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**Searching new alternatives for
development:
National Systems of Innovation and
Transformative Change as seen
from underdevelopment**

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Abstract

The most pressing problem for Humankind – if it keeps avoiding a nuclear holocaust – is to manage the increasing contradiction between production and sustainability that has opened the possibility of a climate holocaust. Such contradiction and the related increasing inequality reframe development as a global issue for both South and North as the Sustainable Development Goals make clear. Assuming that development involves values, facts, trends and proposals, new alternatives are discussed. That is done in connection with two well-known conceptual frameworks for innovation policies: National Innovation Systems and Transformative Change. Both are considered from a Southern perspective. Both suggest that special attention must be given to the issue of power; for that the focus is put on the interactions between technology and economic, political, ideological and military relations. From that point of view the notion of underdevelopment is revisited. In such context specific traits complicate the global challenges. But the capability of innovation in scarcity conditions that many regions of the South have been obliged and able to build opens alternatives for a world in need of frugal and inclusive innovation. Main conclusions point to the role of knowledge democratization and developmental coalitions in transitions to sustainability based on collective learning.

Introduction

This paper aims to contribute with the search of new paradigms for development in dialogue with the National Innovation Systems and Transformative Change frameworks. It is organized as follows. In section 1 a general perspective of development is sketched; methodologically it combines normative, (theoretical-)factual, prospective and propositional approaches. In section 2 the normative, (theoretical-)factual and prospective approaches are considered in connection with the National Innovation Systems and Transformative Change frameworks; particular attention is given to the issue of power and to revisiting the characterization of underdevelopment. Section 3 considers in a similar way the propositional approach; it is argued that both frameworks point to the centrality of knowledge democratization; such (very difficult) task is seen from a Southern point of view; the recent experience of Latin America is considered; developmental or transformative coalitions appear to be necessary and not impossible. Conclusions recall that actual trends concerning productive patterns, (in) equality and (in) sustainability simply cannot coexist; thus, deep transformations will take place in social relations, prevailing technologies and the interactions between the former and the latter. The question is if such transformations will be mostly harmful and suffered by most of Humankind as patients or if plural and collective agency will open better possibilities.

1.- The guiding thread: towards new development paradigms

1.1 Why a look from underdevelopment

This paper is written from the perspective of Interdisciplinary Development Studies, anchored in the classic Latin American conception of development as an integral social transformation - once often called “structural transformation” -. (Rodríguez, 2006) This perspective is akin to current frameworks for understanding the systemic behaviours of science, technology and innovation and how they play in transformative changes. “The concept of a system, on the one hand, and the idea of power, on the other, form part of the theoretical approach to development that gave rise to Latin American structuralism...” (di Filippo, 2009: 184); “The idea of structures essentially concerns the stability of the technical or institutional rules internalized by actors (be they individuals or organizations), while the idea of structural change is historically dynamic and refers to the modification of rules or their internalization” (Ibid).

The paper aims at contributing to the current thinking on the main social and environmental challenges of today and tomorrow taking centrally into account underdevelopment. Social and

environmental challenges are interconnected and must be faced together, by policies and collective action working towards what can be called Sustainable Human Development. Concrete tasks in such direction are posed by the Sustainable Development Goals (SDG). (UN, 2015) It has been widely stressed that they concern the Global North as well as the Global South. Development can't be seen any more as a problem specific to the South, to be solved by "catching up" with the North, but as a planetary issue. But, if normative aims should be similar and if some fundamental challenges are shared, situations are different and developmental strategies cannot be the same, much less exported from the central to the peripheral countries. In particular, the centre-peripheral approach, highlighted by the Latin American structuralist thinking, emphasizes "...the asymmetrical character of technical progress arriving from the centre and the concentrated distribution of its benefits..." (Di Filippo, 2009: 185). This asymmetry was well understood by Christopher Freeman: "The basis for a sustained (although cyclical) movement away from these lower limits of human misery and degradation was provided, *outside the Third World countries*, by successive technological revolutions' (Freeman, 1984: 502, emphasis added). Such lower limits of human misery and degradation, a mark of underdevelopment, are still with us; the challenging question is how to harness knowledge and innovation to redress them.

The National Innovation Systems framework, particularly in some of its expressions, as well as the Transformative Change framework, offer strategic conceptual landmarks that highlight fundamental traits of the current socio-technical dynamics, the needed directions of change and the forces that may either support or oppose them. Looking at National Innovation Systems and Transformative Change from underdevelopment is one of the necessary contributions for further elaborating both frameworks. That stems from the specificity of the "peripheral condition", yesterday studied by the Latin American tradition recalled above; such "condition" has changed but has not vanished. Moreover, the almost neglected issue of underdevelopment must be reconsidered in the light of the main contemporary social and technical changes. If this is not done, some fundamental social and environmental challenges will simply not be adequately addressed. When the problem of underdevelopment is considered, something that holds not only for the South but also for the North becomes apparent: yes, new innovations and transformative policies are needed for (Sustainable Human) Development, but the problem is more about politics than policies. If changing politics is at stake, new actors and new alliances will be required; academics working with different frameworks but committed with the Sustainable Development Goals need to pay attention to actual possibilities of collective agency for fostering such goals. Thus, the issue of power, its different dimensions and its distribution, should be put at the top of the research agenda. If not well inspired lists of policies can keep expanding while the real world of politics goes in another direction, as it is happening today in so many places, South and North.

1.2 A methodological path

Despite all what has happened and been studied since the issue of development jumped to the top of political and academic agendas more than seventy years ago, many so-called friends of development equate it with economic growth. That makes easy the task of development foes. Such mistake – criticized since the beginning by heterodox conceptions of development, the Latin American one included – has very damaging consequences. That is particularly so when the increase of GDP is used as a bluntly measure of development. That option has been contested from several points of view that stress in particular the very defective character of such measure (Stiglitz et al, 2009), its weak connections with human well-being and its often strong connections with environmental damage. Nevertheless, even in the case of socially progressive governments, leading economists assert that the increase of the GDP is making possible a "jump to development". In the global South at least, such perspective frequently leads to neglect environmental issues, to base productive policies on the expansion of primary and extractive activities, and to pay scant attention to advanced education, knowledge and innovation policies. Such strategies reinforce and are reinforced by rising aspirations to consume more -completely justified in the case of deprived people, but particularly eager in the case of the middle and upper classes -. Thus, economic growth, understood as "business as always", becomes central for success of governments -with the concomitant ruling continuation of the incumbent

political parties- in very different political regimes. And that is simply not sustainable, socially and environmentally.

