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Published Version:
Mining Governance Mechanisms: Innovation Policy, Practice, and Theory Facing Algorithmic Decision-Making / Pelizza, Annalisa; Kuhlmann, Stefan. - STAMPA. - (2017), pp. 1-23. [10.1007/978-3-319-06091-0_29-1]

Availability:
This version is available at: https://hdl.handle.net/11585/698704 since: 2020-02-20

Published:
DOI: http://doi.org/10.1007/978-3-319-06091-0_29-1

Status date: submitted 01/08/2016

Mining Governance Mechanisms. Innovation policy, practice and theory facing algorithmic decision-making

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Abstract (max. 250 words)

The shift from governance *of* to governance *by* information infrastructures has major implications for innovation policy. With algorithmic governance, regimes of inclusion/exclusion "sink" in information infrastructures that act as decision-makers. Inclusive governance of innovation thus needs to dig deeper into technological details. This chapter focuses on one major aspect that characterizes algorithmic decision-making, namely the overlap between policy and practice. Drawing upon the innovation dance metaphor, we ask whether any space for theory can be acknowledged when algorithmic governance tightly couples policy and practice. We first attempt to theoretically answer this question by introducing the Science and Technology Studies notion of "de-scription" as a translation of rules and behaviours from extra-somatic material devices to explicit textual instructions. We propose that space for innovation theory can be conceived of as a descriptive activity. We then exemplify the overlapping argument against the case of blockchain technologies. Blockchains are the algorithmic software underpinning peer-to-peer electronic payment systems – the most renowned of which is Bitcoin. We argue that blockchains "inscribe trust" into software, and thus constitute self-standing governance mechanisms. By analysing a recent controversy in the Bitcoin community, we show that space for theory is more likely to emerge when a controversy arises, that requires description in order to recruit new allies. This evidence suggests that the relationship between theory and inclusion might be inverted: inclusion might not be the outcome of theory, but space for theory is the result of controversies in which opposite factions carry out recruitment strategies.

Keywords (10-20):

governance of innovation; inclusion; innovation policy; innovation practice; innovation theory; innovation dance; governance by information infrastructures; algorithmic governance; blockchain; Bitcoin; script; description; controversy; strategic intelligence

1. Introduction. The ICT-mediated inclusion challenge for governance of innovation

The concept of innovation policy is built on the assumption that "innovation" – a perceived or intended process of material, social, and often also cultural change, incremental or disruptive – can be "governed" (Kuhlmann, 2013, p. 985). How to design governance of innovation in a way that it recognizes less represented actors, and facilitates their participation, is a key concern of contemporary innovation policies (Borrás & Edler, 2014; Lundvall & Borrás, 2005; Smits & Kuhlmann, 2004). Broader inclusion is seen as positively affecting the directionality of new policies, the extent to which new actors can be involved (De Saille, 2015; Kuhlmann et al., 2016), and even the same definition of what "grand challenges" are (Kuhlmann & Rip, 2014).

A contribution to inclusive governance of innovation comes from information and communication technologies (ICT). Since their mass adoption in early 1990s, ICT relationship with the governance of innovation has been mainly framed in two ways. Either by looking at ICT as powerful tools to foster democratic debate, or as emergent technologies in need of governance. In the first case, ICT have been conceived of as a key asset to support participative policy innovation, under the rhetoric of the "Internet revolution"; in the second case, as a technological domain that needs *ad hoc* governance tools.

However, as the backbone of our technology-dense societies, ICT are never neutral tools, but rather active participants in shaping actors and governance. Algorithmic software, for example, has the potential to "inscribe" sensitive decisions in technical details. As Kitchin has recently pointed out, "we are now entering an era of widespread algorithmic governance, wherein algorithms will play an ever-increasing role in the exercise of power, a means through which to automate the disciplining and controlling of societies" (Kitchin, 2016, p. 2). In this regard, a growing literature at the intersection of media studies and science and technology studies (STS) is pointing out how regimes of inclusion and exclusion "sink" in information infrastructures that not only sort and filter information, but can also act as full-blown decision-makers (Beer, 2009; Introna & Nissenbaum, 2000; Gillespie, 2014).

Given ICT pervasiveness in our techno-social environments, this "sinking" has had major consequences for what was traditionally framed as "cyber-democracy", that is the "kinds of relations occuring within [the Internet] which suggest new forms of power configurations between communicating individuals" (Poster, 1997). First, the embeddedness of decision-making in algorithmic governance reveals that the "Internet sphere" has long ceased to be a separate domain of society. Second, it shows that individuals are not the only nor the pivotal actors of those relationships. At the same time and for these very reasons, inclusive governance of innovation cannot avoid taking into account contemporary algorithmic conditions of knowledge production and decision-making (Hoppe, 2010).

While algorithms can be conceived of as omnipresent technologies not only for knowledge production, but also for decision making, how these technologies in turn affect the directionality of innovation is an under-investigated field of reflection. A similar endeavour should take into account not only the multiple ways in which ICT can support the inclusion of heterogeneous types of knowledge in innovation processes (i.e., "governance of technology"), but also how algorithmic innovation itself is productive of new regimes of inclusion/exclusion, forms of knowledge and governance patterns (what we call "governance by technology"), that in turn affect the directionality of broader innovations.

This chapter aims to contribute to a similar endeavour by focusing on one major aspect that characterizes algorithmic knowledge-production and decision-making, namely the overlap between policy and practice. With this, we mean that formal rules, possibilities and constraints cannot be disentangled from actual use, and can be accessed only in practice. Another way to describe this overlap is saying that policy is "inscribed" in software, which in turn is endowed with agency.

In Section two we further elaborate the shift from governance *of* information infrastructures to the governance *by* information infrastructures, and we suggest that this shift has major implications for inclusive governance of innovation. The main argument is that code, protocols, software and algorithms are not only technologies to be governed, but full-blown governance actors enacting regimes of inclusion/exclusion from innovation processes. Furthermore, given their invisibility, decision-making becomes inaccessible to traditional innovation policy actors. Inclusive governance of innovation is thus expected to dig deeper into technological details that are usually invisible to innovation policy actors.

