When Service Ecosystems Collapse: Understanding the Demise of the UK Green Deal

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Abstract

The concept of the service ecosystem is increasingly being drawn upon to explain the drivers, occurrences and consequences of socio-economic actors' service exchanges towards value creation. Existing research has proposed how service ecosystems may successfully transform, but no work to our knowledge has examined how transformations may fail. To address this gap, this paper examines how a service ecosystem fails to transform and survive by developing a conceptual framework based on the concept of entropy from systems theory. A series of propositions are formulated, linking inadequate management of entropy to a service ecosystem's subsequent state of disorder and collapse. The conceptual framework is illustrated through a unique case: the introduction and demise of the Green Deal in the UK. We propose that entropy is intrinsically embedded in systems' trajectories and can be understood as the tendency towards loss of value co-creation. The viability of a service ecosystem depends on its capacity to reduce entropy, which requires continuous action to import resources from the environment, achieve heteropathic resource integration and/or re-institutionalise. Where systemic actors and networks of actors within the system fail to manage increasing entropy, resources from the system are dissipated back to the environment and institutional arrangements collapse.

Keywords – Service ecosystem; entropy; survival; institutions; resource integration.

To cite: Badi, S.; Razmdoost, K. and Murtagh, N. (2017), When service ecosystems collapse: understanding the demise of the UK Green Deal, Naples Forum on Services, Sorrento, Italy, 6-9 June 2017.

Introduction

Scholars have been increasingly returning to the concept of a *service ecosystem* to explain the drivers, occurrences and consequences of socio-economic actor's service exchanges towards the achievement of a common goal- value creation (Vargo and Lusch, 2016). Seen as a complex collaborative system (Taillard *et al*., 2016), a service ecosystems is defined as a "relatively self-contained self-adjusting system of resource-integrating actors connected by shared institutional logics and mutual value creation through service exchange" (Vargo and Lusch, 2016, p. 10). The emphasis in a service ecosystem view is on service as the foundation of social and economic exchanges and value creation with service provision seen as the process in which multiple social and economic actors integrate their resources to co-create beneficial value (Wieland *et al*., 2012). A great emphasis is placed on the complexity and dynamism of the social systems through which service provision, resources integration, and value co-creation takes place. Wieland *et al*. (2012) underlined the significance of systems perspectives, including general systems theory and complexity theory, in offering a more comprehensive lens in understanding the dynamism and complexity of service ecosystems and the systemic nature of value and value creation. System thinking was adopted in marketing and service research by scholars such as Alderson (1965), Dixon (1984), and Layton (2007), Ng *et al*. (2012) among others because of its superior capacity to offer a holistic understanding of dynamic and complex marketing systems. The relevance of complexity theory to the marketing domain was also advocated by Holbrook (2003) who underlined the significance of the concept of complex adaptive systems in understanding the dynamic and complex nature of markets. Despite its philosophical and methodological power, Wieland *et al*. (2012) highlighted that a systemic view of value creation remains in its embryonic stages.

Service ecosystems provide a multi-level multi-aspect view of how service exchanges transform. Taillard *et al*. (2016) suggest that service ecosystems emerge through the creation of a shared intention among its actors. In this view, meso-level actors of a service ecosystem play an intermediary role between higher-level institutions that guide and limit micro-level individuals and interactions and those interactions and individual intentions that shape the establishment of institutions and institutional arrangement. Service ecosystem transformation can also be enabled by the emergence of resources such as technological advances (Vargo et. al, 2015) or the changes in the institutional arrangements such as a new policy (Koskela-Huotari *et al*., 2016). The latter transformation, which is the focus of this research, can be achieved by including new actors in the service ecosystem, redefining their roles and/or reframing resources being integrated by actors involved (Koskela-Huotari *et al*., 2016). Service ecosystem transformations are guided through social practices generated in the new institutional arrangements (Frow *et al*, 2016). The study of Taillard *et al*. (2016) and few others (e.g., Ben Letaifa *et al*., 2016) looking at service ecosystem transformation mainly explain the emergence of a stable service ecosystem. However, in this paper we contest two important elements of this approach: the notion that service ecosystems emerge, and the premise that this transformation results in a stable system. Firstly, service ecosystem transformation is a ubiquitous phenomenon in all markets as many of the challenges facing our world today require existing service ecosystems to be destabilised and transformed. Energy intensity, water shortage and social inequality are examples of problems that we face as a result of existing service ecosystems. We argue that service ecosystem transformation is a movement from an existing ecosystem to a new ecosystem. This is implied by the fact that value is socially constructed and should be understood in social context (Edvardsson *et al*., 2011). Therefore, any new or refined value co-creation influences existing meaning creation as it changes the social context. For example, the invention of the phone had implications for existing communication practices such as the telegraph (Edwards, 2003). In fact, social actors in a service ecosystem institutionalise emerged solutions through maintaining, changing and disrupting the existing institutions (Vargo *et al*., 2015). In other words, the term *emergence* may only be applied to the instances where new resources are integrated (i.e., heteropathic vs. homeopathic; Peters, 2016) such as the creation of a new solution.

The second aspect of service ecosystem transformation that is scarcely dealt with in the literature thus far is the susceptibility of service ecosystem transformations to tensions and conflicts (Banoun *et al*., 2016). If not resolved, these tensions may lead to value co-destruction in the shape of relationship decoupling, resources withdrawal and resource misuse (Plé and Chumpitaz Cáceres, 2010; Mills and Razmdoost, 2016). For instance, the actors may not accept the new institutional arrangements or may not be capable of reframed resource integration. The literature, then, has made a promising start in describing the transformation of service ecosystems embedded in different markets (Taillard *et al*., 2016; Sivunen *et al*., 2013; Pulkka *et al*., 2016) but is silent on how a service ecosystem may not survive a transformation and ultimately collapse. This highlights the need to develop theories on the dynamics of service ecosystem transformation considering the processes of their survival and viability in the long term. The research question underpinning our study is:

How does a service ecosystem survive a transformation?

