The possible dynamic role of natural resource-based networks in Latin American development strategies

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Abstract - This paper explores the potential of natural-resource (NR) based networks for serving as platform for development strategies. The main argument against such potential use is the claim that they have low technological dynamism. If that were the case, natural resources would indeed be incapable of serving as core of a development effort. The paper holds that the changes induced by the ICT paradigm in the organisation of global corporations, the process of globalisation of production and the hyper-segmentation of markets have profoundly modified the conditions in all sectors, including natural resources. It analyses the recent and prospective forces driving innovation towards the "decommoditisation" of the natural resources themselves as well as the conditions that are making it more likely to weave networks of innovation up and downstream as well as laterally from the natural resource base, constructing a production and innovation network, which is taken as the unit of analysis. Finally it looks at the conditions under which full advantage could be taken of this potential for both development and poverty alleviation strategies. The paper uses evidence from case studies to illustrate how some of these transformations are already taking place in Latin America.

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Table of contents

List of figures

List of boxes

1. Introduction

The success of the four Asian Tigers in catching-up in development and the major growth leaps of China and India have posed a double challenge to the Latin American countries. It demonstrates that development is achievable; however the window of opportunity used by the Asian countries is no longer available to newcomers. It is then necessary to identify a viable technological opportunity space and to develop an adequate strategy for taking advantage of it. Given the rich endowment of natural resources enjoyed by the region, and the accumulated experience in the exploitation of these resources, we ponder the questions (a) whether natural resource (NR) based industries together with the processing industries, provide such a space for innovation and (b) whether they could serve as a platform for successful development strategies. This paper answers the first question positively and opens the space for answering the second one.

In line with the neo-Schumpeterian and evolutionary tradition we start from the idea that some industries offer more opportunities for innovation and dynamism than others, and that in the past NR industries have not been in the list of industries with higher opportunities. However we believe that the reasons for this view are largely historical, i.e. they are mostly linked to the manner in which these industries developed since the 1920s (within the mass production paradigm) and to the typical behaviour of raw materials Multinational Corporations (MNCs) during the 20th Century. In our view these conditions are changing. NR based industries and their user-markets are becoming more dynamic. Instead of remaining a multidimensional 'curse' and a constraint on development, they may become the basis for a technologically dynamic and sustainable development strategy. This is crucial for most developing countries, which rely heavily on exports of primary goods - three quarters of the states in Sub-Saharan Africa and two thirds of those in Latin America (LA), the Caribbean, North Africa and the Middle East still depend on primary commodities for at least half of their export income.

The paper is organised as follows. In section 2 we discuss the main arguments in the literature contributing to the generalised perception that NRs are non- dynamic activities, and therefore not good for development. In section 3, we discuss the changes in the world economy that are enlarging the opportunity space for innovation and dynamism in all sectors, including natural resources. We also argue, that these changes demand that the analysis should no longer be restricted to the primary product, but rather to encompass the whole network of activities up and downstream, from the initial investment to the final user. In section 4 we discuss the forces that are driving or influencing innovation in the natural resource-based networks in this particular period and which are defining a new opportunity space for dynamism. Finally, in the concluding section, we offer a summary of the argument for a strategy based on combining natural resources with technology in this particular period, and we discuss the challenges and risks facing policy makers when engaging in such a strategy.

2. The ahistorical case against natural resources in development

Concerns about whether and how natural resources can contribute to processes of development have arisen since Adam Smith. However, it was not until the 1950s that these concerns became central to the development agenda, when structuralists, preoccupied with the poor economic performance of Latin American and African countries at that time, and reacting to the neoclassical prescriptions for these countries to specialise in NRs to take advantage of their resource abundance, strongly objected specialisation in NRs for three types of reasons.

First, Prebisch (1950) and Singer (1950) emphasised several types of demand and supply rigidities, all of which would explain a continuous downward trend in the relative price of primary commodities relative to manufactures. On the demand side, they highlighted two problems: (a) NRs face relatively low income elasticity, so countries heavily specialised in NRs would not benefit from increases in world demand associated with world income growth, and (b) their demand growth was slower than that for manufactures, because technological progress in the manufacturing sector tends to be raw-materials saving. On the supply side they also identified two problems: (a). that NRs were not favoured by technological progress, which was concentrated mostly in manufactures, thus, in the words of Singer (1950): "they do not provide the growing points for increased technological knowledge, urban education, the dynamism and resilience that goes with urban civilization, as well as the direct Marshallian external economies (Singer, 1959, p. 476)"; and (b) that the little technological progress they experienced did not translate into larger demand or greater profits but in reduced prices, benefiting consumers in foreign countries and not producers in developing countries supplying the NRs.

Other scholars, such as Nurske (1958) provided a second set of reasons to object NR specialisation focused on the instability of export prices of NRs. They noted that prices of commodities were very unstable. Countries that relied heavily on commodity exports would therefore be very vulnerable to constant fluctuations which would affect their economy not only via abrupt changes in tax revenues but also via changes in the rate of exchange and local investments (Nurske 1958).

Finally, a third group of scholars emphasised problems arising in association with the particular way in which NR activities were exploited in developing countries. The observation was that in developing countries, NR activities were typically dominated by MNCs, which repatriated the benefits and did not invest locally. This also meant that the local development of backward and forward linkages was very limited, closing off the main way in which the emergence of any activity could contribute to development (Singer, 1950; Hirschman, 1958; Singer, 1975).

