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► **To cite this version:**

Tommaso Venturini. The Fish Tank Complex of Social Modelling on Space and Time in Understanding Collective Dynamics. Michiru Nagatsu; Attilia Ruzzene. *Frontiers of Social Science: A Philosophical Reflection*, Bloomsbury, 2019. hal-01672283

HAL Id: hal-01672283

<https://hal.science/hal-01672283>

Submitted on 23 Dec 2017

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The Fish Tank Complex of Social Modelling on Space and Time in Understanding Collective Dynamics

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Forthcoming to appear as a chapter of

“Frontiers of Social Science: A Philosophical Reflection”

Michiru Nagatsu and Attilia Ruzzene (eds.), Bloomsbury Publishing

A change of speed

In the BBC documentary *The Blue Planet*, the British naturalist David Attenborough narrates marine life commenting on the ‘time-lapsed’ images of a tropical reef. The images are beautiful and surprising. Played at accelerated speed, the sequences reveal corals for what they actually are: not minerals or plants, but animals who grow, crawl, hunt and fight to survive. In sibling documentary, *The Frozen Planet*, Attenborough again uses the same acceleration technique to show a crowd of starfish swarming over a seal corpse. In both cases, the effect is startling: the change of tempo shatters the relation between the action and its scenery. While the expected actors disappeared (as the fishes of the reef) or froze to death (as the seal), the theater wings suddenly come alive and take the center of the stage.

A similar effect, I hold, can be experienced in social phenomena by abandoning the spatial metaphors we traditionally use to understand them. Considering our collective existence, we often picture ourselves as *coming from* different cultural milieus, *crossing* social spheres, *entering or leaving* institutions, *following* norms and conventions. In all these expressions, individual movements are portrayed as occurring *in the background* of stable collective structures. Social sciences themselves have much encouraged such topological thinking, separating individuals from aggregates and placing the firsts inside the seconds. I refer here to the classic *micro/macro* distinction, which not only distinguish actors from structures, but also picture them as nested levels, with actors moving through structures as trains travelling through railways.

To be sure, most social theories admit relations between the two levels: agents are bound by structures, but also feed back into them; systems emerge from actions, but also inform them. Yet, relation does not question separation and our social imagination remains trapped in a sort of ‘fish tank complex’ – a conceptual framing where actors moves against a static background, like fishes in a plastic aquarium.

Such separation, of course, has its use. In collective life, not everything changes at the same time and it is often convenient to take some things as settled, in order to highlight faster transformations. Still, conceiving such distinction temporally instead of spatially has a key advantage – it remains open to graduation and change of speed. Social entities cannot lie between micro and macro (except in the few theory admitting the existence of a meso-scale) and are not supposed to jump from one level to the other: they are either actors or structures. Social change, on the contrary, can slow down or speed up and what seemed stable and structuring can suddenly transmute as corals bleaching at the speed of global warming and ocean acidification.

In this chapter, I discuss the limitations of the spatial framing of collective dynamics both in modelling and in social theory; propose an alternative approach based on the technique of versioning; and, finally, provide a concrete example extracted from a project on French parliamentary activities.

The topological framing of collective modelling

A good way to appreciate the inherent *spatiality* of our sociological imagination is to consider the ways in which collective dynamics are implemented in computer models. Modelling is instructive because the formalization of computer code forces scholars to be explicit about their theoretical premises and conceptual metaphors, thus allowing to observe them more distinctly. The examples of such formalizations are not in shortage. In the last decade, a variety of models derived from biology, chemistry and physics have been applied to social dynamics in the hope to harness their complexity through the precision of formal languages (Gilbert & Conte, 1995; Castellano, et al., 2009; Vespignani, 2011; Naldi, Pareschi & Toscani, 2010; and most articles in the *Journal of Artificial Societies and Social Simulations*).

These efforts have produced many interesting results, but (so far) no major breakthrough. This modest yield, I believe, depends to a large extent on the constraints that a topological framing has imposed on collective modelling. Though the alleged aim of most models is to reproduce (and sometimes to predict) the *dynamics* of collective phenomena, close inspection reveals that temporal features are rarely salient in models. Most often, change is limited to local aspects of a globally static architecture.

