

The Critical Constructivism of the Actor-Network Theory and the Knowledge-based economy of the Triple Helix: theoretical possibilities and practical implications¹

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1. Introduction

This paper analyzes two theoretical approaches and their main presupposes, pointing their convergent points and proposing how these theories can complement themselves. Thus, this paper aims to discuss the critical constructivism, represented by the actor-network theory (ANT), and the Knowledge-based economy represented by Triple Helix Theory (TH), investigating the adherence between these theories and the implications of a synthesis of their principal common presupposes. In a general way, we assume that the ANT referential can suggest important reflections that certainly could contribute for a differentiated conception of the TH that equalize the centralized trends, or for answering questions involving structural/material and voluntarie/subjective actions.

The social constructivism is pointed as an important source of contraposition, especially in 1970 decade, during the bureaucracy and Marxism predominances. However, many uses of this concept simplify the process of social construction of the reality (Hacking, 1999). A serious limit is that social constructivism (as well as other approaches predominantly subjective) considers that the constructed reality only exists separated from the material questions (Peci & Alcadipani, 2006). In this way, Science and Technology Studies (STS) researchers

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strengthened the *critical constructivism*. They discuss that modernity have separated scientific activity from any other one, introducing dichotomies between, for example, scientific and not-scientific thought and between society and nature (Latour, 1999a, 2005).

In this way, Latour (1999b), through a series of empirical studies, have evidenced the possibility of two different interests combined in just one objective is considered. According with Latour (1999b), this implies in changing the reference from “social” to “collective”. “Collective” refers to the associations between human and non-human actors. The Actor-Network Theory (ANT) converts the dissociation between “objective” and “subjective” into one single circulating entity. Therefore the process of collective construction is not only social. Everything is constructed in this way, including the facts. For this, the mobilization of a diversity of heterogeneous elements and the association of them around common objectives are necessary.

The second theory aborded in this paper, the Knowledge-based economy, found its contributions in the idea that the technological and socio-economic developments are related with the capacity of countries in appropriating and using the knowledge in a productive and efficient way. On this context, the Triple Helix (TH) is presented as an important practical actions referential because it approaches and relates the roles of the main spheres that generate, consume and regulate the knowledge: university, industries and governments (Etzkowitz & Leydesdorff, 1996). These roles are not circumscribed anymore, but begin to assume a hybrid and dynamic characteristic, contingent to the social and economic collective necessities. An Example are the university research groups that assume a “quasi-firms” characteristic, when they absorb enterprise qualities that allow them to explore entrepreneur activities, integrating research and businesses under an ampler University institutional mission that is contributing for the economic development, beyond solely research and education (Etzkowitz, 2003b). The TH approach recognize the elements and situations heterogeneity, which are difficult to be completely foreseen, but need to interact in order to promote collective action as, for example, the “Entrepreneurial University” (Martin & Etzkowitz, 2000). The success or the failure depends on the adaptation and improbable configurations creation capacities.

After this introduction, we discussed the critical constructivism of the actor network theory. In the third part, the Knowledge-based Economy of the Triple Helix is presented and their principals presupposes. The analytical possibilities of the integration of these two perspectives are discussed in the fourth part, highlighting the possibilities offered by ANT to TH. In conclusion, we regard some limits and possibilities of theoretical connection discussed.

2. The Critical Constructivism of the Actor Network Theory

The term Actor-Net Theory (ANT) gives emphasis to the connections between actors, considering also the material devices, and represents the impossibility of existence of actors outside the net. The imbrications in nets create identity to the actors and provide them with motivations and resources. Any actor, human or non-human one, will not be able to act if it not take position in a bigger configuration that also acts together (Geels, 2005).

The ANT makes possible a descriptive look of the daily action, which allows accessing the interior of the black-box and the perception of how, in fact, they had become what they are. With the focus in the connections and actions, the ANT allows the exploration of a central argument. This argument is related with the idea in which the construction process of the reality involves, among other things, considering human and non-humans beings in interaction. Examples of this interaction are demonstrated by series of empirical studies. Latour (1999b), for example, explains that nothing in the common definition of society could explain the connection between politician that defends public investments in a new war weapon and the limits of chemistry and physics that need be surpassed in order to make the new weapon become possible. The connection of two apparently isolated fields is being by translation movements, by which it becomes possible to admit the possibility of two interests, that are distinct and distant, could be combined in only one objective. It was affirmed by Latour (1999b) that calling the first ambition “purely politics” and the second one of “purely scientific” is nonsense, because exactly the “impurity” is what will allow the achievement of the two objectives.

