The Latent Role of Universities in Boosting Innovations: An Informational Approach

14

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Abstract

The chapter looks at universities in their relation to other entities in society. It proposes new metrics for gaining insight into these relationships. The possibilities for the reorganisation of the relationships between universities, industry and government so as to stimulate economic growth or innovation can themselves be classed as innovations. Whilst universities often are the locus of specific innovations, their broader discursive role provides a means of exploring contesting perspectives on innovation. In doing so, they can contribute to a broader public discourse where some innovations which were once seen to be controversial become normalised. The discourse dynamics illustrated by the Triple Helix allows for the description of this process as one where redundancies of expectation are produced not only within the transactional productions of the academy (i.e. academic papers) but also within the management of institutions surrounding education, including university management, academic quality agencies, institutional ranking organisations, academic journals, as well as other institutions which the university is associated with such as health or law.

Keywords

Entrepreneurship · Incubation · Success · Policy making

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The origin of the concept of national system of innovations, according Freeman and Soete (1997) can be traced down to the middle of nineteenth century when Friedrich List's book "The National System of Political Economy" (1841) first appeared. Since then a system's perspective to innovation studies was first introduced by Freeman (1987) with reference to the Japanese system of innovations, then generalized by Lundvall (1988, 1992) and Nelson (1993) to the theory of "national systems of innovation", and then conceptualized to the theory of Triple Helix (TH) model of university-industry-government relations (Etzkowitz and Leydesdorff 1995, 2000).

Knowledge generating institutions are reputedly considered to be principal drivers of innovations. Whilst what this means remains obscure, it is suggested that the appropriate institutions for generating new knowledge which may be turned in innovations are the universities. However, the nature and role of the universities has been contested: from the Newman's classic 'Idea of a University' (1953) and his appeal for Universities teaching 'universal knowledge', or the Humboldtian ideal of Bildung, to recent market-driven characterisations where universities become competing 'knowledge enterprises' there continues to be much debate—particularly as modern institutions are affected by pressures of an 'educational market' (Brown 2012; Barnett 2013). In presenting the Triple Helix, we frame our discussion around a generalized dynamics of communication which principally has focused on the discursive relations between universities, government and industry. Universities can be seen to contribute to a nonlinear dynamic of knowledge exchange within society, and that the study of this dynamic can bring deeper understanding of the relationship between universities, innovation and the economic growth that is produced. Drawing on this, in the second part of the paper, a more generalized view of this dynamic is taken in order to account for recent examples of innovation which appear to arise outside the traditional bounds of university, government or industry. Emphasizing a generalized discourse dynamic in three dimensions without reifying institutional entities allows for a deeper consideration of innovative processes within the context of the discourse dynamics described, and a deeper consideration of the discursive role played by Universities.

In the Triple Helix (TH) metaphor, innovation system comprises three key actors: University, Industry, and Government, responsible correspondingly for the functions of knowledge production, wealth generation, and normative control (Etzkowitz and Leydesdorff 1995, 2000). The model assumes that economic development increasingly relies on knowledge based development than simply on manufacturing. The most appropriate institution for generating new knowledge and new technologies which can further be transformed to innovations are universities. However, the role of universities in innovations seems to be more diversified, and the role of knowledge generating institutions in the network of relations among the key actors constantly grows. The spheres of actor's activities increasingly overlap and in the area of overlapping actors can partially substitute for one another. Overlapping spheres of activity can be schematically presented with the help of a Venn diagram (Fig. 14.1).

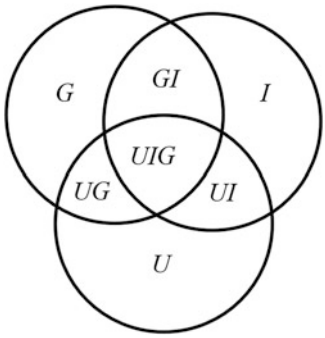

Fig. 14.1 Graphical representation of the TH model: *U* university, *I* industry, *G* government

TH actors operate as selection environments for each other. The interactions among the selection mechanisms govern the system's evolution. Universities, primarily responsible for research and educational functions, tend to engage in business, in the form of small innovative companies. Corporations, making ties with universities, improve their own R&D and personal training activity. They may also be able to use the university's infrastructure in order to conduct their own R&D activities, and thus shift part of their costs to the state as the main source of funding for universities. Governments stimulate development and implementing of innovative technologies, and can support small innovative enterprises through priority financing of specific universities and legislative regulation. Universities and industry can partially substitute for the state in the creation of an innovation infrastructure. Inter-substitution of activities spheres can be graphically presented as a vector *V* rotating in a three-dimensional coordinate system formed by three institutional actors (Fig. 14.2). The values of the components of vector *V* along the axes define the relative importance of the corresponding institutional actor at the specific moment of innovation processes.