A discussion of the three most common modelling approaches will elucidate this point. For the sake of space, this review will be highly schematic and neglect exceptions and complexities. While interesting experiments which exceed the three approaches below exist (I will discuss one at the end this chapter), they remain in the minority.

(1) *Variation*. The first way of handling change is derived from mathematical analysis. In such approach, elements are fixed from the beginning and their relations are defined by a predetermined set of equations, which are recursively computed until a stable equilibrium (or a repeating trend) is reached. Nothing new can be created in the model and its components cannot acquire novel properties or alter their associations. Most models of equilibria in economic (e.g. Nash, 1951, Tobin, 1969) and ecological (e.g. the 'Lotka–Volterra equations' as in Hofbauer & Sigmund, 1988) systems fall within this tradition. As the model consists in the parallel computation of equations, the only type of changes admitted is the increase or decrease of quantities. Though these models can be extremely sophisticated, the nature of change is generally determined from the beginning and the only surprises can come from the interaction among the equations, which can sometime lead to different equilibria.

(2) *Circulation*. The second modelling approach focuses on the flow of entities through a grid of connections (generally a network). Such systems admit the existence of mobile components, which move according to the system topology, the state of its connections and the position of other components. Epidemics (Keeling & Eames, 2005) and routing (Cordeau, Toth & Vigo, 1998) problems are generally modelled through this approach. Though these models allow some degree of dynamism, both the configuration of the network and the nature of the movable items are essentially static. The vectors of the circulating entities can change, but the shape of the grid and the rules of movement coordination are fixed from the beginning.

(3) *Interaction*. A more sophisticated approach is implemented in agent-based models (Epstein, 2006). In such models, change does not derive from general equations or from the overall configuration of the system, but from a multitude of local exchanges among

myriad calculating agents. As the mobiles of the previous approach, the agents of these models move through the system, but in addition they also encounter and interact with other agents. Faithful to the emergent nature of collective transformations, the evolution of these models cannot be analytically computed. The dynamism of these systems derives, however, from a restricted and constant set of interaction rules. The pride of these models is indeed to generate the maximum of global variability from the minimum of local instructions. Classic examples of such models are the analysis of urban segregation of Thomas Schelling (1971) or the evolution of cooperation by Robert Axelrod (1984). Connecting movement and interaction recursively, agent-based models capture some elements collective change. Transformation, however, does not concern the nature of the elements or the architecture of the system, which are never affected by the interactions they contain.

Despite their differences, all above approaches share the same *spatial framing of temporal phenomena* and constrain collective dynamics in a topological arrangement where interaction occurs locally, while resulting patterns are consistently global. In simpler words: too much attention is given to the distinction between “local exchanges and global patterns”, not enough to the interaction between “things that change quickly and things that change slowly”.

The shortcomings of the micro/macro divide

The spatial framing encountered in collective modelling is largely inspired by the classic framing of social theory, where it is customary to assume a fundamental partition between a ‘micro-level’ of local and ephemeral exchanges and a ‘macro-level’ of far-reaching and long-standing aggregates. Expressed in terms of levels, this distinction stages the study of collective life through a topological metaphor in which “macrobehaviours” are always an aggregation of “micromotives” (Schelling, 1978). Far from being limited to human phenomena, this framing has been applied to all sort of collective behaviours, from social animals (Moussaid et al. 2009) to biological organisms (Dawkins, 1982); from mental processes (Minsky, 1988) to artificial entities living in silico (Epstein & Axtell, 1996).

Though it is reasonable (and analytically convenient) to assume that, in collective existence, not everything changes at the same time and that some elements can be taken as fixed to focus on those that transform more quickly, the micro/macro framing comes with two major limitations.