The notion of reality introduced by the ANT is a critical one because it implies to change the references that determine what is social. Latour (1999b), using resource of the semiotics, offers an optional term to the “social”, what is made possible requiring that the new term could represent something which meaning was not so easily changed in the opposite of the nature. The term chose was “collective”. The use of this term it is possible preventing the bias that the idea of “society” instigate on everything that is not social⁶. “Collective” is the opposite of “society”, because it emphasizes the associations between human and non-humans beings: an interchange of human and non-human properties in a corporation core (Latour 2001). However, when “collective” is used and the dualism is rejected, it does not means that disrespecting the characteristic traces of many parts that integrate the collective. As Latour (1999b: 193 e 194) affirms,

The name of the game is not to extend subjectivity to things, to treat humans like objects... but to avoid using the subject-object distinction at all in order to talk about the folding of humans and nonhumans. What the new picture seeks to capture are the moves by which any given collective extends its social fabric to other entities.

Latour expresses that Science and technology socialize non-humans to have human relations. He used this terms to substitute the modernist expression that say that Science and technology allow mind breaches with the society to access the objective nature and impose order to the efficient substance (Latour, 1999b).

The change in the reference from “social” to “collective” is a necessity that would make possible the understanding of that exist, *a priori*, a kind of ontological symmetry between the

⁶ Instead of social dynamics, the use of collective dynamics avoids the semiotics bias caused by the disregard of the non-social or non-linguistic characteristics of these dynamics, when we emphasize only the term social, as explained by (Michael, 1996). About the sociology preference of the collective term instead the social one, Latour (1999) says that collective refers to the human and non-humans combination, unlike society, which is an artifact imposed by the modernist conformity.

human beings and the objects. It is something that was not cogitated by the social scientists when they had ignored the important paper of the objects in the reality analyses (Peci & Alcadipani, 2006). The main idea is that the society is made of human and non-humans, individuals and objects. Frequently, human and non-humans are never dissociated. They form, collectively, nets that constitute what we call "reality". Each action that we do is associated or is mediated for non-humans that also act, presenting, as well as the human beings, action capability (Peci & Alcadipani, 2006).

Therefore, the construction process is not only social, but also collective. Everything is constructed in this manner, additionally the facts. But this is only possible when exists the necessary mobilization of various heterogeneous elements and they are associated around common objectives. It is in the associations heterogeneity that the involvement of human and non-humans beings are revealed (Peci and Alcadipani, 2006). Around a fabrication (synonymous of construction, commonly used by Latour (Latour, 2000)), are apparent fragilities, interests, science, computers, solidity, history and multiples other elements, impossible to be totally perceived in its integrality. Latour (1999b) does not consider, however, that the manufacture process is a play in which the addition of isolated elements is always equal to all the parts together. The elements introduced never leave the process with the same properties and initial characteristics. They change other elements and also they are transformed.

The distinction between the ANT and other chains is, primordially, by the influence of the science sociologist David Bloor and its thesis about the Sociology of Scientific Knowledge (SSK) or *strong programme in the sociology of knowledge* (Bloor, 1976). Relating the creation, stabilization, transmission and maintenance of knowledge, Bloor (1976) showed some of the main questions presented by the sociologists of this field. The symmetry, derivative from the SSK and later investigated in other universes of analysis, made possible to the ANT the idea of the same ontology between discursivity and materiality, and humanity and objectivity.

The symmetry is an innovative perspective offered by the sociology of knowledge. In this field, Bloor (1976) identified that all the previous perspectives treated with internal social processes and, mainly, do not with questions attributed to external influences, for example, with the description process of a specific field of scientific knowledge. Bloor (1976) criticizes, for example, the methodology of the *research programs* (Lakatos, 1979), for its approach on the independent capacity of the scientific disciplines to consolidate themselves spite of all external influences from a infinity of contingencies.