Etzkowitz and Ranga (2012) suggested describe the TH evolution via Knowledge, Consensus, and Innovations Spaces which are correspondingly related to functions of novelty production, normative control, and wealth generation. Each of the Spaces involves activity of all three actors, but the weight of the actors in each of the Spaces is unequal. The Knowledge Space, based on R&D activities, is primarily occupied by universities because universities perform the leading role in creating new knowledge. The Consensus Space is mostly controlled by government, and the Innovation Space, based on knowledge-based entrepreneurship, belongs to the Industry sphere.

Depending on specific initial conditions in various regions, the innovation process may comprise consecutive initiatives that lead to building the mentioned spaces in different time sequences. Etzkowitz and Ranga (2010) discuss the situation in two regions: Norrköping in Sweden and New England in the United States. While in the first region the sequence of space generation was Consensus → Innovation → Knowledge Space, in the second it was Knowledge → Consensus → Innovation Space. The creation of Spaces entails a change of the corresponding

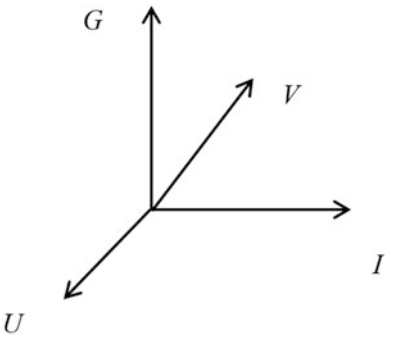

Fig. 14.2 Cartesian coordinate representation of the TH model (from: Ivanova and Leydesdorff 2014a)

actors' relative roles. For example, the Consensus → Innovation → Knowledge Space sequence in Sweden reflects a shift of emphasis from Government to Industry, and then to Science. This process can schematically be depicted as a rotation of the vector *V* in Fig. 14.2 in the three-dimensional coordinate system. The rotation changes the relative value of the vector components, and accordingly the corresponding contributions of *U, I, G* institutional spheres.

Thus, the evolution of the TH system can be presented as rotations of the vector *V* in three-dimensional coordinate system. Rotations in three dimensions belong to the non-Abelian (i.e. non-commutative) symmetry group, as opposed to rotations in a two-dimensional coordinate system, which can be described by an Abelian (i.e. commutative) symmetry group. Whereas communication in system with two actors (for example, university-industry or industry-government relation) can be described by linear equations, the order of rotations in a three dimensional system cannot be interchanged without changing the final result. In other words, the pivotal role of universities comprised in changing the dynamics of the innovation system by shifting it into non-linear domain.

Constant variations and non-linearity characterize a TH system because of the non-linear dynamics. A nonlinear dynamical system can have the following features: first, the system contains feedback loops; second, areas are present where more than a single state of equilibrium is possible; third, the system can be considered as fractal; and fourth, there is a sensitive dependence of the systems dynamics on initial conditions (Peters 1996).

The Triple Helix model can be further generalized to a Quadruple (Baber 2001; Carayannis and Campbell 2009). Although these generalizations can be broader than that of TH, they do not bring any substantially new dynamics into the system (Ivanova 2014) when compared with a TH system because the same kind of non-commutative symmetry is responsible for the system's non-linear behavior.

Equations describing the communications among TH actors in a model approximation can be reduced to a modified form of generalized Lotka-Volterra equations (Ivanova and Leydesdorff 2014b) which can generally be used to describe the evolutionary dynamics of self-organizing eco-systems (Hofbauer and Sigmund 1998). A set of possible solutions of generalized Lotka-Volterra equations, depending of initial conditions and the values of the coefficients, comprises as

well chaotic solutions, point attractors, limit cycles, etc. Initial conditions and coefficient values are implicitly defined by corresponding STI policy.