This overlapping of innovation practice and policy does not seem to leave much space for innovation theory. However, innovation theory is a key "dancing partner" (Kuhlmann, Shapira, & Smits, 2010) that can unfold assumptions and rules of thumb implicit in policy and practice. Carving out a space for theory is thus paramount in order to sustain the participation of new or underrepresented actors in innovation process. We will discuss this issue in Section three. We focus in particular on innovation theory as an open and accessible space to engage in explicit debates about guiding principles and actors to be included, and on the risk that the close overlap of innovation practice and policy entailed by algorithmic governance can get rid of any role for innovation theory. We thus ask whether and how any space for theory can be acknowledged in algorithmic governance.

We first attempt to theoretically answer this question in Section four by introducing script theory and in particular the notion of "de-scription" as a translation of rules and intended behaviours from extra-somatic material devices to explicit textual instructions. We propose that the space for innovation theory we are looking for can be conceived of as a descriptive activity carried on by scholars and analysts during moments of crises and ruptures.

This understanding of theory as de-scription will be empirically tested in the next sections. In Section five the practice/policy overlapping argument will be exemplified against the case of blockchain technologies. Blockchains are the algorithmic software underpinning peer-to-peer electronic payment systems – the most renowned of which is Bitcoin. They allow transactions between two parties, that by-pass financial institutions and other intermediaries (Nakamoto, 2008). They use cryptographic "proofs-of-work" that – we suggest – "inscribe trust" into blockchains bearing trace of past transactions (Ethereum Community, 2015). We argue in particular that blockchains constitute self-standing governance mechanisms that closely overlap innovation practice and policy, to the extent that policy cannot be disentangled from digital practices.

In Section six we ask whether in this tightly coupled blockchain dance any space is left for innovation theory. Following a recent major controversy in the Bitcoin world, we show that – despite recurrent claims going in the opposite direction – some space for theory articulation is not only possible, but needed. In particular, the Bitcoin controversy over blocks enlargement reveals that theoretical articulation can be traced in the efforts to de-scribe technical mechanisms to recruit new allies in the debate.

In the Conclusions (Section seven) we stress the theoretical and analytical gains of establishing a dialog between script theory and the innovation dance metaphor. In the light of the analysis of the blockchain controversy, we argue that space for theory is more likely to emerge when a controversy arises, that requires description in order to recruit new participants that do not have experience of rules and decisions inscribed in software. This evidence also suggests that the relationship between theory and inclusion might be inverted. While governance of innovation assumes that inclusion is a much desirable result of theory, the Bitcoin controversy shows that space for theory is not created in a pacified environment, but it is the outcome of controversies in which factions carry out recruitment strategies.

2. From "governance of technology" to "governance by technology"

When it comes to governance of innovation, ICT have mainly played two roles, being conceived of either as tools for democratic inclusion or as an emergent domain in need of governance. With this chapter we propose a third approach, subsumed under the label "governance by technologies".

The first strategy stresses the alleged disintermediation potential of ICT, rhetorically depicted as crucial tools to enhance democratic participation (Dahlberg, 2011). Already in mid-1990s Castells (1996, p. 392) praised "the extraordinary potential of computer communication networks as instruments of grassroots self-organizing and public debate at the local level". More recently, Coleman & Blumler (2009) suggested that ICT have opened the possibilities of more direct participatory, disintermediated communication and political action.

All in all, ICT's democratizing potential has been one of the most influent drivers of digital innovation. While the literature in this regard is endless – ranging from 1970s' Bulletin board systems to early 2000s "Web 2.0" platforms (Pelizza 2009) – it suffices here to briefly recall its discursive roots. The original rationale focuses on the possibility entailed by ICT to by-pass traditional political intermediaries. This by-passing would allow citizens to communicate louder and clearer with policy-makers, or even to take direct political action (Van Dijk, 2000). As Formenti has pointed out, the disintermediation argument finds its roots in such principles as localism, individual empowerment, distrust in professional expertise, direct commitment of individual citizens to political affairs. These principles were introduced by the Jeffersonian ideal of democratic self-governed townships in which decisions were taken during public open assemblies (Formenti, 2008). Through the mediation of 1960s and 1970s counterculture movements, direct commitment and distrust in intermediaries were then inherited by the democratic rhetoric associated with early computer networks (Turner, 2006), and later on with digital communities (Pelizza 2010a; Pelizza, 2010b).

It is worth noticing that the disintermediating rhetoric does not take into account an important aspect: technical disintermediation does not need to imply political disintermediation. ICT may by-pass human intermediaries, but not intermediaries *tout court*. They can rather entail automation, that is, delegation of tasks to devices. STS analyses of practices supported by information infrastructures, for example, have shown that fewer human intermediaries in information exchanges do not necessarily entail disintermediation. They can rather reveal a delegation of tasks to techno-social artifacts that implement decisions taken elsewhere (Kuhlmann, 1985; Oudshoorn, 2011; Pelizza, 2016). Therefore, an important issue in this case concerns which kind of participation to innovation processes can take place, when devices take over human tasks.

The second approach to the relationship between governance of innovation and ICT conceives of the latter as technologies to be governed. The field of Internet Governance (IG), for example, can be seen as an extension of technology assessment techniques in which assessment does not only concern specific technologies (e.g., the TCP/IP protocol), but the Internet as a pervasive yet independent sphere of techno-social activity. IG research thus focuses also on the institutions established to negotiate the Internet's technical coordination (Hofmann, Katzenbach, & Gollatz, 2016).

IG studies conduct an important activity geared towards assuring free, continuous and equal access to Internet, especially by focusing on its technical layers. Furthermore, the most recent studies have the merit of having shown that broad stakeholder inclusion does not automatically entail democratic participation to governance mechanisms (Malcolm, 2015). However, by considering Internet as an independent sphere of governance, IG is less interested in fostering participation and inclusion in broader innovation processes. With some recent exceptions (see among others Musiani et al., 2016), IG's focus on Internet seems to linger at the "governance of technology" level, where technology – even an encompassing definition of "technology" – remains the primary object of concern.

Given their pervasiveness in our techno-social environments, however, ICT are never only tools, nor is Internet a sphere separated from broader techno-social phenomena. From Lawrence Lessig's formulation of "code as law" (2006) to Laura DeNardis' "protocol politics" (2009), from Bowker and Star's "infrastructural inversion" (1999) to Galloways' protocol-based "virtual bureaucracies" (2004), software, protocols, and information infrastructures have been acknowledged as governance actors shaping more or less inclusive (and included) identities.