After considering it, Bloor (1976) presents four dogmas that must guide the scholars that could become affiliated themselves to the SSK. They are: causality; impartiality, symmetry and reflexivity. The first one considers the conditions which bring about beliefs – created or caused from. The second one estimates impartiality between truth and falseness, rationality and irrationality, success and fails. Both the sides of these dichotomies must be explained and not only those that are linked to the social aspects considered not true, as the irrationality and failure. The symmetry considers that the style of the explanation must be symmetrical - the

same cause would explain, for example, true beliefs and false beliefs. The last dogma is related to the reflectivity, that is, in principle, the explanation standards of the SSK that must be applied to sociology and vice versa.

Among these dogmas, two have great influence in the construction of the ANT. They are the impartiality and symmetry. In "Laboratory Life", Latour and Woolgar produce a series of empirical evidences for the SSK, which, before this, was limited only to the theoretical abstractions and examples of Bloor (1976) (Latour & Woolgar, 1997). Using the idea of impartiality and symmetry, Latour and Woolgar (1997) explained that it would not be enough, in the understanding of the sciences development, the reduction of its cognitive dimension in few social factors. It would be necessary, in contrast, to penetrate in a deepest scope where the scientific production is inserted, considering its social dimension and its scientific dimension in a same level of importance. Not concerning the SSK, social, psychological, economic dimensions, among others, are only included in the analysis when it is not working. For example, to explain why the French believe in astrology, since it has no scientific evidence, any kind of extra scientific explanation may be reasonable in order to understand these expressions, that look like illogical and meaningless. However, nobody look for explanations in social, psychological or other to understand why the French believe in astronomy, because believing in astronomy is seem as something logical and meaningful (Latour & Woolgar, 1997). Considering that what is explained in logical terms does not need any explanation outside of the cognitive dimension of science is an asymmetrical behavior. Latour and Woolgar (1997) break definitively with this kind of philosophy of science.

About the symmetry principle, Latour and Woolgar (1997) increase the Bloor's theoretical and methodological contributions. Marques (2006) argues that especially in the ontological level, the notion of symmetry of Latour and Woolgar (1997) is distinct. It refers not only to equitable, relevant and sufficient treatment between losers and winners in the science history, as proposed by Bloor (1976). The generalized symmetry kind of Latour (2005) encourages consider society and nature in the same ontological plane. If in an asymmetric way it is expected to consider that only people can be agents and perform the world, when the symmetry notion is introduced by Latour and Woolgar (1997), human and non-humans are considered equitable and accomplices in the criation of performativite agencies (Marques, 2006). The generalized symmetry principle is also exploited by Michel Callon, who spoke not only about the conflicting viewpoints and conflicting claims of science and technology but also society and nature in a symmetric plane (Callon, 1986).

Utilizing the scope of the generalized symmetry is possible to understand a fundamental pressupost of ANT, related with the refusal to perceive the world from divisions between distinct clusters with intrinsic qualities. The symmetry allows to perceive that the world, reality and all entities are products of precedent relations, fabrications and constructions, where exist a mix and interaction between objective and subjective. Each entity, as a Minister of State, the special research, a social network, a computer or the ANT, are marked by one essential quality: the

hybridism between human and non-human attributes. Considering this perspective can present many possibilities, especially for science and technology studies. This is the reason why the origin of ANT is precisely in this field.

3. The Knowledge-based Economy of the Triple Helix

The foundations of Knowledge-based Economy (KBE) are from the 1960s, when it was tried to represent the economy trends with the introduction of new means of production and knowledge distribution, advances in information and communication technologies and the information economy (Godin, 2006). Peter Drucker was one of the most emphatic disseminators of the knowledge economy. In his book "The Age of Discontinuity", Drucker devoted an entire chapter (Chapter 12) to discuss the increasing importance that the knowledge industry has been occupying in the economy since the latter half of the twentieth century (Drucker, 2003). For him, knowledge was necessarily linked to a practical skill, producing tangible results in resolving problems and can be systematically applied at work. This form of knowledge would be distinct from intellectual knowledge only, not reflected in practice (Drucker, 2003).

In the 1990s, there was a revival of the knowledge economy involving the concept of KBE. In 1996, a report was published by the Organisation for Economic Co-operation and Development (OECD). This document was decisive in the unification of the discourses of both member countries as countries that have enhanced engagement⁷ about the knowledge and information role in the future economic growth. The concept of KBE began to attract the policy-makers attention, generating a large umbrella to science and technology matters (Godin, 2006).