The non-linearity extremely increases the role of STI policy in providing an optimal environment for generating innovations. The mistake cost of the STI policies increases in the case of non-linear innovation environments, in comparison with linear ones, and wrongly applied policy can push the system into in an effective or alternatively a chaotic mode. For example, recent considerable expenditure on innovations in Russia did not result in any considerable shifts in the Russian economy.

14.1 Synergy and the Mathematical Theory of Communication

Another not commonly realized role of the universities refers to the synergy of communications among actors. Figure 14.1, illustrating the overlap among institutional spheres, allows for an explanation in terms of information theory. The overlapping parts can be considered as a reduction of uncertainty so that system entropy is decreased in comparison with non-overlapping (non-communicating) institutional spheres. Mutual information between two random variables minimizes maximum entropy and is formulated, according Shannon's mathematical theory of communication, as follows:

$$T_{12} = H_1 + H_2 - H_{12} \tag{14.1}$$

The mathematical theory of communications was developed by Shannon (1948) with reference to technical systems. However, communication in social systems is different from communication in technical systems, as was acknowledged by Weaver when he stated that "[t]he concept of information developed in this theory ... has nothing to do with meaning ..." (Shannon and Weaver 1949, p. 27). Information in social systems is defined with reference to a receiving system which supplies information with meaning. Weaver (1949) suggested complementing Shannon's original diagram representing communication process with the semantic box at the sender sides with which to code the information. A similar semantic box can also be added at the receiver side with which to decode and supply meaning to the received information.

Codes of communication are used at the symbolic level to supply communication with meaning. The codes operate as expectations entertained reflexively in the communications among human beings. They open horizons of meaning that offer options. Options add to the redundancy as the complement of the information; adding options thus changes the maximum entropy—that is, the definition—of the system. The interactions among codes of communication may generate redundancies (as feedback on the forward arrow of entropy production). Increases in redundancy can be measured as a net reduction of prevailing uncertainty (measurable in bits). This generation of redundancy (options) can be considered as a

hallmark of a knowledge-based system: new knowledge provides more options than can be realized.

New options can be generated as mutual redundancy when two (or more) codes of communication are instantiated; for example, in the case of introducing a new technology in a market or when writing an evidence-based report for a government agency. In this latter case, one needs text that can be read using the various perspectives involved, and thus one generates redundancies deliberately (Fujigaki and Leydesdorff 2000). We propose to specify mutual redundancy between systems in analogy to the concept of mutual information as specified in Shannon's theory, but using whole sets. In addition to mutual information, the overlap can be considered as containing redundancy as a surplus of information. We can thus define an "excess" information value Y_{12}—equivalent to H_{12} but with the plus sign, so that maximum entropy increases, since we do not correct for the duplication in the case of redundancies—as follows (Leydesdorff and Ivanova 2014):

$$Y_{12} = H_1 + H_2 + T_{12} = H_{12} + 2T_{12} \tag{14.2}$$

The corresponding value of R_{12} can now be found by using Y_{12} instead of H_{12} in Eq. (14.2), as follows:

$$R_{12} = H_1 + H_2 - Y_{12} = H_1 + H_2 - (H_{12} + 2T_{12}) = -T_{12} \tag{14.3}$$

Since T_{12} is necessarily positive (Theil 1972, 59 ff.), it follows from Eq. (14.3) that R_{12} is negative and *therefore* cannot be anything other than the consequence of an increased redundancy. This redundancy—reduction of the uncertainty—can be measured in bits of information, but the sign is negative.

For the three-dimensional case, one obtains:

$$R_{123} = T_{123} \tag{14.4}$$

Introduction of mutual redundancy corrects for the alternating sign in mutual information with each additional dimension. In empirical configurations, the resulting value of R is the result of generation of redundancy on the one side versus the historical process of relating and the generation of uncertainty, on the other. When the resulting R is negative, (evolutionary) self-organization prevails over organization (at specific moments of time) in the configuration under study, whereas a positive R indicates conversely a predominance of organization over self-organization as two different sub-dynamics. In the case when there are only two sub-dynamics presenting two selection mechanisms the interaction among codes can lead to mutual shaping and a "lock-in" to a stable regime (Leydesdorff and van den Besselaar 1998). In the TH model the selection mechanisms in addition to stable regime allows for a various kinds of dynamics where various regimes (e.g., meta-stable, hyper-stable, or global) become possible.