To answer the above research question, we adopted concepts from systems theory, specifically the concept of *entropy*. We formulate a conceptual framework and a series of propositions linking entropy to a service ecosystem transformation. The conceptual framework will be illustrated through a specific case study: the introduction and demise of the Green Deal (GD) in the UK (2013-2015). The Government's flagship energy efficiency programme was introduced to encourage millions of households to take out loans for the installation of energy efficiency improvements such as insulation and upgraded boilers. However, in 2015, with less than 10,000 loans in place, the Government scrapped the scheme which was labelled a "total flop" (Gosden, 2015). The GD offers a unique and extreme case to explore with a wealth of academic and policy implications. This conceptual description will offer insight to service ecosystem theory into failed service ecosystem transformation, contributing to the literature on service ecosystems viability, i.e. their survivability and well-being (Wieland *et al*., 2012).

The paper is structured as follows: the second section begins by laying out the theoretical foundations of the research by introducing the concept of entropy. This is followed by the development of a set of propositions linking entropy to service ecosystem transformation. The following section presents an illustrative example of the UK GD. A final discussion section concludes the paper, draws out managerial and policy implications and outlines directions for future research.

What is entropy?

The concept of entropy has been adopted in a wide range of disciplines such as information theory, cybernetics, organisational systems, and socio-economic systems. It was used as a measure of 'ignorance' and 'lost data' (Gell-Mann, 1995), 'disorder' (Shannon and Weaver, 1949; Garner, 1962; Markina and Dyachkov, 2014), uncertainty (Ursacescu and Cioc, 2016), complexity (Fasolo *et al*., 2009) 'chaos' and 'disorganisation' (Katz and Kahn, 1978) and the propensity of a system to 'run down and die' (Daft *et al*., 2010).

The origin of the word 'entropy' comes from the Greek word τροπή, which means "transformation" or "evolution". It was first used by Rudolf Clausius in thermodynamics (the study of heat and energy) with the concept being the cornerstone of the second law of thermodynamics. While the first law tells us that energy cannot be created or destroyed but can only be transformed, the second law underlines the inefficiency, deterioration and decay in this process[i]. Hence entropy is a measure of the energy that will not do work within the system (Atkins, 2010). It is also a measure of the amount of disorder in the system (Boltzmann, 2012), for example, when an ice cube melts and transforms into gas when heated, the water molecules which were once contained in a well-defined form in the ice cube will now float randomly in the gas. The entropy of the gas is, therefore, higher than that of the ice cube (Boltzmann, 2012). As stated by the second law of thermodynamics, in an isolated natural system (i.e. a closed system), entropy will always tend to stay the same or increase. Intriguingly, this implies that energy in our universe, which is largely regarded as a closed system (Hawking, 2001), is gradually moving towards disorder.

General system theory was introduced in the early 20th century by Von Bertalanffy as a logical and mathematical approach to understanding the complexity of our world. General system theory moves away from a reductionist to a holistic approach in studying the phenomena under investigation and has been applied in many domains including medicine, biology, economics and organisational studies. According to system theory, systems can be classified as open or closed, depending on how they interact with their environment. As opposed to a closed system which does not interact with its environment (e.g. a washing machine), an open system strongly interacts with its external environment in order to survive. An open system imports energy from its external environment, transforms these input supplies (e.g. human, material, financial and information resources) within the system, and exports the output back to the environment (Katz and Kahn, 1978). This takes place in a cyclical process: the output provides new sources of energy for the inputs, re-activating the cycle of transformation. Whilst these cycles of transformation are continuous, the system remains in a steady state of dynamic equilibrium, i.e. its internal order characteristics remain the same. Open systems are highly complex and interactions among the different elements of the system are non-linear and dynamic. The complexity of a system largely increases its unpredictability and as Martínez-Berumen *et al*. (2014) argued, this complexity cannot be removed, but needs to be managed so as to reduce its undesirable effect on the system's performance. Examples of open systems are living organisms, organisational, social, economic and political systems.

As Prigogine (1978) contends, a system undergoing transformation experiences a common set of related events. First, the system is brought to a state beyond equilibrium, often termed the 'edge of chaos' as a result of internal or external changes, or fluctuations. At such point, self-organisation processes come into play with the system and its elements re-organising in non-linear stages of instability and discontinuity. This eventually transforms the system into a coherent structure with higher level of complexity, greater structural stability and order (Prigogine, 1978). Ebeling and Volkenstein (1990) define self-organization as "the spontaneous formation of order in open systems, which export entropy". This prevents the system from descending into chaos. According to complexity theory, such a system is termed a 'dissipative' structure because the exportation of entropy is characterised by heat loss (MacIntosh and MacLean, 1999). As indicated by Prigogine (1978), dissipative systems can exist in a state of imbalance, going against the inherent propensity towards a state of thermodynamic equilibrium, dictated by entropy.