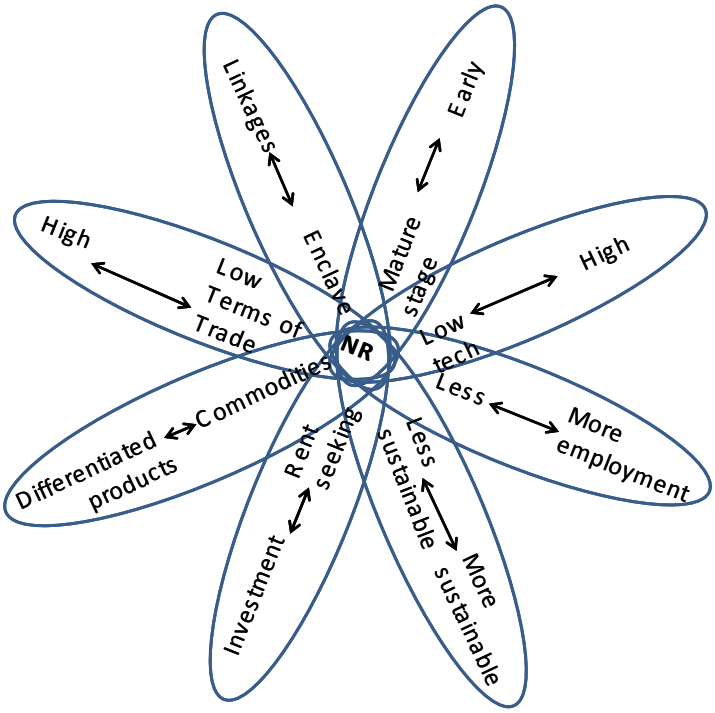
Since the 1990s these concerns have been reinvigorated in association with a wave of empirical studies which has argued that since the 1960's there seems to be a negative association between NR abundance (or specialisation) and growth (Sachs and Warner, 1995, 2001; Auty, 1990, 1993; Gylfason et al, 1999). In these more recent studies explanations for this supposedly poor performance of NRs have focused on two types. First, it has been argued that NRs typically generate voracity effects – i.e. conflicts between different social groups to capture the economic rent generated by these resources (Torvik, 2002), and a rentier state, i.e. a government which, gaining most of its revenues from external sources, is freed from the need to levy domestic taxes and becomes less accountable to the society it governs (Auty, 1990). Second, it is held that NRs make countries susceptible to Dutch Disease i.e. the appreciation of the real rate of exchange caused by the rise in NR exports, which leads to a contraction of the tradable sector, and the tendency of a booming resource sector to draw capital and labour away from a country's manufacturing sector, thus raising production costs.

Some of these arguments have been challenged by existing research. For instance, some studies have shown that the Dutch Disease may be less common in developing countries, where resources are typically unemployed and therefore their opportunity cost is lower (see for instance Gelb, 1988; Fardmanesh, 1991). Others have questioned the potential negative association between instability in export prices and growth. (See, for instance, Knudsen and Parnes 1975). More recently, Lederman and Maloney (2008) have challenged the whole set of studies that claim to have found a negative association between NRs and growth by simply replacing the absolute measure of resource abundance used in these studies (e.g. Sachs and Warner, 1995) – natural resource exports as a share of GDP – by a relative measure – net exports of natural resource-intensive commodities per worker. Bravo-Ortega and de Gregorio (2005) went further and showed that this association can turn positive if measures of human capital are considered.

It is also the case that several of the empirical trends observed by the detractors of NRs, although they might have been true at some specific periods of time, may no longer hold nowadays. This is because technological revolutions, such as ICT (Information and Communication Technologies), substantially change the context and the conditions, so that the unquestionable trends visible in the empirical data of the past may have changed significantly. It was true for example, as observed by Prebisch and Singer, that in the 1950s and 1960s manufactures experienced steady and stable price increases, while raw materials decreased in price and were marked by volatility. Since the mid 1980s, though, the combination of low cost labour in China and the greater productivity brought about by ICT have been lowering the price of manufactures and towards the end of last century rapid demand growth due to globalisation increased the price of energy and raw materials (Kaplinsky, 2009). Something similar can be said about the relative income elasticities of manufactures and materials. In relation to food, for instance, it is clear that after a certain threshold, increased incomes do not increase food consumption. But that is if the growth pattern is about greater incomes for the same consumers, as in the 1950s and 60s. Globalisation, by contrast, is about constantly incorporating new consumers. Singer himself in an article published in 1975 questioned some of his earlier views in his article of 1950, recognising the historical nature of his previous observations. In his more recent article reflecting the increasing importance of technology, he sustained that what matters is not so much which type of commodity to produce – i.e. manufactures or NRs – but who develops the technology.

The debate however is still open, and indeed in many academic and policy circles the dominant idea continues to be that NRs are a potential curse for development. Figure 1 summarises the superficial and simplified perceptions that combined, often without distinction, have contributed to the view that NRs are not dynamic and therefore have a low potential to contribute to development processes. The figure shows three problems often present in the literature analysing the supposed lack of dynamism of NRs. First, NRs are often grouped together and located at the lower end of the spectrum of several dimensions used to characterise industries(See Figure 1)., without distinguishing between industries as diverse as mining, oil, crops, wine, etc. The implication of this has been that the worst criticisms of the worst forms of NR-based industrial activity have been 'transferred' to the rest of the NR industries which do not share the same characteristics. Second, no distinction is usually made within each NR sector between its different segments or the activities along the value chain –some of which may be more sophisticated. Finally, all these different dimensions often used to disqualify the potential contribution of NRs to development, are often entangled together, as if they were all the same, with little effort in distinguishing one from the other or in understanding their implications.

Figure 1. Superficial perceptions of all natural resource industries as a compendium of all that is negative



It is difficult to believe that sectors as dynamic technologically as oil production could be put in the same category as growing lemons. Yet, those are the combined perceptions that prevail, hence, no matter how much conditions may have changed, the widely held view is still that NRs are not a good platform for engaging in a development process.

In the remaining sections of this paper we will challenge this view by concentrating on the forces that are currently driving innovation in the NR industries. Our premise is that innovation potential defines the opportunity space for growth (and, therefore, for development). It is also what defines most of the external dimensions indicated in figure 1: whether a product or sector is characterised by high tech, far from maturity, differentiated, with more linkages up and downstream, and favouring new investment locally. In essence we will endeavour to examine closely the commonly used, but largely unproven, argument that **natural resource industries** cannot contribute to growth and development because they are not dynamic. Surprisingly few studies have systematically analysed this aspect of NRs.