This is clearly evident with algorithms. By ordering and sorting data, people and behaviours out, algorithms enact regimes of inclusion/exclusion, and act as full-blown decision makers. Issue credit, for example, is based on rote algorithms. Trading algorithms take financial decisions at a speed that excludes any human supervision (Knorr-Cetina, 2014), and can determine the solvency of the world's leading banks (MacKenzie, 2012). But algorithms also take decisions about what is visible or not on the web (Introna & Nissenbaum, 2000); regulate access to public space (Graham, 2005); determine who is who on social networks (Lovink, 2013).

With the expressions "governance by information infrastructures" or, more specifically, "algorithmic governance" (Kitchin, 2016) we stress this shift from conceiving of ICT either as a distinct "democratizing layer" added on top of existing techno-social arrangement or as a technological domain to be assessed, to seeing them as pervasive artefacts that do things.

The move towards governance by information infrastructures has major implications for inclusive governance of innovation. According to Gillespie, public relevance of algorithms unfolds along six dimensions: patterns of inclusion, cycles of anticipation, evaluation of relevance, the promise of algorithmic objectivity, entanglement with practice, production of calculated publics (2014, p. 168). Drawing a parallel with the governance of innovation is straightforward. The first dimension may refer to the (algorithmic) choices behind who comes to be considered an innovation actor, and who is excluded. Cycles of anticipation characterize innovation processes as well as algorithmic governance, and can therefore be deeply influenced by the latter. Evaluation of relevance points to the criteria by which algorithms determine what is appropriate and legitimate knowledge, and could thus affect the learning processes that support innovation. The promise of objectivity is expected to black-box, and therefore strengthen, the role of algorithmic decision in innovation processes. The fifth dimension refers to how actors change their practices to suit algorithms they depend on, and might thus be extended to innovation stakeholders. Finally, the production of calculated publics points to how the algorithmic representation of actors performs new forms of identity, and might trigger new identities for innovation actors.

All in all, acknowledging the governing potential of ICT and algorithms raises new questions. If it is software that decides rules, norms and behaviours, then according to which principles does it decide? How can inclusiveness of innovation processes be assured once it is algorithms that establish who can access them? If algorithms are productive of new regimes of inclusion/exclusion, which are the spaces (either physical or virtual) for debating algorithmic governance? In other words, when inclusion/exclusion regimes are established by software, inclusive governance of innovation has to dig deeper into technological details that are usually invisible and inaccessible to traditional innovation policy actors.

The following section addresses this issue in the light of the innovation dance metaphor. While at this stage it refrains from identifying specific innovation policy, practice and theory actors, it discusses these three functions as “dancing partners”. It highlights the key role of innovation theory as a space for debating principles, actors and modalities of algorithmic governance, and thus for supporting the participation of new or underrepresented actors in innovation process.

3. The dance among innovation policy, practice and theory

Different metaphors have been developed to depict the interactions among innovation practice, policy, practice and theory. Among these, the dance metaphor stresses the learning-based nature of innovation (Kuhlmann et al., 2010), and it is thus well equipped to account for governance by technologies.

Innovation practice, policy and theory can be seen as “partners on a dancing floor”, moving to the varying music and forming different configurations. The metaphor aims to illustrate the mutual interaction of the three forces: (i) dynamics of *innovation in practice*, the (ii) role of *public and other policies*, and (iii) the role of *innovation studies*, as “theory in action”.

> Taking a closer look at the dance floor one can see two of the dancers, innovation practice and policy, arguing and negotiating about the dance and music while the third, theory – not always,

> but often and to an increasing extent –, provides the other two partners with arguments and sometimes also with new music: Practice and policy increasingly have expectations vis-à-vis the contribution of social science based intelligence to their dance (Kuhlmann 2013, 985).

We are interested in the particular potential of theory as a "dancing partner", participating in the dance and academic discourse at arm's length to practice, and its ability to unfold assumptions and rules of thumb implicit in policy and practice. There is a chance that theory can open spaces for debate and facilitate increased reflexivity about algorithmic governance mechanisms at work.

We want to explore this chance with the present chapter because a major implication of algorithmic governance for inclusive governance of innovation is the invisibility and inaccessibility of decision-making to traditional innovation policy actors. This invisibility can be read as an overlapping of practice and policy that does not seem to leave much space to theory. However, this lack of a space for theory risks to reduce the possibility to support the participation of new or underrepresented actors in innovation process. We thus ask whether any space for theory can be carved out in algorithmic governance. A guiding question of the present chapter is: how can spaces for theory be acknowledged and enabled?

4. Theory as description. Introducing script theory

We first attempt to theoretically answer this question by introducing script theory. We propose that the space for theory we are looking for can be conceived of as a "de-scriptive" activity carried on by opposite factions during moments of crises and ruptures.

The concept of "script" refers to the instructions and modalities of action embedded in the material design of a device, or artifact. So, for example, the imperative "bring back the hotel keys before leaving" is translated or "inscribed" in the heavy weights that hotels (used to) add to room keys (Akrich & Latour, 1992). A script is defined as a screenplay or scenario

> defining space, roles and interaction rules among diverse (human and non-human) actors who come to play those roles. According to this understanding, all the decisions taken during the design stage act a delegation of capabilities and skills between the artifact, the user and an assembly of techno-social devices (*dispositifs*) that constitute their setting (Akrich, 1990, p. 85) authors' translation).

Two main forms of script translation are possible: the translation of a script from a verbal form to a material device ("in-scription"), and the opposite movement of script translation from an extra-somatic material device to words and speech ("de-scription"). So, for example, a speed bumper "in-scribes" in plastic the warning "slow down". The same warning, however, could be "de-scribed" with an imperative verbal form (i.e., "slow down!") by a policeman controlling vehicle circulation.

Despite their symmetry, the tendency towards inscribing rules and instructions in extra-somatic devices tends to be much stronger than the opposite movement of description. Description takes place only in exceptional circumstances: "the de-scription is possible only if some extraordinary event – a crisis – modifies the direction of the translation from things back to words and allows the analyst to trace the movement from words to things" (Akrich and Latour 1992, 260).

Furthermore, the opposite movements of inscription and description tend to be carried out by diverse social actors and institutions through diverse forms of knowledge and materiality. Thus, the analytical endeavour proper to scholars is a textual description of the design work (i.e., inscription) carried out by engineers:

> the aim of the academic written analysis of a setting is to put on paper the text of what the various actors in the settings are doing to one another; the de-scription, usually by the analyst, is the opposite movement of the in-scription by the engineer, inventor, manufacturer, or designer (Akrich and Latour 1992, 259).