Building a theoretical framework: Entropy in service ecosystems

A service ecosystem perspective offers a more dynamic, comprehensive and systemic perspective of value co-creation (Wieland *et al*., 2012). This is based on the Service-Dominant Logic definition of service as an application of resources for the benefit of another party (Vargo and Lusch, 2008). In this view, service is the fundamental basis of exchange where actors exchange the application of resources rather than resources (Vargo and Lusch, 2004). A service ecosystem zooms out from an individual's behaviour (i.e., individual-level) and dyadic relationships (i.e., micro-level) to include network, regional (i.e., meso-level), society and national (i.e., macro-level) actors (Leroy, Cova and Salle, 2013). In fact, a service ecosystem defines market as the synchronised and ongoing exchanges that are circumscribed by these levels (Chandler and Vargo, 2011). Therefore, value co-creation at each level influences and is influenced by the integration of resources at other levels and among other actors in the ecosystem (Akaka *et al*., 2013). Value co-creation is guided and limited by actor-generated institutions including norms, rules, meanings, practices, symbols and other collaboration means (e.g., government policy on carbon emission, culture, language, governance mechanisms, regulations, contracts, and practices), and institutional arrangements that are interdependent assemblages of institutions (e.g., political system, legal system, and policy arrangement) (Vargo and Lusch, 2016). The ecosystem metaphor has been used to reflect the increasing complexity of the business environment and it focuses on collective value creation (Moore, 1993). It is a strategic perspective that is underpinned by the premise of the harmonious relationship between the entire service ecosystem and its individual elements (Taillard *et al*., 2016).

The service-ecosystem is conceptualised as an open, complex, social and self-organising system in which its behaviour (i.e. transformation) is fundamentally a product of the interaction of its different elements, rather than a single element or an external effector (Martínez-Berumen *et al*., 2014). Hence, achieving complete control of a service ecosystem, is virtually impossible. The premise of this paper is that seemingly new service ecosystems are in fact transformations of existing service ecosystems. Wieland *et al*. (2012) referred to service ecosystem's transformative processes when they conceptualised value as 'change in the viability of a system' and emphasised the attributes of complexity and openness as important to the dynamic nature of the service ecosystem. This is the definition of *systemic value co-creation* adopted in our paper which Wieland *et al*. (2012) further elaborates on by describing each occurrence of resource integration and value co-creation as inducing change in the nature of the system itself and hence creates a new context for the following episode of value co-creation. Hence, systemic value co-creation is seen to delineate the fundamental quality of the entire system and acts as an integrative concept that describes its most intrinsic character (Meynhardt *et al*., 2016).

In this paper, we propose that service ecosystem transformation is an entropy driven process. A service ecosystem may be regarded as a social system and 'in a natural way the law of entropy acts to increase the instability of the system' (Bratianu and Orzea, 2012). Meynhardt *et al*. (2016) view value in a service ecosystem as an order parameter irreducible to the individual or collective level. Value is also seen as unstable and continuously fluctuating between the states of order and disorder. Disorder is characterised by systemic uncertainty and instability and is witnessed during phases of competing and conflicting perspectives of value among systemic actors (i.e., actors within the system). Under these conditions of high entropy, value co-creation processes may discontinue or, in severe cases, value destruction may take place (Plé and Chumpitaz Cáceres, 2010; Mills and Razmdoost, 2016). Hence, we propose the concept of entropy as an indicator of the state of a service ecosystem, which is related to the state of systemic value co-creation in the system. We propose that the amount of value-co creation is a measure of order and stability in the service ecosystem, while entropy is a measure of a systems' disorder and instability, witnessed by the decreasing state of value co-creation. We see entropy as a system parameter, or property, that acts in the opposite direction of stability, continually moving the system towards disorder and destroying systemic value. We posit the following proposition:

> **Proposition 1:** Entropy is a fundamental property of a service ecosystem representing the state of systemic value co-creation.

Systemic value is seen as an improvement in the system and an increase in the ability of the system to adapt to its environment, or what Wieland *et al*. (2012) describe as an improvement in the system 'viability', that is its well-being and survivability. Wieland *et al*. (2012) define a viable system as that with an increasing capacity to survive continuously over time, which constitutes its contextual value creation (value-in-context). Thus, we propose that entropy can be used to assess the viability of a service ecosystems. If the level of disorder (which is determined by the uncertainty and discontinuity of value co-creation) is high, then the system lacks viability. On the other hand, if the entropy is low (determined by the high level of value-co-creation) the system has greater viability. The long-term viability of the service ecosystem is at risk as entropy increases. Hence, to ensure the viability of a service ecosystem, entropy should be kept to a minimum.

Walker (2015) argues that open systems succeed at preventing a decent into a chaotic and disorganised state by developing negative entropy (negentropy); a process of superior organisation and higher capacity to transform resources. This is achieved by bringing in the needed resources (human, material, energy and information) from the system's environment. Through importing resources from its environment, the objective of negentropy is to support the system in reaching a more stable state of 'order'. Without these fresh supplies of resources, the system will eventually die (Daft *et al*., 2010)[ii]. Within the Marketing domain, Wieland *et al*. (2012) argues that a service ecosystem is an open system and has the capacity to improve its own state by importing resources from its environment. The service ecosystem also has the capacity to improve the state of another system through resource sharing and application. As to what are the resources in a service ecosystem, Vargo and Lusch (2006) differentiates between operand and operant resources. Operand resources are usually physical such as machinery, buildings and raw materials and on which an activity is done. On the other hand, operant resources are those that perform the activity on other resources, such as the specialist skills, knowledge and competence of individuals as well as organisational culture, norms and routines. Operant resources may also include relational resources such as relationships with customers, suppliers and other members of the supply chain (Hunt, 2004). Hence, we propose the following:

> **Proposition 2:** A service ecosystem must continuously offset the entropic process by importing new operand and operant resources from its environment.

In fact, previous studies have pointed out to the need for deliberate mechanisms in order to reduce entropy in a system. In organisational systems, Daft *et al*. (2010) and Bratianu and Orzea (2012) pointed out that management interventions seeking to introduce more order in a system will directly result in the reduction of entropy. Heylighen (1990) also underlines the need for internal control mechanisms, termed *effectors* that deliberately work to ensure the system and its structure evolve into a stable state by removing or offsetting disturbances that could damage the system and by importing the required energy and resources from the system environment. Hence, we propose that a service ecosystem can steadily reduce its entropy. As a complex self-organising system, a service ecosystem can counteract the consequence of increasing entropy through the activation of a number of effectors. These will support the system in reaching a dynamic equilibrium state and to adapt to changes in its environment.