One can further ask whether there is a smooth transition between organization and self-organization? To answer this question, Eq. (14.1) can be written as follows:

$$H_{12} = H_1 + H_2 - \alpha T_{12} \tag{14.5}$$

Here: $\alpha = 1$ for organization and $\alpha = -1$ for self-organization. When communication code sets coincide and the message is uniquely interpreted one would have a net entropy decrease and $\alpha = -1$ in Eq. (14.5). The coefficient varies in the interval: $-1 \leq \alpha \leq 1$. The coefficient α can be considered as a correlation between two sets $\alpha = \alpha(r)$, where r is a correlation and $(1 - r)$ a distance. The supply of meaning can be numerically modeled with help of multiple trace theory used for item recognition (Hintzman and Block 1971; Ivanova and Leydesdorff, in preparation).

In summary the model of communication can be considered as comprising three levels which change the linear model into an evolutionary one because feedback and feed-forward loops are possible among the levels. At level A, information is transmitted; at level B, information is organized and thus made meaningful in a vector-space. Reflexivity reveals that this vector space is constructed and therefore a potential subject of reconstruction: the possibility of reconstruction opens horizons of meaning (level C). This layer generates horizontal differentiation among the codes of communication as a top-down pressure.

Codes of communication are no longer actor-attributes, but operate as second-order variables on the communications. The codes emerge in a self-organizing mode, that is, insofar as constraints on the communication are removed. The system itself has to find these resonances by varying historically because the agents are first-order. The generation of redundancy can enter the historical instantiations reflexively under the condition of self-reinforcing loops tipping the balance towards the prevalence of evolutionary self-organization over historical organization.

Redundancy is a more crucial subject of study in the case of innovation than information. A system without sufficient options can be locked-in. However, redundancies are not generated on the side of the (first-order) variation, but by the codes of communication operating upon one another as selection mechanisms. When three or more selection mechanisms operate, auto-catalysis and self-organization is an option, and options can then be generated at an increasing pace. However, the warp and woof of meaning generation and self-organization are not harmoniously integrated as in textiles, but differentiated and disturbing one another since operating at the same time. These dynamics lead to a fractal manifold in different directions. Through breakages—interruptions—new options are generated (Ivanova and Leydesdorff 2015; Freeman and Perez 1988). This fractal structure is instantiated by the emergence of TH like patterns at different levels: first-order relations among agents, second order positions in systems, and next-order perspectives. Thus additional options generated through the interaction of communication codes can be expected to lead to the emergence of new organizational formats.

14.2 Universities and Innovation: Generalizing the Communication Dynamics

In the preceding section, we specified a generalized dynamic of meaning and communication. In investigating the role of Universities in the innovation processes, it is useful to inspect the mapping of the communication model onto the institutional entities of Universities, Industry and Government more closely. In much of the Triple Helix discourse, this mapping has followed Institutional theory with its concern for regarding institutions through the lens of the transactions they engage in. In this context, the academic discourse is an indicator of transactions within the University, the production of patents is an indication of transactions within innovative firms, and the production of policy documents is a transaction of government. There is however, a question about the claims of New Institutionalism, and the broader theory of the firm (Coarse 1937). Real Universities, Government departments or industrial firms are subject to social dynamic forces which extend beyond the production of visible documents. Willmott, for example, has recently criticized institutional theory arguing that:

> A constructionist ontology is domesticated by a neo-positivist epistemology that tends to treat is objects of investigation as givens, rather than as media of domination. Institutional theory thereby precludes consideration of how its objects of investigation can be adequately researched without reference to asymmetries of power in processes of institutionalization. (Willmott 2015)

The study of communicative transactions might indeed be considered a poor representation of institutional dynamics, and appears to ignore dynamics of power. In acknowledging the criticism above, we nevertheless draw attention to the emphasis within the Triple Helix communication dynamics on mutual redundancies. Power exerts itself within constraints which are indexed by measurement of mutual redundancy. With a more generalized dynamic of communication, Willmott's criticism can be addressed because constraints exercise themselves in many ways, including in the production of communication, presenting a possibility for a deeper analysis of institutional dynamics with a more generalized analysis of constraint.