3. Re-introducing history and focusing on networks

One of the main weaknesses of the literature doubting the possible dynamism of natural resources is supposing that there are universal truths about certain sectors and that these truths do not change over time. Yet, evolutionary economists hold that technological change is the very heart of economic growth together with the constant changes in the relative dynamism of companies, industries and sectors. In this paper it will be argued that the information and communications technologies, together with the techno-economic paradigm that has evolved as the optimal way of using their potential to the fullest, are changing the opportunity space for

innovation in natural resources and especially in the whole network of activities up and downstream, from the initial investment to the final use.

In the past thirty years the spread of ICTs –in particular the capacity for low cost instant communication across the world– has led to a fundamental transformation in (a) the organisation of companies, (b) the location of production and (c) the structure of markets. Such profound changes demand a reassessment of the conventional wisdom about each and every sector. (Perez 2008)

The changing organisation of companies has resulted in the formation of complex networks of collaboration along value chains, locally, nationally and globally; between large and small firms; between business and universities, etc. The geographic redistribution of production has allowed the global optimisation of location in terms of relative advantage of every one of the component activities (be they core, peripheral or accessory) of each of such networks, whether they are led by a global corporation or are the result of associations. The change in the way markets are defined and segmented is providing a widening spectrum of opportunities for strategic targeting, positioning and repositioning, going from the basic commodity segment to innumerable specialised niche markets, in every sector and product, be it in manufacturing, in services or in the primary sector.

These transformations have several consequences when analysing the potential contribution of NRs to development. One is that the "foreign enclave" model of natural resource production is no longer tenable or competitive (although it may still survive under special circumstances). Global corporations are increasingly incorporating and stimulating local capabilities and weaving local networks of collaboration (see Box 1: The mining industry) as well as assuming some local social responsibility. Another consequence is that the "commodity" notion of natural resource products will only apply to a part –though large– of the wide spectrum of segments and that even the commodity segments have increasingly become technologically dynamic through the intense incorporation of process innovation including high tech changes in the product, such as genetically modified (GM) seeds.

Equally, the identification of technological dynamism with manufacturing, and within manufacturing with a few branches classified as high tech, has been rendered obsolete. The most obvious transformation has occurred in the service sector due to the natural tendency of ICT towards intangible services. The service sector must now be seen as a very broad spectrum going from the strict personal services or basic sales personnel with little skill, through various software services of medium complexity and to the very highly specialised knowledge intensive business services (KIBS) and the most sophisticated software and R&D activities, all of which have been growing in importance. Many of these high tech services are now helping transform the natural resource sectors. The manufacturing sector itself is rapidly segmenting into commodities at the low end, with high-volume, low-price and narrow profit margins, and a whole range of higher-value added differentiated or adapted products commanding much higher profit margins and often capturing extraordinary innovation rents. As to natural resources, market segmentation is occurring in the various sectors at different speeds and with varying intensity, through using technical change to cater to specialised niches at one end or through rescuing traditional methods (such as organic crops) to aim at health or environmentally conscious niches (See Boxes 2 and 3: Wine and Coffee industries). The high tech niches are an area of increasing interest in research both in specialised materials and chemicals and in the bio-sciences. The traditional niches demand innovation in organisation, marketing, packaging and distribution..

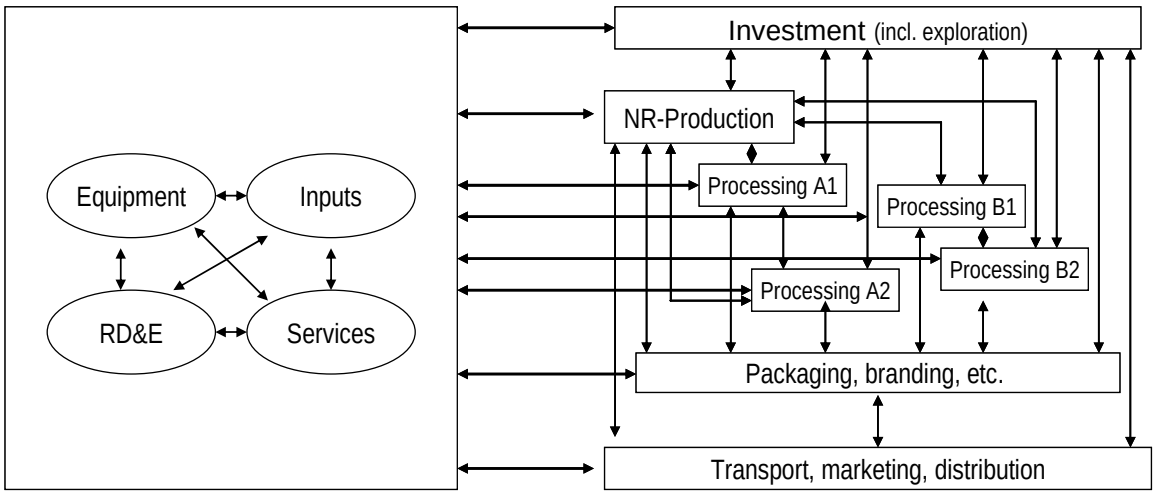
A final consequence of the transformation brought about by ICT is the tendency to make network links along value chains and to cooperate technologically between users and producers. Thus, it is no longer useful to see natural resources as just the extracting or growing or fishing

activity on its own but rather to embrace the complete network from the contributors to the investment process –especially capital goods– through the production and various processing activities all the way to packaging, distribution and use at the market end, including all services provided along the way (See Box 4: Agricultural sector in Argentina). Only then will it be possible to judge the capacity of the sector, in all its components, to contribute to a development process and even to initiate a catching-up effort (See Box 5: Agricultural machinery sector).

What remains is that whatever the sector, there will be some product areas that are much more dynamic than others. Even within a single company, there is likely to be a "bread-and-butter" basic product that provides the volume and low margins and the high end which is more technology intensive and brings in the higher profits. Thus, when considering what products to target as core of a development strategy, it is important to map and identify the technological opportunity space that would allow a dynamic path (See Box 6: Eucalyptus for pulp, paper and woodboards).

