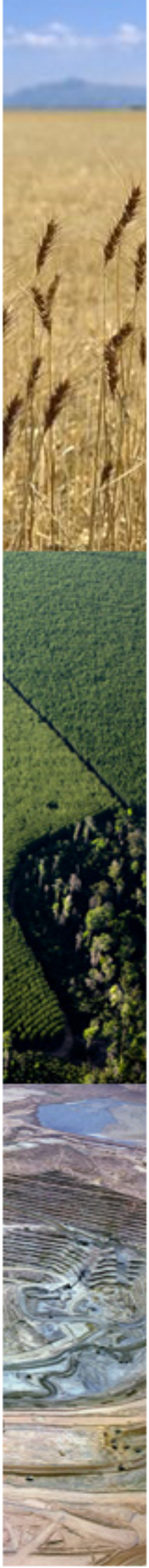

Opening up Natural Resource-Based Industries for Innovation: Exploring New Pathways for Development in Latin America

BACKGROUND PAPER | Towards a Framework for Analysing the Transformation of Natural Resource-based Industries in Latin America: The Role of Alternatives

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Background Paper: Towards a framework for analysing the transformation of Natural Resource-based industries in Latin America: the role of alternatives

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Natural Resource (NR) based industries are central to the economic structure of most Latin American Countries (LAC) economies. These industries are highly questioned on a number of grounds regarding their capacity to contribute to the development goals of the region. Most attention in the region has focused on how to change the economic structure to move away from NR based industries and, concentrate in the so-called high tech industries (e.g. IT, biotechnology, nanotechnology). In this project we focus on a different issue/question: *Can NR based industries get transformed so they can serve as a platform for development in the LAC region?* We know from the innovation literature that industries get transformed through the creation of alternatives (or projects which offer solutions to existing problems using different practices, technologies, organisational arrangements, etc.). In this paper, therefore, we explore a framework that will help us to identify and investigate alternative ways of exploitation of NR based industries in LAC. To do so we adopt and adapt some of the concepts and frameworks developed by the transition literature - interested in the unsettling of incumbent industrial structures which are problematic and the emergency and possibility of alternatives.

The paper is organised as follow. First, we discuss why we believe developing countries are now in a better position than in the past to develop their own alternatives, and in this way pathways of development. Second, we focus on the alternatives available for emerging economies: changing factor proportions and/or changing the industry or developing alternatives **within** industries. Third, we develop the socio-technical transitions framework, which is attracting increasing international attention amongst researchers because it tries to bring together the unsettling of incumbent industrial structures which are problematic and the emergence of alternatives. More specifically this framework proposes to bring together two aspects of analysis. Finally, we discuss how we might apply it to NR industries in Latin American contexts, and how we might make it empirically operational through a variety of research methods.

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1. Introduction

LAC are heavily specialised in NRs. Commodities based on natural resources account for at least half of the exports of two thirds of the Latin American and Caribbean economies. The exploitation of NRs has been and still is highly questioned on a number of grounds, but perhaps the four stronger criticisms that these activities have received are that they face low technological and demand dynamism, that they operate typically as enclaves at the point of exploitation, i.e. with very limited backward and forward linkages; that they are hierarchical and exclusive towards low income groups; and that they might produce long term social and environmental damage (Hirschman, 1958; Singer, 1974; Sachs and Warner, 2001; Auty, 1990; Gylfason et al, 1999).

These observations have led some analysts and commentators to conclude that natural resources are incapable of serving at the core of a development effort in LAC (e.g. ECLAC, Cimoli and Porcile 2009). Under this view, the principal challenge is to re-structure LAC economies in ways that move them away from NR dependency, and instead establish other (knowledge-based, high added value, and inter-linked) sectors at the heart of their economies. The economic development challenge over the last 20 years has been seen in terms of inducing a structural shift into knowledge intensive sectors, for example, ICT sectors, or biotechnology.

Though undeniably important, these structural arguments have to contend with the persistent significance of NR industries to LAC economies today and for the foreseeable future. On the one hand, this can appear quite alarming, since LAC economies remain locked-into dependencies upon international commodity markets. On the other hand it opens up a re-structuring question complementary to the rise of new sectors: might NR sectors themselves be transformed and re-structured in ways that render them less problematic for LAC economies, and actually allows them to play a more progressive role in economic development (Perez, 2010). **The transformation of NR sectors has received much less attention in research and policy circles. It is the focus for this research project.**

Industries get transformed and re-structured; the literature on innovation tells us, through the creation of alternatives, or new projects which propose technologies and organisational practices that departure from the conventional ones in a given industry. Within each industry there are dominant ways of solving problems, and alternative ways of addressing them. The dominant ways are the ones more widely spread that privilege the mainstream, and are highly institutionalised, benefiting typically from a historic accumulation of technological, institutional, infrastructural and social supports. The alternatives are practices that departure from these highly institutionalised ways of solving problems, and typically promise better economic, social and/or environmental results than the dominant ways. They can be more or less radical. The more radical ones, will be truly *path- breaking*, in the sense of transforming the industry and eventually taking it in a different direction of change - or pathway. The less radical ones, instead, will be only *path-repairing*, through feed backs into the dominant pathway. The overall aim of this paper is to develop a framework that helps us to identify and explore different types of alternatives (more or less radical, we are interested in both) within selected NR based industries, and study their evolution in relation to their capacity to transform problematic NR industries, as path repairing or breaking.

Conventionally, emerging economies have found it difficult to maintain, develop and/or select their own alternatives. Section two of this paper, discusses a number of reasons why it might now be possible (but with considerable effort) for emerging countries to open up industrial structures (NR and others) and develop technological and organisational alternatives of development that better fit their own market conditions and institutional and political forces. In association with this discussion, in this section we introduce the notion of pathway, a concept increasingly utilised in the innovation literature, instead of trajectory, to refer to directions of change in a less deterministic way. Section

three of this paper focuses on the alternatives available for emerging economies that one can find in the development and innovation literature: changing factor proportions and/or changing the industry. In that vein, section three discuses ideas from the appropriate technology movement and the sectoral systems of innovation literature. Each has something to contribute, but is also problematic. Section three concludes, therefore, by introducing a different perspective to approach the study of alternatives in emerging economies, a **socio-technical transitions framework**. This approach emphasises the possibility of developing alternatives **within** industries. It is this feature of the framework that suggests promise for our research aims. Section four develops the socio-technical transitions framework, which is attracting increasing international attention amongst researchers because it tries to bring together the unsettling of incumbent industrial structures which are problematic and the emergence of alternatives. More specifically this framework proposes to bring together two aspects of analysis. The first aspect analyses incumbent structures of exploitation in NR industries, and their associated technological trajectories, and why these are problematic in terms of social, economic and environmental development. The second aspect analyses the development of alternative structures for exploitation (which advocates claim to lead to more progress development pathways), and assesses the momentum behind these alternatives. The two aspects come together when we consider the extent to which problems in the incumbent NR industrial structures provide windows of opportunity for the development of the alternatives, or, conversely, the momentum and commitments to incumbent NR trajectories effectively lock-out the robust development of alternative pathways. Section Five discusses how we might apply it to NR based industries in Latin American contexts, and how we might make it empirically operational through a variety of research methods.

Throughout the paper we use the situation of agriculture in Argentina as an example.

2. Developing alternative ways of exploiting NR in emerging economies: old limitations and new possibilities

The extraction and processing of NR, as with the production of any other good or service can be carried out at particular times in several ways, i.e. utilising different techniques and or ways of organisation; with different intensities of capital (machinery) and labour, and other inputs; with different types of labour organisation; with exploitations of different scale; with different degrees of integration of suppliers and costumer in the decision making process; with different forms of involvement, and linkages of other firms, and organisations; and with different types of networks, patterns of ownership, and forms of governance, among others. However, the trend, up to now, has been that at particular times, certain ways of organisation have prevailed over the others, and that they have diffused, typically from advanced to less advanced contexts. This is not necessarily because these have been the most efficient ways of organisation (or techniques in the neoclassical language), according to the relative price of factors, as the neoclassical theory would suggest[1], but because these techniques or ways of organisation have better fitted market and non market conditions at particular times (such as institutional factors, political forces, etc), of particular contexts, typically of advanced countries.

Conventional evolutionary economics has developed the idea of technological paradigm, and trajectory, to give account of the influence of both market and non-market conditions on the selection of particular technologies and organisational modes at particular times, and their evolution over time. A technological paradigm is a model and a pattern of solution of selected technological

[1] Neoclassical theory would suggest that there are infinite possible techniques, defined as the ratio K/L and that the more efficient would be chosen based on relative prices. Relative prices in turn are dependent on the relative abundance scarcity of each factor in each country. This assumes however, that products are homogenous among other things, so it does not hold when heterogeneous products are considered.

problems (Dosi, 1982). It is a collectively shared logic which narrows down the range of possible technologies and organisational modes available to solve economic and social needs, to a model of optimal practice to take advantage of a pool of general purpose technologies. Given some problems or needs, within a paradigm, certain technologies get selected to solve these problems and others are left excluded, based on "technological potential, relative costs, market acceptance, functional coherence and other factors" (Perez, 2009, p.186). Directions of change (or trajectories) are thus to some extent also determined by the current paradigm which function as a 'selection environment' for the further creation and retention of innovative variants, generated either within or beyond the regime.