The Triple Helix Theory (TH) aims to resolve two key issues of KBE. The first one is related to the priority of the focus in local spaces on creating innovative environments. The second one is to try to solve the dichotomy between descriptive and normative (Etzkowitz & Leydesdorff, 2000). For this, the TH represents a tool (an entity) for collective action in three key spheres of KBE: University, Industry and Government – UIG (Etzkowitz, 2003a; Etzkowitz, 2008; Etzkowitz & Leydesdorff, 1996, 1998, 2000).

Etzkowitz (2008) argues that the interaction between these three entities is a central part for both innovation and economic growth in the KBE. From this perspective, the University has a key role in knowledge-based societies, as well as industry and government, in the past, were key institutions in industrial society. Government and industry continue important, since the first provides stable relationship and stability of economic institutions and the second represents the production locus that sustains the market and generate jobs and taxes. However, the leadership of development process currently rests in the University, which now

⁷ There are 32 member countries of OECD: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States. In May 2007, OECD countries agreed to invite Chile, Estonia, Israel, Russia and Slovenia to open discussions for membership of the Organisation and offered enhanced engagement to Brazil, China, India, Indonesia and South Africa (OECD, 2007).

assumes the role of direct contribution to economic development. The advantage of the University over other institutions producing knowledge, for instance, the departments of research and development (R&D) inside industries, is in its continuous, dynamic and unique source of new ideas from new students and a structure not rigid and focused (Etzkowitz, 2008).

The TH allows seeing the final product formed by the motion of three helices and the resulting spaces that let the fine performance of mutual relationships and functions. As stated by Etzkowitz (2008), the model helps explain why the three helices maintain a relatively interdependent and distinct status, and show where interaction can happen, and explain why the dynamics can be formed with different intensities and gradations of dependence and interdependence, confluence and conflict of interest.

From the UIG interactions arise hybrid organizations. These organizations are composed (Etzkowitz & Ranga, 2010) by (i) entities of R&D, as academic researchers groups, public research, R&D departments and other cultural and artistic organizations in general that share interdisciplinary research practice, (ii) non-R&D actors, as those who work with design, production, marketing, sales, technology adoption, implementation of new ideas from the combination of existing knowledge, interaction between users, acquisition of patents and licensing, among other things, and (iii) organizations resulting from the combination of elements originally characteristic of at least two of the constituent helices of TH. In this category are classified interdisciplinary research institutes, consortia, research contracts between Academia and industry, translational research institutes, technology transfer offices of universities, technology parks, business incubators, research institutions fostering, technological entrepreneurship and other more flexible organizational forms.

Relationships interposed between the various entities, according to Etzkowitz and Ranga (2010), can result in joint construction and skills, training and consolidation of markets, creation and change in organizations and institutions, networks, technology transfers, purchases of goods and services, incubation and financing activities, among others. All these relationships contribute in some way creating collaboration or moderating the natural conflicts between entities historically considered incommensurable. Implemented, these relationships allow roles replacement. This occurs when each helices of TH, besides acting in their traditional functions, also assume the role that was designated to the other helices. For example, the Government, besides acting in the regulation and control, provides funding to finance activities. Similarly, the University can act not only in teach, research and extension activities, but also investing resources in activities of technology transfer, encouraging entrepreneurial projects or fostering technology-based incubators. The industry can also assume the University role, training human resources, specially in research practices in the same level than Academia. In settings where the industry is not consolidated or has no interest in these relationships, other institutions can assume their role. Examples of such institutions are professional associations, commercial representatives and other local leaders who assume the direction of fostering partnerships with the University and government (Etzkowitz & Ranga, 2010).

It is important in HT perspective the fact of considering the innovation not only in the Schumpeterian view, in his discussions about leadership in big capitalist corporations, nor only through government intervention on the market (Dagnino, 2007), as in Latin American thought. Etzkowitz (2008) argues that more important are the knowledge production, becoming a significant element, more important are the actors that develop new products, institutions of knowledge generation and the government, owning a new status of institutional performance.