A shift to more efficient and sustainable ways of paying attention to the needs of people is urgent. Such shift must be at the same time technological and social, in particular ideological. It includes a change of paradigm in development, where social and environmental sustainability takes central stage; it has already started but is still very weak. Academic work has supported and gave evidence for that shift (see for instance Orozco et al, 2015).

Our main methodological assertion is that the search for new paradigms for development must combine without confusing them the analysis of values, facts, trends and proposals. When discussing about development it is necessary to combine normative, (theoretical-)factual, prospective and propositional approaches in an articulated conception. When assessing different conceptual frameworks, it is necessary to distinguish whether the particular issue under consideration has mainly normative, (theoretical-)factual, prospective or propositional content. From such methodological point of view, we suggest some elements that could be considered in each of those approaches.

The normative approach can explicitly connect Sen's conception of development – as the expansion of freedoms and capabilities – with the fundamental issues of sustainability in a notion of Sustainable Human Development that is, at the same time, ethically sound, widely accepted and action-oriented.

The (theoretical-)factual approach should pay special attention to power. That can be partially done by focusing the analysis on the interactions between social relations and technology looking specifically -following a long intellectual tradition- at how technology partly emerge from social relations and, in turn, helps, up to a certain point, to reinforce them and, eventually, contribute to its change.

From the perspective of underdevelopment, the analysis of present interactions between social relations and technology highlights the emergence in the (old or new) “central countries” of a capitalist knowledge society that is the main configuration of power in this age. It is the main reference for understanding underdevelopment today. The capitalist knowledge society, like the capitalist industrialization in the XIX Century, rises in a small part of the world and deploys its impacts worldwide, but by its very nature hampers the distribution and generalization of the seeds of its dynamic. The latter can be masked by the remarkable technological homogenization following the massive access to some artefacts, but the crucial differences -cultural, economic, political as well as scientific and technological- between accessing artefacts and building socio-technical alternatives, continue to be present, being in no small measure an explanation of the persistence of underdevelopment.

The prospective approach should discuss what appear to be main trends, on the one hand trying to insert them in the conceptualization elaborated for the (theoretical-)factual approach, and on the other hand exploring the possibilities that such trends may open for overcoming high inequality, underdevelopment and lack of sustainability in the new global context. A widening consensus seems to be emerging: it says that the world is evolving in bad directions; scare concerning social and environmental threats may help to shift course and open new perspectives.

The propositional approach should be rooted in considerations as the above sketched ones, concerning normative, factual and prospective approaches. A main process to consider is that advanced knowledge has become a fundamental lever of power, for good and for bad. This and prevailing trends show that new innovation policies and, more generally, new knowledge policies are needed; they should aim at knowledge democratization and, particularly in the South, at the expansion of socially valuable knowledge with frugal and inclusive aims.

The deep transformations that are needed will not take place if collective actors, particularly social movements and political parties, do not become strong protagonists; if they do, academics and policy makers may follow suit. As already said, politics is more important than policies; the issue of power should be central for assessing possibilities and suggesting strategies.

2. On development, power and underdevelopment

In this section, the normative, (theoretical-)factual and prospective approaches to

development are elaborated in dialogue with the two frameworks under consideration; then, with such basis, a rather brief consideration of power is presented, and the issue of underdevelopment is revisited.

2.1 The foundation: a normative conception of development

For thinking and acting, values should come first. A wide normative consensus must be the foundation of the deep changes that are needed. Sustainable Development Goals (SDG) make an important contribution both to such consensus and to elaborating and implementing concrete proposals for change.

A first consequence, explicitly stated in the SDG, is that development concerns both North and South. Particularly, “catching up” should be dismissed; it never was the same as development; when used outside the restricted comparison between industries in different settings as a synonym of development, it implies that development is where the highly industrialized countries of today have settled themselves. This is precisely what growing inequality and environmental problems in such countries belie. Moreover, today, if the whole South aims at catching up with the North, most countries will fail, and a climatic catastrophe will hit the whole world. “On the assumption that India and China become industrialized in the same way and to the same extent as Europe and the United States, it is difficult to see how humankind will be able to handle industrial pollution and its climatic repercussions” (Salomon, 2001: 326).

Previous assertions converge with the following: the transformative change framework “does not assume that innovations and socio-technical system change will necessarily come from the Global North or that other countries need to play catch-up with those innovations. On the contrary, the assumption is that both the Global North and Global South must be in a position to contribute to transformative change and that mutual learning can be beneficial. In this framing, it is clear that diverse pathways are possible and that local generation and adaptation within a complex process of system transformation should be embraced.” (Schot & Steinmueller, 2016: 21) Playing catch-up with existing innovations is achieved mainly by importing technology and receiving technology transfer. The normative approach stresses that catching-up is neither the aim nor the road to development. This has been clearly stated by one of the founding fathers of the National Systems of Innovation framework: “In the long run, how much one wants to rely on imitation, licensing and purchasing know-how, and how much one wants to rely on one’s own problem-solving capabilities, will depend partly on what kind of society one wants to live in” (Freeman, 1992: 48). Both statements share the conviction that the road towards the changes needed to bring into life the SDG is not one alone, valid for everyone, and that all societies may contribute and should be encouraged to contribute to its achievement. This perspective is not exactly new (see, for example, Edgar Pisani, 1984), but its message is amplified by the global nature of the SDG and integrated in a new paradigm of development.

Nevertheless, the SDG list and caring about sustainability are not enough: a widely consensual but also more general and orientating conception is needed. It can be based on the conception of development proposed by Sen (1999) and known as Human Development (UNDP 2011: 1); it has contributed to a major change in development theory (Evans and Heller, 2015) that can be seen as dismissing the old dominant paradigms.

Combining Sen's conception with Sustainable Development, a normative characterization follows directly: Sustainable Human Development is (i) the expansion of people’s freedoms and capabilities, both individual and collective, (ii) in order to lead lives that they value and have reason to value, (iii) in ways that preserve such possibilities for future generations, (iv) assuming that the expansion of freedoms and capabilities is both the defining aim of development and its main tool, which (v) implies treating people not as patients but as agents.