The notion of script is particularly helpful to address the functioning of algorithmic software for decision making. In a more evident way than any other digital device, algorithms define roles and intended behaviours, and delegate capabilities and interests to them. Rules, behaviours, skills and interests are thus "in-scribed" in algorithms. When a search engine filters search results, it does so on the bases of some inscribed rules. When an e-commerce algorithm suggests the next items to buy, it is actually projecting an intended behaviour. When social media platforms display friends' posts or adverts, they do so on the basis of a series of assumptions about what are users' interests and skills. At the same time, algorithms delegate tasks to other actors. So, for example, a facial recognition algorithm detecting a suspect according to a set of inscribed rules triggers an alarm to the local police, thus delegating them the task of investigating the suspect's intentions.

If we follow script theory, we can assume that in algorithmic governance the opposite movement of de-scription does only take place when some ruptures or controversies happen. In similar critical moments instructions and norms are expected to become visible, and actors can negotiate them. We thus analytically propose to conceive of innovation theory as a space for debate that can be traced whenever a de-scriptive activity takes place. So, for example, algorithmic governance would be reversed-engineered, the practice/policy coupling would be loosened and new space for theory would emerge whenever there is a need to describe technical functioning to new stakeholders. A similar occurrence is exemplified in Section six with the case of peer-to-peer electronic payment systems. Before that, we introduce this innovation as a kind of algorithmic governance which inscribes trust in code, a self-standing governance system in which practice and policy overlap to the extent they cannot be disentangled.

5. Cryptographic blockchain technologies, or of trust built in consensus algorithms

We address the question on whether any space for innovation theory is left by discussing one of the most disruptive contemporary innovations: the case of peer-to-peer electronic payment systems. Cryptographic payment systems allow transactions between two parties that by-pass traditional financial intermediaries (e.g., banks). They do so by using consensus algorithms that "inscribe trust" into blocks of code – so called "blockchains" – that bear trace of past transactions. Saying that "trust is inscribed in code" means that it is software, not humans, that enforces a trustful behaviour. For this reason, in what follows we argue that blockchain technologies (and related currencies) couple innovation policy and practice in a way that they cannot be disentangled.

It is common knowledge in credit theory that money is first and foremost the measurement of a set of social relations, rather than a mere technical instrument (Ingham, 1996, 2013). As such, it provides social relations with a standardized value, and makes them comparable. Comparison is usually entrusted to a third party, that mediates between two parts that do not know each other. This intermediation can be avoided when using cash currency in physical exchanges, but until a few years ago no mechanisms existed to make payments online without a trusted party. Peer-to-peer electronic payment systems – and the digital currencies that the system issues according to predetermined rules – have been developed by trans-national developer communities to address this constraint. These systems are based on a cryptographic proof that allows two parts – unknown to each other – to directly conduct a transaction without any intermediation by financial or other institutions.

A key characteristic of peer-to-peer payment systems is that transactions are computationally impossible to reverse. This feature protects both sellers and buyers from double-spending the same "block" of digital currency. It is made possible thanks to the peer-to-peer implementation of a distributed timestamp server that generates computational proofs of the chronological order of transactions. To describe the basic mechanism we rely on the original formulation of the Bitcoin initiator, Satoshi Nakamoto. While Bitcoin (https://www.bitcoin.com/) is probably the best known digital currency outside developers' circles, it should be mentioned that since Nakamoto's original formulation in 2008 almost 600 blockchain-based forks have been developed, as it will be discussed later on.

In the Bitcoin system an electronic coin is defined as a chain of digital signatures. "Each owner transfers the coin to the next by digitally signing a hash [i.e., reference to] of the previous transaction and the public key of the next owner and adding these to the end of the coin" (Nakamoto, 2008, p. 2). Consequently, any coin is defined by the history of its transactions, and a payee can verify the chain of ownership by verifying the signatures. What the payee cannot verify is that the payer does not double-spend the money, that is, that the coin is firstly received by the payee, and nobody else. This problem is addressed through the implementation of a timestamp server that works by timestamping a block of transactions and widely publishing them. The timestamp thus publicly proves that a given transaction must have already taken place at a given time. Each timestamp includes the previous timestamp, thus forming a chain of "blocks" which is reinforced at each timestamp; hence the term "blockchain" (see Figure 1).

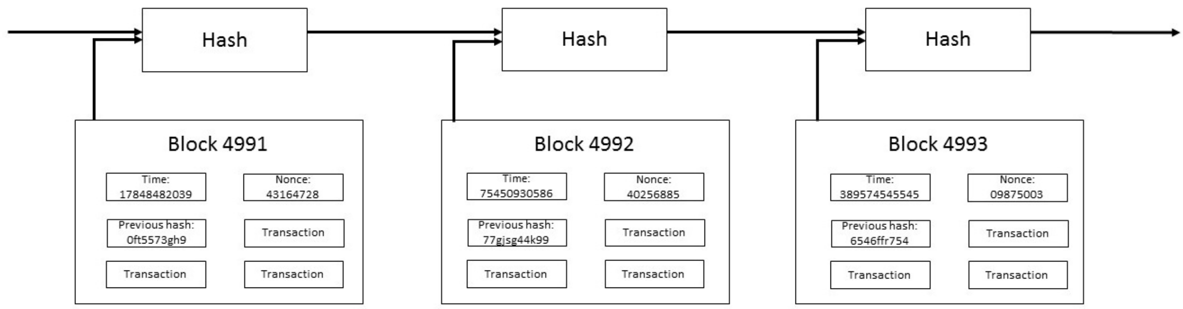

Figure 1 – Visualization of blockchain. "Hash" is the reference to the previous block

The distributed timestamp server is public as it is implemented according to a peer-to-peer architecture that shares a consensus algorithm and makes use of a "proof-of-work". In high-level terms, the consensus algorithm can be described as a mechanism take "inscribes trust in code" by publishing transactions. Each new transaction is broadcast to all peer nodes in the network. Each node gathers new transactions into a block and allocates CPU computational power to find an as much complex proof-of-work for its block as possible. A proof-of-work is a computational puzzle that in the case of Bitcoin corresponds to scanning for a value beginning with a number of zero bits. Alternative currencies have implemented different proofs-of work: Primecoin, for example, requires scanning for unknown prime numbers (Primecoin, 2014). This computational activity is associated to mining new materials and thus minting new coins in the Bitcoin metaphor, hence the name of network nodes as "miners".