What approximate HT to ANT, is evidence that, as Leydesdorff (2000), the TH is not a final and static product, but a space in a co-evolution process, which open up possibilities for each helices transforms, reduces conflicts and shares roles previously restricted, without each helices lose its individual identity (Leydesdorff, 2000). The new organizational formats that break with traditional hierarchical structures and takes a flexible and fluid networks forms are the product of co-evolution. Etzkowitz (2008) calls the movement of emergence of new organizational forms synthesis. In this view, there is an attempt to demystify the idea still dominant of dichotomies between, for example, the government structures and private management structures. This interaction is conceived to overcome these dichotomies and, at least, to share institutionalized political discourse of collective and cooperative action for the development, not only economic one, but also social.

The ideas of entanglement and mutual relationship will outline what is expected of UIGs. There is a barrier to be overcome to become possible, effectively, the performance increase of the whole, compared to the isolation state before practiced. In this context, those regions located around universities take advantage, though Etzkowitz (2008) admits that this is not a rigid rule. Thus, the focus is mainly on local development, so that, by TH, interests are into more specific areas such as municipal. However, a national impact can be observed through the possibilities of public policies do not benefit only large national projects of science and technology and also pay attention to the most promising local initiatives.

4. Analytical possibilities and practical implications

A common core that connects ANT to TH is the concept of co-evolution. It explains simultaneous and reciprocal changing of two or more species, what has been widely explored in academia, although rarely applied to the scope of government (Wilson & Hynes, 2009). In the administration, co-evolution implies the coexistence of different or similar types of organizations, as Martin and Etzkowitz (2000) explain, it causes tensions one to each other, influencing changes in their structures and functions over time. As stated by Wilson and Hynes (2009), in this framework, a way that can be perceived as favorable to the co-evolution is the development of interorganizational cooperative arrangements, which cover a variety of contractual arrangements between companies and institutions of different natures and roles. In a context of fluidity in the borders that divide the science of technology, University of Industry, and public to private, the idea of co-evolution has been incorporated as a fundamental assumption of the TH approach (Geels, 2005; Leydesdorff, 2000; Martin & Etzkowitz, 2000).

Geels (2005) organizes the various applications of co-evolution in the context of economic and business creating three analytical levels. The first one is the level of studies about the innovations emergence. Here, the introduction of innovations in the social environment is analyzed as a co-construction or alignment process that gradually connects heterogeneous elements into a working configuration. This approach is attributed to the study of science, technology and innovation, mainly represented by the *seamless web* (Bijker, 1995), and the ANT approach. The second level refers to the stabilized socio-technical systems, where the analysis assumes a separate and interdependent existence of subsystems. The co-evolution here is relatively autonomous and occurs when the subsystems, performing, influence each other. The TH approach is located in this level. The third level is the macro level, through which the co-evolution is used to investigate the society and development processes through data about technology, demographic and cultural issues. The Geels's organization allows us to recognize that the ANT and TH share the co-evolutionary approach assumptions.

Regardless of analysis levels pointed by Geels (2005), almost natural consequence of the permanent co-evolution is the continuous innovation. That's because, on some level, disturbances will always cause changes in other areas with similar intensity to the prior interaction level. Uncertainties about the relationship between the helices or the components of the networks open windows for potential innovation (or conflict) in the (sub)systems that have been produced. The co-evolution, for example, between institutional reconfiguration and innovations generation/introduction is a central contribution of the TH approach, because it allows you to assign greater importance to the current processes of socio-technical systems, revealing the idea that social change and broader institutional may actually precede the emergence of innovations (Geels, 2005). This recognition connects the three levels of co-evolution and shows that they have influence one to each other.

The large HT current limit is its reduction to the synchronic analysis about the various settings in which UIG interaction can take, in different spaces and times (Etzkowitz and Ranga, 2010). Although all TH models (Etzkowitz & Leydesdorff, 1996) have been widely explored in literature, it was done examining a specific time (synchronous interaction). So, Etzkowitz and Ranga (2010) point it is yet necessary to seek methodologies that can examine the transition between different spheres (diachronic interaction). Here, we assume that the ANT approach can create new possibilities for understanding the TH from a perspective that focuses on the assemblages and performativites construction. The two approaches are in contact, therefore, when TH considers less the static picture of the models widely studied and more the fluid movement of their construction.