Some main clues for the propositional approach stem from such characterization. The emphasis on capabilities leads directly to education and knowledge (the last an issue almost absent in Sen's presentation), thus linking factual and normative approaches. In this way learning processes are highlighted; they become the most important processes when the most fundamental resource in the modern economy is knowledge. (Lundvall, 1992). Emphasis on learning has been an inspiration

for a strong research agenda, both North and South. (Erbes et al, 2010; Jensen et al, 2007; Dutrénit and Vera-Cruz, 2007) But learning, as well as knowledge production and innovation, are social processes that combine different pathways, something that sometimes is forgotten by the unilateral attention paid to what the “Aalborg school” of the National Innovation Systems framework calls the STI (science, technology and innovation) mode of innovation. In fact, here lies precisely the critiques that another founding father of the concept of National Innovation Systems makes to how the concept has evolved in some influent academic and policy milieu: “Actually, we regard the neglect of ‘learning as competence-building’ as the principal weakness of standard economics and the narrow definitions of innovation systems as reflecting a negative spill-over from this misdirected abstraction (Lundvall, 2007: 3). When the DIU (doing, using and interacting) mode of innovation and learning (Lundvall and Johnson, 1994) is taken into account, new actors are recognized as part of the innovation process. Moreover, learning divides or asymmetries come to the forefront. They both have to do with “internal” inequalities and with underdevelopment, so related trends demand special attention in the prospective approach.

The normative approach with its emphasis on agency goes beyond state-based or market-based strategies, suggesting a propositional approach in terms of social actors-based strategies for development. The normative notion of Sustainable Human Development stresses that main transformations will be needed, parting with “business as usual”. A main issue regarding this is the orientation of knowledge production and of innovation. “It is on a global scale that the most extreme effects of worldwide inequality in incomes are apparent. The bias in the world research innovation system is so great as to constitute a danger to the future of human society” (Freeman, 1982: 184) The transformative change framework, with its emphasis on sustainability, goes in the same direction, given that considering sustainability seriously “will need a fundamental change in the socio-technical systems for food, energy, material, mobility, healthcare, and communication provision.” (Schot and Steinmueller, 2016: 16) This change will not be possible if changes in the current politics of knowledge do not take place as well. Such current politics has been described as follows: “There is a growing trend in political circles to regard *all knowledge* as a potential commodity and to subordinate *all knowledge production* under the logic of international competitiveness. This is reflected in a movement in favour of expanding and strengthening intellectual property rights to the extreme and far beyond what promotes socio economic progress and as well in a strong drive toward colonizing academic knowledge and make it subordinate to market demand” (Lundvall, 2007: 39; emphasis in the original). The last observation links the normative approach - that highlights the need to part with business as usual in what concerns knowledge production and innovation - with the role universities should play in development, an important part of the propositional approach.

A rather forgotten author in both frameworks, Everett Rogers (1995), signals the need of moral assessments of innovations in terms of social impacts; he shows empirically to what extent innovations may do wrong, regardless its eventual economic success; this reinforces the normative importance of the orientation of innovations and of research agendas; ethical and justice considerations are growing in the innovation studies agenda (see for instance Papaioannou, 2011).

Linked to the widening of the actors of innovation highlighted in the National Innovation Systems framework and in the work of innovation researchers like Erik von Hippel (1988), another aspect of the normative approach to development appears: all people should be considered agents also in knowledge terms. Elinor Ostrom poses eloquently this normative orientation: “Instead of presuming that some individuals are incompetent, evil, or irrational, and others are omniscient, I presume that individuals have very similar limited capabilities to reason and figure out the structure of complex environments” (Ostrom, 2008: 25).

Since development à la Sen focuses on the capabilities of people to lead lives they value, main attention should be given to how people can pursue their goals by influencing their natural and social environment, that is, to their power. The issue of power has been neglected in the Innovation Systems framework, as it has been forcefully acknowledged: “Another weakness of the system of innovation approach is that it is still lacking in its treatment of the power aspects of development. The focus on interactive learning – a process in which agents communicate and cooperate in the creation and utilization of new economically useful knowledge – may lead to an underestimation of the conflicts over income and power, connected to the innovation process. (...) Post-colonial and class privileges may block learning possibilities and existing competences may be destroyed for political

reasons related to the global distribution of power” (Lundvall, 2007: 33-34). Consideration of power is central when development once again – and as it should – implies change.

Finally, as said at the beginning of this section, for thinking and acting values should come first, but it is also true that when radical changes are envisaged, new values may need to be constructed: “We might therefore define sustainability transitions also as a quest for new value systems” (Grin et al, 2010:2). No less valid is this assertion regarding the quest for new alternatives for development.

2.2 A look to the (theoretical-)factual approach

To observe facts and to interpret them, adequate theoretical focusing devices are needed. Firstly, because as Einstein argued when discussing with Heisenberg on the nature of reality, “It is the theory which decides what we can observe” (quoted in Kumar, 2009: 226) But second, because focusing devices are like lampposts, illuminating the ground under its lamps but leaving in darkness territories outside its scope, which, in the absence of broader perspectives, may lead to the dangerous conclusion that such territories simply do not exist. “Not only is the description of every single fact dependent on some theory, but there also exist facts which cannot be unearthed except with alternatives to the theory to be tested, and which become unavailable as soon as such alternatives are excluded” (Feyerabend, 1988:27)

Both the frameworks we are considering were developed in highly industrialized countries; they are inspired by their realities, which dynamics they attempt to capture through different lens. So, why do we consider that these frameworks are useful theoretical focusing devices when trying to describe and explain main facts of current underdevelopment, one of the methodological requisites building alternatives for development? We will reflect on this from the Latin American tradition in development thinking, vindicating its often-forgotten merits and acknowledging its by now well-known shortcomings. Merits include the vocation for intellectual autonomy, aiming to consider dominant ideas but without subordination; the creativity shown in the comprehension of centre-peripheries relations and of the specific aspects of the peripheral condition; the promotion of heterodox policies. Shortcomings include its excessive emphasis on the role of the State and on economic aspects as well as its limited comprehension of specific technological dynamics, excepting the case of a minority brand sometimes called Latin American thinking in Science, Technology and Development to which the authors of this paper are greatly indebted.