When a node finds a proof-of-work, it transmits the block to all other peer nodes. These nodes accept the blocks only if all transactions in it are valid and not already spent, otherwise they reject it. When they accept a block, nodes pass on working on the next one by using the accepted block as the second-last. It is key to note that nodes always accept and start working on the longest chain to further extend it: if two nodes find a proof-of-work for the same block and thus broadcast different versions of that block, the receiving nodes will start working on the first one that they receive, but keep the second one in case it becomes longer. When the next proof-of-work is found and thus one of the two versions becomes longer, the shorter one will be discarded.

As the European project D-Cent has aptly summarized, “a blockchain is a timestamped ledger shared by all nodes participating in a system based on the Bitcoin protocol” (Roio, Sachy, Lucarelli, Lietaer, & Bria, 2015, p. 11). The same description holds also for non-Bitcoin blockchain-based payment systems. By combining digital signatures and a peer-to-peer network using cryptographic proof-of-work to keep track of a public history of transactions, the blockchain system – be it Bitcoin or an alternative currency – enables users not only to by-pass intermediaries, but also to conduct irreversible transactions without relying on trust. “Bitcoin is a trust management system that allows for the exchange of value in a trust-less environment” (Roio et al., 2015, p. 22).

Or, to use a formulation closer to script theory, trust does not depend on interpersonal relationships between persons or institutions that know each other. Trust is indeed “inscribed” in the system architecture: a) in the timestamp that is given to each block, assuring that at a given point in time a transaction has already taken place; b) in the consensus algorithm, that allows nodes to collectively agree on a set of rules about the updating of the ledger; and c) in the public character of the blockchain, that is collectively and iteratively built by all peer nodes participating in the network. The public, transparent (i.e., all transactions are visible by all participants) and symmetric (i.e., all nodes are equal peers) character of the blockchain makes “virtually impossible for anyone to stop the creation and transaction of bitcoins” (Roio et al., 2015, p. 22).

5.1 Blockchains as self-standing governance systems

Following from this description, it might be evident that blockchain architectures do not only constitute disintermediated electronic payment systems. By providing mechanisms to allocate economic value, representational rights and membership, they aim to develop as self-standing governance systems.

Firstly, the proof-of-work algorithm constitutes the seal of equality for such a system, since any participant in the network will be equally rewarded depending on the calculating power and electricity they invested in mining new bitcoins. Therefore, in proof-of-work-based systems like Bitcoin, value is equated to CPU power. Other blockchain currencies based on a different “proof-of-stake” can value other aspects. Faircoin and Freicoin, for example, measure value in terms of degree of currency holding and number of transactions, respectively (Roio et al., 2015).

Secondly, blockchains do not only root economic value in specific guiding principles (i.e., CPU power, currency holding, number of transactions, etc.). They also strictly couple economic value and representational rights. These latter are expressed as rights to vote: in Bitcoin, nodes “vote with their CPU power, expressing their acceptance of valid blocks by working on extending them and rejecting invalid blocks by refusing to work on them. Any needed rules and incentives can be enforced with this consensus mechanism" (Nakamoto 2008, 8). Therefore, representational power is distributed along with economic value. In the words of Bitcoin's initiator,

> the proof-of-work also solves the problem of determining representation in majority decision making. If the majority were based on one-IP-address-one-vote, it could be subverted by anyone able to allocate many IPs. Proof-of-work is essentially one-CPU-one-vote. The majority decision is represented by the longest chain, which has the greatest proof-of-work effort invested in it (Nakamoto 2008, 3).

As some commentators have noted, blockchain systems substitute bureaucratic requirements for participation – e.g., the need to be registered on a list – with technical requirements. Bitcoin, for example, substitutes "a formal barrier to participation […] with an economic barrier – the weight of a single node in the consensus voting process is directly proportional to the computing power that the node brings" (Ethereum Community, 2015, p. 1).

Thirdly, that blockchains aim to eventually constitute self-standing algorithmic governance systems is also shown by their defensive mechanism from non-members and malicious behaviours, that is, by their regimes of exclusion. The same algorithm that allocates economic value and representational rights offers also protection from attacks. As Nakamoto has pointed out, in order to modify a block an attacker should redo the proof-of-work of the whole block from scratch, and then "catch up with and surpass the work of the honest nodes" (2008, 3). In other words, if the majority of CPU power (or of currency holding, number of transactions, etc.) is controlled by participant nodes, the chain will outpace any competing malicious chains. According to Bitcoin initiator, "taking over" an honest chain is virtually impossible with current computing systems, especially with longer chains, although quantum computing might constitute new threats (Roio et al., 2015). We will see in the next section that it was exactly when this exclusion regime was put in question that the self-consistency of Bitcoin as a governance system started to shake.

In summary, by design blockchains aim to constitute mechanisms in which economic value distribution, political consensus building and exclusion regimes are jointly provided by the same proof-of-work (or proof-of-stake) algorithm. These three elements correspond to three basic functions of sovereign state organization according to liberal theory: economy, politics and security. They overlap to the point that it becomes impossible to disentangle them. In a Bitcoin system, proof-of-work determines at the same time the economic value of a node, its representational weight in decision-making, and who should be excluded from participation since they might want to take the chain over (i.e., those who do not run the official peer client).

That one algorithm performs these three functions at the same time is a perfect example of a technology aiming at virtual sovereignty. This is why, despite all considerations about the actual feasibility of this project (Guadamuz & Marsden, 2015), we propose to conceive of blockchains as self-standing governance systems that "inscribe" in software the rules regulating value distribution, representational power and membership exclusion.

Resorting to the innovation dance metaphor, it may be argued that blockchain technologies couple policy and practice in a way that they cannot be disentangled. The innovative practice of "mining" value for the peer-to-peer network and transferring it among peers goes hand in hand with the policy mechanism that attributes one vote to each CPU (in the Bitcoin case), to the point that distinguishing between financial practices and representational policy becomes operationally impossible.