The TH approach favors the view in which there is heterogeneity of factors and situations that are difficult to be fully planned, but that must interact in order to promote collective actions, for example, what conventionally has been called "Entrepreneurial University" (Etzkowitz, 2003b). The success or the failure may depend on the plastic capacity of adaptation and creation of these unlikely settings. The ANT helps in a better understand:

- (i) when there are closeness between human and non-humans actors and their engagement in networks,
- (ii) when ideologically hermetic boundaries are destroyed in practice, by the symmetry creating,
- (iii) when exist translation of interests and negotiation, and
- (iv) when there are the construction of performativite and assemblages that promote, among other things, the sharing of roles.

In Figure 1 we can identify how all these movements are present in the TH configuration and, consequently, in the entrepreneurial university construction. We can explore some examples related to this interaction. One of them is the approach movement between actors, which can flow from an external contingency. The KBE values the University as a knowledge producer organization, putting it in a condition of extreme importance in the generation of development and imposing to it new roles not previously considered (Etzkowitz, 2003b). Another example is the engagement of public policy and political disputes, which makes all the interests acts on building positive and negative scenarios for the construction of certain assemblages (Latour, 2004).

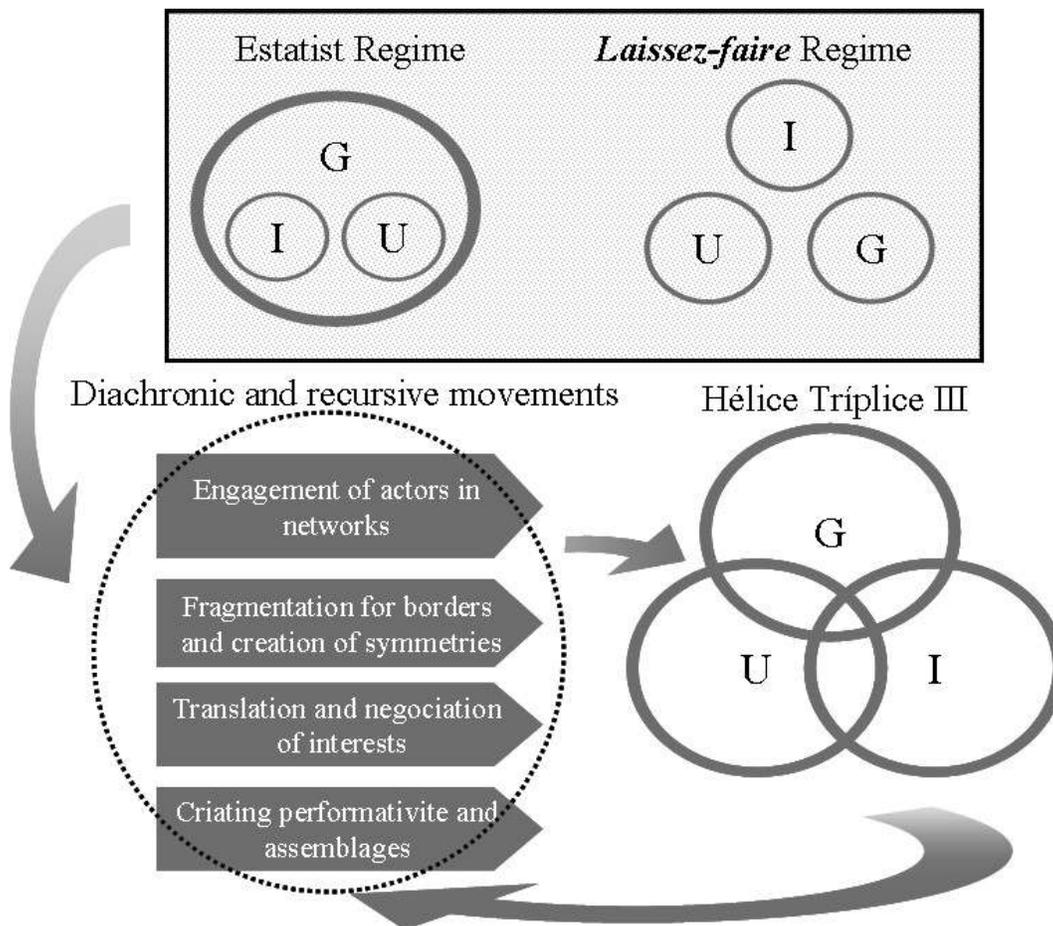


Figure 1: Diachronic and recursive movements in the UIG interactions.