Let’s take the Transformative Change framework first. Even if the main interest of this framework is on socio-technical transitions to sustainability, seen from underdevelopment it offers a very useful focusing device, particularly when based on the multi-level perspective (MLP) that includes niches, regimes and landscapes (Geels, 2004 and Geels and Schot, 2010). As a (small) reformulation of the MLP definition of niches, we propose the following, particularly apt for our purpose: niches are protected spaces where deviant solutions to problems, that is, deviant innovations, appear and can mature in several dimensions without being destroyed by early exposure to the forces that sustain prevailing and dominant ways of solving problems. In what sense an innovation “deviates” and how much it “deviates” are to be determined, but as a first approach, the more the heuristic followed to solve a problem is different from the one currently used, the more deviant the innovation will be.

The socio-technical regimes are “the locus of established practices and associated rules that stabilize existing systems” (Geels, 2011: 21). Different socio-technical regimes concerning transport, energy, food production, may change over time; passing from one of such regimes to another implies a deep transition, in the sense that a whole set of different dimensions (technological, economic, regulatory, cultural) need to change if one regime gives place to a different one. From the perspective of underdevelopment, even though obviously socio-technical regimes exist, and change, first its existence and second its changes are markedly more exogenous than in the Global North. At least this is so since the second half of the XIX century, with the Second Economic revolution in terms of Douglass North (2005), or the uninterrupted amplification of the epistemic base of technology, in terms of Mokyr (2002), that gave rise to what economic historians call the Great Divide. In fact, underdevelopment could be characterized by the exogenous nature of its socio-technical regimes

and of the deep transitions that substitute an old regime for a new one, following a path where local knowledge and expertise usually play a minor role. Two more remarks are worth making from an underdevelopment perspective. The first is that regimes in the Global South are markedly more heterogeneous than in the Global North. In the Latin American school of development economics such situation was called “structural heterogeneity”, implying that it was not a simple temporal lag from the frontier of productivity but a structural trait of the regional economies. This implies that regime transitions are also heterogeneous, with sectors or part of sectors as well as actors totally inserted in the new regime while others literally belonging to older ones. The second remark is that the exogeneity of a regime is related to the sector and its core technologies: the more life-related the sector, like in food production, for instance, more local knowledge is required, leading to an acknowledgement of the need for a blending between imported and indigenous know-how.

The concept of niche is a very useful one, mainly for two reasons: (i) niches allow explicitly for what in Lundvall’s parlance are user-producer interactions in quest for satisfactory innovations (Lundvall, 1985); (ii) niches allow the exploration of heuristics for solving problems that deviate from main-stream ones. In earlier works we have coined concepts akin to niches - interactive learning spaces (Arocena and Sutz, 2000) and innovative circuits - that highlight processes of innovation in underdeveloped countries. However, seen from underdevelopment, niches in the MLP conceptualization bear a promise of change that is very difficult to fulfill there, precisely because of the exogenous nature of transitions in those settings. Moreover, it may be understood that change grows from niches through a process of scaling-up, but non-scaling-up is a well-known problem for those that study grass-root innovations, developed in spaces that can be conceptualized as niches. Diverse reasons explain the encapsulated nature of most niches in underdevelopment. Rogers (1995) presents a wealth of different examples of failures in the diffusion of innovations; the conceptualization of innovations developed by practitioners as “mundane” and rejected for this reason by organizations with power to influence changes in practices has been recently documented (Diaz et al, 2016). If instead of looking at niches only as spaces where the future change in socio-technical regimes gives its first steps, we look at them also as spaces of alternative innovations where problems present in underdevelopment and without adequate solutions are solved, then we arrive to an important point.

Problems solved at niches in underdevelopment -understood from the perspective just highlighted- are of the most diverse nature: they come from agriculture, production, energy, telecom, health; they may be “mundane” or science-based. But the solutions found often share a common trait: they are frugal. And this is so because the reason innovation efforts are pursued in the first place is that there are no satisfactory solutions available, a main reason this is so being that what can be found in terms of solutions has been developed for the most part in conditions of abundance. Abundance of different assets builds a heuristic of problem-solving that leads to unsatisfactory innovations in contexts shaped by scarcity in terms of money, infrastructures or operating skills. This suggests another reflection concerning socio-technical regimes. Reading the literature on MLP, one gets the impression that changes in socio-technical regimes appear mainly as changes in products: different kind of artifacts for transportation, for energy production, for food production. In sustainable transitions it is expected that such changes in artifacts will lead to a more sustainable style of living. But little is said about the processes by which such new artifacts are developed. Differently, what we found in niches in underdevelopment, besides the diversity of solutions developed there, is often a common processual pattern: frugality. Without frugality, changes in socio-technical regimes in underdevelopment, that will continue for a good time to be principally exogenous, will reproduce the structural heterogeneity that is at the roots of inequality and reproduce underdevelopment. New paradigms for development, North and South, can then be seen as embracing a frugal approach to innovation. This is an endeavor where both STI and DIU modes of innovation coming from the South can make a great contribution.

Coming now to the National Innovation Systems (NIS) framework, an outstanding (theoretical – factual) merit from an underdevelopment perspective appears to be its characterization of really existing innovation processes as fundamentally interactive, in such a way that: (i) potentially they are distributed, (ii) they may involve several actors, and (iii) they have usually more impact when they are systemic. Thus, the NIS framework allows going beyond the traditional (but still operating) opposition state versus market and connects with the original brand of Latin American thinking about science,

technology, development and dependence. This, along with the emphasis on the importance of doing, using and interacting for innovation -a radical depart form the lineal model of innovation- help unearthing innovations rendered invisible by an excessive focus on formal settings involving a restricted set of actors as is usually the case.