Figure 2 describes the complex set of interactions among the several activities involved in the exploitation of NRs nowadays. It shows clearly two important things. The first is that when analysing the potential contribution to development the unit of analysis can no longer be the NR-based firms or the narrowly defined NR-based value chain or *Filière*. The unit of analysis should be the NR-based *network*, including upstream, downstream and *lateral* linkages to the different value chains that comprise them, including the Knowledge Intensive Business Services (KIBS) that support them. This is not to say that innovations at the level of the firm or industry will be ignored but this paper will argue that the best opportunities for technological dynamism are to be originated by good quality interfirm linkages within the NR-based network (See Box 7: Biotechnology in Latin America).

Figure 2. Innovative interactions in a natural resource-based network



The second issue illustrated by Figure 2 is that we will gain little by analysing any of the activities within this complex network in isolation. In particular, innovation in this network involves several actors i.e. not only by the actors responsible for the production of NRs, but equally the many agents in charge of processing the NRs, the providers of equipment and R&D, the providers of packaging, etc. A systematic view is necessary therefore to explore the potential contribution of each particular NR to development. And that is also the necessary approach when envisaging a strategy of learning and growth based on them. In order to assess any specific network in a specific country or region there are powerful approaches and methodologies. One is

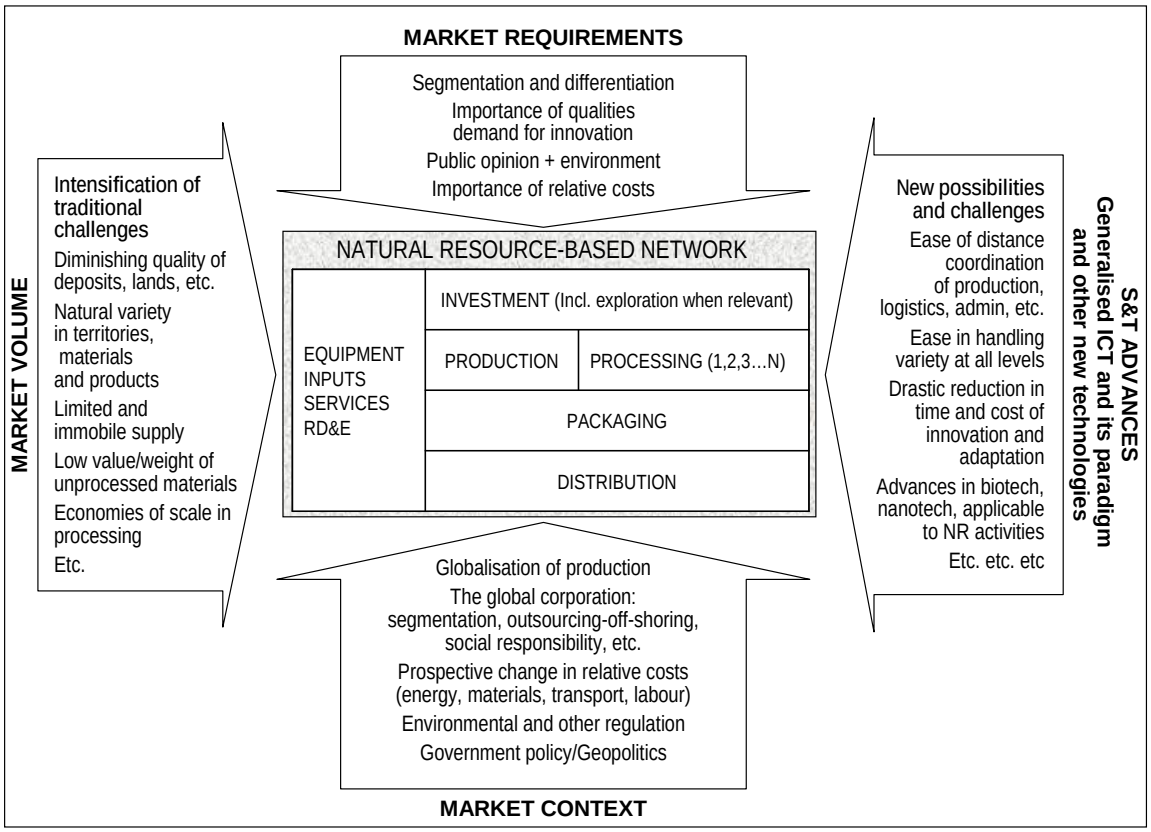
the Systems of Innovation approach (Freeman 1987, Lundvall 1988, Malerba 2005), the other the Global Value Chains type of analysis (Gereffi et al, 2005; Navas-Aleman and Bazan, 2004; Humphrey and Navas-Aleman, 2009; Humphrey and Schmitz, 2002). They each focus on different aspects and are therefore complementary.

In the rest of the paper we discuss the forces that are both increasing and re-shaping the innovation space of NR based industries. In this way, we hope to set the stage for performing more detailed analyses of how these forces affect the different links and the various NR networks.

4. The new (and renewed) forces creating innovation opportunities in natural resource-based networks

Figure 3 represents the driving forces that provide both a stimulus and a specific directionality to the innovation efforts in NRs. They define the new opportunity space in the natural resource-based networks in this particular period.

Figure 3. Forces driving innovation in natural resource-based production networks



As is common in the innovation literature we identify two main drivers of innovation: science and technology advances and demand or market. We have sub-divided the role of markets into three aspects. One is the impact of increasing demand volumes, another that of requirements in terms of qualities and other features and the third is the shaping influence of the general market context, including the changes in the behaviour of global corporations, governments and other agents as well as the new environmental imperatives. Of course, these three aspects are closely intertwined, but to single them out in the analysis permits a more detailed examination of the

influence that each of them is likely to exert on the intensity and direction of innovation in the case of the sectors under study.

These forces apply generally to all natural resource sectors, whether mining or agriculture, energy, fisheries or forestry and to the up and downstream activities. Obviously, they will influence innovation with varying intensity and in different proportions in one sector or another and they will act more strongly in one section or another of the whole network. Let us discuss these sets of innovation-inducing forces one by one, beginning with the role of the increase in market volume.