In all these situations can be observed that the boundaries between public and private, knowledge and practice, or science and technology, were disintegrated when, for example, the public university open space to contribute with the creation of small private businesses, or when it starts to worry about property rights on the results of public investments made in research projects (Etzkowitz & Leydesdorff, 1996). The boundaries between the researcher and research, the entrepreneur and technological artifacts used by him, between scientific practice and extra-scientific interest become very fragile when it is possible to understand and follow the practice of building heterogeneous networks composed of people and things (Latour, 2000). For indeed occur fragmentation of these borders, there is need translations and negotiations. This happens, for example,

- (i) when public policies encourage private investors or vice versa,
- (ii) when new computer systems are adapted to laboratory equipment, allowing the exploration of new knowledge horizons, and
- (iii) when individuals are led to adapt themselves to a new organizational routine, among other endless possibilities. The institutional reconfiguration is, thus, the result of the creation of new performative routines that create structures that permit more flexible interaction between humans and non-humans. These diachronic movements are represented in the Figure 1.

However, these movements are present at all times, during the networks construction, stability, permanence or fragmentation. Therefore, these movements are not only diachronic, but also recursive, in the co-evolutionary sense proposed by Geels (2005), which implies in a simultaneous and reciprocal influence between subsystems that cause reciprocal changes. It is essential to emphasize, however, that they do not happen only in transitions from one to another TH regime. All the time, there are new translations, new commitments, new connections, among other changes, which may, or not, generate relatively stability.

5. Conclusions

It is possible to perceive some interesting contact areas of both approaches. The first one, and perhaps the most outstanding, is related with the fact of both of them suggest a focus on the process. In other words, they discuss about action: the movement in which the performativities acquire certain stability and perennial by the mobilization of a series of hybrid intermediations. There are other points of contact. It can be questioned, for example, which is the role of the non-humans in the context of the TH theory: can the idea that a non-human is able of acting offers some advance in relation to the TH current theoretical landmark? Or it can also be questioned if the information technologies and communication advances limits the TH as a regionalized police, because the territorial borders tend to exert each time less importance in the future collective configuration. In a general way, we assume that the ANT referential can suggest important reflections that certainly could contribute for a differentiated conception of the

TH that equalize the centralized trends, or for answering questions involving structural/material and voluntarie/subjective actions.

A limitation of this study is the lack of empirical evidence that could explore the human/non-human symmetry, involving not only the practice and formulation of public planning in science and technology, but also the UIG interaction models creation. While this fact contains a limitation of this study, it also opens new research possibilities, especially related to the spaces for interaction creation, in a diachronic perspective, similar to Etzkowitz and Ranga's indications (2010). The UIG interaction study in this perspective requires a daily practice focus, not only in humans (researchers, policy makers, entrepreneurs, students, etc..) but also in non-humans (computers, labs, ideologies, scientific frontiers , technical frontiers, etc.).

To explain the UIG interaction, under the TAR viewpoint, the researcher will need a new reality perspective. It implies a new methodology. As methodological directions, Callon (1986: 197-199) offers three principles to be followed by any empirical research based on the TAR:

- (i) The first principle requires an *agnostic attitude* regarding the treatment given to social or materials actors that are parts of the investigated networks. This requires that no point of view is being privileged and also that the researcher is not affixing the identity of the players involved if their identities are still being negotiated.
- (ii) The second principle is the adoption of *generalized symmetry*. In this case, the ingredients are a simultaneous mix of elements that came from the social and natural areas. Once the generalized symmetry principle is chosen, a rule to be respected is to keep the standards when changing from technical to social aspects.
- (iii) The third principle refers to the principle of *free association*. In this case, the investigator must abandon, *a priori*, any distinction between natural and social events. This requires the rejection of the defined boundary hypothesis, which separates natural and social events. Rather than impose a separation between them in the analysis, the researcher follows the actors aiming to identify the manner by which they give meaning and associate different elements from which they construct and expand their world, whether it be the natural or the social world (Callon, 1986).

We assume that the contribution of TAR can lead to a higher effectiveness of the TH as a strategical practice of technological, socio-economic and sustainable developments, in a context where the borders fragmentation in and out these fields is increasigly evident.

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