Cases of real innovation present a backdrop against which to consider this, as an innovation which emerged outside the academy and on the fringes of society, but which has gradually infiltrated mainstream discourse. Like an innovation of cryptocurrency, and its underpinning technology of 'block chain' or 'distributed ledgers' has emerged outside the traditional bounds of the university, government or industry. The current prominence in the discourse within universities, government and industry of block chain, its potential applications and theoretical implications rests on an innovation which belonged initially to the counter-culture. Whilst using the labels of "university", "industry" and "government" for a counter-cultural movement is unhelpful, the Triple Helix discourse dynamics in three

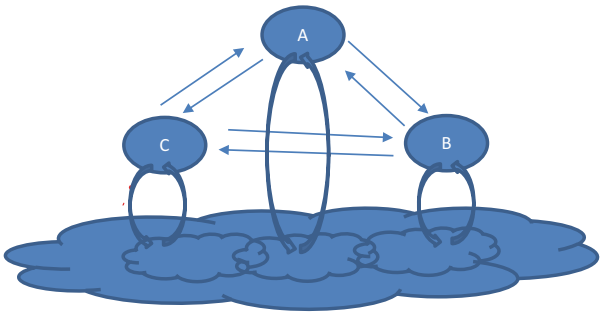

Fig. 14.3 Relation between three entities and their environment

dimensions might be reframed in order to consider the deeper conditions that led to the emergence of block chain.

It is possible to consider emergent discourse from outside the traditional domains of University, Industry or Government, and regard each element of the discourse dynamics as a part of a system of inter-communicating entities engaging in transactions whose boundaries are specified and agreed by researchers (for example, researchers agree that academic papers in the Web of Science index are transactions of the university, or patents are transactions of industry). In other words, the association of transactions with particular institutions is an explicit selection, among many possibilities, made by researchers in an effort to uncover new knowledge through analysis. Researchers themselves are within one of the communicating entities, and their research produces transactions (i.e. publishing academic papers), which helps to define their own entity as a "university". Yet processes of intellectual inquiry exist in many communities outside universities, producing transactions which are not academic papers, but where those communities will similarly self-identify—recognizing activities which belong to their group and those which belong to different groups. The discourse dynamics described can be used to consider how BitCoin and Block Chain emerged from such a nonconformist community.

The behavior of intercommunicating entities—in producing communications of various sorts—is constrained by the dynamics of interaction between them as they define each other in contradistinction to their identification of themselves, and in their relationship with a continually transforming shared environment. This latter element may be seen to be characterized both by systems of expectation and by tangible changes to the lifeworld within which discourses emerge (for example, new technologies or practices). In Fig. 14.3, each entity, A–C, identifies itself in contradistinction to the others with which it interacts. Each is produced as a balance between the mutual information it shares with neighboring elements, and the dynamics between elements which generates new options for communication. Each element must survive within its environment, which it does by selecting specific aspects of information in the environment [what Beer refers to as 'attenuation' of the environment (Beer 1973)], whilst continually transforming the

environment (through making communications, changing work environments, and technological innovation) and through doing so generating new options.

Innovations result in shifts in expectation: they are transformations in the 'code of communication' which translates into new practices, the reorganisation of institutions and sometimes the redrawing of boundaries between communicating entities. Changes in expectation produced by innovation can produce reactive results: radical shifts in expectation are often met with opposition since they represent environmental changes to which other actors have to adapt. Under these conditions, discourses may break apart as changes in expectations produce or reinforce the 'otherness' of discourses in other dimensions. In such conditions of break-up of discourses, Leydesdorff comments on the relation between communicating entities that:

> From the perspective of each binary interface, the third dimension remains then 'latent' as a structural given in the background. This third system entertains interfaces with each of the first two, but not directly (or less so) with their interaction. (Leydesdorff 2003)

This 'otherness' may then be considered as a constraint which shapes the discourse of the other two dimensions. Within the Triple Helix, this produces what Leydesdorff characterises as a 'hypercycle'. He comments that "the hypercyclic integration can be identified as an overlay of negotiations and exchange relations among the institutional carriers of the Triple Helix dynamics". It is within this domain of conflict and negotiation that critique and protest accompany innovation and development. Furthermore, it is within this process that the dynamics of power unfold. Indeed, as Sen and others have indicated, the democratic and inclusive social environment where the challenges of innovation can be explored plays a fundamental role in economic development (Sen 2000). In most developed societies, the University serves the role as a site of dispute where discursive boundaries can be explored and redrawn.