6. Carving space for theory as de-scription

When blockchain technologies couple policy and practice in a way that they cannot be disentangled, new questions arise. As we have suggested when introducing the dance metaphor, while policy and practice can be seen engaging in a partner dance, the role of theory appears less visible. Is any space left for theory in this dance? Is any space for principles articulation possible when policy is inscribed in blockchains? This question is highly relevant in order to establish the conditions of inclusiveness of an innovation process.

As we argued in Section three, theoretical reflection is crucial to design governance of innovation in a way that it recognizes less represented actors, and facilitates their participation. Space for theorization – arenas, fora, debates – allows explicitly addressing the inclusion/exclusion regimes entailed by technological innovation. This is recognized by some projects that are trying to develop more inclusive blockchains. According to the EU-funded D-Cent project initiator of Freecoin, for example, democratic debate is necessary to the technological development:

> the common characteristic of the different [blockchain] pilots and use-case here described is the need to strengthen the democratic debate necessary to consolidate and preserve the management of economic transactions, especially those with a social orientation, inside the local monetary circuit pilots. […] Only through a democratic and participatory deliberation system, citizens can collectively define bottom-up their social needs, and inform the choices made on resource allocation and investment in social objectives and ethical criteria. This concerns the notion of "social sustainability": without participation and real democracy, local monetary circuits run the risk to remain too little, too dependent on the local political cycles, too far from the real demand that may be expressed by the local economic system. (Roio et al., 2015, p. 5)

That democratic debate is key to reinforce a currency is acknowledged, for example, by the Sol Violette currency, a voucher-based schema experimented in Toulouse, France. Vouchers are distributed by local authorities to specific target groups, and their circulation is regulated by a bottom-up decision-making process. Since the currency is considered a common good, the governance model supports explicit (i.e., not inscribed in code) consensus building activities at every level (http://www.sol-violette.fr/).

Recalling the script lexicon introduced in Section four, in what follow we propose to look for the space of innovation theory as an activity of description. The question on whether the strict coupling of policy and practice in blockchain innovation leaves any space for theorization can methodologically be answered by looking for articulations of inscriptions and descriptions. When does the default inscription strategy leave space to descriptions? Which actors can descriptive strategy involve, that are usually left out by inscription? According to script theory, inscriptions are expected to happen at the design stage, to involve mainly developers, to be the default modality in the day-to-day use of digital currencies, at least as long as no incidents occur. Descriptions, on the contrary, are expected to take place in exceptional circumstances (e.g., at conferences, in online fora and media outlets whenever a rupture happens), and to involve not only developers, but also technical and non-technical users at different levels.

In order to follow the alternation of inscriptions and descriptions in the blockchain innovation process – and thus to recognize when and under which conditions space for theory can emerge – we focus on the most diffused blockchain, namely Bitcoin, and the major controversy that the Bitcoin community has faced since May 2015. The dispute concerns the size of the Bitcoin blocks. With the sudden interest by financial (i.e., banks and insurance companies) and high-tech companies towards the digital currency, the issue emerged, of how to scale-up the software so that a quickly growing number of peer nodes could join the network. The number of nodes and transactions the Bitcoin network can handle is related to the block size. The original design by Nakamoto established the block size as a cap on the number of transactions that can be processed by the network every ten minutes. The cap was meant to ensure the involvement also of older computers in running the network, so that it was not taken over by big players able to afford last-generation computing power.

However, with the increasing number of nodes and transactions, the network started to show signs of delay that brought to unsuccessful transactions. For this reason, a coalition of actors started lobbying to raise or even remove the cap. Soon two factions emerged, even within the restricted (5) group of core developers. On one hand, those who valued Bitcoin's decentralized architecture the most, and could not accept that the funding principle of peer distribution was questioned in the name of other important but secondary principles, like transaction speed. On the other hand, those who valued Bitcoin's enlargement the most, and were willing to sacrifice Bitcoin's decentralized governance to the promise of global success as a cheaper, faster payment network than PayPal or Visa.

This dilemma revealed essential divergences about the guiding principles of the Bitcoin project, and how it should be governed. The match was conducted through an articulation of inscriptions and descriptions. On the one hand, both sides of the block size controversy tended to keep inscription as the default strategy. This is first and foremost evident in the mechanisms of vote as download. Already since its original formulation, every new release of the Bitcoin client software has been put to the vote. People downloading one or another software release essentially voted on which changes they accepted based on which version of the client they chose to run. The same voting/downloading mechanism was invoked also when the block size controversy led some developers to build a new fork, *Bitcoin XT*. This fork would have raised Bitcoin Core's block cap from one to eight MB, while also adding further functionalities.

Forks are normal parts of open-source processes, where everyone can propose modification. In this sense, they constitute forms of debate that are inscribed in code. Therefore, while in principle democratic, they are scarcely accessible by non-core developers. In January 2015 585 forks from Bitcoin Core could be counted, each of which created parallel and independent blockchains supporting alternative currencies (Roio et al., 2015, p. 16). In this regard, the novelty introduced by Bitcoin XT in fall 2015 was the fact that the new fork did not intend to set up a new currency, but to continue mining and exchanging Bitcoins, only with a modified block size.

Bitcoin XT was developed without the shared consensus of the Bitcoin community, and was thus highly controversial. This triggered a counter-move that inscribed dissent in a malicious software, *Bitkiller,* that tore down the computers that downloaded the Bitcoin XT fork with denial-of-service attacks. Even the largest U.S. Bitcoin company, *Coinbase*, was briefly forced off-line after moving to XT. Following this line, also the counter-counter move resorted to an inscriptive strategy. In June 2015 *Coinwallet.eu*, a Bitcoin exchange, began spamming the Bitcoin Core network with spam transactions disguised as "stress tests". The whole system slowed down to the point of almost collapsing (Pearson, 2015).

That inscription is the preferred default strategy by Bitcoin community members on both sides of the controversy (i.e., Bitcoin Core developers and Bitcoin XT proponents) is also shown by their vision of politics as the cause of Bitcoin's weakness:

> it never occurred to me that the thing could just fall apart because of people getting crazy and having fundamental political disagreements over the goals of the project (Popper, 2016)

> Mr. Maxwell was equally dismissive of Mr. Hearn's camp — saying that they had politicized what should have been a technical decision (Popper, 2016)

> he began politicking users to switch to his client. […] He completely introduced a new level of politics to Bitcoin beyond what it had ever experienced. In addition, [he] has managed to make the scaling issue, a complex technical issue, into something that is a political litmus test, like abortion, or gun control, something that was sorely missing in a technical community (TheBitledger, 2016)

In these words, only rules and decisions that are technical – that is, inscribed in code – are unbiased, manageable and ultimately effective. Once they unfold into political (i.e., explicit) debate, they risk to undermine the project at its roots. However, it is worth noticing that through the same words by which the two factions accuse each other of "politicking", they are actually deploying a rhetorical form of politics aimed at delegitimizing the opponent.