Conceptually, the micro/macro divide ends up framing most research questions as the search for the pathway leading from one level to the other. Should the inquiry begin from the micro or the macro? Are macro mere aggregates or a *sui generis* phenomena (Durkheim, 1987)? How do global properties emerge from local interactions (Boudon 1981)? Is it possible to reconcile the two levels by an encompassing theory (Bourdieu, 1972, Giddens, 1984, Archer, 1995)? By presupposing the existence of two levels, the micro/macro framing takes as solved the very question that it should open to investigation: how are stability and evolution obtained by slowing down or speeding up the stream of collective change? How are institutions established by the repetition of interactions, and innovations produced by the propagation of variations? How does time matter in shaping social structures (Abbot, 2001).

Empirically, by constraining change to local circuits and stability to global structures, the micro/macro framing privileges phenomena that fit its assumptions and confines

modelling to phenomena where change is clearly circumscribed. These phenomena include, for instance, variations of values in markets with preset rules (e.g. Neumann, 1945); spread of diseases (e.g. Daley & Gani, 1999) or species (e.g. Bak & Sneppen, 1993) in a stable habitat; flowing and queuing in a fixed network (e.g. Gawron, 1998); circulation of memes through media (e.g. Leskovec, Backstrom & Kleinberg, 2009) and many other dynamics of such kind (Macy & Willer, 2002). Even worse, wary of situations blurring the micro/macro border, modelling efforts often abstract from actual processes and focus on artificial simulations where actors and structures can be separated by construction (Venturini, Jensen and Latour, 2015). A particularly unfortunate choice in a time when the spread of digital media is increasing the availability of data on social phenomena (Lazer et al., 2009 and Rogers, 2013).

These conceptual and empirical limitations illustrate what I have call the 'fish tank complex of collective modelling' – an analytical setting where social actors perform against a fixed background, like fishes swimming through an artificially static aquarium (as opposed to actual sea reefs which evolves with the colonies that they host). This 'fish tank complex' holds social modelling (and sometimes social sciences) from addressing the situations of structural change where old institutions dissolve and new arrangements crystallize; the moments in which a new species transforms an ecological environment (Levins, 1968; Gordon, 2011); an innovation 'creatively destroy' an industrial market (Schumpeter, 1976); a compromise is proposed to defuse with a social crisis (Callon, Lascoumes & Barthe, 2009).

The topological divide described above is so deep-seated in our social imagination that it is difficult to find alternatives that would be *natively temporal*. Even approaches that refuse the micro/macro distinction tend to define themselves in relation to it. As an example, I will mention *actor-network theory* (or ANT) – not only because this approach is extreme in its denial of any binary divide, but also because it is the ground in which the reflections of this chapter have germinated.

Developed in the French tradition of Sciences and Technologies Studies, ANT proposes a unconventional approach, whose originality comes largely from a stubborn rejection of all distinction between agents and structures. In the article founding such approach (at the time called "sociology of translation"), Michael Callon and Bruno Latour (1981) explicitly avow the priority of temporal dynamics over spatial arrangements:

We cannot distinguish between macro-actors (institutions, organizations, social classes, parties, states) and micro-actors (individuals, groups, families) on the basis of their dimensions, since they are all, we might say, the 'same size', or rather since size is what is primarily at stake in their struggles (p. 279).

While the approach developed by Callon, Latour and others, (cfr. Latour, 2005 and Law, 1999) gained a growing success, it has never succeeded to cut loose from the spatial framing against which it was introduced (which explain, in passing, why the label 'actor-network theory' stuck over the name 'sociology of translation' proposed by its inventors). ANT's contribution remained, as a consequence, primarily *negative*: it encourages researchers *not* to take for granted the division between interactions and structures and follow instead the heterogeneous and *ad hoc* distinctions constructed and de-constructed by social actors. But what ANT does not provide is much positive advice on how to describe social phenomena. In a dialogue intended to explain ANT to young researchers, Bruno Latour (2003) repeats it at least three times:

ANT is first of all a *negative* argument (p. 62)... it's about *how* to study things, or rather how not to study them. Or, rather, how to let the actors have some room to express themselves ... ANT is a method, and mostly a negative one at that; it says nothing about the *shape* of what is being described with it (p. 63).