This discursive role of the University cannot be reduced to a description of it as a "locus of innovation". Constrained descriptions of the University have emerged in recent years as education itself has become subject to market forces. Market innovations in academia, including metrics for journal and institutional ranking, teaching appraisals and student satisfactions, have also changed expectations about the nature of the university within the academy itself, and this in turn has changed the rhythms of academic life (Graeber 2015). The study of communication dynamics highlights the effects of these changes and their larger-scale economic impact.

14.3 University Participation in Innovation Dynamics: The Case of BitCoin

BitCoin is a relatively recent innovation in finance. The theoretical work behind the establishment of a virtual currency was first announced in a paper by Nakamoto (2008) sent not to an academic journal, but to an online cryptography mailing list.

The unorthodox nature of this communications was further amplified by the fact that Nakamoto's identity remained a mystery: there was some suggestion that 'he' was a nom-de-plume of a collective (Frisby 2014). The paper specified the creation of a "chain of digital signatures" which would act as an open and transparent ledger of transactions in the currency. The idea was that a scarce digital asset could be created where the exchange of which from one owner to another could be verified "by digitally signing a hash of the previous transaction and the public key of the next owner and adding these to the end of the coin". The technical language was understood within the cryptography community to whom it was directed. The initiative had support from various countercultural groups who had been exploring the possibility of a virtual currency for a number of years. Nakamoto's suggestion included some ingredients missing from earlier attempts to found a virtual currency: notably, that the money supply should be controlled through a process of verifying the transactions within a peer-to-peer "distributed ledger" of transactions which would be rewarded with the creation of new currency. The distributed ledger, or Block Chain, effectively fulfilled the purpose of a central bank in controlling the money supply, and in serving as an object of trust for users of the currency: indeed, Nakamoto saw the 'block chain' as a replacement for trust in third parties like banks: "an electronic payment system based on cryptographic proof instead of trust" (Vigna and Casey 2015). In being distributed, the ledger was copied in its entirety across the different users of the currency. Mass replication meant that there was no central authority which could make changes to it: change had to occur through a collaborative process of verification.

Fiat currency is, as Marx and many others have commented, a symbolic codification of exchange (Marx 1867). BitCoin represents a shift in the mechanisms whereby the symbolic codification is established. Without a central bank to uphold the value of the currency, trust falls on the veracity of the ledger and the transactions within it. In other words the operation of Block Chain is executed by a network of the nodes running BitCoin software. Other cryptocurrencies appeared after BitCoin operate the same way, but with its own software. Those institutions which were challenged by it saw BitCoin as both fascinating and disturbing. Attention was drawn to the fact that the currency was ideally suited to illicit transactions in drugs or weapons (Martin 2014). Due to various initiatives to regulate the currency, including the closing-down of one of the major BitCoin exchanges (Decker and Wattenhoffer 2014), the price of BitCoin fluctuated significantly, limiting the ability of BitCoin to be the reliable tool for value store. In 2013 and 2014 regulatory organizations like Financial Industry Regulatory Authority and European Banking Authority warned about the huge risks in investing in BitCoin. In 2014 Bloomberg called BitCoin as a worst way of money investment. However, despite this and worries about its technology and doubts about its viability, BitCoin survives with increasing acceptance for the payment of online services. In 2015 BitCoin was recognised as one of the best ways of investment. And despite the huge volatility that can be witnessed even today, the current (2017) price exceeds $10,000 compared to under $600 in 2014.