Another fundamental feature of the NIS framework is its insistence on the relational nature of innovations, from a micro perspective (“in the bench”) to the macro-institutional perspective. This relational, interactive penchant of the NIS framework, particularly in its Aalborg version, articulates well with the Latin American school of thinking on science, technology and development. Lundvall explicitly recognized this in the first version of a text with an expressive title: “Innovation System Research and Policy: Where it came from and where it might go:

An early contribution not referring explicitly to ‘system’ may be found in the work of Sabato who as early as 1968 proposes that for S&T to help development processes a systemic view should be taken, proposing as a focusing device the figure of a triangle (famously known all over Latin America as the “Sabato triangle”) with Government, Production and Academia in its vertex (Sabato and Botana, 1968). It may be seen as a forerunner to the Triple Helix concept but the ‘NSI’ flavour of Sabato’s approach is also unmistakable: for Sabato much more important than the strengths of each vertex were the strengths of the sides connecting the vertex: if the sides of the triangle are weak, each vertex sought to articulate outside the triangle (this leading to brain drain and to blind technology transfer) (Lundvall, 2007: 14).

The usual weakness of the Sabato’s triangle sides in the South is what gives NIS in underdevelopment their ex-ante characteristics, mainly weak or missing institutions and un-coordinated efforts among actors, as well as a powerful bias towards exogenous influence. NIS there are conceptualized as a top-down created institutional fabric that may have the form but not the dynamics of effective NIS. From this standpoint, the main challenge for a propositional approach is how to build opportunities for distributed learning, meaning the opportunity for all to become agents in producing and using knowledge, a most important resource in our contemporary material and spiritual life. This is also a global challenge, perhaps more difficult in the South than in the North but present in both. Popular actors need to have voice in transformative changes, so often the guarded kingdom of expert knowledge; thus, connecting popular actors and advanced knowledge via generalized learning processes is a necessary step towards new paradigms for development.

2.3 Some consequences of a prospective sketch

Here we briefly consider five usually acknowledged global trends (Arocena & Sutz, 2018).

First, the role of knowledge in social relations will keep on rising. This means that “big science and large technological systems [...] transform the extra social world, nature and the environment – and *with it* the social world” (Schroeder, 2007: 49). That happens both for good and for bad, something sometimes forgotten although rather obvious. Would not our Earth be a nicer and safer place if innovations related with atomic energy had not taken place? In general: “Scientific progress and technological change are *not* neutral. New S&T helps some, but hurts others.” (Taylor, 2016: 187) Increasing impact of knowledge generation and use with different types of consequences is a main element for the propositional approach: as a “frame for innovation policy, transformative change, takes as its starting point that the negative impacts or externalities of innovation can be greater than the positive contributions.” (Schot & Steinmueller, 2016: 21)

Second, growth and more so diversification of production of goods and services tend to keep rising. This trend is mainly a consequence of the previously remarked and seems to be quite self-sustained. In fact, up to now economic growth has meant for many people better living conditions, so it fosters an almost universal aspiration to increase consumption that becomes in itself a propeller of growth and makes growth a clue of political legitimacy.

Third, the possibility of a climatic holocaust has appeared in the horizon, carrying us nearer to midnight in the clock that the Bulletin of Atomic Scientists invented when the possibility of a nuclear holocaust made its appearance. Advanced scientific and technological knowledge allows an

accelerated expansion of production and consumption in ways that have already caused great environmental damage and opened the possibility of a catastrophe. Such threat can be the decisive factor in the emergence of new combinations of knowledge generation, production styles and social relations. More specifically, sustainability “will need a fundamental change in the socio-technical systems for food, energy, material, mobility, healthcare, and communication provision.” (Schot & Steinmueller, 2016: 16) Sustainability will need the building of a Sustainable Innovation System, as a Costa Rican researcher proposed some years ago. (Segura, 2003; see also Cassiolato et al, 2014)

Fourth, “financial markets have become the main drivers of the world economy” (Hodgson, 2015: 136) in what seems to be a deep trend, as showed by the fact that financial capital has not really seen its power eroded despite being the widely acknowledged main culprit of the great recession of 2008.

Fifth, the trend to increasing inequality within most countries that has been detected during the last decades is said to have lasting foundations (Piketty, 2014). From our point of view this fifth trend in some sense recapitulates the four previously recalled. On the one hand, trends one and fourth foster the fifth one: “In recent decades, the combination of financial capital and scientific-technical knowledge has gained unparalleled potency in the production of inequality between those who control the combination and those who do not.” (Tilly, 2005: 115) On the other hand, inequality fosters poverty which in turn fosters the demand for economic growth (second trend above) while increased inequality means that less powerful groups and countries have fewer alternatives to pollutant activities and little force to control them, so resistance to environmental and climatic damage (third trend above) is weak.

Summing up prevailing trends point to the expansion of production and of inequality, both knowledge-based, as well as of environmental damage. That lacks social and environmental sustainability but it is the dominant scenario: “The current NIS actors are implicated in the building up and maintenance of prevailing production, distribution and consumption pattern (I would add embedded in socio-technical systems). For dealing with SDGs we need to move away from these patterns in a radical way. Is a focus on learning sufficient then? This may lead to optimisation of current patterns and not to new ones? How do we secure a radical reorientation of current patterns and socio technical systems?” (Johan Schot, private communication). A focus on learning is surely necessary, particularly in the South, but no sufficient, either there or in the North. Power, its sources and its configurations in Innovation Systems are unavoidable issues to which we now turn, complementing the (theoretical-) factual approach.

2.4 About power

As already stressed, the (theoretical-)factual approach should pay special attention to power. That can be partially done by focusing the analysis on the interactions between social relations and technology. The National Innovation Systems framework is particularly useful for such analysis in the case of the social processes of innovation, seen as interactive, distributed and (potentially) systemic; such framework, particularly in the Aalborg version, considers several collective actors and not only dominant ones. In turn specific “socio technical regimes”, as analyzed in the “transformative change” framework, are relevant examples of the interactions between social relations and technology; needed transformations in those systems require new technologies as well as economic, political and cultural changes (Geels, 2010). Socio technical regimes deserve special attention, moreover, because they can be the setting of specific policies and coalitions oriented to social and environmental transitions.