Versions

To find a *natively temporal* description of collective dynamics, I therefore searched beyond the limits of social sciences and found an interesting (and unexpected) inspiration in the field of software development. I refer here to the technique of 'version or revision control'. Versioning – the ensemble of conceptual and technical instruments developed to compare different editions of the same documents and to track their evolution over time – is one of the most important and yet most overlooked information techniques of modern collective life.

Versioning has been around since early modernity. According to Elisabeth Eisenstein (1980) the idea of 'versions' emerged with mechanical printing, when the possibility of reproduced exact copies made western societies sensitive to the variances between hand-copies of the same manuscript. Filing cabinets, carbon papers and Xerox machines traced for decades the evolution of legal, administrative and commercial documents, but it is with the advent of digital technologies that versioning entered its golden age. The association of versioning and digitization goes both ways. On the one hand, digitization facilitates the tracking of an increasing variety of inscriptions (see the brilliant work of Ben Fry on Darwin's Origin of Species – <http://fathom.info/traces>). On the other hand, version control constitutes one of the pillars of digital computation. In digital environments it is so easy to duplicate and modify a documents that keeping track of changes becomes vital.

This is especially true for software, a peculiar a type of document whose extreme formalization implies that even a single-character transformation can be of great consequences. It is therefore not surprising that the first advanced systems for revision control were introduced by and for software developers. The first of such systems was the SCCS (Source Code Control System) developed by Marc Rochkind (1975) at Bell's Laboratories is in the early '70. Some ten years later, Walter Tichy (1982 & 1985) introduce the RCS (Revision Control System) and the idea of storing modifications as 'deltas' from a 'master version' (thereby saving significant storage space).

From the onset, digital versioning has been a social technology, aiming to support collaboration among code writers. At first, editing conflicts were avoided by a simple system of locks, preventing developers from modifying a file if someone else was already working on it. In the late '80s, however, a more sophisticated approach was introduced by the CVS (Concurrent Version System) developed by Dick Grune and Brian Berliner (1990). CVS implemented a server-client system with a 'central repository' containing the 'root version' of documents, and personal workspaces where developers could create 'local branches' of them. This allowed developers to work simultaneously, but required them to 'commit' their changes by merging them to the master version stored on the server. Various technical problems connected to CVS (particularly connected to file naming and hierarchy), however, discouraged developers from using branching functionalities and locking was still largely used.

To address such problems various open-source and commercial systems were introduced (*ClearCase*, *Perforce*, *Subversion* to name a few), but the step forward came in

2005 with the release of *Mercurial* (by Matt Mackall) and *Git* (by Linus Torvalds, the father of Linux). Despite their differences, both systems make branching and merging easier by scaling down the unit of change from documents to commits and 'changeset'. A few years later, in 2008, Github was launched offering free online storage for Git-versioned projects and, more importantly, enhancing revision control with social-networking functionalities. The success of Github was fast and massive, reaching 1 million repositories by 2010 and 10 million by 2013.

Despite its enormous importance in our collective life, version control has so far received little attention from academic research and has generally been discounted as ancillary to software development. I found most of the information discussed above in the introduction of technical books or in developers' blog posts. The details in which I described the history and the technical features of revision control may therefore seem amiss in a book on social sciences. I believe, however, that the idea of versioning is directly relevant to the study of social life for at least two reasons.

The first reason why sociologists should be concerned about versioning is that this technique has long left the domain of software development and has started to impact a variety of other collective actions. The most famous example in this sense is Wikipedia. Everyone knows how in less than a decade Wikipedia has radically revolutionized the encyclopedic genre and grown to be one of the most influential sources of information about almost anything. There is little doubt that Wikipedia's success is due to the collaborative nature of the online encyclopedia which is in turn made possible by the revision control integrated in its technical infrastructure (Niederer & Dijck, 2010 and Venturini, 2006). Yet little has been written about the importance of such function and how it has shaped the interaction in Wikipedia (and this despite the fact that scholars have extensively drawn on Wikipedia versioning data for research – for example Kittur, Aniket & Kraut, 2008; Viégas, Wattenberg & Kushal, 2004; Borra *et al*, 2015). This absence is noted in the 'Talk page' of the 'Version Control' Wikipedia's article:

Integrated revision control is a key feature of wiki software packages such as MediaWiki, TWiki, etc. Comparison of wiki software lists revision control for several wiki packages. It's hard to imagine a wiki functioning very well without revision control; for example, the ability to revert a page to a previous revision is critical for defending a public wiki against vandalism and spam, to allow legitimate users to correct their mistakes, and to allow groups of editors to track each other's edits. I certainly think this warrants a mention in Version control, but on Wikipedia I must cite our sources. It's not enough for something to be true or even obviously true; it must have been written about in some reliable source. I.e., I would need to find some reputable news article or scholarly paper which discusses the role of revision control in wiki software, so I could cite it here. I also need to avoid self-references. -- Teratornis 22:11, 4 July 2007 (Wikipedia "Talk:Version_control", en.wikipedia.org/wiki/Talk:Version_control, accessed on 10/03/16

Wikipedia is the clearest example, but the effects of the generalization of revision control are worth studying. What happens to team work when everyone can easily know who modify which part of a document and when? What happens to co-authoring when the proposed modifications can be easily reviewed and accepted or discarded? What happens to personal communication when I can save drafts of our emails or SMS? And, more generally, what happens to society when 'Undo' (Ctrl+Z or Cmd+Z) becomes a widespread function of our life?

The second and subtler reason why social scientists should be interested in versioning techniques is that they address the same conceptual problems that challenge the understanding of collective life. How do aggregates maintain their identity when all their components change over time? No line of code can be preserved from the first to last version of a program exactly as all members of an institution can change during its existence. How can we handle modifications overlapping at different scales and in different moments? The edits made on a lower level of code, for example in the way functions are invoked, can trickle up to each of the function exactly as a constitutional amendment can trickle up to a variety of regional laws. How is structural coherence sustained when thousands of modifications are negotiated independently? Large pieces of software can be developed by hundreds of coders contributing simultaneously to different portions of the codebase in a similar way to which international treaties are negotiated on multiple diplomatic tables. Version control has answers to these questions and they all rely on a temporal rather than on spatial framing.

The example of the Law Factory

To illustrate how the concepts and (equally important) the techniques of versioning can be imported in the social sciences, I will relate the example of a research project I observed and facilitated at Sciences Po Paris.

The project “The Law Factory – Do Parliament Members lay down the Law?” was born from a collaboration between a French NGO (regardscitoyens.org), the médialab (medialab.sciences-po.fr) and the Centre d’Études Européennes of Sciences Po. The question set on the table by Olivier Rozenberg (our expert on political sciences) was to assess how much French laws are actually transformed by parliamentary debates. This is a classic question for political scientists who have long discussed the relative weight of the legislative branch in the balance of the separation of power. In particular, we wanted to know whether laws were substantially amended by the *Sénat* and the *Assemblée* or whether the parliamentary debate had a more symbolic function. As the subtitle of the project reads “Do Parliament Members lay down the Law?”.

As they concern the process by which norms are created, such a question could hardly be fit in a binary framing opposing institutions and individuals. Lawmaking is supposed to be the very moment in which the members of a society decide (through their elected representatives) the rules of the collective game – the moment in which the structures are as flexible as the game of alliances and oppositions shaping them. The impossibility to cut parliamentary processes into a micro and a macro level was not only a theoretical problem. In practice, it also meant that both qualitative methods (customarily used to describe micro-interactions) and quantitative ones (generally used to aggregate macro-patterns) were unfit for this project. Yes, we could have dissected the the parliamentary journey of a few bills to observe in-depth their transformation, but how to know if results could be generalized? And yes, we could have devised some statistical measures of parliamentary transformation and compute them for all French laws, but how to know whether those metrics were not too simplistic (and could differentiate substantial from cosmetic modifications)?