Within this theoretical framework, technological paradigms are relatively stable, however, from time to time new paradigms and directions of change (or trajectories) emerge. The emergence of new paradigms and trajectories is usually associated with (a) difficulties and unsolved technical and other problems, which put pressures on existing practices, thereby inducing change, (b) changes in consumers values, attitudes, behaviours, which influence the selection criteria on the basis of which technological trajectories are chosen, (c) scientific developments, which open opportunities to solve problems in new ways, so challenging existing trajectories (Dosi, 1982). The idea is that at the time of changes several competing patterns of solution would be available. Nevertheless, then, one trajectory would emerge (the one that more easily can benefit from existing institutional and political forces) and then diffuse.

Developing countries are not seen as playing active roles in shaping patterns of solutions, and selecting "the" trajectory followed by industries. This is because, they have been typically adopters of technologies and directions of change shaped in advanced contexts, responding to political forces and institutional forces of these contexts. Some analysts, however, believe that the historical circumstances that have explained this situation up to now have started to change during the current IT period (e.g. Perez). This is because the current paradigm is allowing and creating incentives to develop all kinds of diversity: diversity of goods, technologies, directions, etc. During the Fordist period high value was associated with standardisation[2], during the IT period instead, what is worth is differentiation. This shift is reflected in the innovation literature, which has started to use the term pathway instead of trajectory to refer to directions of change. A pathway is the particular direction in which interacting social, technological and environmental systems co-evolve over time to solve particular social problems (Leach, Scoones and Stirling, 2010). The term 'pathway', includes a broad set of possible, alternative directions for innovation, and embodies the idea that directions of change can be shaped by actors, policies, institutions, etc. Trajectory, instead, appears relatively autonomous and determined, with little room for re-directing it.[3]

The following set of issues is increasing the possibilities of developing countries to develop their own pathways of technological development.

[2] During the Fordism (or mass production period), most industries in most countries had to adopt similar techniques, those that were useful to gain scale economies, standardise products and save costs (Nelson, 2008), typically from advanced countries. There were few incentives and market and technological possibilities for differentiation; capabilities, R&D and others, were mostly concentrated in advanced countries; innovation processes were mostly centralised, with little involvement of users and other stakeholder (following typically a lineal model); MNCs concentrated most of their innovation activities at home, typically in advanced countries, and communication between central and remote places was difficult. During the current IT paradigm, however, which favours and allows for easy communication and diversity of all kinds, these conditions are changing.

3 In this project, we use the term trajectory therefore more often to refer to the direction of change associated with the (highly institutionalized) dominant way of solving problems and the term pathway, to refer to the real and potential changes associated with alternatives.

First, we are experiencing an unprecedented segmentation of markets, which are increasingly demanding diversity; diversity of goods, processes, technologies, labour conditions, etc[4]. Developing countries have now then the possibility to sell to global markets unique products that take into account their unique resources and capabilities to satisfy this diversity, and given the links existing between products and process technology, this means that now they have the chance to have a greater participation in the choice and shaping of their own technological pathways. Moreover, we are witnessing a geographical decentralisation of innovation activities, involving increasingly remote places in emerging countries, and the associated diffusion of knowledge and capabilities across borders (capabilities are now spread, not just informal R&D labs, but also across all the skills necessary to produce. In 1970, only 2% of global R&D was conducted in developing countries, in 1990 10.2% and in 2000 21% (Bell, 2007). These trends are increasing the possibility that emerging countries can become involved in the development of their own technologies and organizational arrangement, particularly in areas of NR which require local knowledge (see more below) [5].

Second, some emerging economies, which are growing in importance, such as China and India, are taking the lead in developing unique products and technologies which are better suited to the conditions of developing countries. Examples of these types of products include, the development of cell phone pay as you go airtime, portable water filters, electricity free refrigerators and chargers, cheap laundry soaps and detergents and cars (Tata) (Kaplinsky, 2010). These developments could play an important demonstration effect, encouraging other emerging economies to follow similar pathways. They are also generating knowledge which could be relevant for other emerging economies, interested in following similar trajectories, to the extent that they share similar contextual characteristics. The growing importance of south to south investment and trade will definitely help in the process of diffusion of these practices and knowledge.

Third, MNCs, which played a key role in the diffusion of standardized products and organizational arrangements across countries during the Fordist paradigm, are now descentralising innovation activities and are providing their subsidiaries with degrees of freedom to carry out local explorations and alliances hitherto unimaginable (Marin 2007; Marin and Arza, 2009). Developing countries thus could "use" subsidiaries in ways that they were not allowed before, in order to develop technologies better adapted to their local conditions, which will be useful for both the local context and the corporation.

Fourth, the diffusion of new IT technologies is increasingly allowing and encouraging connections between different centres of knowledge creation and remotes sites, in ways unimaginable before. Remote sites are not any longer disconnected, they can now get involved in processes of knowledge creation using better their own resources and capabilities, combined with external knowledge and

4 Some consumers in advanced contexts are paying higher premiums for a more diversified set of goods, often and increasingly that incorporate methods of production and characteristics that respect environmental and social challenges in the context where they are produced. The growing importance of "gourmet" eating and health concerns (resisting additives, pesticides, GM crops, etc.) – together with the quest for ethical and environmentally friendly products – and the increasing importance of market segments such as "organic" or "direct" that command premium prices because of health and social concerns, are just a few examples of this segmentation in NR markets. There is also an increasing mass of consumers from the growing emerging economies which are willing to pay for goods with different characteristics, which are more adapted to their realities e.g. lower quality in some cases, collective goods, specific or generic drugs, seasonal goods, etc

5 Also, the diffusion of new IT technologies and the transformations of the transportation services to handle small quantities and special requirements with high efficiency and decreasing costs, is enabling firms in emerging countries to take advantage of these new opportunities to sell in world markets, by facilitating the ease of direct communication with specialized users or distributors (this allows both the acquisition of information about the precise characteristics of a required material, for example, and the identification of sufficient clients to build a reasonably sized niche), and making it possible to cater to a globally disperse niche by producers spread all around the world.

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capacities, necessary to get involved in global networks. This can help them in two ways in the process of developing their own technological pathways. On the one hand, they can acquire knowledge and capabilities that then can be used to develop technologies better adapted to their context. On the other, they can have a voice in the shaping of the knowledge and innovations that will shape future technological trajectories.

Fifth, more specifically, in the case of industries related to NR we are experiencing an incredible process of knowledge intensification linked to these activities, which is opening new opportunities for emerging economies highly specialised in these activities to get involved in the process of creation of this knowledge, since a lot of it has to be local, due to the characteristics of NR. The case of agricultural machineries in Argentina exemplifies this point (see Box 1). Generic applications need to be adapted to local climate and soil conditions meaning that knowledge activities have to take place in situ. Local actors, then which have gained experience in knowledge creation activities, can use this experience in the development of technologies and pathways which are better fitted to local requirements.

In sum, there seem to be new opportunities for developing countries to play a more active role in the selection and development of their own technological alternatives that better fit their own economic, social and environmental challenges. Some emerging economies have started to do so, as described above. However, we should be cautious. Most developing countries are still heavy importers of technologies, paradigms, and directions of innovation, selected and mostly developed in the context of advanced economies. Important challenges still need to be addressed so that developing countries can take advantage of these new opportunities.

The most important of all these challenges is perhaps the need to develop not only technological capabilities, but also "selection" and "shaping" capabilities. Innovation studies during the last 30' years or so have deepened substantially our understanding about the kind of technological capabilities that need to be developed in emerging economies to catch up "along trajectories of technical progress that had already been mapped out by prior innovation in advanced economies" (Bell, 2009)[6]. We think that these studies have made a substantial contribution to the understanding of innovation in emerging economies. However, if indeed new opportunities exist, for developing countries to develop their own technological alternatives opportunities, then we need to pay more attention to the capabilities necessary for producers, consumers, policy-makers and citizens in developing countries to select and shape their own technological pathways, many of which will not be concentrated so much on firms, but more dispersed around the social machinery.

We explore in more detail the dimensions that need to be considered when exploring these kinds of capabilities in Section 4. Before that, in Section 3, we discuss some different types of alternatives available for emerging economies that have been discussed in the existing literature.

3. Available alternative pathways for emerging economies: what the development literature has to tell us

The development literature has been concerned with the different alternatives open for developing countries regarding technology since the 1970's, with the Appropriate Technology (AT) movement. At that time, however, debates about alternative technologies, following the neoclassical tradition,

[6] These studies have emphasised the importance of incremental forms of innovation (as opposed to radical innovations) and organizational changes for emerging economies, the centrality of firms in the process of building and accumulating technological capabilities, the key role played by innovation capabilities as opposed to production or operational capabilities (the ones necessary to use existing capabilities), the importance of non R&D capabilities, such as design and engineering, entrepreneurial, marketing and project executing capabilities, learning activities within firms, increasing knowledge linkages between firms, and so on (Bell, 2009).

focused most attention on capital/labour ratios, and/or on issues related with the scale of the production units encouraged. Emerging countries, which were assumed to be labour abundant were advised to choose, among the infinite techniques that were supposed to be available, technologies – or factor proportions – which were intensive in labour, and small scales of production, which were supposed to be more compatible with the reality of emerging economies. The focus of this literature was certainly helpful in raising the question of alternative possibilities, and introducing some plurality into the discussion and analysis of technologies in emerging economies. However, this literature said very little about the contexts of choice, which may constrain the ability to choose freely (Willoughby, 1990)[7].