MARKET VOLUME:
Growing demand as intensifier of the endogenous drivers of technological innovation in natural resources

The sheer rhythm of growth in volume of materials, energy and food brought about by globalisation puts a strong multiplier on most of the traditional drivers of innovation in NRs, much more so as it is likely to be accompanied by increasing prices.

Given the natural limits to resources, it has generally been the case that increasing supply means the incorporation of new land or the extension to new mines, usually going from the best to the less good (at least among what is known), from the nearer to the most distant, and therefore to higher costs. These shifts to less competitive sites have traditionally been the endogenous drivers of innovation in the natural resource industries. Yet, increasing productivity under less advantageous conditions to match the better ones does not mean reaping any technological rents; the advantage tends to remain with the better conditions or is transferred to the consumer in lower prices. This fact underlies some of the doubts about the dynamism of natural resources.

This is different from the classical situation in manufacturing, where growing volumes have usually led to process innovation in order to achieve economies of scale and other increases in productivity or to adding new plant with improved technology. In most cases, additional products imply less cost and either lower prices or greater unit profits.[4]

An area of natural resources where manufacturing conditions were almost achieved was extensive agriculture. The so-called “green revolution” based on the mechanisation of the different phases from planting to harvesting, the massive application of petrochemical pesticides and herbicides and the use of standard seeds on very large expanses of land established the greater and determining segment in terms of costs and prices in many agricultural commodities (both vegetable and meat). Although this situation still applies for certain crops –and in some cases has been intensified by genetically modified seeds– the increase in market volume is now shaped by another trend which distinguishes “niche” segments from standardised commodities in the natural resource sectors. In the section about market segmentation, we will look at how, in some cases, extraordinary profits can be gained from targeting niches, including enhancing the value of the variety in products that naturally accompanies territorial differences. This can work even for small countries exporting small amounts of a product such as Jamaican Blue Mountain Coffee (See Box 9 - Blue Mountain coffee).

But if prices increase enough, pushing against the limits of natural resource availability can make it attractive to access almost unreachable deposits, under the sea, deep underground or in inhospitable landscapes such as the Arctic or Siberia. Major innovation is required in those cases for exploration, extraction and transport. The case of the deep ocean oil reserves found in Brazil and the complexities of its exploitation are a vivid example of this. In a previous occasion, when the OPEC price rise in the 1970s drove the developed economies to try to increase their own reserves, Norway not only became an important producer of undersea oil but it promoted the

[4] This is no longer true in the case of commodity manufactures (Kaplinsky 1993. 2005, 2009)

emergence of a whole network of specialised suppliers of equipment and services that are today moving to participate in the Brazilian fields.

The growth in demand for raw materials is directly tied to the increase in processing capacity. The question of location will naturally present itself. For multiple reasons, the choice has traditionally been to process near the users, rather than near the source. However, the increases in the cost of energy and their consequent impact on freight rates, together with the global warming concerns may change this trend. Unprocessed materials have very low value in relation to their weight (which means high transportation and environmental costs), so setting up the processing plant in situ, could begin to make sense. All the more so, given that most such processes are themselves energy intensive. To respond to those imperatives, innovation in process plant to make it more flexible, perhaps relatively mobile and less dependent on economies of scale are likely to be some of the innovation challenges to confront.

These requirements, together with those presented by the variety in conditions discussed above will also request innovation upstream from the equipment industries and from the business services sector in the networks (See Boxes 1 and 5: Mining and Agriculture in Argentina).

Finally, “natural resources” are by definition embedded in the territory and are therefore physically immobile. However, innovation and investment are constantly changing the value of such resources (See Box 6: Eucalyptus for pulp, paper and wood boards). This can work in both directions; the rubber plantations of Brazil were immensely valuable until synthetic rubber replaced them in use. The same had happened to Chilean saltpetre and Peruvian Guano when synthetic fertilisers were introduced, yet recently, the preference for organic produce has increased demand for natural fertilisers and a revival in value has occurred. The need for better batteries (for mobile and alternative energy) has exploded demand for lithium, which had limited uses until a couple of decades ago. The medicinal qualities of plants are being increasingly pursued by pharmaceutical companies and changes in world demand for certain crops can lead to revaluing or devaluing some lands and to shifting land use. Discovering new uses for existing resources (or new resources that can serve established purposes) is a constant process that has always brought forth ingenuity, experience, innovation and science to the task. Under current conditions of increased demand and diversification of production, the efforts to identify alternative inputs and to value and revalue resources through innovation are likely to also increase.

Basically, one can say that with greater or lesser intensity the specific characteristics of natural resource-producing activities had always demanded a certain amount of adaptive innovation and a search for increasing productivity. The advances in all those industries across time are witnesses to that process. The question of whether the price rewards have historically been commensurate with the investment and innovation effort is not so simple. If the product is approximately homogenous the better fields with less effort may reap bigger profits or, worse still, the price may come down below that of the higher cost innovator. Those phenomena underlie many of the doubts about the adequacy of natural resource production for driving development strategies.

In what follows, the paper will look at the features of the current context that may not only intensify the endogenous drivers of innovation in the natural resource industries but may help overcome some of the traditional obstacles to reaping sufficient profits from them.

This section looking at the impact of increasing demand volume should not end without mentioning the countervailing force of environmental concerns on such growth. In the medium term increasing prices and emissions regulation are likely to curb these demand trends. This constraining effect and the possible innovative responses to it will be discussed in relation to the other drivers.

MARKET REQUIREMENTS:
The changing shape of markets inducing "demand pull" product innovation

One of the significant changes enabled by ICT in relation to markets brings another dimension to the profitability issue in the area of natural resources. The hyper-segmentation of markets facilitates the creation of special materials and differentiated niche products (See Box 9: Jamaican Blue Mountain Coffee) where semi-monopoly conditions may exist for certain periods of time, allowing the amortisation of successive innovation efforts.