Yet – even in the mist of similar claims – there is evidence that space for theory and debate can emerge. From August 2015, when the Bitcoin XT fork was firstly announced by those pushing for block enlargement, the number of posts, articles, comments and rebuts have increased in specialized outlets, public web arenas and even mainstream newspapers. Even if accusations of censoring the controversy on the Bitcoin top discussion forum (https://bitcoin.org/en/community) were voiced by multiple sides (Haynes, 2015; Hearn, 2016; Popper, 2016), blogs, mailing lists, social networks and other web fora have hosted debates between the supporters of both factions. For example, "the wider community on the social media site Reddit has been eager to support the side of the debate they believe is best for the future of bitcoin" (Haynes, 2015, p. 1).

Contributes from the Core side tried to describe the inner workings of the new Bitcoin XT fork with an eye to uncovering suspect surveilling functionalities (see for example Goat, 2015), while contributes from the XT side described the technical constraints that would have shortly brought the main Bitcoin Core release to collapse.

We may thus ask when and why the default inscription strategy left room to descriptions. Following the events and debates that occurred during 2015, we suggest that the alternation of inscriptive (the default choice) and descriptive (the exception) strategies was first and foremost triggered by controversies. Without the rupture caused by the alleged need to rise the block size, not so many debates supported by descriptions of technical functioning would have probably appeared. Furthermore, we suggest that inscriptive and descriptive strategies appealed to diverse intended actors, in a moment in which long-standing Bitcoin members' interests diverged, new actors pushed to enter and further new actors had to be recruited to support opposite factions. We exemplify this hypothesis with a brief analysis of the posts, articles and interviews published by the major actors of the controversy in the second half of 2015.

6.1 The block size controversy recruiting new participants

In August 2015 through a vehement post on the *medium.com* blog Mike Hearn, probably the most outspoken exponent of the enlargement faction, announced the Bitcoin XT fork to be released in the following fall. He gave the announcement by launching a major accusation against his opponents (identified in his words as some members of the restricted group of core developers, keepers of the Bitcoin Core) of not allowing space for debate. On the contrary, he engaged in a description of his opponents' technical arguments: "so let us instead discuss those arguments. There have been many. As each one came up, Gavin and myself have written articles analysing them and rebutting them. Sometimes the answers were common sense, other times they were deeper and required more work, like doing network simulations" (Hearn, 2015).

Compared to the previously mentioned claims opposing the technical doing to political discussion, this overture to a descriptive activity comes unexpected. Even more so since Hearn's final solution reaffirms the inscribed model of algorithmic governance. As a matter of fact, at the end of the post the solution to the long controversy is once again delegated to software:

> This leaves one last mechanism for resolving the dispute. We can make a modified version of the software, and put it to a vote of miners via the usual chain fork logic used for upgrades. If a majority upgrade [sic!] to the new version and produce [sic!] a larger than 1mb block, the minority would reject it and be put onto a parallel block chain. To get back in sync with the rest of the network they would then have to adopt the fork, clearly resolving the system in favour. If the majority never upgrade [sic!], the fork would never happen and the 1mb limit would be hit. (Hearn, 2015)

What is therefore the reason for a (temporary) shift to a descriptive style? Which were the needs that brought Hearn and others on his side to translate the closed algorithmic mechanisms into textual descriptions? It is Hearn himself that provides some hints at the beginning of the post.

> Such a fork has never happened before. I want to explain things from the perspective of the Bitcoin XT developers: let it not be said there was insufficient communication. Bitcoin forking is a topic that may interest many people, so this article is meant for a general audience. It doesn't assume previous knowledge of the debate. (Hearn 2015)

In his words, resorting to description is necessary to overcome possible resistances to the new fork by Bitcoin participants. Lack of communication (i.e., description) might be considered a reason for not adopting Bitcoin XT. Furthermore, description is necessary to recruit new participants among the "general audience". In other words, the target of this descriptive effort are not developers involved in the controversy, but potential "customers" external to the Bitcoin world, who might be interested in joining not in the main Bitcoin chain, but in the newly released Bitcoin XT fork.

Hearn's enlargement strategy is evident also in his discursive attempt to stretch the definition of the Bitcoin technical community. In particular, he laments that companies' and wallet developers are not considered part of the technical community, and therefore their voice (supporting block increment) is not heard, even if they "represent many of Bitcoin's most passionate, devoted and technical people" (Hearn 2015). Resorting to description is functional for the XT proponents to expand the class of those who should be considered technical people: not only core developers and their affiliates, but also client developers at corporate companies and start-ups.

A similar effort to open up the usually inscribed governance model to non-members of the Bitcoin community underpins also the comments of the Bitcoin Core faction. For example, a counter-post published on August 19 2015, few days after the XT announcement, has the goal "to help readers see through the bullshit to gain a clearer picture of what is actually going on. As we have stated multiple times, we are bitcoin believers, and our goal is to educate […] the intellectually inclined" (Goat, 2015). However, in this case the target is not a "general audience" made of lay people, but those who already have some basic knowledge and interest in Bitcoin's philosophy.

Along this line, in September and December 2015 the Bitcoin Core community organized meetings in Montreal and Hong Kong to discuss available alternatives to scale the Bitcoin architecture (Popper, 2016). The goal was to "reach consensus on what should be done". Also these meetings were aimed to enlarge the members' base through open participation. Participants were expected to be not only developers, but also academics (Hertig, 2015), while the meetings website reported also companies' representatives among the organizers (https://scalingbitcoin.org/hongkong2015/#about).

A fourth moment in which the two opposing parties adopted a descriptive style was in January 2016, a few months after the actual release of Bitcoin XT. In that occasion Hearn took the floor because of what he depicted as an imminent technical breakdown: "the network is on the brink of technical collapse. The mechanisms that should have prevented this outcome have broken down" (Hearn, 2016). To prove this point Hearn engaged in a description of the number of transaction and blocks reached in the previous months.