By 2015, the technology underpinning the BitCoin phenomenon gained mainstream attention. The idea of a distributed ledger of transactions as an object of trust became a focus of inquiry as to how other institutions might be transformed with a similar kind of innovation. The fundamental innovation was seen to be in database technology (the Block Chain is a replicating distributed database) alongside rethinking as to how the worldwide web currently operates through a process of centrally addressing specific servers rather than addressing distributed data (Benet 2014). These technological issues led to participation in Block Chain research by Microsoft and IBM alongside industrial participation ranging from banks and law firms to the media. The UK government released a report outlining the potential transformation of industry, government and public services (Walport 2016). 'Smart contracts', peer-to-peer networks, and a fundamental reorganisation of the worldwide web were all discussed within academia, industry and government as an important technology.

In terms of discourse dynamics, what has been witnessed is a very rapid transformation from where BitCoin was a 'niche' activity mostly discussed in the finance industry, to where it is an important topic in academic, government and industry literature. Very quickly, there has been a generation of both mutual information and mutual redundancy between many different communities—not least between universities, government and industry. These continue to generate many options for development. The speed with which this has occurred together with the unconventional roots of the innovation demands further explanation.

14.4 Institutional Isomorphism and the Block Chain Disruption to Institutions

The communicating entities that engage in transactions are not homogeneous. All organisations comprise many different kinds of activity—from management to production. Whilst the self-organisation of communication involves a process of defining boundaries where each boundary is determined by other discourses, this process can be seen to occur within institutions themselves. The discourse of management distinguishes itself from the discourse of the accounts department or the discourse of production. Whilst many innovations concern one particular aspect of an institution's activities (usually production), other discourses like management are relatively untouched and perform a function of managing new kinds of production produced through innovation. In the university, this might take the form of managing new courses, or programmes of research. Block Chain, however, may be seen not only as an innovation in production, but also in management, and in finance. It addresses the trust which underpins the existence of institutions and so its impact on discourse at many levels has been simultaneous.

DiMaggio and Powell's concept of 'institutional isomorphism' (1983), where there is an increasingly universal set of expectations which emerge around the activity of 'management' within institutions provides a framework for conceiving how mutual information amongst managers across sectors has a dynamic impact on

institutional life. Whilst management is characterised by high mutual information, differentiation between codes of communication is upheld by the activities of institutional workers (academics, industrialists, politicians). Indeed, this differentiation is essential for managers to maintain—without it, the institution would have no identity and there would be nothing to manage. With the internal differentiation of expectations within each institution, there is a case to argue that an analysis of institutional communication dynamics needs to consider transactions at different levels within the institution, between different roles, as well as looking at the dynamics between institutions. Between different institutional roles there are mechanisms for maintaining trust in the institution. For example, within the university, managers coordinate educational activities whilst monitoring quality with various forms of audit. In academic publishing, this function is performed by editors. Since the technologies of Block Chain represent an alternative to organising processes of maintaining trust, the combination of institutional isomorphism alongside dissatisfaction with levels of bureaucracy arising from existing practices of audit creates the conditions where a viable alternative stimulates communication across different domains. From the perspective of Triple Helix theory, this activity would be indicative of a shift of expectations, and consequently, innovation. However, since the source of this innovation is not a University, and other stakeholders are equally interested in Block Chain (government and industry), a question remains about the role of University in this innovation process, and in innovation more broadly.

Block Chain and BitCoin are innovations which open up a contested space in the discourse. The ideas around the technologies have to struggle to establish legitimacy in different domains of practice. Walport's UK government report of 2016 was an intervention which signalled the legitimacy of the exploration of the potential of block chain across a number of different domains. The contest created by BitCoin and Block Chain between those who suggest the impact of the technology is overstated, and those who see it as a fundamentally new opportunity unfold within academic journals, curriculum review teams, IT firms, government and managers across many different sectors. The question is, How are such contests to be managed, and how might they resolve themselves?

Block Chain has implications which cut across the knowledge domain: there are technological implications to be explored, sociological, political and governmental issues, educational, legal and medical scenarios where the technology requires exploration. Within each domain of discourse, there are also critiques of existing institutional structures, as well as critiques based on historical examples. There are also conservative arguments which defend the status quo. The University as a site of engagement across disciplines and discourses offers the space within which the contested implications of a new technology—particularly a fundamental technology—may be explored. The conditions the university provides for this include the scope of its knowledge-base, the availability of its scholars and students, and a non-threatening environment for the exploration of new ideas. In other words, the role of the University in innovation is as a structurally-embedded social entity for managing the variety of communications produced within society.