There are two different directions of market segmentation that achieve the so-called "decommoditisation". One is differentiation, which may come from the enhancing of a natural difference through branding or other means or from creating a special product through scientific research and technological innovation (See Boxes 2 and 3: wine and coffee industries). The other direction is customisation to fulfil user specifications. Broadly, one could say that differentiation is often initiated by the producer to create a new space in the market; whereas customisation is performed at the request of the user.

In this case, direct access to the users is crucial. Precisely, one of the characteristics of the current paradigm that enables taking advantage of niche products is the ease of direct communication with the specialised 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. At the same time, the transformation of the transportation services to handle small quantities and special requirements with high efficiency and decreasing costs makes it possible to cater to a globally disperse niche.

The strategy of product differentiation through the development of special materials has been widely adopted by the metallurgical and chemical companies to escape the low margins of standard and bulk materials. So-called "boutique" steels made in small batches and specialty chemicals have been the route to higher margins and greater price stability. Since some of these special products are developed jointly with the clients who specify them, they are a sort of customisation. The important point is that the expectation of new, adapted and finely specified materials is becoming the norm on the part of manufacturers, because the probability of fulfilling those requirements at a reasonable cost has increased significantly in relation to the prevailing situation in mass production times.

In the direction of differentiation, there are certain market segments such as "organic" or "direct" that command premium prices because of health and social concerns. In these, thanks to the new distribution systems, it is possible for small producers to participate profitably in global trade. The success and possible staying power of these segments is revealed by the fact that global corporations such a Nestlé decided to bring out a brand of instant coffee with "Fair Trade" certification (Dawar and Mitchell 2006)

But the traditional source of premium prices has been the natural variety in the products themselves. Different percentage of metal in the ores, lighter or "cleaner" oil, better grapes for a certain type of wine, more beautiful woods, bigger eggs, sweeter oranges or more aromatic cocoa have segmented natural resource markets in the past in terms of quality with the expectation of premium prices for the top of the range. This is increasingly the objective of branding and business model innovations, which occupy a growing proportion of the total market.

Yet during mass production times the direction of innovation, especially in consumer products, was to standardise shapes, sizes and tastes. Guided by the values that spread about unblemished perfect fruit and vegetables, innovation in agriculture was not only oriented towards the mechanisation of all phases, but also to make a product of standard appearance, easy to harvest and to handle for transport. Better taste was not necessarily among the goals. The current

segmentation of markets allows the exploitation of the whole range, from the highly mechanised and standardised "perfect tomato" to the flavourful organic variety that rescues the largely forgotten original tastes. But doing this successfully demands innovation in natural methods of pest and weed control, in conservation, packaging transport and distribution and possibly also in normative certification, image and branding.

This variety has further dynamic consequences when the direct consumer is not the public but the processing industry. The fact of having to deal with different grades of ore or with different shapes or flavours of fruit or with different compositions of oil, or with variety in hardness of wood, demands innovation in the user industries downstream (see Box 5 about agricultural machinery in Argentina). A change in supplier could also force a series of adaptive changes, so much that decisions on vertical integration often take the security of homogeneous supply into consideration.

If variety in inputs stimulates innovation upstream, so does the variety in expressed consumer demand. 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– opens a wide range of profitable possibilities. This in turn induces the fabrication industries to demand that their input suppliers fulfil those requirements, so that the pressure goes right up the whole value chain (See Box 6: Eucalyptus for pulp, paper and wood boards).

Finally, as will be discussed in the following sections, the excessive use and wastage of energy and other natural resources inherited from the mass production paradigm –and still prevalent– is likely to be curbed by regulation, carbon taxes, public opinion and price increases. The consequences are likely to modify demand requirements from the fabrication industries in a profound way. Diminishing the use of materials can lead innovation in several directions: smaller products, less material per unit of product of whatever size, less packaging material or different methods of packaging, durable upgradeable products, etc. All those trends, while reducing the rhythm of growth of the commodity segment, accelerate that of the more specialized and customized ones. This opens a world of innovation possibilities for the metallurgical, chemical and other processing industries, augmenting the possibility of obtaining technology rents in materials.

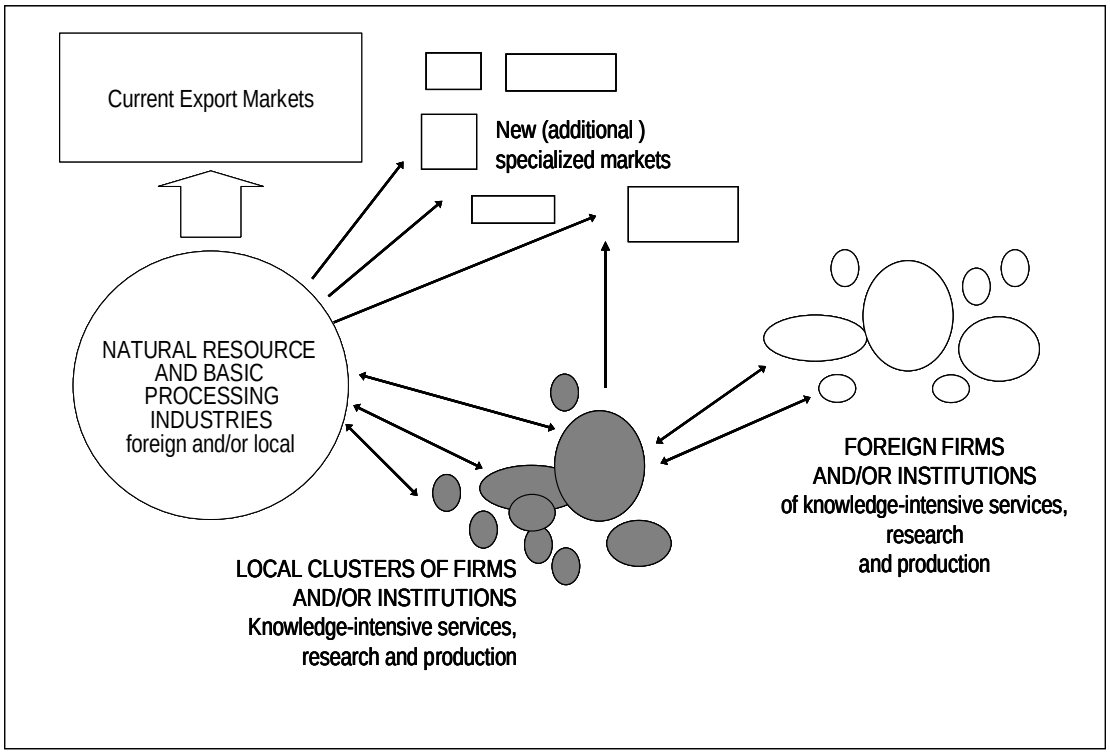
In all these trends the waters are uncharted and any strategies based on them are bold bets on the future. However, all successful processes of catching up and forging ahead have been such audacious endeavours by individuals, governments and societies.