In this post Hearn also lied down explicitly that raising the block limits was aimed to recruit new users: "the community needed the ability to keep adding new users. So some long-term developers (including me) got together and developed the necessary code to raise the limit" (Hearn, 2016). Besides his above mentioned allies (i.e., wallet developers, major mining pools), the new "users" that – according to Hearn – were pressing to join the network were investors, exchanges, payment processors. What is striking here is that the term "users" is introduced to depict a set of actors that in the orthodox Bitcoin governance model would be assimilated to the main categories of sellers and buyers.

The introduction of the term "user" – not familiar in a decentralized peer-to-peer network were every node counts for one – marks also a shift towards a different conceptualization of Bitcoin: not as a self-standing governance system anymore, in which economic value, representation and membership are dealt with as a whole, but as a mere payment system. To give an example, Hearn provocatively described Bitcoin Core as

> a payments network that:
>
> - Couldn't move your existing money
> - Had wildly unpredictable fees that were high and rising fast
> - Allowed buyers to take back payments they'd made after walking out of shops, by simply pressing a button (if you aren't aware of this "feature" that's because Bitcoin was only just changed to allow it)
> - Is suffering large backlogs and flaky payments
> - … which is controlled by China
> - … and in which the companies and people building it were in open civil war? (Hearn, 2016)

No reference is made to the representational and membership functions provided by the Bitcoin network as a self-standing governance system (see Section 5.1). Here the author is recruiting "users" who might be interested in fast and cheap payment systems, not in a governance system that provides also mechanisms for political consensus building and membership recognition.

The day after this post was published, as a reaction a comment was released on *The Bit Ledger* blog (supporting the Bitcoin Core faction). The author of this comment depicts by opposition the intended Bitcoin participant as someone interested in the governance system and not only in the payment network: "someone who put Bitcoin first. […] People who care about bitcoin do not promote Altcoins because it's clear this would fracture Bitcoin and undermine the very method in which bitcoin secures itself" (TheBitledger, 2016). In other words, this comment is oriented towards new and old Bitcoin participants, that for the reason of considering the network not only a payment system, but a self-standing governance system cannot be reduced to the role of "users".

In summary, the block size controversy shows a crisis that reflects deep conceptual differences in the understanding of the Bitcoin network either as a self-standing governance system or as a payment system. In the midst of this controversy, opposing factions need to recruit new actors to support them. To this end, replacing the default inscription mode with description is necessary to share algorithmic governance mechanisms with non-developers, or with developers who nonetheless have not previously taken part in core development.

The two factions also tend to address different actors through this descriptive endeavour. Bitcoin Core appeals to developers, intellectuals, even companies, provided that they show some commitment towards the Bitcoin experiment not only as a payment system, but as a self-standing governance system. On the other hand, the Bitcoin XT faction tends to appeal to more clear-cut actors: wallet developers, investors, exchanges, payment processors, to finish with the all-encompassing category of "users", that nonetheless does not fit the peer-to-peer character of blockchains.

It should be stressed that the fact that the two factions discursively recruited these actors does not imply that they succeeded in having them on their side, nor that one of the two factions was more democratic. It shows that description as the translation of norms and rules in verbal text is more likely to take place when there is an interest in recruiting new actors to support one's own position in a controversy. That this triggers better democratic participation in innovation is all but demonstrated.

It remains that in this case space for theory was ultimately carved out, despite the multiple claims for technical concreteness. We can conceive of theory as an elastic space triggered by controversies that shrinks with day-to-day "peaceful" use, and widens with the need to recruit new actors to set the dispute. Like in any war, the battlefront is never the only key to success. Besides the line of fire against the immediate enemy, the outcome of a war can heavily depend upon the support of the civilians that are not directly involved on the battlefield.

7. Conclusions

The Bitcoin block size controversy shows the analytical gain of establishing a dialog between the innovation dance metaphor and script theory. By looking for the space for theory articulation as a descriptive endeavour, we have been able to detect temporary overtures to explicit debate even in the midst of recurrent bipartisan claims for technological inscription as the default strategy for controversy settling.

Space for theory is more likely to emerge when a controversy arises, that requires recruiting new actors. In order to involve new participants that do not have skills or experience to understand rules and decisions so far inscribed in software, descriptions are needed to open up the inner mechanisms of algorithmic governance, and put them to a vote. These are the exceptional moments when explicit debates can take place, and new actors can access them. These debates can take the shape of physical meetings like those organized by Bitcoin Core in Montreal and Hong Kong, or of virtual debates going on through articles and posts in discussion fora, specialized magazines and mainstream journals. In both cases, these descriptive efforts aim to recruit new actors to strengthen the ranks of opposing factions. By so doing, they also enlarge the participation to the innovation process.

What are the consequences of a similar understanding for inclusive governance of innovation? The block size case suggests two possible scenarios. On one hand, approaches to the relationship between theory and inclusion usually assume that inclusion is a much desirable result of theory. In this scenario, inclusive debates can take place when a space for theory is established. On the other hand, that relationship might also be inverted. We have seen in the Bitcoin controversy that space for theory in the form of explicit debate and description is the outcome of the need to include new actors to reinforce the opposite factions in a dispute. The necessity of inclusion requires translating scripts into a descriptive text and a form of materiality that is accessible to diverse actors. In this scenario, space for theory is not created in a pacified environment that conceives of inclusiveness and democratic participation as values *per sé*, but as a result of controversies in which factions carry out recruitment strategies to overcome the opponents.

With this, we do not mean to imply that the innovation process is a constant struggle in which factions grant theory some room only when it promises a vantage point over their opponents. Rather, we aim to suggest a methodological strategy for theory actors in a landscape (i.e., algorithmic governance) where the overlap of innovation practice and policy seems to leave little room to innovation theory. We suggest that if theory aims to extend inclusion, it should not wait for proper debating fora to be established, but actively engage in unfolding governance by technologies when it is more likely to succeed, that is, when controversies arise. All in all, a similar suggestion could contribute to the current debate on "strategic intelligence" (Edler et al., 2006; Padilla, 2016). Strategic intelligence fora should not be seen as separate spaces for debate, but could exploit the descriptive and inclusive potential of controversies, thus increasing the odds for wider inclusion even in tightly coupled algorithmic governance.

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