More recently, most developments studies, particularly in LAC, have abandoned the ideas coming from the AT movement and started to focus almost exclusively on the kinds of goods and industries that should be encouraged in emerging economies. The dominant idea is now that certain industries carry more potential for development than others because they provide more opportunities for technological innovations and growth, linkages and diversification. Developing countries, thus, are encouraged these "more dynamic industries", regarding both to markets and technology, because they are thought to provide more opportunities for growth.

Under these views, NR based industries are not considered to be dynamic, as discussed above but worth reiterating here. First, because they are typically considered to be low tech, i.e. with limited investments/efforts in knowledge and technology related activities. So, they are often thought to offer limited opportunities for innovation, for furthering diversification and for inducing linkages with other sectors of the economy. Second, because they are considered to be mature, i.e. in the latest stages of development in their life cycle, when technologies, goods and markets are consolidated, dominant design exists and barriers to entry are high. So, they are thought to offer low opportunities for innovation via introduction of new products and technologies, and by new entrants (which explain a high proportion of the growth of industries)[8].

One strong assumption under all these views is, however, that once the industry gets selected, the technology and trajectory and implications for development are determined. This is in line with ideas coming from the sectoral systems of innovation literature which suggests that each sector is characterised by a particular knowledge base, demand, institutions (e.g. norms, routines, laws, regulations, policies, standards), and set of firms and their networks of interactions; all of which affect the organization of innovative activities within these sectors, and therefore its trajectory and potential to contribute to a process of growth and development.

The emerging field of transition studies offers an alternative perspective. This literature emphasises the existence of competing pathways within each activity (or industry organized to satisfy societal functions, such as the utilization of NRs) (i.e. intensive or organic agriculture), some of which are

[7] Without accompanying changes to wider social, economic and institutional contexts for technology choice, it can be difficult for these alternatives to flourish. Such historical experience is important for the study of alternative development pathways for NR industries, since it suggests the analysis of pathways has to attend not just to the narrow characteristics of technologies, but also the qualities of the social, economic and institutional changes that have also to be a part of the pathway. Some within the emerging 'social technologies' movement in Brazil and other countries of Latin America (and which has family resemblances to appropriate technology) recognise this interdependent linkage between societal change and technological choice.

[8] These concerns have been around for more than 60 years now, since Prebisch (1950) and Singer (1950) presented their (then) radical ideas about the declining terms of trade of NR-based industries. The fact that many East Asian economies have experienced extraordinary growth and development trajectories over the last 30 years without having enjoyed large endowments of natural resources has given more credence to these perceptions. But, rejection of NR industries as potential drivers of growth became particularly acute from the 1980s onwards when a large body of literature began to emerge around the so-called 'Resource Curse': postulating that large endowments of natural resources can hinder development prospects (See Auty, 2001; Sachs and Warner, 1995).

characterized as dominant, if they are more institutionalized and benefited by existing infrastructures and knowledge, while the others are characterized as niches, when they offer alternatives to the historical way of solving a societal function. The relevant question becomes thus, not so much which sector to choose, but rather which socio-technical regime to encourage within each activity, in this case NRs, in order to increase the potential contribution of this industry to development. It is precisely for this reason that this paper makes the case for moving from a sectoral innovation systems perspective to a transitions approach to study the potential transformation of NR based industries based on the emergence of alternative ways of taking advantage of the resources.

The idea of a 'socio-technical' regime developed out of earlier ideas about technological regimes and paradigms. A socio-technical regime is an established configuration between technologies, institutions, infrastructures and human behaviour which has developed over time to realize solutions to an economic problem/opportunity or a societal function/challenge (Geels, 2002). In our case here, the societal function that is being addressed is how to take advantage of NRs in a region which is NR abundant. A regime has different social and environmental implications compared to the implications arising from less established, niche alternative configurations. The transition literature explores the factors shaping contending socio-technical configurations and contributing to the selection of particular pathways. Dominant, regime-derived pathways are defined as those that privilege the mainstream, and highly institutionalised, way of solving problems that benefit from a historic accumulation of technological, institutional, infrastructural and social supports. Niches or alternatives, on the contrary are considered a source for transformative ideas and capabilities (note: regimes began life as niches). We turn to this framework in section three.

4. A socio-technical transitions analytical framework

In any given industry, the central problem for researching transitions to alternative pathways is to understand whether, and how, we move from a relatively stable and incrementally innovating 'regime' of socio-technical configurations, and towards much more economically integrated, environmentally sustainable and socially just regimes. The socio-technical dimensions of these regimes consist in (Rip and Kemp, 1998; Geels, 2002; Smith, 2007):

- guiding principles and search heuristics,
- knowledge base,
- favoured technologies,
- industrial infrastructures,
- user relations and markets,
- dedicated policy institutions and political power, and
- cultural meaning attached to specific regimes.

We can use these dimensions to characterise the socio-technical regime associated with any given NR industry, but also to characterise the *envisaged* (and often poorly formed) socio-technical characteristics of alternative niches and their development pathways.

The regime and alternatives can then be compared and contrasted in order to get some sense of the multiple dimensions of radical change that each alternative demands. Some will 'fit' quite easily into a reformed regime; others imply a complete transition to a new regime, were they to become the new regime. So, for example, a move from export-led, soya-dominated agriculture to intensive mixed farming is relatively easier than a move to organic farming in terms of capabilities, technologies, markets, and institutions. Transitions analysis is interested in interactions between regimes and niches across these multiple dimensions, the intermingling and contentions between pathways, and how the development of alternatives in 'niches' may over time transform the

dominant regime and lead to new pathways of development. As an example, Table 1 shows the different dimensions that characterize conventional or industrial food production vs organic food production.

Socio-technical dimension	Conventional food	Organic food
Guiding principles and search heuristics	- Maximise output using external inputs.	- Optimise output within natural constraints.
Knowledge base	- Biochemistry. - Food technology. Transport logistics.	- Soil science and ecology. - Crop varieties. - Seasonal food.
Favoured technologies	- Agrochemical inputs and pest control. - Animal disease controlled with drugs.	- Crop rotation, nutrient recycling, biological pest control. - Animal health promoted through careful husbandry.
Industrial infrastructures	- Specialised and intensive production, e.g. dairy, arable, vegetables. - Multiple/large commercial operations. - Globalising food chains.	- Mixed production of crops and livestock on single farming unit. - Ideal is mixed farm. - Local food economies.
User relations and markets	- Farm outputs supplied to food processors and supermarkets. - Processed and packaged foods.	- Consumption of farm output is close to source of production. - Whole-foods.
Dedicated policy institutions and political power	- Price support for outputs. - Extension services provide information about knew agrochemical inputs. - Public R&D.	- Certification of organic standards. - Financial help for conversion to organic. - Specialist extension services.
Cultural meanings	- Food for profit / convenience.	- Food for sustainability.

Table 1: Socio-technical dimensions in conventional or industrial food production vs organic food production. Source: (Smith, 2007).

4.1 Analysing socio-technical regimes

The starting point for socio-technical transitions analysis is to understand the multiple path-dependent processes that provide a broader, 'socio-technical' explanation for existing industrial forms (cf. sectoral innovation systems). A regime perspective views industrial actors as tending to favour incremental innovation and systems improvement over radical innovation and systems transformation. This arises from a host of processes that promote stability, informs governance strategies, and perpetuates the regime trajectory (Walker, 2000; Unruh, 2000). These processes include:

- *Capabilities.* The innovation activities of incumbents are constrained by existing capabilities and knowledge (Dosi 1982; Nelson and Winter 1982), which channel technical developments into restricted subsets of all possible directions (Kemp et al., 1998; Elzen et al., 2004). Innovative activities and investments are also constrained by existing beliefs and perceptions, routines and habits. The accumulation of capabilities around the use of Zero Tillage technologies in the agricultural sector in Argentina is a good example of how this mechanism operates. This is limiting explorations in other possible directions within the agricultural sector (such as ones involving for instance rotation between agriculture and cattle) but also in related sectors, such as the agricultural machinery sectors, as showed in the example discussed in Box 1.