“The legitimate authority to push change through, or the resources available to build consent, to raise informed dissent, or even to block change, will depend on power relations across the networks of actors involved in a regime.” (Smith, Stirling & Berkhout, 2005: 1508)

In previous work a “Marx-Mann” conceptual scheme for the study of power was presented (Arocena & Sutz, 2014; Arocena, 2017, 2018). Here it is summarized. Power is defined as “the ability to pursue and attain goals through mastery of one’s environment.” (Mann, 1986: 6) That requires intervention in nature as well as social coordination, so (the interactions between) technology and social relations appear as main sources of power. In the theory elaborated by Michael Mann

(1986, 1993, 2012, 2013) the coordination of collective action in Ideological, Economic, Military and Political (IEMP) relations generate relevant power organizations because they are means for attaining fundamental human goals. Intervention in nature and its interactions with social relations is highlighted in the materialist conception of history; now, strong material or technological power is not restricted to productive forces but includes also, for instance, destructive forces and communication technologies. Thus, a Marx-Mann scheme may assume that great amounts of power stem from: (1) technologies that enable the use of material resources; (2) social relations that generate organizational strengths mainly by coordinating ideological, economic, military and political activities; (3) interactions between technology and social relations.

The Industrial Revolution and related social changes shaped the emergence first of industrial capitalist societies and then of state industrial societies, the “two predominant modes of production” of the twentieth century (Castells, 1996: 16). The “marriage of science and technology” in the West during the late 19th century multiplied technological power and shaped the track towards knowledge-based economies. The TICs Revolution entwined with the restructure of capitalism in the North during the last decades of the 20th century paved the way for the emergence of the capitalist knowledge society.

The increasing centrality of knowledge is directly related to inequality because knowledge is a resource that increases with its use and decreases when it is not used, thus benefiting regions or social groups that are already strong concerning knowledge and damaging those who are weak. A trend to favor those already favored in the academic reward system was famously termed the “Matthew effect” by Merton (1968). A generalized Matthew effect seems to be acting in society at large in relation with knowledge and learning.

2.5 Underdevelopment today

“The centre-periphery outlook, which is the characteristic framework of the historical and structural approach, has always been the starting point for Latin American structuralist economics. The power of hegemonic centres over peripheral societies in the world order is ultimately based on control of the scientific and technological processes that ensure their predominance in the cultural, economic and politico-military spheres.” (Di Filippo, 2009: 188)

Underdevelopment was stressed by heterodox conceptualizations of development in order to characterize the situation of peripheral countries that could not industrialize and modernize their economies mainly because (industrialized) central countries used their power to avoid it. Thus, the former could not follow orthodox recipes to catch up with the latter and should choose alternative ways, as Japan and other countries of East Asia did.

Today the peripheral condition cannot be characterized by lack of industrialization but by a more fundamental trait that has been at the root of such condition since the emergence of the centre-periphery world system in the last decades of the 19th century. Namely: specialization in productive activities with comparatively low added value stemming from advanced knowledge and high qualifications. Generally speaking, that means a scarcely diversified and low complexity production which usually is a source of lasting poverty (Reinert, 2007). Related economic dynamics generate a weak commercial demand of advanced knowledge, mostly addressed to external producers, thus inhibiting endogenous knowledge generation, innovation and learning processes in general (Arocena and Sutz, 2010). Thus, the expansion of capabilities is fettered. The peripheral condition reinforces disadvantages at international level, concerning economic power but also political, military and even ideological power. Central (knowledge-based) countries often use their advantages of power to prohibit the use today of some efficient productive policies they used yesterday (Chang, 2002).

Summing up underdevelopment can be characterized as the combination of the peripheral condition with external IEMP subordination to the centres of the capitalist knowledge society. It is a fundamental example of the interactions between technology and social relations. It hampers the expansion of freedoms and is a remarkable cause of inequality.

3. On politics and policies

The following assertion is a realistic starting point. "To sum up the general picture: the world population will most likely continue to grow until stabilized around 11 billion about 80 years from now, it has proved to be difficult to liberate affluence from economic growth in practical policymaking, and it has so far also been difficult to reduce the environmental impact of economic growth." (Johnson and Villumsen, 2018: 182)

We read the following assertions as saying that some fundamental economic, political and ideological power networks of the capitalist knowledge society oppose advances towards less inequality and stronger sustainability. "The power of firms to shape specific policies and wider political debates has increased since the 1970s, first because of the emergence of a pro-business neo-liberal discourse, which highlights free markets, privatization, and de-regulation, and, second, because of the political mobilization of corporate interests in response to social and environmental regulations." (Geels, 2014: 27) Power and politics are apparent when conceptualizing "relations between policy makers and incumbent firms as a core regime level alliance, which often resists fundamental change [...] and] can turn into a stable and hegemonic 'historical bloc' if it also achieves consensual legitimacy in civil society via widely accepted discourses." (Ibid) Alternative counter-hegemonic 'historical blocs' are needed; are they feasible?

3.1 Towards knowledge democratization

The previous assertions imply that prevailing knowledge policies (that is, policies related with education, science, technology and innovation) have to be altered in a sense that benefits the majority of people and can thus be termed democratic knowledge policies. Moreover, "a fundamental transformative change is required, one that involves the democratising of control over innovation production and diffusion and the creation of negotiation spaces or market niches for alternative technologies to become established, capture imaginations and win constituencies among actors that would otherwise be excluded." (Schot & Steinmueller, 2016: 18)

In other words, democratization of knowledge challenges in a fundamental sense powers that be and thus goes beyond policies to the realm of politics. In such realm, alternatives to the hegemonic 'historical bloc' have to open their ways, finding spaces for sustainable and egalitarian actions in interstices not entirely controlled by the prevailing power configurations. In particular, "sustainable innovation journeys can be facilitated by the creation of technological niches, i.e. protected spaces that allow nurturing and experimentation with the co-evolution of technology, user practices and regulatory structures" (Geels & Schot, 2010: 80). From a perspective that sees innovation as stemming from the interactions between different actors, some type of niches can become interactive learning spaces, in the sense that the combination of several types of agency generates new solutions to social problems, possibly altering prevailing technological and institutional trajectories as well fostering collective learning.

