in *Journal of Contingencies and Crisis Management*, which had a special issue on critical infrastructures in 2007. This special issue addresses the consequences of institutional restructuring quite directly. Of particular interest here is de Bruijne and van Eeten’s (2007) “Systems that should have failed” that discusses how reliability is upheld in a deregulated infrastructure even though they would be expected to be rendered more vulnerable according to both main stream safety paradigms (NAT and HRO). Their analysis concludes that the institutionally restructured energy systems seem to

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operate quite close to the edge of failure, but that they nevertheless have maintained reliability by developing so-called “networked reliability”, networks of skilled operators that are able to deal with problems as they arise. These operators are middle level professionals that have an exceptional degree of knowledge about the system they operate, and the roles and tasks of the people and organizations involved in maintaining and operating the system (Schulman et al., 2004). In the same edition Schulman and Roe (2007) argues that the vulnerabilities of CI’s are not solved by design only and stresses the role of operators and managers and their ability to respond in a flexible way. There are few ways to control the external perturbations an open system like the power network is subjected to, so the ability to respond to these is a critical factor.

The four authors behind the work cited in the previous paragraphs, de Bruijne, van Eeten, Schulman and Roe in many ways constitute the core of the research community on the reliability consequences of institutional restructuring. In a joint article (Schulman et al., 2004) they addressed issues of relevance here. They argue that the demands for regularity of infrastructures have been raised whereas the organizations maintaining them have been dismantled. CI’s are now managed by networks of organizations, “with competing goals and interests”. Here too, their answer to the challenges posed by institutional restructuring lies in the concept of network reliability. As has also been noted by de Bruijne (2006) this form of reliability depends on real-time management, improvisation, communication and coordination. Hence networked reliability may be obtained in a situation where operators and managers with system responsibility are able to respond flexibly to external perturbations as they present themselves, rather than to foresee everything in contingency planning. This is of course partly dependent on the increased availability of real time data and increased information handling opportunities provided by ICT in general, but it is also a possible outcome of restructuring since reporting of safety critical parameters often are a part of the “product” to be delivered by subcontractors.

4 Summary and discussion

One of the overall conclusions of the literature review on institutional restructuring in the electricity sector is that the literature are no clear answers as to whether the deregulation has lead to increase or decrease of regularity of the electric power supply. The reports reviewed raise issues as to whether fragmentation of the industry has led to a loss of governmental control, reduced local knowledge, decreasing levels of investment and maintenance, communication problems, as well as decreasing access to competence and manpower in crisis situations. Of the scientific studies reviewed, there seem to be a predominance of studies focusing either on the economic aspects of the institutional restructuring, or the technological vulnerability of energy systems. There are relatively few empirical studies of the effects of restructuring on reliability and capacity for effective crisis management. The lion’s share of the studies that deal with these issues are associated with a group of researchers connected to the University of Delft in the Netherlands (Mark de Bruijne and Michel van Eeten), University of California, Berkeley and Mills College in the US (Paul Shulman, Emery Roe and Todd M. LaPorte). These researchers voice many concerns about the consequences of institutional restructuring, but still seem to maintain that reliability is upheld through networks of “reliability professionals”. However, many questions remain unanswered. In fact much of the existing literature In our view, there are (at least) four important issues regarding the consequences of institutional restructuring, which have not been sufficiently addressed in the existing research:

1) The future of “reliability professionals” and “networked reliability”. The networks of professionals that have had “long careers in many facets of electricity generation, transmission and distribution” (Schulman and Roe 2007: 45) have been described as the key to the reliability of the electricity sector in restructured institutional settings like the Californian electricity sector. These “long careers” have given the professionals a view of the big picture of how their system functions. However, the very logic of restructuring strategies

like outsourcing is to create independent organizations which are, at least in principle, substitutable. This implies that it will be increasingly difficult to see the big picture of the electricity sector that covers a number of different organizations with competing interests. The future department heads, control room supervisors and dispatchers and operators will therefore most likely *not* have the same general and varied background as the reliability professionals that reportedly hold the key to the current reliability of the electricity systems of Western societies. How reliability is to be maintained when the competence of reliability professionals might not be available should be an important question for future research.

2) How are crisis and emergencies handled in an institutionally fragmented industry? The restructuring of the energy sector have undoubtedly changed the framework conditions for crisis management. The crisis management which were previously dealt with within the boundaries of one organization, now involves several organizations, both public and private. How the necessary cooperation and coordination between the organizations involved is accomplished should be addressed in future research on crisis management.

3) How is learning and human resources development upheld in an institutionally fragmented environment? This question is very much related to the previous two issues. Institutional restructuring usually implies a specialization in that each of the organizations created is expected to focus on their respective core competences. However, the reliability of the energy system as a whole is reliant on the interfaces between its different components. This means that the various parts should have some knowledge of the tasks of the other constituents of the system. How this can be accomplished, should be a subject for future research.

4) How can issues of reliability and crisis management best be incorporated in the contracts regulating the relationships between the organizations constituting the value chain of the energy system? The relationships between different legal entities are usually regulated by contracts. A contract specifies which services are to be delivered, and the quality of these services. Such contracts often imply that the quality of the service is to be measured in some way. Both the specification and measurement of a service implies that the product is fairly concrete and has stable and predictable properties. When it comes to reliability and the ability to handle crises, this is not always the case. As noted by Weick (1987), reliability is a dynamic non-event” which is not easily explicated? For instance, the informal aspects of organizations are usually considered critical for safe operations, and even more so for emergency handling. This characteristic is something that is *not* possible to describe in a contract or other formal documents. In fact, the formalization of organizational relationships may even go at the expense of the informal, latent resilience networks that are crucial for the ability to deal with emergencies (Weick et al. 1999). Thus, something may be “lost in translation” when reliability and the capacity for crisis management is transformed to a product that can be bought and sold. This too, should be a topic of future research.

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