GENERALISED ICT AND OTHER S&T ADVANCES:
Innovation opportunities based on all-pervasive ICT and new radical technologies in gestation

From a practical standpoint, the coordination of networks of innovation before the advent of Internet and computer processing had innumerable inconveniences. Agricultural production or energy and mineral extraction, forestry or fishing, are by their very nature activities that take place wherever the resources are naturally available and rarely very near the urban areas where high technology service companies and R&D laboratories tend to be located. The new information processing and transmission facilities have made it infinitely easier to establish interactive networks with intense communication for coordination of production and services, logistics, administration, etc. Also, the degree of autonomy that the modern global corporations give to their faraway units to adapt the general strategic guidelines to the specific circumstances encountered locally makes it much easier for them to take advantage of local suppliers and even to promote their development (See Box 1 on mining). Given the peculiarities of production sites, there are many services that have to be customised and this creates a win-win situation between the potential suppliers and the NR producers.

Seen from the other side, it is also possible for potential suppliers of technical and scientific services to form clusters or associations and to specialise in what could be the needs of the different elements of a particular NR-based network. With time and if they establish a fruitful user-producer relationship with the NR companies, they can form global networks of their own with other knowledge based groups, companies and institutions and not only serve as suppliers to the locally based companies but also export their services or some specialised products. See Figure 4.

Figure 4. The development of high tech service clusters associated with the needs of NT producers



These new possibilities related to local knowledge-intensive services and technological development are multiplied in their impact by the ease with which information technologies allow the handling of variety at whatever level. It has already been discussed that throughout history the peculiarities of lands, reservoirs, mines, etc. have been the most typical source of impulse for innovating in these sectors. Under the new conditions, this variety is handled with great ease, while the time and cost of acquiring and processing the necessary information for research and innovation have been drastically reduced. The same can be said about testing prototypes and measuring their impact. The availability of specialised digital instruments and the possibility of designing new ones or adapted software have also expanded enormously. An example of this is the computerised system designed and adopted in Chile for adaptable irrigation systems (INNOVA Chile 2007, PP. 20-21)

Equally important and versatile in their impact are the advances in biotechnology and nanotechnology. Although these technologies have the potential to unleash a technological revolution of their own, they are still in early phases of development and depend on the capabilities provided by information technology. The impact of genetically modified crops in agriculture, the work in tissue culture as means of plant reproduction, the development of vaccines for cattle and fish (See box 7: Biotech), the growing use of bacteria for mining (leaching) and for digestion of oil spills and other polluting agents in water already indicate the

many directions in which this new knowledge base is being incorporated in the natural resource sectors.

Nanotechnology is allowing advances in materials, facilitating emulsion processes, developing energy-saving and pollution reducing surfaces and catalysts, making protective coatings for preservation and advances that could help in handling and packaging natural products. (See Box 8: nanotechnology)

In terms of catching-up in development, the likelihood that the breakthroughs that will lead to the next technological revolution may come from these technologies is quite high. Participating in their development in these early stages could place the Latin American countries in a good position for a major leap forward when these technologies become all-pervasive, low cost and high growth. This is precisely what the Asians were able to do on the basis of their early involvement with the fabrication of electronic components and products, before the advent of the microprocessor and the personal computer.

The life sciences and the material sciences in general have made great strides in customisation and so has chemistry. After the maturity of classical bulk petro-chemistry and its products, the industry has moved strongly towards the growing branches of fine chemistry as well as to experimenting with water chemistry and other environmentally friendly lines of innovation. In this effort, the possibility of compu-synthesis opens methods of research that reduce costs and times significantly.

Energy is another area where a world of opportunities is open for the use of natural resources. The obvious case of Brazil and its development of bio-fuels is a successful example. But wind, waves, solar, biomass and many other sources are ready to be incorporated into the energy mix of each country and innovation in them is increasingly important and feasible, while it is becoming economically profitable due to other contextual factors that are discussed below.

THE MARKET CONTEXT:
Globalisation and the environment as shapers of the strategic opportunity space

The question of who controls the levers of technology, investment and markets is a crucial one when considering the innovation space available for firms or countries. In connection with this, it is important to identify the general trends in the behaviour and the interests of those decision makers. In that sense, this section will differ from the previous three in that it needs to signal prospective trends (rather than those that are in force already) and in that it focuses on the strategic and political context rather than the techno-economic.

Changing Global Corporations

The extractive industries (mining and energy) and some of the other natural resource sectors have traditionally been under the control of giant international corporations. Their behaviour toward the host countries during most of the 20th Century has been at the origin of much of the pessimism surrounding the idea of using natural resources as a platform for growth and development. This was largely because MNCs were supposed to operate as enclaves, independently of the host economy and repatriate most of it profits (Singer, 1950; Singer 1975).

Things have changed substantially however since the late 1970s. The diffusion of new technologies and organisational arrangements, and deep changes in world competition, have seriously affected the possibilities for international firms to look for, monitor, create and exploit advantages. Managers of MNCs nowadays enjoy an unprecedented degree of flexibility in moving production around, and in transferring know-how and knowledge from one location to another (Kogut, 2002). They therefore are more aware of and often make use of the knowledge that exists in host economies (Cantwell, 1995, 2001; Kogut, 2002; Hedlund, 1986; Dunning,

1994; Cantwell and Sanna-Randaccio, 1993). In the words of Hedlund (1986) international: business is now about 'actively seeking advantages originating in the global spread of the firm' rather than just exploiting centrally created technological assets.