- *Economics.* Existing technologies tend to be cheaper and more efficient in the short run because they have benefited from long periods of dynamic increasing returns (e.g. learning-by-doing and using, scale economies and positive network externalities). This puts them in advantageous positions compared with novel practices (Arthur, 1989; Dosi 1982), and explains why developing countries adopt them massively in most industries, particularly in the export-led industries. Thus, they face important economic barriers to move to uncertain alternatives, since this means departing from important economic benefits gained from investment in existing technologies. The adoption of GM in the agricultural sector in Argentina once again provides a good example of this economic barrier to change. GM soya bean explains 25% of the country exports, and 8% of all tax revenues. Moving to alternative technologies in this sector would mean therefore that the government has to offset one of the most important sources of income at the moment, which is also being used to maintain the current exchange rate, and therefore the only industrial policy of the government.
- *Vested interests.* Incumbents have sunk investments (in capital, competencies and social networks, for example) that they will try to protect. They therefore resist radical change that threatens them. Large, established industries may contain divisions and individuals with more radical ideas, but they are less often empowered to implement these if core business interests are thereby challenged.
- *Politics and power.* Incumbent businesses, regulators and others enjoy important positions in the current system. Economic power bestows considerable influence; they have voices that will be listened to by innovation policy processes (Smith et al., 2005). Innovators outside this nexus rely on future expectations to make their case. 'Outsiders' need not be small players, for example large information technology companies can be outsider innovators, but have a potentially transformative role to play in a move to 'smarter' technologies that threatens some incumbents. However, 'outsider' innovators are often relatively weakly organised compared to incumbents. Whilst today's shareholders, workers and customers can invest, vote and exert influence in numerous ways, tomorrow's stakeholders in more sustainable systems are a constituency less immediately powerful politically or economically. The Argentinean agricultural system assures that the voices of big business are heard by providing companies, such as Monsanto, Singenta, Dow and Bayer a place in the discussions of Conabia (the main body responsible for GM approvals).
- *Infrastructure.* Existing technological devices may be embedded in dedicated infrastructures that make their substitution with alternatives difficult (Jacobsson and Johnson, 2000).
- *Institutions.* Government regulations and subsidies, professional associations, and market rules have co-evolved as part of existing systems and tend to reinforce existing trajectories of development (Hughes, 1983; Walker 2000). In the case of Argentina, the way these different institutions have evolved together to provide support for the use of biotechnology in the agricultural sector has prompted some analysts to identify a Bio-hegemony in this country (Newell, 2007): "bio-hegemony has been produced and sustained by an alliance of interests which included powerful agribusiness producers and traders (such as Cargill), export-oriented elements of Argentine capital (such as Biosidus, Relmo, and Don Mario), multinational biotechnology firms (such as Syngenta, Dow and Monsanto), large commercial banks, and supportive elements within the Argentine state itself" Newell, 2009, p. 35).

These processes interact and mutually reinforce one another, thereby structuring the way industries commit to certain socio-technical trajectories rather than others (Geels 2002). Systems that have become 'locked-in' to these trajectories are difficult to unsettle and re-direct.

Innovation research in both evolutionary economics and STS traditions argues transformative processes be conceived as challenges of socio-technical re-configuration (Rip and Kemp, 1998).

Considerable technical, economic, sociological and political work has to be done to align discourses, actors, artefacts and institutions into a working ensemble. Consider all the material, discursive and institutional elements and changes needed to make an organic food system succeed: specialized knowledge, reliable techniques, skilled workers, investment capital, supply and distribution infrastructures, maintenance services, willing customers, profitable markets, acceptable environmental impacts, and so on, and so on. Considerable social agency is required.

Developing such highly novel, 'path-breaking' socio-technical configurations takes place in the context of the deeply embedded, substantially institutionalized and widely reproduced 'socio-technical regimes' characterised above (Unruh, 2000; Geels, 2002). At times, it can appear as though societies are 'locked-in' to certain regimes, such as the intensive GM soya bean complex in Argentina. However, inflexible path-dependent alignments can, under certain circumstances, become a source of fragility as circumstances change. For instance, in Argentina the highly concentrated benefits and dependencies under the soya boom, and the inability of the soya 'socio-technical regime' to address this problem through incremental reforms, is leaving this mode susceptible to criticism and growing dissent. In addition, internal misalignments, brought about by technical changes or shifts in ownership for instance, can combine with external processes, such as concentration of wealth, growing impoverishment, rising environmental awareness, demographic change, and resource shifts. Such processes can unsettle regimes and open windows of opportunity for alternatives to develop, and perhaps seed transitions towards radically different configurations.

Clearly, we are talking about a very complex and heterogeneous collection of processes here. There are a variety of ways of simplifying and thinking about that complexity. The multi-level perspective (MLP) on socio-technical transitions is one way (Rip and Kemp, 1998; Geels, 2002). It provides analytical purchase by suggesting a multi-level framework for situating and relating dynamically the structure- and agency-oriented processes above. The framework consists of three levels, each of which is increasingly structural and beyond the agency of individual organisations. These levels are:

- a niche level (in which organisations innovate alternative ideas and practices for the exploitation of NR).
- a regime level (in which the established practices of NR exploitation are highly institutionalised).
- a landscape level (which represents the social, economic and environmental context in which the NR industry is situated and operates).

Each of these 'levels' is elaborated below.

The innovative configuration of novel socio-technical practices (e.g. organic food, or cattle-and-forestry) is considered to take place in '*niches'*. These spaces of socio-technical agency afford some protections for the alternative practice, which cannot compete directly with the incumbent, more structured and structuring selection environmental associated with the incumbent socio-technical *regime*. An example could be to consider organic food, or the cooperatives of small producers in the north of the country producing vegetables, as currently constituting niches, in the context of a soya-based agricultural regime in which prevailing production infrastructures and institutions are highly disadvantageous towards these alternative systems.

In their different ways, both the niche(s) and regime(s) define and relate to a specific 'societal function', such as ways of exploiting natural resources. The realisation[9] of these societal functions is the starting point for the analysis and the reconstruction of the niche and regime socio-technical configurations. At the same time, niches and regimes are situated in similar '*landscape'* contexts, though they experience them and identify with them differently. For instance, processes articulating social pressure for reducing rural poverty (e.g. social movements, policy measures, new business

[9] We use 'realise' to denote the dual, iterative processes of, a) figuring out needs, and b) satisfying those needs.

strategies), means different things for actors and processes configuring an alternative food niche (e.g. a potential opportunity), compared to the incumbent soya regime (e.g. an inconvenience). Another landscape pressure might be industrial policy commitments to ICT or other industrial sectors, informed by re-structuring views on economic development, and which put pressure on NR sectors to argue and demonstrate their continued relevance for future economic development.

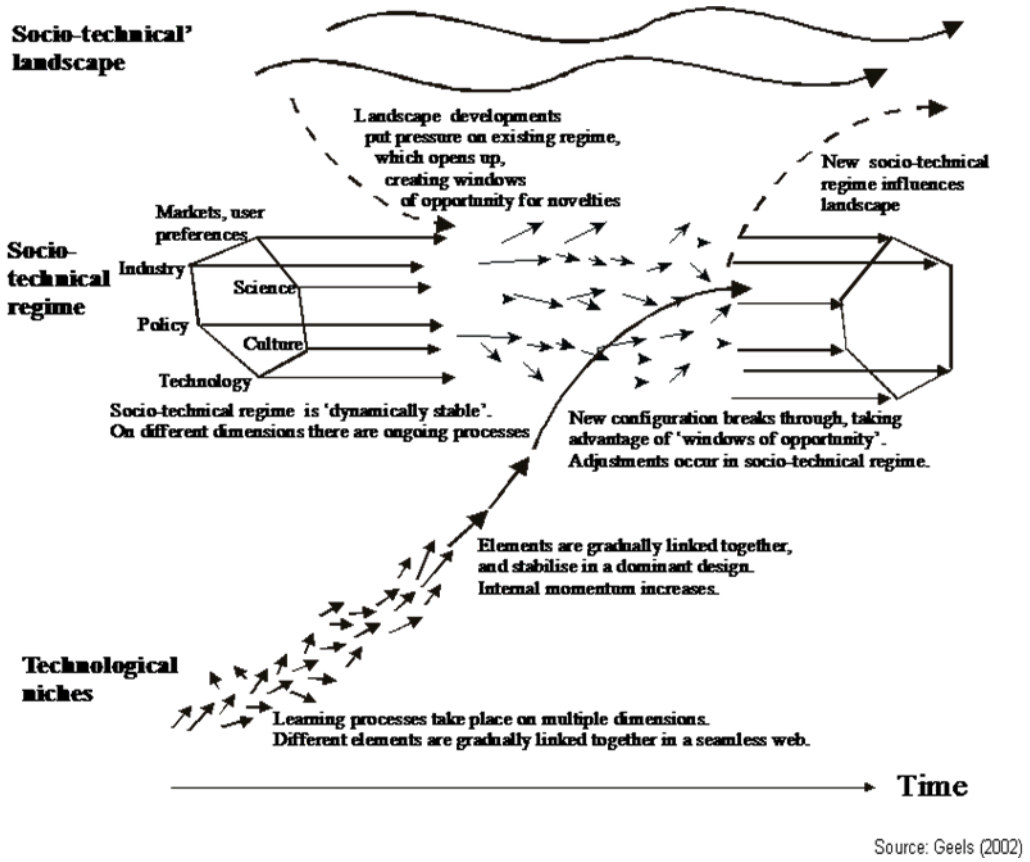

Figure 1: The multi-level perspective on socio-technical transitions.