In connection with the policies required for democratizing knowledge, a remarkable convergence between the two frameworks considered here appears in Geels (2014: 37) when discussing the possibilities of broad socio-technical innovations stemming from the civil society, that "would entail a relative shift from the dominant STI-mode of innovation (Science, Technology and Innovation), which emphasizes upstream research and development investment in 'green' technologies, to a DUI-mode of innovation (Doing, Using and Interacting) (Jensen et al., 2007), which emphasizes 'learning by doing', 'learning by using' and broader social interactions in green reconfigurations of concrete transport and energy systems. Although these broader innovations have more sustainability promise, such a shift in the mode of innovation is likely to be resisted by incumbent regime actors, which underlines the importance of the topic of this paper." (that is, politics and power)

A more general convergence is apparent in previous remarks and in the following ones. During the first years of this century a new stage seemed to emerge concerning STI policies that have as its general reference the notion of Inclusive Innovation Systems. That is suggested by considering innovation policies partly as social policies and conversely. Its principal motivation is the concern about inequality. Combined with the fundamental issue of sustainability, it suggests putting inclusive

and frugal innovation at the top of the priorities for knowledge policies. In such sense, it would be possible to speak of innovation policies as social and environmental policies, and conversely. Such point of view pays special attention to changing academic policies and evaluation systems as well as to transforming universities. (Arocena et al, 2018) Now, typical policy activities in the transformative change framework include (Chataway et al, 2017: 24-25):

- "Stimulation of experimentation with niche technologies, scale-up and acceleration of socio-technical transitions".
- "Promoting social, inclusive, frugal and pro-poor innovation".
- "Bridging science/engineering, social sciences and humanities in the educational system".

Summing up, fostering inclusive and frugal innovation, and transformative change more generally, requires alternative knowledge policies in a broad sense, while this in turn does not look feasible without incorporating actors usually excluded, that is, without connecting popular actors and advanced knowledge. And so, the problem shifts from policies to politics.

3.2 On alternative 'historical blocs'

Neoliberalism dominated the ideological and political landscape in Latin America during the last years of the 20th century. The consequences were negative for equality and for sustainability. In many cases they were also negative in terms of economic growth. Relevant social actors resisted neoliberal orientations, often converging with progressive parties in more or less formal coalitions that opened the way to popular governments. Their programs gave priority to diminishing poverty and inequality, an issue in which they were quite successful as they came into office when the commodity boom was starting. Such programs gave attention, in some cases, to sustainability, an issue concerning which they were on average much less successful. Grosso modo, complying with the redistributive programs seemed to require economic growth based on extractive activities and current technological patterns. Conflicts were frequent, often opposing poor people in need of jobs who could only find them in polluting activities and poor people living in environments highly damaged by such activities. Main social and political actors related with deprived sectors don't seem to be aware of, or believe in, assertions like the following one: "The essence of sustainability lies in the recognition of agency in social choices about technological futures." (Smith et al, 2005: 1508)

Neoliberal ideologies and policies are once again on the rise in Latin America. Economic, political and ideological factors help to understand such momentous change. Among economic factors one pretty obvious is the weakening of the external demand for commodities. In such context the politics of distributional coalitions poses increasingly hard problems. Different strategies were followed in different countries but, broadly speaking, changes were pursued only in the realm of social relations, not in the realm of interactions between social relations and technologies, because technology is more or less implicitly assumed to be given, that is, beyond the reach of popular agency. Thus, for example, alternative socio-technical configurations for wind energy, where different ideas and power positions are at stake (Smith & Stirling, 2018: 72), are simply below the radar of most popular actors. Here ideological power operates; Mann explains that one of the sources of ideological power is the human need to know how the world works. Popular and progressive actors in Latin America have been challenging strongly up to recently the idea that there is no alternative (TINA) concerning social power but they seem to accept TINA concerning technology.

"We historians of technology should challenge the view that there are no real alternatives to the currently dominant unsustainable energy, mobility, food, water, healthcare and other sociotechnical systems whose guiding routines are focused on intensive use of fossil fuels and other natural resources, waste production, mass production, mass consumption, mechanization, labor productivity. This is unsustainable because the costs and benefits are distributed in a highly unequal way and their so called externalities, for example global warming, threaten the future of our planet. For sure, if we continue to cling to an ideology fuelled by a belief in the power of the market and innovation to solve all problems, we will not be able to stop climate change and we will make ordinary people pay for the costs. As a society we need alternatives to these sociotechnical systems that have reached the limits of their capacity to

adapt. We need to provide these alternatives, without giving up democratic ideals and giving in to a technocratic super State.” (Schot, 2016)

Incumbents are frequently backed by the power of international finance, trade regulations and property rights, as Andersen and Johnson (2015: 289) show in the case of coalitions in the South that try to provide low-carbon technologies. Since popular actors and advanced knowledge are usually estranged, alternatives are not easy to build. This is surely not the only big problem concerning transformative change towards social and environmental sustainability, but we conjecture that Sustainable Human Development cannot ignore such problem.

Different approaches to such challenge are needed. One of the several merits of grassroots innovation is its potential contribution in that direction. Grassroot innovations have been characterized as the outcome of the joint work of networks of different socially engaged actors to generate bottom-up solutions, where central issues include the interest and values of the communities concerned as well as the control they have over the process involved and the outcomes. (Smith et al., 2017: 3)

“The cultivation of knowledge, skills, capabilities, working practices and community development is simultaneously a requirement for grassroots innovation and a measure of successful outcomes.” (Smith & Stirling, 2018: 84) Perhaps it opens possibilities for popular actors to have agency not only in the realm of social relations but also to (i) connect with advanced knowledge and (ii) fight in socio technical regimes.

In previous papers focused on knowledge democratization (Arocena & Sutz, 2017) we have given special attention to the generalization of advanced and active learning directly connected with creative work. Something related with such aim is presented as follows: “Grassroots innovation and innovation democracy have important implications for training and skills acquisition at all levels in society. They require the rethinking of current ways in which training is organized, supported, and practiced. (...) actions might most productively aim at enabling skills to be acquired in more interdisciplinary and problem-oriented ways; combining intellectual and practical skills and reducing barriers between trades and professions.” (Smith & Stirling, 2018: 87)

Mann’s theory of power stresses the relevance of interstices, seen as social spaces not completely covered by institutionalized power relations, so they can be sites where new types or relations can emerge. The notion is clearly related with those of niches as described in the transformative change framework. Interactive learning spaces can be niches where interstitial emergence (a clue notion in Mann’s theory) takes place. Now: “Innovation often feeds off more subversive cultures, and grassroots innovations contribute spaces for being subversive. By this we mean providing opportunities to challenge dominant visions and values, to suggest other arrangements that are counter to the prevailing institutional orders, and to disrupt particular patterns of authority and domination in society.” (Smith & Stirling, 2018: 91) That is what interstitial emergence means. Mann says that such notion is based on Marx’s characterization of the emergence of the bourgeois society in the pores or interstices of the feudal society. A comparable “deep transition” seems necessary if sustainability is to be guaranteed.