We propose that these internal effectors involve two main mechanisms: heteropathic resource integration and re-institutionalisation. First, Peters (2016) argues that resource integration can take two forms: homopathic and heteropathic. While homopathic resource integration is summative, heteropathic resource integration is largely emergent. Important in this categorisation is the notion of emergence which is defined "as a process through which new emergent properties (e.g. entities, structures, totalities, concepts, qualities, capacities, textures, mechanisms, etc.) are generated." Hence, heteropathic resource integration, as Peters (2016) contends, specifically results in an increase in 'resourceness' as even though the base resources may remain unchanged, however, new emergent properties may appear such as higher-level structures and relationships. This is in contrast to homopathic resource integration through which no new properties are generated. Vargo and Lusch (2016) offers an interesting conceptualisation of innovation as the “institutionalization of novel resource integration” and argue that innovation is often hindered by existing institutionalized patterns of resource integration resisting change.

Alongside value, institutions and institutional arrangements are the binding elements of a service ecosystem enabling as well as constraining value co-creation (Vargo and Lusch, 2016). The work of Banoun *et al*. (2016) illuminate a service ecosystem evolution as a process of ‘re-institutionalization’ and describe it as the development of new rules that become common place among systemic actors and act as critical coordination mechanisms. Banoun *et al*. (2016) describe innovation as the “breaking, making and maintaining of these institutionalized rules” that support novelty by allowing actors to co-create value in unique manners. Most importantly, novelty and innovation are seen to be underpinned by an “institutional change of how resources are integrated”. Hence, we make the following proposition:

> **Proposition 3:** A service ecosystem can counteract the consequence of increasing entropy through the activation of internal effectors: heteropathic resource integration and re-institutionalisation.

Hence, to remain viable with entropy maintained at a controlled levels, the service ecosystem must have subsystems to ensure these effectors are activated. The status of the ‘effectors’, as the determinants of a service ecosystem viability, reflects the actions of these subsystems. These subsystems include: actors and the network of actors, which determine value creation (Pulkka *et al*. (2016). An actor-to-actor designation is crucial to the ecosystem view with those network actors assuming both service provider and service beneficiary roles simultaneously and have a common purpose - value co-creation (Vargo and Lusch, 2016). In the face of environmental turbulence, these value co-creation networks need to preserve a level of resilience and flexibility that allows the ecosystem to adapt to changes inflicted by market conditions. Acting as a complex adaptive system will allow the network of actors to reconfigure and self-organise ‘at the edge of chaos’ (Prigogine, 1978). As explained by Wieland *et al*. (2012), in order to achieve greater viability (i.e. survivability and well-being), system actors should seek consonant (i.e. compatible) and resonant (i.e. harmonious) relationships. This is seen to create the most beneficial value co-creation relationships among actors. The ability of network participants to co-evolve is paramount in this context (Pulkka *et al*. 2016). Thus, the following proposition is posited:

> **Proposition 4:** For entropy to be maintained at controlled levels, the service ecosystem must have subsystems to ensure the effectors are activated. These subsystems include actors and the network of actors.

However, as Martínez-Berumen *et al*. (2014) argue, when such effectors are weakened or cancelled, the system will surrender to the effect of entropy and its structure gradually starts to degrade. Martínez-Berumen *et al*. (2014) explains the system's collapse by it moving in a direction contrary to that established by its structure, 'homogenising with its environment' and returning to its most likely natural state: disorder. We propose that a direct indication of a service ecosystem's homogenisation with its environment is the dissipation of its operand and operant resources back to the environment through the loss of actors and the disentanglement of the network of actors. Maximum entropy is characterized by the discontinuity in value-co-creation and perhaps value destruction, and ultimately the collapse of the system's institutional arrangements. Hence, the following proposition is posited:

> **Proposition 5:** When the service ecosystem effectors are inadequate, the service ecosystem will surrender to the influence of entropy with the system dissipating its operand and operant resources back to the environment; its institutional arrangements begin to buckle and eventually collapse.

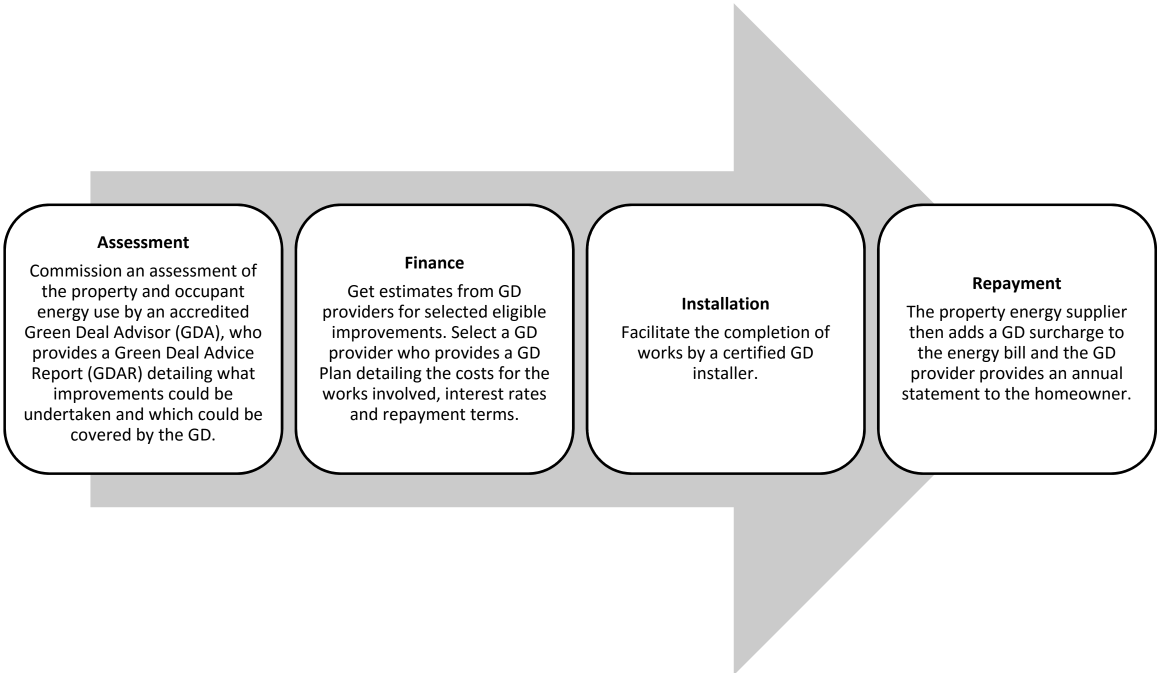
An illustrative case: the UK Green Deal (GD)