Eventually, our NGO friends (all coming from a software development background) came up with a more original solution. They observed that if “code is law” (according to the famous aphorism by Lawrence Lessig, 1999), then law can also be treated as code. Following this intuition, they extracted from the official websites of the *Sénat* and the *Assemblée* all available information on the amendments submitted on the 300 laws

discussed between 2008 and 2014 by the French Parliament. After an extensive cleaning, this information was coded in through Git versioning format (as explained above generally used to track the revisions to software), formalizing amendments as ‘commits’ to laws ‘master version’.

The potent formalization offered by Git allowed to create an extremely flexible visual online interface allowing, scholars, journalists and engaged citizens to explore the lawmaking process of the French Parliament (lafabriquedelaloi.fr). The exploration starts from a vast overview comparing how long different laws were discussed in different branches of the parliament and how many words were changed through these discussions (see fig. 1a). It then allows users to drill down progressively disaggregating the data and identifying how precisely each article of each law was modified at each passage (see fig. 1b); considering all amendments proposed by different political groups (see fig. 1c); and reading the transcription of each word spoken by each parliament member on each specific article at each stage of the discussion (see fig. 2d).

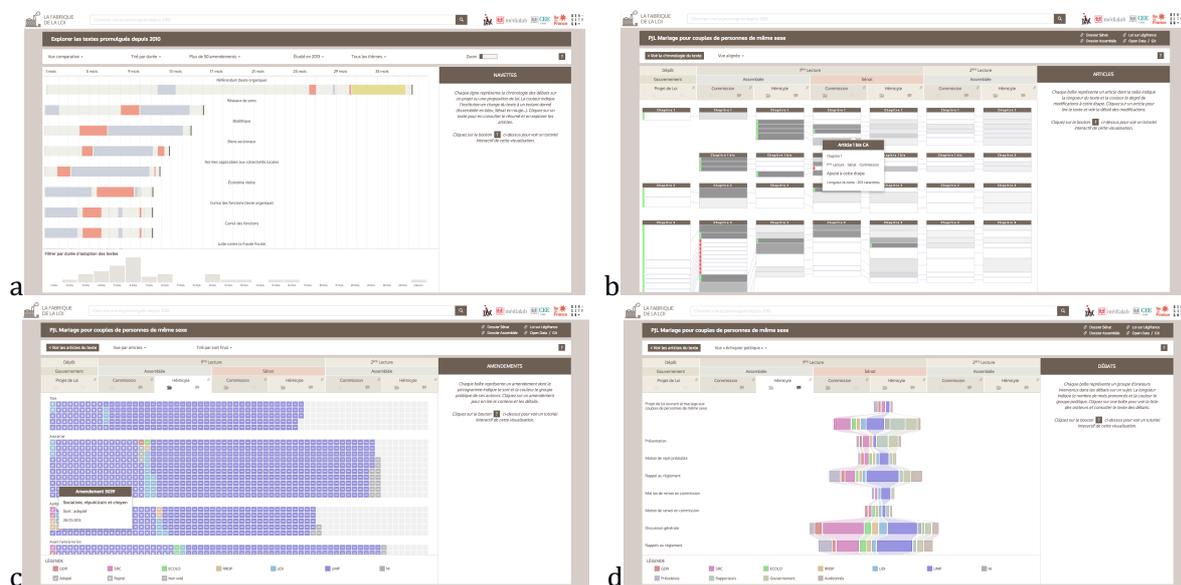


Figure Error! No sequence specified. Four interfaces of the lafabriquedelaloi.fr platform

The originality of such a platform is that it allows to move from one-figure metrics to debate minutes (and back), dissolving topological separation and promoting instead the observation of temporal dynamics. The different layers of the interface are designed and implemented in order to encourage a seamless navigation from one to the other, allowing users to identify stable trends and turning points. And the heart of this remarkable feat, it is worth remembering, are versioning techniques (see fig.2).

The screenshot shows the website 'LA FABRIQUE DE LA LOI' with a search bar and navigation options. The main content is 'Article 4' of a bill titled 'Projet de loi pour une République numérique'. The page lists several amendments (I, II, III) to existing laws, detailing changes to the Code de relations entre le public et l'administration and the Code des communes de Nouvelle-Calédonie. The amendments focus on digital accessibility, data reuse, and public information.