The MLP theorises transitions arising through interactions between the three levels: it is the way niches, regimes and landscape processes interact that determines the specific transition process and the characteristics of any new pathway that develops (if any) (Smith *et al*, 2005; Geels and Schot, 2007). On rare occasions a niche develops and grows, and it displaces more and more of the incumbent regime provision. Hybrid versions emerge as niche ideas are appropriated into an adapting regime, and which gets changed as a result (Smith, 2007). Further destabilisations and growth opportunities arise, but eventually a new regime becomes discernable.

Research to date has used the MLP to orientate the analysis of various kinds of transitions:

1. Historical analyses explaining successful transitions at varying scales (e.g. the move from sail shipping to steam shipping, the move from coal/town gas to natural gas, the rise of the turbojet).
2. Analyses of current 'green' or environmentally sustainable niches, and explanations of the difficulties they face in becoming more widespread (e.g. wind energy compared to fossil-fuels).

3. Both 1. and 2. inform prescriptive and prospective uses of the framework that develop policy recommendations for 'strategic niche management' and 'transition policies' that might improve the chances of sustainable transitions.

Analytically, socio-technical systems of varying scales have been studied (e.g. international steam shipping, bio-gasification systems, eco-housing practices). Prospectively, policy jurisdictions of varying scales have undertaken transition policies (e.g. cities, regions, nations) (Loorbach, 2007).

The 'niche' and 'regime' is a matter of empirical definition; in terms of the scale of practice in which one is interested, be it transitions in agricultural practice, dominant processing technologies, entire food systems, or other units of analysis. The point is that one has to remain aware and open to activities going on beyond the core unit of analysis, and interpret them in terms of what it means for one's core research concerns. Contexts and pathways for change will vary from case to case for complex socio-technical systems (Smith *et al*, 2005; Geels and Schot, 2007). In the context of sustainability, it is the possibility of accelerating transitions away from unsustainable regimes and along more sustainable pathways deriving from niches that preoccupies analysts and policy-makers.

Here, a particular mode of 'purposive transition' or 'transition management' is debated (Kemp *et al*, 1998; Rotmans *et al*., 2001; Smith *et al*, 2005; Loorbach, 2007). Socially negotiated visions for future food or other systems form a point of departure for policy processes that back-cast to the deliberate experimentation with alternative niches (Rotmans *et al*, 2001). These niches are sites for social learning, expectation development, network building and, in cases where niches are promising, the institutionalisation of these practices through the development of further projects. Even in countries and situations where transition approaches do not form part of the policy institutions (which is most places around the world), it is nevertheless often possible to discern groups of actors trying to develop alternatives (e.g. entrepreneurs, civil society groups, research programmes).

The MLP has its challenges, which are not fatal but need to be borne in mind. It can give the false impression that the successful development of a niche and its displacement of an incumbent regime is inevitable and coherent. This is never the case. It is better to see multiple, incoherently-formed niches providing diversity and ideas, and that sometimes exert an influence over more mainstream and established systems.

The focus on 'transitions' has very much been influenced by a European concern to transform their economic sectors into more sustainable forms, such as the move from fossil-fuel energy sectors to low carbon energy sectors. Arguably, these kinds of transitions might not be so self-evidently urgent or relevant for Latin America. Irrespective of the normative concern, however, is the central focus of the MLP on problematic processes of lock-in, and a concern for avoiding lock-in through a diversity of niche options. This can be relevant for other normative concerns, such as more socially just or economically resilient patterns of development. Consider, for example, concerns about over-reliance and lock-in to highly concentrated forms of agricultural system (e.g. soya). Historically, these have been shown to be less resilient to international and national shifts in circumstance. Nor have they been responsive to these changes. The MLP analytical tool for understanding regime path-dependencies (and lock-in), and analysis of niches as sources of innovative ideas, capabilities, and alternatives that can protect against lock-in, could be useful for the Latin American context. It is in this sense that we are interested in the MLP, rather than transitions *per se*. The intellectual interest in this project rests in understanding whether and how the MLP can be adapted to the Latin American context, and a new, Latin American analytical framework developed as a result.

4.2 Analysing alternative niches

Of course, socio-technical experimentation in development is not new. What is promising, however, is the way the MLP situates this within a mid-range analytical framework that seeks to identify, contextualise and thereby understand wider developmental promise. It is noteworthy how development practice and the development literature are rich in exemplary local sustainability initiatives. These path-breaking projects suggest alternative pathways for NR industries. The local consequences of these initiatives are evaluated, praised or criticised; as are the processes by which the specific initiatives came about. Such contextually rich studies provide some helpful tips for others wishing to emulate the initiative elsewhere. However, broader institutional (political and economic) processes that influence the diffusion of path-breaking sustainability initiatives are beyond the full grasp of these micro-level studies. At the same time, macro-level analysis tends to abstract narrow technical and economic performance characteristics from the initiatives, for use elsewhere, much as we see in international technology transfer negotiations. As such, they imply a straight-forward and universal (neo-classical) calculus for deciding whether to adopt that presupposes an economic rationale or hurdle blind to the 'niche' contexts that enabled these initiatives to get established despite unfavourable regime selection pressures. Macro-level studies tend also to presume a single, rational decision-maker when the reality is of initiatives emerging and diffusing through networks of social and technological activity by differently situated and perceiving actors. Socio-technical transitions theory may well provide a link between innovative agency in local initiatives and incumbent structures of technological practice in their broader socio-economic contexts, and analyses their respective, interacting transformations over time.

Local projects (or experiments) can be conceived as contributing to networks of alternative practice (i.e. niches), and which can then draw upon hypotheses for how path-breaking 'niches' contribute to transitions to new structures. In this case, we are interested in how niche socio-technical practices in NR industries attain momentum through diffusion from one development initiative to another, and how this constitutes alternative pathways to exploiting NRs. Berkhout and colleagues consider the experience of 'sustainability experiments' in Asia and their contribution to niches and alternative development pathways. Sustainability experiments are understood as "planned initiatives that embody a highly novel socio-technical configuration likely to lead to substantial (environmental) sustainability gains" (Berkhout et al., 2010). These initiatives are where the earliest stages of a process of socio-technical learning take place.

Whilst the emphasis of these moves from Europe to Asia (and elsewhere) has rested mainly in environmental sustainability, the transitions framework can and has been used to study other normative issues, such as employment, social welfare, health, and economic development. So, for example, the MLP framework has been used to look at the transition to sewer systems and sanitation in urban centres (cf. earlier house-to-house collection or disposal in the street) (Geels, 2006).

Networks of similar initiatives can be conceived as **niches** that provide a protective space in which local-scale sustainable solutions can be nurtured, and from which they can be diffused into new localities and contexts. Existing transition studies suggest that niches grow and contribute to pathway momentum through three inter-linked processes:

a) **expectations** contribute to successful niche building when they are robust (shared by many actors), specific, and of high quality (substantiated by ongoing initiatives);

b) **social networks** contribute when their membership is broad (plural perspectives) and deep (substantial resource commitments by members); and

c) **learning** processes not only accumulate facts, data and first-order lessons, but also generate second-order learning about alternative ways of valuing and supporting the niche.

Niche practices become influential to the extent that processes 'a' to 'c' above become robust enough not only to facilitate diffusion, but also exert influence over wider institutional changes, such as policy support.

Future research needs to test the **hypothesis** that niches grow through replication of initiatives in different locations; that strategic learning across replicated initiatives facilitates scaled-up adaptations; and that elements of these translate into new business models and markets. Self-replicating diffusion is challenging for local initiatives; support is needed for both niche development and initiative-to-initiative networking. This suggests niches do not provide blueprints, but rather reservoirs of ideas and practices; and that dedicated work is needed to transfer and adapt from across locations, scales and contexts (e.g. into commercial prospects). Of course, given historic difficulties in scaling-up and diffusing exemplars, it is likely that future, niche-oriented research will also end up studying the difficulties experienced by our hypothetical path-building processes: when is social learning ignored; when do expectations deflate; and why do networks fragment? What wider structural changes are needed for niches to flourish? In sum, why are some niche pathways utopian?

An under-developed aspect to the transitions approach is the under-theorised relations between located socio-technical initiatives and the emergence of an influential, abstracted, niche-level identity and interest, based around stylised socio-technical practices. How do strategic niches influence institutional reform? This includes evidence that experience with, say, skills or infrastructure issues, gathered from earlier initiatives, is mobilized into demands for reforms to training policy, say, and industrial strategy. Whilst the literature argues successful niches prompt facilitating institutional reforms within the wider energy regimes, it is unclear why this would happen, given path-dependencies in those regimes. So what *political* roles do path-breaking sustainability niches need to play in order to influence these reform processes?

How do niche advocates develop collective **identities** and **interests**; what repertoires of niche activism press for reforms? Where are the 'opportunity structures' for pursuing demands? The social technologies movement in Latin America, and the appropriate technology movement of an earlier generation, are and were mobilising a set of political and institutional demands around alternative technological styles (Willoughby, 1990). Social technology advocates are aware of the broader social changes required for socially just and environmentally sustainable transformations, whilst seeing practical experimentation as furnishing a material base for such wider changes (see *Saber Cómo* 92, September 2010[10]).