This role for universities in the discursive environment of innovation is itself contested. Marketisation in education has been a management-driven initiative which places emphasis on the university as an innovation and education factory, where the status of each individual institution is prioritised above its structural role within society. Status and success is established through discursive productions in recognised journals and successful recruitment onto popular courses. These forces operate as constraints in the self-identification of the university as an institution distinct in its transactions from businesses or government, but similar in its transactions at the level of management. In other words, in terms of Eq. (14.5), α is negative for institutional management (thus communication codes coincide), and positive for the institution's discursive functions. The Block Chain innovation creates redundancies of expectation at the level of management as well as at the level of discourse thus making α positive for both management and the institution's discursive productions. Its fundamental effect is that questions about the development of technology become closely related to questions about the way the institutions which ask those questions operate and are managed.

14.5 Conclusion

The data analysis techniques described in this paper provide a lens through which to view the university in its relations to other entities in society. New metrics bring opportunities for gaining insight into these relationships. The possibilities for the reorganisation of the relationships between universities, industry and government so as to stimulate economic growth or innovation can themselves be classed as innovations. The effects of innovations are often contested. Competing views of innovation characterise the internal dynamics of power within institutions. In most institutions, including government, management processes will eventually select "winning" innovations, providing appropriate levels of resource to develop good ideas further. The making of good decisions relies on a process of exploring the boundaries of dispute created by different kinds of innovation.

Whilst universities can be the locus of specific innovations, their broader discursive role provides a means of exploring contesting perspectives on innovation. They can do this because they possess sufficient redundancy of ideas and knowledge to auto-catalyse discourse in new areas. In doing so, they can contribute to a broader public discourse where some innovations which were once seen to be controversial become normalised. Importantly, the universities capacity for doing this is dependent on it maintaining a sufficiently broad knowledge-base: this breadth of knowledge and experience can be threatened by excessive market forces which reject branches of knowledge from the academic on the grounds of them not being fashionable.

The BitCoin and Block Chain story illustrates the role of universities as the site of contest between discourses, and as an actor in the process of normalising technologies which in their inception were seen as challenging. The issues surrounding Block Chain particularly are not just issues about technical

implementation or new kinds of software: they are issues about trust in institutions and their management processes, including universities. The discourse dynamics illustrated by the Triple Helix allows for the description of this process as one where redundancies of expectation are produced not only within the transactional productions of the academy (i.e. academic papers) but also within the management of institutions surrounding education, including university management, academic quality agencies, institutional ranking organisations, academic journals, as well as other institutions which the university is associated with such as health or law.

The way a society conceives of innovation and economic growth is itself an innovation: inevitably innovation theories are the "slaves of some defunct economist" (Keynes 1937). Whilst some innovation activity can be accommodated within an existing paradigm, other innovations—particularly those concerned with communication or trust—change expectations and demand new theories and new approaches to the institutions which are seen to be responsible for supporting innovation. Universities are faced with conflicting narratives about themselves. The Triple Helix presents a generalised dynamics of communication which can help clarify the nature of the relationship between universities and their society. Using the Triple Helix to view technical innovations which challenge the way institutions are organised, such as Block Chain, can help to make the case for a balance to be struck between the market forces which tend to constrain the university's activity, and the role of the university as a site of disputation. Into this higher level contest about the nature and role of universities in the relation to society, it might be hoped that the analytical techniques of the Triple Helix help government, industry and universities to head the plea of Pope Pius XII who argued for the acceptance of scientific discovery within the Catholic Church: "One Galileo in two thousand years is enough" (Beer 1975).

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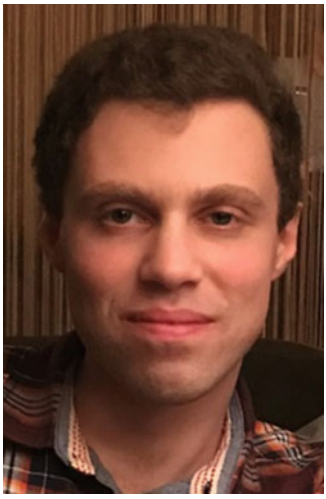

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