Hess (2013) offers a “political coalition perspective” of transitions towards sustainability. It draws attention not only to state actors but also to non-state actors, as incumbent regimes, grassroots social movements and actors that may be associated with countervailing industrial power.

Above it was stated that transitions oriented by the notion of Sustainable Human Development are often blocked by hegemonic 'historical blocs'. When thinking about alternatives, counter-hegemonic alliances seem to be necessary. It is worthwhile remembering that, for Gramsci, “a critical component of any full hegemony was the creation of a 'national popular' will and culture.” (Anderson, 2017: 90)

National popular movements oriented to the left of the ideological spectra have been main components in many of the politically progressive coalitions that have been in office recently in Latin American experience. In several cases such coalitions have deep roots in the civil society struggles against military regimes in the 1970s and 1980s. Ideologically they were built in the opposition to the predominance of neoliberalism during the 1990s. Politically they were able to win several elections during the first years of this century. Economically they brought the state back in such a way that distributional policies were quite successful. Sustainability was a major concern only in Bolivia and

Ecuador, where ideas and actors linked with “indianism” were fundamental; but nowhere Sustainable Development policies had a leading position. The “national popular’ will and culture” did not include an autonomous conception of knowledge neither of the interactions between social relations and technology. Thus counter-hegemonic alliances lacked specific knowledge policies related with inequality, underdevelopment and the environment. In such conditions it is very difficult to tackle that great tension of our time between production and sustainability; in order to be able to finance distributional policies economic growth was fostered in ways that scarcely challenge underdevelopment but threaten the environment. In a word, such alliances can be termed distributional coalitions, not developmental or transformative coalitions. It seems less than probable that alternative ‘historical blocs’ may become deeply transformative if advanced knowledge is kept distant from popular actors.

Conclusions

The prospective main question is not if a great transition will happen but what type of transition(s) will take place.

It is said that the “Great Acceleration of the post-1945 period” -first of all in the growth of human population and in the use of fossil fuels- launched the Anthropocene as a period where the human impact becomes a main factor in the history of the Earth; it is anticipated that such impact will be moderated because both processes of growth are in course of deceleration, but Humankind will keep living in the Anthropocene (McNeill & Engelke, 2014: 208, 209). Lasting consequences will have the “Great Acceleration”; some of the more momentous are problems stemming from climate change, as the alteration of water supply and precipitation patterns, the frequency and damage generated by extreme weather events including heat-related human death, the rise of sea levels and the spread of infectious diseases (Ibid: 69).

Prevailing production and consumption patterns compound such problems and environmental damage more generally. They also seem to foster inequality that, as already recalled, is connected in several ways with lack of sustainability. That does not mean that technological and economic prevailing trends cannot persist and even expand in some regions, as happened during the heydays of the second globalization, most notably in China. But it does mean that, if persistence dominates (the interactions between) technology and economic relations, great shocks will keep taking place at the level of ideological, political and military relations; both persistence in the former and shocks in the latter will increase climate damages.

In fact, the ideological and political landscape of the West has already been spectacularly altered. A main consequence is the decision of the US to retire from Paris Climate Agreement. Sustainability and equality are being harmed by the different processes that have been weakening democracy. Neoliberal globalization, propelled by the capitalist knowledge society, has concentrated benefits and decision power in the top echelons of social stratification, the 1%. The chauvinistic reaction in the central countries backed by many losers of globalization and fond of tough ways of handling social conflicts, is a second process that weakens democracy and makes the international institutions less able to cope with global threats, including nuclear and climate. Similar consequences stem from a third process, the concentration of power in the top vertex of increasingly authoritarian regimes, particularly in the main challengers of Western hegemony.

The three processes – in order to be brief let us call them neoliberalism, chauvinism and authoritarianism – leave small spaces open for democratic and plural engagement in collective decisions. Directly or as defect options, because most people are pushed to be patients (including the cheerleaders of strong men), they foster individualism and consumerism. Decreasing satisfaction of the many is to be expected concerning their possibilities of living lives they have reasons to value.

Can counter-hegemonic worldviews and agency open better possibilities? Our developmental reading, with an emphasis on power, of the National Innovation Systems and the Transformative Change conceptualizations stresses some of the several necessary conditions for an affirmative answer. One seems to be the expansion of frugal and inclusive innovation as a project in the realm of interactions, first of all, between ideology and technology. It requires reinvigorating in a new sense a lesson from the past: “Technologically progressive societies were often egalitarian ones.”

(Mokyr, 2017: 17) The type of innovation that is needed should define what technological progress means.

Yesterday, when development was a task for the South frequently equated with economic and technological catching up with the North, it could be imagined that economic backwardness could in some sense be an advantage because it could help to progress quicker than advanced countries by learning from their experience. Today, when (sustainable human) development is a global challenge, a very different advantage can be detected in (some regions of) the South: the capabilities to innovate in scarcity conditions (Srinivas & Sutz, 2008) are potentially inclusive and frugal; if strongly combined with advanced knowledge and high qualifications, they can offer a powerful tool for overcoming underdevelopment and a reference for the North.

Frugal and inclusive innovation is being fostered in several niches, seen as interstices in prevailing power configurations, where in particular grassroots innovation promotes agency and interactive learning spaces connect advanced knowledge with the needs of deprived sectors. Distributed innovation can become systemic, ascending from niches to socio-technical regimes, if they are backed by broad alliances for transitions towards sustainability that are able to face economic powers that be. At the general or landscape level, we suspect that developmental coalitions are needed, based on popular actors and with feasible strategies for building inclusive learning and innovation systems; that is the role of politics.

Concerning such historic challenges, the role of academy cannot be but modest: helping to understand telling experiences, to anticipate possibilities, to suggest policies; perhaps above all, as Hirschman taught, cooperating in the detection of hidden or neglected resources that can be put to work for development. All that needs to organize ideas in conceptual frameworks that -as ideal types or focusing devices, not as ontologies- help to understand actual processes and inspire collective action. Often those two aims are difficult to combine. But collaborating with development understood as social transformation – as in the Latin American tradition and in several others – has never been a simple task.

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