On this latter point, we have to look at sustainability niches the other way around, from the external perspective of actors committed to the incumbent NR regimes. Sustainability transitions theory argues that niche performance is interpreted by actors situated in a wider context. Tensions emerging in mainstream NR regimes, such as crises of inequality, displacement and environmental sustainability, cast niche solutions in more positive light, and thereby attract interest from policy-makers and businesses worried about the regime. What innovations do sustainability niches offer concerned businesses and policy-makers in the regime? How do these solutions perform in terms of interest for, say, accelerating development, enhanced profitability, or reducing environmental impacts, and at what cost? This speaks to the translation mode of diffusion: what niche innovations can be adapted into reforming conventional development relevant under different contexts in the future? The structural influence of the political economy of NR regimes on niches is important here.

[10] http://www.inti.gob.ar/sc92/inti7.php

5. Applying a transitions framework to this project

The above discussion suggests a number of analytical steps for our project:

1 Identify and analyse existing dominant NR trajectories using socio-technical regime concepts.

2 Identify the economic, social and environmental problems associated with these trajectories, many of which will be linked to traditional concerns associated with the exploitation of NRs discussed before, but also including landscape pressures in the wider economy and society.

3 Identify and characterise alternative pathways for the NR sectors which address some of the problems identified in the dominant trajectories.

4 Choose some alternatives for analysis in case studies using niche concepts to assess the momentum and support for these alternatives.

5 Compare niche dynamics and regime dynamics in order to assess these different development pathways over time.

We will develop each one of these steps below and illustrate how it could be applied using the example of the agricultural sector in Argentina.

❖ <u>Identify and analyse existing dominant NR trajectories using socio-technical regime concepts.</u>

As a first step we need to identify in each one of the selected sectors per country the dominant trajectory. Dominant trajectories are defined as those that privilege the mainstream, and highly institutionalized, ways of solving problems that benefit from a historic accumulation of technological, institutional, infrastructural and social supports. Information about the dominant trajectory per industry and country can be collected using secondary data (e.g. previous studies about the sector in the country) and interviews with key informants.

Based on this kind of data, for the case of the agricultural sector in Argentina, we can say with little hesitation that the dominant trajectory is the one followed to produce (99% of) soya, the crop that dominates the agricultural scene in the country since the mid 1990's (soya and its derivates explain 25% of all Argentina exports, Argentina is the third world producer and the second world exporter of soya, and the first world exporter of soy sunflower oil, flowers and pellets). This is an intensive and extensive technological trajectory which has developed on the bases of the co-evolutions of several elements:

- Genetically modified seeds (RR soya), developed by Monsanto to tolerate Monsanto's herbicide, based on the chemical glyphosate. This seed has implanted a gene, the RR, which allows the growing crop to be sprayed with glyphosate, killing weeds and other plants but allowing the crop to grow on.
- Widespread use of herbicides, in this case glyph sate. It has been calculated that every year 300 millions litters of herbicide is used in Argentina for soya production
- Zero tillage, which involves planting crop seeds in previously unprepared soil. In 1990 the proportion of the area cultivated under ZT was almost negligible; in 2000 it was applied on 50 per cent of the total cultivated area; and in 2005/6 it had reached 70 per cent.
- The separation between the ownership of the land, and its exploitation. This is a phenomenon that results from a new actor which has entered the agricultural scene in

the 1990s', the contractor, which owns machinery and knowledge, and rent big extensions of land to plant the crop.

- Little state intervention in directing the trajectory, which almost completely shape by markets, but increasing state dependence on the sector for revenues
- Little involvement of local consumers since almost all production is exported

❖ Identify the economic, social and environmental problems associated with these trajectories (note each will also be providing benefits too).

This is about understanding public debates about the sector and its future, and can be done through narrative analysis. For example, in Argentina the huge expansion of the soya production and exports[11] associated with the adoption of the technological trajectory described above has brought a lot of optimistic views about the possibilities of the sector in a country that suffered historical external exchange shortages. This was particularly significant at the beginning of the soya boom, when the country was going through the deepest crisis in its history. However, more recently, several national and external analysts have started to point out some significant problems and risks of such a trajectory, which are questioning its positive features and threatening the whole sustainability of the model in the medium- to long-term. Some of the more important of such problems include:

- The excessive concentration of land use in only one commodity. As a result of the transformations induced by the adoption of the technological trajectory described above soya explains now 25% of total exports and 50% of all agricultural exports. This would put the country in huge economic risks since prices are highly volatile and demand, all external, is very sensitive to health and other moral concerns. It is also problematic because it threatens the food sovereignty of the country. The expansion of the GM soya has been spectacular. In 1993 only 500000 hectares were cultivated with GM soya, in 2010 this number has increased to 19 millions, 4.5 millions of these hectares have been dedicated before to other production systems such as dairy, rice, cotton, sunflower, fruit trees, horticulture, cattle and grain (Joensen *et al*., 2005). In some cases we have the precise numbers: soya has displaced 44% of the area before dedicated to rice, 26% of the area before dedicated to maize, 34% of the sunflower plantations, and 6% of wheat. The area before dedicated to cotton drop 12 times, the area dedicated to cattle lost 13.5 millions in the Pampas, and 30% of dairy farms disappeared. As an effect of these changes, the cattle production lost 3 million units, the potato harvest fell between 1997/98 and 2001/2 from 3.4 million tons to 2.1 millions, green peas from 9000 tons to 1800 tons, lentels from 9000 to 1800 tons. As a result some increasingly perceive that the soya success is heavily dependent on one commodity is very vulnerable to volatile world markets.
- There are safety questions over the transgenic modifications introduced into GM RR soya. Several studies have indentified health hazards and toxic effects in animals associated with GM RR soya, including cellular changes in organs, more acute signs of aging in the liver, enzyme function disturbances, and changes in the reproductive organs (Antoniou *et al*., 2010). Were similar issues to be identified in studies conducted on humans, or that the conclusions can be extended to effects on humans, then this could seriously threaten the whole world market for transgenic food, and again the whole sustainability of a model that is being used in most Argentinean agriculture.

[11] Between 1990 and 2007 the total production of grains (mainly soya, maize and wheat)and total exports of soya exports more than double

- The restrictive effect of the activity, such as is organised under this technological package, to create employment. This is a very land and inputs intensive technology (extensive in land), which barely demands labour in a country with high rates of unemployment, particularly in the country side, where most poverty is concentrated. In GM RR soya farms labour levels decrease between 28 and 37% compared to conventional. It has been estimated that the activity demands only 2 workers per 1000 hectares. This has meant massive displacements of people from the country side to the cities, and an increase in poverty in the rural areas.
- The increasing concentration of land, associated with the technological trajectory followed by the sector, which is leaving most of the population out of the benefits created by the activity, and concentrating in a few hands key decisions regarding what to do and how to do it with a NR key for the country. Together with the diffusion of this technology has taken place a massive displacement of small and medium farms, which also again has had substantial negative effect on rural employment. Just as an indication, according to the National Agricultural Census, between 1992 and 2002, 87.688 farms disappeared, most of them small and medium exploitations, and accordingly, the middle size farm increased in 25.3%. However, some more recent estimates indicate that the number of small farmers has decreased by around 300.000.
- The concentration of knowledge and key aspects of the technology in a few dominant MNCs. Nowadays, although there are some national companies which introduce variations to the GM seeds originally developed by MNCs, the reality is that a handful of companies, namely, Monsanto (USA), Novartis (Switzerland), DuPont (USA), AstraZeneca (Holland) and Avantis (Switzerland) dominate 100% of the key aspects of the technology of GM seeds, 60% of the agrochemical market, and 30% of other seeds. This again, leaves the possibilities of future development based on this technology and others key strategic decisions for the country in a few hands. The conflict that Monsanto is having with the Argentina government during the last years is only one example of the situations that could be created by this concentration of knowledge and therefore power in a few companies. In the impossibility of getting royalties associated with use of Soya RR seeds in the country, due to specific circumstances and internal regulations, the company has closed all R&D activities in Argentina and is threatening the government to stop producing varieties that will address Argentinean particular diseases and climate conditions.
- The use of herbicides has increased substantially in association with this technological package, mostly because several new weeds are become resistant to glyphosate. Every year more than 30 million litters of agrochemicals are sprayed in Argentinean land, which has been identified to be causing several severe health problems. More than 30 studies in USA and Latin America have identified for instance increases in cancer affections, spontaneous abortions, and birth defects, among other problems in the areas where the glyphosate is sprayed. This situation has taken some courts in Argentina to banned or restrict the spraying (see for instance the case of Ituzaingo, or the conflict in the province of Chaco). It has also been identified that the herbicide could be contaminating the maternal milk of women that are exposed to glyphosate and different fruits and vegetables that grow near by areas that are sprayed, such as strawberries, lettuce, carrots, etc. This has taken the court in New York in 1997 and in France to forgive Monsanto to advertise the Roundoup herbicide as biodegradable.
- Different studies in Argentina and other countries have identified several ecological problems which question the possibilities of the trajectory to sustain on time without destroying future possibilities of using the land. These include: (a) erosion of soils, fertility and nutrients. In Argentina's Pampas two decades ago, nutrient budgets were

stable due to the use of crop and cattle rotation which allowed nutrient recycling (Pengue, 2001) . But since the introduction of RR soya this balance has been broken. A study of the nutrients of Argentinean soils predicts that they will totally consumed in 50 years at this rate of nutrients depletion (Ventimiglia, 2003), (b) Deforestation, in the last nine years 2.500.000 hectares were deforested to expand soya cultivation, (c) loss of species and biodiversity and (d) potential desertification. Several of these problems have been associated with the "pampeanisation" which is the expansion of the logic of the Pampas, to areas rich of biodiversity such as Yungas, Great Chaco and Mesopotamia.