The theoretical framework and propositions developed above will be illustrated through a specific case: the UK Green Deal (GD). The purpose of an illustrative case study is to help the reader in visualising how the concepts can be applied to an empirical setting. The UK GD is chosen for the well-documented evidence that it offers to exemplify the concepts we developed above. The illustration was drawn based on the review of published scholarly peer-reviewed articles and government reports on the GD between 2013 and 2016. The review was not systematic, but selective, and the illustrative case study is not intended as a point of reference for all the issues surrounding the GD. It should also be noted that, with all theoretical generalisations, the inferences we make must rest as propositions until proven or disproven by further evidence.

Overview of the Green Deal (GD)

The GD was hailed as a "vibrant new market in energy efficiency" (DECC, 2010) and "Europe's most innovative and transformational energy efficiency programme" (Guertler *et al*., 2013). Driven by the national Climate Change Act (2008), which set a legally-binding target of 80% reduction on 1990 levels of greenhouse gas emissions by 2050, and the EU Energy Efficiency Directive (2012/27/EU) which set a target reduction of 20% in primary energy use by 2020, the UK Government introduced the GD as a flagship policy (Barker, 2011; HM Government, 2013). Fully live from 28th January 2013 (Marchand *et al*., 2015), it was intended to offer a mechanism for homeowners to enhance the energy efficiency of their properties[iii] without an upfront cost and to make solutions available to households irrespective of their financial resources. The scheme was intended to support energy efficiency improvements through private finance, shifting responsibility away from government and the public purse and onto individual householders. The cost of the works was covered by a loan from the GD Finance Company and repayment was through a surcharge on the property's energy bill. The loan was therefore attached to the property and the individual homeowner was responsible for repayments only while occupying the property. The steps required of householders to undertake GD work are illustrated in Figure 1 below.

Figure 1: The GD Process



Eligible improvements were required to comply with the 'Golden Rule' that the cost of the work would be fully repaid by the projected savings in energy bills over the loan period and the loan period must be shorter than the expected life of the measures. The GD was introduced in conjunction with a revised Energy Company Obligation (ECO) scheme in which the largest energy suppliers were required to provide improvements to homes to achieve a target level of CO_2 reduction. The suppliers were required to target hard-to-treat properties (e.g. solid wall construction) and there were financial penalties for failing to meet the target. The cost of ECO was recouped across all customer bills. However, in late 2013, political and industry pressure focusing on these costs led to a reduction in targets and a decrease in focus on hard-to-treat homes. The combined GD and ECO schemes replaced previous schemes including Warm Front (2000-2013), Carbon Emissions Reduction Target (CERT; 2008-2012) and

Community Energy Saving Programme (CESP; 2009-2012), which had targeted low income, poor quality housing and included supplier obligations to install improvements.

A critical driver of the scheme was legislation on 'consequential improvements': the requirement for householders improving their property to spend an additional 10% of the project cost on energy efficiency improvements. This would have required around 2 million households to consider these improvements (Guertler *et al*., 2013). However, due to adverse media coverage, the policy was dropped in the run-up to launch of the GD. The launch of the GD in October 2012 was very low profile (Guertler *et al*., 2013). In fact, on the day of the "launch" the Department of Energy and Climate Change (DECC) failed even to issue a press release. Throughout its short life, the GD experienced difficulties and ultimately, its success criteria were not realised (NAO, 2016): initial targets included an expectation of at least 10,000 completions in the first year leading to 14 million by 2020 (Barker, 2011). Further, the scheme was expected to stimulate growth in the energy efficiency sector, leading to an increase in jobs in the sector from 27,000 in 2010 to quarter of a million (Huhne, 2010; Barker, 2012). By December 2015, 14,000 homes had had improvements through the GD although only 1% of these were funded by GD finance (NAO, 2016). In the first year of operation, loft insulations decreased by 90% and cavity wall insulations by 77% (Hayman, 2013). Rates of these installations had been running at 700,000 per year subsidised by CERT and CESP, but no longer qualified for subsidy under the GD. Funding for the GD was withdrawn in July 2015, effectively terminating the scheme. ECO is due to end in March 2017.