Figure Error! No sequence specified. An example of visualization of law versioning

Everything needs to change, so everything can stay the same

In this chapter I claimed that our understanding of social phenomena is often constrained by a spatial framing unfit to render temporal dynamics. In different modelling approaches, I encountered the same binary separation between local exchanges and global patterns – a separation that closely mirrors the micro/macro divide typical of classic social theories. Exiling actors and aggregates on two separated levels, such separation conceals the moments of structural change where individual and collective actions interfere directly.

To overcome such topological framing, I proposed therefore a description of collective dynamics based on the notion of ‘versioning’. Instead of opposing local and global levels, this approach draws our attention to the speeding up and slowing down of social processes. It gives us conceptual and (more importantly) technical tool to observe how old arrangements are liquefied and new ones crystallized.

Our focus on change, however, might be questioned. Such focus, it could be argued, may disguise the general stability in the distribution of social resources (power and wealth in particular). Yes, the collective fabric can be constantly weaved by the interactions of a multiplicity of agents acting at a variety of speeds and distances, but what is the advantage of such an intricate description if, in the end, the same asymmetries are reproduced over and over again? Little good will come of the claim that everything can change in theory, if nothing really does in practice. At best, it will make sociological investigations uselessly complicated. At worst, it will mislead individuals that their actions are not constrained by a social system whose forces exceed them.

I cannot but disagree. The image of a structural apparatus, on overarching social systems existing on a different level and imposing its norms on individual actors may encourage some to rebellion, but it also inflates the power of inertia and belittles the forces of change. Let's go back to the example of collective modelling I discussed above. Most formal models imported in the study of social phenomena are borrowed from natural phenomena where global properties emerge from the blind interactions of local entities. It can be atoms generating material properties; molecules provoking chemical reactions; cells composing organs and organisms. All these cases have in common that the micro-entities have no clue of what is happening at the macro level, they act (or rather 'react') on the exclusive basis of the information on their immediate proximity. One of the most common and most telling metaphor is that of social insects: like ants moving sand grains through their nest – and thereby constructing it without the slightest idea of its global architecture – human beings would create their social structures without really understanding them.

But human interactions are slightly more sophisticated than ants' (and ants' interactions, it seems, are more sophisticated than most entomological models, cfr. Gordon, 2015). Humans have developed all sorts of informational and technical devices to extend the reach of their knowledge and of their action (which explains, by the way, why actor-network theory was developed in the tradition of *Science and Technology Studies*). Social organization is not the global effect of myriad local actions. It's a complex fabric whose threads extend at variable lengths; a story with a millions themes, starring on a page or lasting through chapters and books; an ecosystem of species surviving through evolution; a software architecture of a million branching and merging versions.

Contesting the spatial framing of social theory, I do not mean to overstate the important of chance. A temporal understanding of social phenomena focuses on stability as much as on transformation. It does, however, draw attention to the fact that stability (exactly as change) is a consequence of collective action. The 'constraints' that according to Emile Durkheim constitute the very essence of social facts (1966) are not stable because they are sited in some higher layer of collective life, some macro-context shielded from micro-interactions. They are stable because the actions that uphold them last longer or are persistently repeated.

"Everything needs to change, so everything can stay the same" says Tancredi Falconieri, in *The Leopard (Il Gattopardo, 1958)* of Giuseppe Tomasi di Lampedusa. With this enigmatic line, the heir of Salina's principedom justifies his choice to join the cause of the Italian Unification even though this threatens the status of the Sicilian aristocracy to which he belongs. With ruthless political intelligence, the young Prince understands that his vantage is best preserved by aligning with the forces of change rather than resisting them. Power and privileges, he acknowledges, are not structures sustained by an inherent logic, but arrangements that endure only when they are constantly updated. And the opposite, of course, is also true. Challenging traditional bias and asymmetries begins with understanding their history and dynamics "directing our attention not to the social but towards the processes by which an actor creates lasting asymmetries" (Callon & Latour, 1981 p. 285, 286).

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