❖ Identify and characterise alternative pathways for the NR sectors being proposed by different advocates.

Problems or tensions within the dominant regime often open windows of opportunity for changes and niches to prosper. We define therefore alternatives as all those projects (or group of projects, see discussion bellow) that address in some way some of the problems identified with respect to the dominant trajectory. Alternatives are not only defined regarding the technology in a hard sense (e.g. different types of machineries, and other inputs involved, the intensity of use of capital, labour or other inputs, etc.), but also regarding other aspects characterizing the socio-technical regime that surrounds the technology such as the labour organisation that characterise the model; the scale; the way in which the activity integrates suppliers and costumer in the decision making process, and links with other firms; the type of networks developed, patterns of ownership, and forms of governance, among others . We are interested in projects that somehow help to diversify the way in which things are done in general, regarding the dominant way, promoting socio-technical diversity and ultimately the economy. Alternatives will be identified in a first stage using the description of projects funded by innovation funds in Argentina, Brazil and Chile. We expect innovation funds provide a good source to identify projects that constitute alternatives to the mainstream or dominant ones, because these types of projects in early stages usually require a fair amount of public support. However, to the extent that these funds operate under the prevailing regime or paradigm, then other sources can also be used to identify alternative projects.

We recognise that we could have two types of alternatives:

- Isolated projects - are single projects that address some of the issues concerning the dominant trajectory but that have not expanded to involve other actors, institutions or users.
- Niches are network of projects addressing similar issues, which involve different actors, including users. It is important for a niche to develop to have users involved in some way. Otherwise we stay in the stage of pure laboratory experimentation rather than 'experimentation' in the real world. In a niche alternative projects are networking, lessons are being shared, and there are social, economic or policy actors that are promoting the future development of this alternative (e.g. lobbying for policy support, seeking investor capital, positioning the alternative as a solution to debates about the future of the NR). It is also the case that in a niche there is already: (i) A clear 'socio-technical' vision for the alternative pathway: guiding principles, favoured technologies, industrial organisational models, markets and user relations, policy and institutional support, (ii) an established constituency of support for the alternative, e.g. some business interests, government departments, public research institutes, social or environmental NGOs, and (iii) a minimum number of practical projects exist that are experimenting with a prototypical version of the alternative 'socio-technical' exploitation of the NR.

Examples of alternatives to the dominant regime in Argentina include all the organic productions projects developing not GM seeds (like certified organic farming, biodynamic farming, agroecology, among others), projects promoting the development and association of small farming producers in different parts of the country, projects that foster a diversification of the type of production, and also more radical projects that advocate for a new way of living in sustainable communities.

It is our intention evaluate each one of the single projects and determine which are getting the status of niches, if at all, and exploring the extent to which they are linked to other similar projects, and explore how they interact with the dominant regime.

- Using agreed criteria, choose some alternatives for analysis in case studies using niche concepts to assess the momentum and support for these alternatives.

  A mixture of survey work (e.g. web-based where practicable) and in-depth case study will be used to interrogate networking between initiatives, the roles of intermediaries, and the technical, economic and political performance of the niche. Our core analytical concerns are for niche building processes, evidence of niche influence on institutions, and thus the momentum building behind these alternative sustainability pathways under different contexts.

- Compare niche dynamics and regime dynamics (and any interactions between the two) in order to assess the potential for each alternative pathway in the future, and identify the broader changes necessary for those alternatives to become mainstream NR industrial structures. We are interested in understanding for instance the way in which incumbent regimes restrict the potential of niches, but also that as regimes become unsettled so they are more susceptible to transformational influence from niches.

It should be noted, that the MLP framework is neutral as to which niches should be promoted and whose momentum should be encouraged towards becoming influential pathways for NR development. Rather, the MLP provides a framework for analysing a plurality of alternative projects and explaining their relative success in building momentum in the context of historical regime trajectories of development. These alternatives can be in interaction (and competition) with one another as much as with the regime they seek to transform or displace. Symmetry in the analysis of niches, regimes and pathways is warranted. In each case, however, it is important that the problem framing be kept broad – the ambitious transformation of NR industries – and that the analytical framework is also wide enough to consider the complex factors relevant to such a framing. The MLP is alluring because it meets these criteria, and provides an account for how pathways may variously build, fizzle out, or decline over time; but the MLP is also challenged, precisely because it tries to bring the details of innovative agency into play with long-term societal change (Smith et al. 2010).

The main elements of our framework and their interactions are summarised in Figure 2.

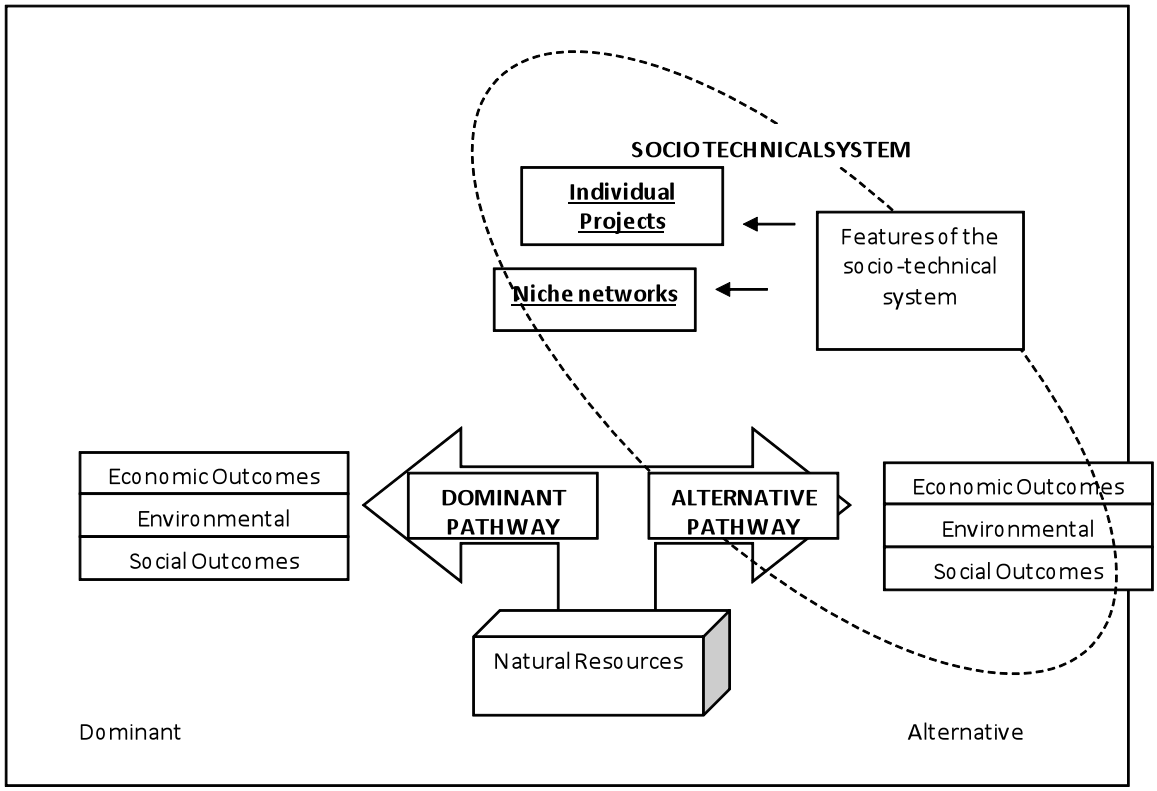

Figure 2: Main elements of the socio-technical transitions theoretical framework.

Our framework to identify and explore dominant and alternative pathways includes four main elements:

- Individual Projects
- Niche Networks
- Features of the socio-technical regime (e.g. structural and organizational characteristics of the networks, industrial structures and infrastructures, guiding principles, user-relations and effective demand, policy and institutions)
- Economic, environmental and social outcomes.

Individual Projects and niche networks

Individual projects supported by public funding are our starting point. However, as discussed before a niche is formed when there is a network of projects interacting with each other and involving users and institutions besides firms. So our main units of analysis will be the network and its main structural and organizational characteristics.