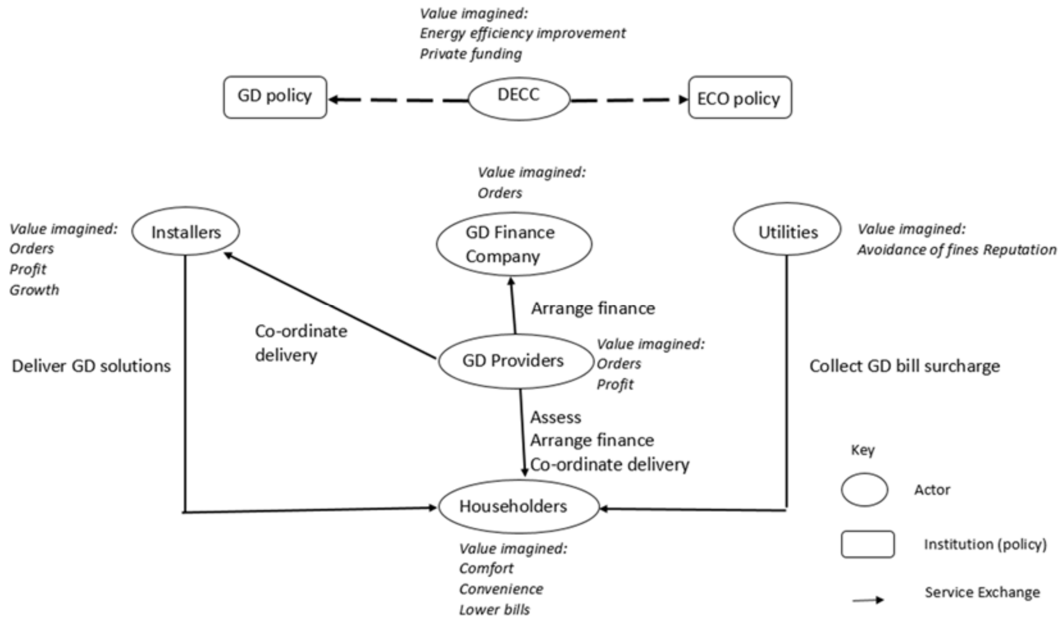
Green Deal (GD) Service Ecosystem Transformation

In this section we discuss the GD transformation in relation to each of our propositions.

Proposition 1: Entropy is a fundamental property of a service ecosystem representing the state of systemic value co-creation.

Although the GD was positioned as an "once-in-a-lifetime" approach (Huhne, 2010), it followed a series of earlier policies targeting energy efficiency, greenhouse gas (GHG) emissions and allied objectives. While it was being designed, CERT, CESP and an earlier implementation of ECO were in operation. Most of the actors for the transformed service ecosystem for the GD were active in value exchange in the earlier schemes: the utility companies, householders, SMEs who installed insulation, new boilers, double glazing, etc. Figure 2 presents a simplified view of the primary actors and exchanges in the GD service ecosystem.

Figure 2: Primary actors and exchanges in the GD service ecosystem



The introduction of the GD was a complex undertaking with high uncertainties and was reliant on multiple subsystems to align and co-create value successfully, including the support of other policies such as the Department for Communities and Local Government (DCLG) 'consequential improvements', enticing new types of businesses to participate in the energy efficiency market, facilitating training and accreditation, ensuring quality, and encouraging private finance (Guertler *et al.*, 2013).

As a social system (Bratianu and Orzea, 2012), the natural law of entropy was active in increasing the instability of the GD Service Ecosystem (SES) and its transformation. Particularly, and from the outset, the GD suffered from conflicting perspectives of the value to be realised by the service among systemic actors as further explained:

- The most critical disparity was that between DECC, as instigator of the SES transformation, and householders, who were assumed to adopt the role of ongoing drivers, in line with an ecological modernisation rationale that economic utility impels action (O'Keeffe *et al.*, 2016). DECC aimed, through the GD, to improve energy efficiency and reduce GHG emissions in a measurable way that could facilitate meeting legal targets set in the Climate Change Act 2008 and the EU Energy Efficiency Directive 2012. Householders however were more interested in convenience and household warmth than GHG emissions (Marchard *et al.*, 2015) and other motivations such as health, well-being and comfort were ignored (Rosenow and Eyre, 2016).

In addition, householders were required to pay an upfront fee of the order of £120 for the initial assessment, in contravention of the ‘no upfront costs’ ambition. Furthermore, there were issues around trust and quality of the installation work completed and indeed these were the primary cause of failure alluded to by government (UKG, 2015): whereas the householders expected quality installations by approved trades, the primary objective of some installers was profit, at the expense of customer satisfaction.

- The utility companies sought to safeguard their reputation, avoid fines and minimise costs but their costs increased (NAO, 2016) and they applied pressure to DECC to change their targets and focus.
- Although the GD Finance Company was not-for-profit, interest rates on GD loans were set at around 7%, well in advance of interest rates available in retail banks at the time (Rosenow and Eyre, 2016).

These conflicting views of value have contributed to the disorder and instability of the GD service ecosystem, and is an evidence of entropy taking action, decreasing systemic value.

Proposition 2: A service ecosystem must continuously offset the entropic process by importing new operand and operant resources from its environment.

As an open system, the GD Ecosystem could have reduced the entropic process by bringing in the needed resources (human, material, energy and information) from the system’s environment (Walker, 2015; Daft *et al*., 2010; Wieland *et al*., 2012). The resources and institutions that could have been harnessed from the wider context include:

- *Financial resources*: the need for further injection of capital was recognised by the Government in response to the very low uptake of the scheme and Government loans were necessary to aid start-up (£25m in 2013), to prevent collapse of the GD Finance company (£34m in 2014; Rosenow and Eyre, 2016) and to facilitate training (£3.5m in 2012; Guertler *et al*., 2013). Cashback and subsidies to householders were offered in 2014-2015 to stimulate demand: these grants were capped and were fully subscribed, in one phase within 24 hours of availability. Attempts at injecting resources from the environment (cashback; grants) drove demand which could have increased alignment of perspectives on value but the capped amounts meant that insufficient external resources were applied to counteract the increasing entropy. Adequate long-term incentives should have been introduced to increase demand and embed energy efficiency into the market.