We define networks as a set of actors linked by some kind of relational tie. Relational ties include both exchanges of knowledge, finance and material resources needed to undertake those innovations and make the pathway a reality and shared viewpoints/narratives on the best pathways for the NR sector, and towards which their innovative activities are contributing. We will study them as affiliation networks, since in our case they will be identified by collaborative projects funded by innovation funds. Affiliation networks are the networks in which actors (organisations) are joined together by common membership to groups and they can be represented as a graph consisting of two kinds of vertices, one representing the actors and the other the groups (see Malerba et al 2006).

Features of the socio-technical regime

The main dimensions of the socio technical system which are key in shaping technological trajectories are: ii) the knowledge bases and technologies of importance to the relevant pathway; ii) the characteristics of the existing actors involved in the pathways; iii) the institutional framework; and iv) demand and users' environment.

Knowledge bases and technologies refer to the specific characteristics of the technologies, scientific disciplines, artefacts and inputs relevant in the use and production of knowledge in a system. As asserted by Malerba (2004) "[k]nowledge differs across sectors in terms of domains" (p.19). Domains include the sources and levels of technological opportunities, complexity of knowledge bases, appropriability conditions and cumulativeness in knowledge accumulation. Of particular interest here is how new and dynamic knowledge bases connected to new technologies (particularly ICTs, bio- and nano) have been applied and modified the knowledge bases of traditional sectors.

Actors and networks include the agents involved in innovative activities of relevance to a sector (or pathway), together with their characteristics and interactions. Important actors are firms (which can be categorized as users, producers and input suppliers), non-firm organisations (which can be universities, financial institutions, government agencies, etc.) and individuals (such a consumers, researchers and entrepreneurs). Networks can be more or less open, complex, inclusive, distributed, collaborative, decentralised, interactive, transparent, etc. On one hand, aspects such as strict control of property rights, strong concentration in the production of intellectual assets, restrict engagement of social actors may indicate dominant pathways. On the other hand, alternative pathways could be associated with the development of public knowledge goods and use of a variety of IPR strategies (such as creative commons), distributive generation of knowledge and high level decentralized collaboration with diverse stakeholders, such as non-governmental organizations.

Institutions consist of the 'rules of the game', including norms, routines, rules, laws, regulations, policies, standards etc, which affect the behaviour of organisations, as well as their interactions (Malerba, 2004; 2005; Edquist, 1997). Institutions create positive and negative incentives that underpin not only stability, but also transformations in the systems (Geels, 2004; McKelvey, 1997; Johnson, 1992; Edquist, 1997). Based on Geels (2004), who considers institutions as central to the constitution of socio-technical regimes, we define institutions to include regulative, normative and cognitive rules shaping and constraining behaviour. In this specific research proposal, the innovation funds and its operation are certainly a key institution and a key entry point for the examination of the involved organizations. Institutions around the creation and operation of the innovation funds will also be the focus of the expected impact of the project in terms of institutional building. At the same time, the study will not be restricted to this specific institution, and a wider range of norms, routines, rules, laws, regulations and policies will also be acknowledge as they influence the evolution of the innovation networks.

Demand in each particular sector includes the type of clients and the type of market that dominate the sector, and is crucial for the rate and direction of innovation. Shifting attitudes amongst consumers, such as growing environmental demands, is important here, especially how this translates into effective demand for products, marketing and the strategic development of new products.

Changes in these dimensions also explain the creation of opportunities for new alternative pathways or diversity. The triggering effect could be for instance, changes in the knowledge bases , the advent of new scientific disciplines, the migration of knowledge from other sectors, the introduction of new regulatory regimes and the entry of new organisations and so on (e.g. McKelvey, 1997; Malerba, 2005; Malerba 2004, Metcalfe, 1998). Thus, new alternatives are boosted as a result of alignments among changes at multiple levels (Geels and Schot, 2007). First, for instance, technological bottlenecks within regimes may contribute to changes in knowledge bases triggering changes in organisations and interactions. Second, changes in landscape elements such as global governance

and international institutional frameworks may put pressure on different systems that shape the transformation of the innovation space and technological opportunities. In other cases, changes in knowledge bases of other sectors may lead to changes and increased innovation in a given system. Our research will seek evidence for such mechanisms in the cases studied, and thus assess the potential for alternative pathways in those cases.

Economic, environmental and social outcomes

Finally, we understand that the structural and organisational characteristics of networks and other features of the socio-technical regime, which structure each pathway, will combine in specific ways to explain different outcomes. We are particularly interested in three types of outcomes, and their interactions: 1) economic, 2) environmental and 3) social.

Regarding economic impact we are interested on two types of issues: inter-sectoral linkages and diversification towards new technologies, and knowledge intensification. The first, refers to the extent to which the NR centred activity is using linkages with sectors such as ICT and biotech, and encouraging therefore the diversification of the economy. The second, refers to the extent to which the activity is becoming more knowledge intensive via the incorporation and development of new technologies.

Regarding social impact, we are interested on the impact on inclusion. More specifically we are interested in exploring two types of inclusion: 1) the extent to which and how the activity is including different types of social actors in the process of strategic decision taking, and the role of ICT technologies in this process, and 2) the extent to which the activity is serving as a vehicle to include marginalised economic groups, via creation of productive employment, skills, etc. We are also interested in the extent to which specific pathways contribute to reducing income disparity e.g by serving low-income markets, local employment, generation and contribution to local economy, etc.

Regarding environmental impact we will evaluate the extent to which the activity is promoting the sustainable use of NRs by taking care of three issues: [a] the danger of exhaustion of the non-renewable resources, [b] the destruction of ecosystems and [c] the threat of serious pollution of air and water.

It is important to bear in mind that some of the times the selected pathways will have contradictory outcomes regarding these three dimensions. In these situations we will be interested in exploring the governance of the pathways, particular with respect to their ability to balance the three objectives.

It is also important to mention, that some outcomes will not yet be manifest materially. Indeed, expectations are a key theme in the study of niches, since so much research into sustainable solutions is forward-looking. In many situations, therefore we will not only focus on benefits that have already taken place but also on expected outcomes amongst key actors in the NR sectors.

6. Conclusions

The purpose of this paper has been to take seriously the proposition that NR based industries are now in a historically new position to be a major source of development for LAC economies. In order for this argument to work, however, it is necessary that NR industries re-structure into more dynamic and innovative forms whose development pathways address economic inequalities, social justice, and environmental sustainability concerns.

Having considered the basis for being hopeful about NR reform, we considered the existing literature on appropriate technology and sectoral systems of innovation. Appropriate technology

debates argued that different pathway choices are available, but provided insufficient attention to the contextual factors that open-up or close-down (i.e. select) the options available. Sectoral systems of innovation perspectives, on the other hand, provide helpful ideas about improving the innovativeness of a sector, but say little about changing the direction of those innovative efforts in terms of the industrial structures that emerge.

For these reasons, we considered at length an emerging literature on socio-technical transitions, that provides a framework for considering the dynamics of re-structuring sectors (or, more precisely, socio-technical regimes). Drawing upon a 'multi-level perspective' framework (MLP), we suggest that this project can analyse NR based industries through a combination of analysis of the recent historical development of NR 'regimes', and analysis of the development of alternative 'niches'.

We have suggested some methods for how we might go about making MLP concepts empirically operational and susceptible to research and analysis.

The project workshop needs to reflect upon the adequacy of the MLP for our purposes, adaptations that need to be made, and its refinement into research methods that allow us to provide a robust analysis of the prospects for NR based industrial development in LACs.

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ANNEX 1

Box 1: Developing agricultural machinery for special ecological conditions

The rapid and widespread diffusion of ZT technologies in Argentina in the 1990's provided new opportunities for the agricultural machinery sector. These opportunities did not emerge simply as a consequence of the general scale and growth of demand – associated with the impressive expansion of the sector - which indeed in general, favoured imports more than domestic production of machinery. Probably more importantly such opportunities emerged in association with the appearance of particular market niches that facilitated the evolution and consolidation of specific producers of agricultural machinery.

The favoured segments were the specialised self-propelled sprayers (and other producers of agricultural implements) and seeding machines (or planters). By contrast, the more generally applicable tractors and harvesters produced locally reduced substantially their share of the domestic market in the 1990s, in parallel with the diffusion of ZT technologies. The favourable position of seeding machinery and self-propelled sprayers can be explained by the combination of two factors: (i) ZT technologies require complex and precise planters as well as implementers, included spraying machines, which have to be closely adapted to the local ecological and organizational characteristics of their operational conditions, and (ii) Argentina, together with Brazil, was a pioneer in the diffusion of ZT technologies (Although ZT research and extension programmes have been implemented in more than 40 countries, massive adoption only occurred in a few regions, such as Argentina and Brazil, where networks that used participatory research and extension already existed and were strong. These two conditions meant that the necessary equipments were not available to import at the time they were required by the innovative agricultural producers in Argentina. Some domestic producers, in association with institutions of agricultural technology (such as INTA) responded very well to this challenge by the timely incorporation of several product innovations required by the producers adopting ZT managements systems. Indeed, several observers of the phenomenon of diffusion of ZT in Argentina and Brazil, have argued that the rapid diffusion of this technology would not have been possible in these countries without the active participation of these specialised suppliers of machinery.