- *Knowledge*: practical knowledge from actors in previous SES such as the SMEs in the energy efficiency sector; and theoretical knowledge from academic commentators were not harnessed. Expert opinion on the economics of the value proposition, on the politics of introducing another energy efficiency scheme and on the social demand for such schemes was available to policy makers while the GD was being designed and throughout its duration (Rosenow and Eyre, 2016). Indeed, almost the opposite took place with the Government continuously denying the problems associated with the GD (Guertler *et al*., 2013).

- *External economic and social actors*: while major retailers such as supermarkets and DIY stores could have become important actors in the GD SES as they enjoy a large customer base and wide reach across the UK population, due to the uncertainties surrounding the scheme, they were reluctant to join the scheme and failed to support it. This further reduced overall consumer confidence in the scheme (Guertler *et al*., 2013).

The inability of the Government to apply sufficient additional financial inducements, to harness knowledge and expertise, and to attract more economic and social actors to take part in the GD illustrate a system which is significantly isolated from its environment.

Proposition 3: A service ecosystem can counteract the consequence of increasing entropy through the activation of internal effectors: heteropathic resource integration and re-institutionalisation.

As time progressed and problems became more visible, there was scope to encourage key actors collectively to identify novel approaches to co-create value through engaging in heteropathic resource integration (Peters, 2016; Vargo and Lusch, 2016). However, such emergent knowledge was not harnessed and opportunities for heteropathic resource integration were unrealised. Indeed, operant resources internal to the system such as market knowledge and practical skills within the SMEs and utilities were not capitalised. In addition, DECC could have pursued greater transparency in terms of communicating the problems facing the GD in order to reduce uncertainties in relation to the success of the GD, and building confidence in the scheme and managing actors' expectations (Guertler *et al*., 2013). The system's governing instructional arrangements were determined at the outside, with roles for GD Providers, GD Finance, GD installers, training providers, etc., and were positioned in a static network of responsibilities.

As entropy increased and failure became more likely, re-institutionalisation (Banoun *et al*. 2016) was not considered. Institutional arrangements that could have been considered included the consequential improvement regulation, and the previously successful CERT and CESP programmes. The GD details could have been made clear and well-understood ahead of phasing out the old policies of CERT and CESP (Guertler *et al*., 2013). In addition, the withdrawal of the consequential improvement policy was highly damaging to the uptake of the GD and its viability. According to the Department for Communities and Local Government (DCLG) the consequential improvement proposals could have significantly increased demand for home energy efficiency measures with 2.2 million households would likely have taken up the GD as a result (Guertler et al., 2013). This, as Guertler et al. (2013) argue, illustrate the failure of one policy to deliver highly critical grounding for another policy, hence signalling the institutional failure in underpinning the GD.

Proposition 4: For entropy to be maintained at controlled levels, the service ecosystem must have subsystems to ensure the effectors are activated. These subsystems include actors and the network of actors.

The development of consonant and resonant relationships among the GD network of actors was important in order to create the most beneficial value co-creation relationships and support greater viability (i.e. survivability and well-being) of the system (Wieland *et al*., 2012). However, relationship building was adversely affected by poor communication among GD actors, and most significantly the public with lack of public awareness characterising the GD for its duration (Green Deal Assessors Association, 2015). Actors in the system (installers, utilities, householders) were also confused on policy (O'Keeffe *et al*., 2016).

The Government, in this case DECC, as an important actor in the service ecosystem should have ensured that adequate effectors are activated. However, the Government ability to foresee and remedy the problems associated with the GD was exacerbated by its weak institutional capacity at the time. In early 2012, the DECC had undergone institutional change by establishing an Energy Efficiency Deployment Office (EEDO) tasked with the coordination work in relation to developing, deploying and evaluating energy efficiency policy. However, the department was newly introduced and hence was institutionally immature. In addition, all through the GD development, the supporting policy actors' networks experienced considerable instability and decline. The reduced funding incurred by main energy agencies, such as the Energy Saving Trust and the Carbon Trust, resulted in their formal supporting roles being substantially cut down. Alongside this, the Energy Efficiency Partnership for Buildings, a group of actors from the supply chain and non-governmental organisations, also experienced significant funding cuts which lead to a substantial reduction of its activities. Collectively, these reasons may have meant the government was unable to foresee and manage the complications with the GD development (Guertler *et al*., 2013).

Interestingly, the hasty phasing out of the old policy frameworks and premature introduction of the GD was explained as being associated with the 'Year Zero' syndrome with the new coalition government attempting to make a 'fresh start' and 'turn over a new page' by abolishing the old policy frameworks associated with its Labour predecessor (Guertler *et al*., 2013). However, while democratic, as Riddell and Haddon (2009) argued, this often does not result in robust policy.

Proposition 5: When the service ecosystem effectors are inadequate, the service ecosystem will 'surrender' to the influence of entropy with the system dissipating its operand and operant resources back to the environment; institutional arrangements begin to buckle and eventually collapse.

Entropy continued to increase, with perception of value decreasing for the primary actors: installers were gaining little additional business despite, in many cases, having invested in training (O'Keeffe *et al*., 2016); utilities found their costs increasing (Morse, 2016); householders remained largely unaware of the scheme and the Government achievement of energy efficiency was showing dramatic reduction compared to previous schemes (Hayman, 2013). Indeed, the closure of the earlier schemes before the launch of the GD and delays and uncertainty around its introduction meant that the earlier service ecosystems dissipated and actors and resources were lost to the transformed system. An example provided by Guertler *et al*. (2013) of such market turbulence is the reluctance of insulation distributors, following the GD launch, to supply their customers, the installers, with insulation products, due to the fear that the low anticipated demand will result in installers not finding customers and hence distributors ultimately not getting paid. In fact, by the end of 2012, the delay in introducing the GD and the discontinuation of CERT and CESP resulted in the loss of about 800 jobs as a result of the substantial decline in retrofit activity. The GD has significantly disturbed the existing energy efficiency service ecosystem jeopardising hundreds of small insulation firms and putting thousands of jobs at risk. By January 2013, over 4,000 jobs in the insulation sector had been lost (Guertler *et al*., (2013) and this loss of jobs in the retrofit and insulation sectors had caused ta significant loss of resources from the system (Guertler *et al*., 2013) with the service ecosystem for the GD increasingly deemed as 'failed' (Goodall, 2013). The formal withdrawal of finance from the scheme by the government in July 2016 was perhaps the 'killer blow': although many of the actors in the GD service ecosystem still exist, the loss of the financing mechanism, a pivotal resource, represents an overwhelming failure of the system.

Conclusion

The systemic and contextual nature of value co-creation is largely unrecognised and its full implications not well understood (Wieland *et al*., 2012). Our research question: *How does a service ecosystem survive a transformation?* Encouraged us to investigate the processes of disorder and instability in service ecosystems. We have set out to extend the service ecosystem theoretical conceptualisation by introducing the concept of entropy from system theory to explain service ecosystem instability, disorder and ultimately collapse.

In this paper, we proposed that entropy is a property of a service ecosystem and an indicator of the state of systemic value co-creation in the system. We view service ecosystem transformation as an entropy driven process and, in conformance to the usual and ordinary course of nature, the law of entropy acts to increase the instability of the system moving it gradually to a state of disorder. Hence, entropy is a measure of service ecosystems' disorder and instability, witnessed by competing and conflicting perspectives of value among systemic actors, destabilisation of the dominant view of value and ultimately the destruction of systemic value. Thus, the ability of the service ecosystem to survive, i.e. its viability, is dependent on its capacity to reduce entropy. We proposed that a service ecosystem has the capacity to continuously offset the entropic process by importing new operand and operant resources from its environment and through the activation of internal effectors particularly heteropathic resource integration and re-institutionalisation. Hence, to remain viable with entropy maintained at a controlled level, the service ecosystem must have subsystems to ensure these effectors are activated. These subsystems include the actors and the network of actors and, in the face of environmental turbulence, these value co-creation networks need to maintain a level of resilience and flexibility that allow the ecosystem to adapt to changes inflicted by market conditions. However, when the service ecosystem effectors are inadequate, the service ecosystem will surrender to the influence of entropy with it likely to be maximised when the system dissipates its operand and operant resources back to the environment destroying systemic value. The institutional arrangements of the service ecosystem begins to buckle and eventually collapse.

The relevance of entropy as a theoretical construct in service ecosystems is clearly illustrated by the GD case study. The investigation of GD paints a vivid picture of a service ecosystem failed transformation and ultimate collapse. The propositions above have a number of important implications for policy-makers, management practitioners, and other service professionals who might consider introducing novel initiatives or new market mechanisms:

- Most significantly, policy makers should develop an extensive appreciation of the concept of a service ecosystem as a strategic perspective that underlines the systemic nature of service provision. Indeed, in terms of service, markets should be understood as a myriad of open, self-organising, co-evolving and interacting service ecosystems. Policy makers should realise that a service ecosystems view calls for collaborative, integrated action among systemic actors to ensure the functioning, stability and long-term viability of the service and its provision.

- Furthermore, the premise that most seemingly new service ecosystems are in fact transformations of existing systems carries the implication that any new policy initiative must consider how best to use what has gone before if it is not to undermine its new arrangements. A newly elected government that takes a 'Year Zero' approach and terminates previous legislation before the introduction of its replacement is jettisoning resources that can contribute to the success of their own policy projects. In particular, the more ambitious the new policy, the more important it is to utilise existing resources including expertise, knowledge and skills for the new service ecosystems they seek to build. To do otherwise is to invite failure.

- In addition, a clear understanding of entropy, how it affects service ecosystems and how it can be reduced, will help policy makers in several ways. A greater appreciation of entropy will help policy makers understand that the introduction of a new market mechanism is a complex process of service ecosystem transformation. This systemic transformative process should be understood as one that is dynamic, and prone to entropic processes of disorder, instability, and failure. However, service ecosystems can be stabilised through deliberate internal actions by systemic actors through the activation of effectors. Hence, faced with turbulence, policy makers should deliberately seek to stabilise the system though importing operand and operant resources, heteropathic resource integration, and re-institutionalisation. Each service ecosystem is unique, hence policy makers embarking on a new market initiative should purposefully seek a clear understanding of the network of actors, their resources and the systemic value co-creation processes that underpin the existing service ecosystem. Following this, a deliberate effort should be made to ensure that adequate effectors are in place to stabilise the system and support its long-term viability.

Through the introduction of the concept of entropy, this paper contributes to a greater understanding of the systemic and contextual nature of value co-creation and its implications in service ecosystems. Further research is needed to pursue an operationalisation of entropy and to develop models for its assessment in service ecosystems. The entropy of the service ecosystem can then be employed to assess the risks faced by a newly introduced initiative, regarding its viability in the long term.

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[i] In simple terms, the second law states that while heat will naturally flow from a hotter to a cooler entity, at the heart of this is the thermodynamic property of entropy (usual symbol S) defined by the equation: $\Delta S = \delta Q \div T$ where ΔS is the change in entropy, $\delta Q$is the heat transferred into the system and T is the absolute temperature when heat interred the system.
[ii] Indeed, the law of negative entropy, as argued by Katz and Kahn (1978) dictates that for a system to survive and sustain internal order, the amount of energy (i.e. resources) that should be imported from the environment must be far greater than that needed for the process of transformation and exportation.
[iii] The measures which could be included were: double, triple or secondary glazing; draught proofing; cavity, solid wall and loft insulation; boiler replacement and wind or solar renewable energy.