As a consequence, MNCs have started to decentralise 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). Thus, local subsidiaries are modifying their behaviour towards local suppliers, and local sourcing of services and R&D (see Box 1: Mining). They can count on specialized capabilities that range from merely seeds of research and engineering capacity, which can be strengthened and enhanced, to truly advanced research groups that are already participating in international networks.

The situation is different in the agricultural sector where production has traditionally been locally controlled. In those activities the science and technology efforts usually had a long history due to having to face local specificities as discussed above and to the need to provide training and extension services. From the 1970s the growing awareness of the importance of technology accompanied by government support usually led to an intensification of the research effort, but it is only with global competition that consciousness has grown about the importance of using and guiding research. Since innovation is increasingly seen as the way to augment and maintain exports, local producers have begun to take a serious business-led interest in it. (See boxes 3, 4, 5 and 9 on the Agriculture and Coffee industries). Thus, both the legacy conditions and the new forms of competition create a context that could enable local innovative behaviour in local firms, in foreign firms and in the possible network linkages of both.

Improving negotiation strategies of developing countries

The increase in prices of energy, minerals, food and other natural resources that occurred in the mid 2000s can be seen as a foretaste of the trends to come. Under the effects of financial speculation –which doubtlessly accentuated the trend– there is an undeniable prospective imbalance between the capacity for increasing supply and the trends in demand that result from the globalisation of production and the incorporation of successive millions of new consumers (notably from emerging economies such as China and India) into the market. These trends are likely to be present in all natural resources accompanied by the segmentation of markets already discussed.

This mixture of high prices and relative scarcity may have several interesting effects that can be incorporated into the negotiating strategies. On the one hand, the high prices provide economic leeway for self-financing the technological upgrading of the local networks, either directly by the acting companies, local or foreign, or through special taxation regimes destined for that purpose. On the other hand, there is likely to be competition between the user countries to guarantee security of supply. This may create favourable conditions to attract investment in exchange for such guarantees and/or to negotiate conditions for the acquisition of technology and other aspects of interest just as China has negotiated in exchange for market access (Zheng and Williamson, 2007). For the global companies in NR, the access to the best lands or mines or fields or fishing areas is likely to become an important element in their strategies, thus creating a negotiating ground that can be used to achieve a win-win situation. This context stimulates innovation in business models, in financing mechanisms and in government policy.

Another aspect of this relative scarcity that can be put to good purpose is the possibility of incorporating the lower grade ores through artisan mining and the lands of more difficult access for producing organic foods or special woods, organising such activities with training and various ways of support to achieve sustainable forms of overcoming poverty. This too opens opportunities for collaboration and innovation. The success of the DeBeers support for artisan miners in Botswana is a case in point (Warhurst 2008). The Santa Filomena gold mining

community supported by IPEC (Hentschel et al. 2003) in Peru is another. Microfinance and government policy can support the replication of these cases across the continent.

Opportunities opened by environmental concerns

The environmental movement is one of the prospective trends with more profound and lasting consequences. This was already partly discussed in the section about how the new conditions in the market are driving innovation in natural resources. Here it is important to highlight the strategic and policy implications of the attempt to curb global warming.

The current highly skewed patterns of globalisation are unsustainable both environmentally and economically. Moving a very high proportion of all types of fabrication processes to China –and to Asia in general– has meant an explosion in transcontinental freight traffic of raw materials and final products as well as internal transport between ports and processing plants (for both fabricating and packaging materials), between these and fabrication plants, from these final producers to ports and finally from the ports of destination to the final commercial outlets. Initially this spurred a massive wave of investment and innovation in ships and container systems as well as in logistic management by specialised companies –such as UPS, DHL, etc.– or by distributing companies such as Walmart or Tesco for their own supply chains. The result was a significant reduction in transport costs, some due to economies of scale and others to innovation in processes. Examples of the latter are the introduction of microelectronic RFID tags (radio frequency identification) for supply chain management, inventory tracking and automatic redistribution systems.

The initial freight cost reduction stimulated further globalisation of production both of very heavy items such as automobiles and of highly perishable ones such as packaged salads (as the case of Kenya producing just-in-time salad bags to be in dozens of UK super-markets in less than 24 hours from order to delivery (see Dolan and Humphrey, 2000). Under these conditions, both the fabricating companies and the commercial networks made their production and transaction costs calculations for decision making, based on significant cost savings on cheap labour and diminishing costs of transport and logistics. This was the prevalent situation from the 1990s until the mid 2000s and much of the experience in off-shore outsourcing resulted from this situation.

The mid-2000s saw the violent increases in the cost of oil, materials and food and the “take-off” of widely shared concerns about global warming and the need to apply restraining policies. This began gradually to modify the real and expected dynamics in the relative cost structure in labour, materials, energy, transport, etc. and to reshape some company strategies and government policies. Freight costs began to rise, some assembly operations were brought back from China to Mexico and carbon capping or trading schemes were introduced by some countries. In 2005 Mexico used to be slightly more expensive than China as an outsourcing site (by about five percent in 2005). By 2008, China was already 20% more expensive than Mexico regarding average manufacturing costs (Engardio 2009)

This process was cut short by the financial crash and the global recession, but it is likely to begin again with the recovery. In 2009, the shipping industry is going through a serious crisis due to the radical reduction of freight movements. This means that the recovery of freight volume will somewhat lag the recovery, but the likely combination of high fuel prices with some form of carbon taxing will eventually bring the resumption of increasing transport costs. As mentioned before, the underlying relationship between demand and supply growth in energy, even in the

absence of the likely taxes or caps, is bound to lead to rising prices, thus affecting the cost balances between labour and transport.[5]

Significantly increasing transport costs, as long as they are seen as permanent trends, may bring a greater propensity to do materials processing *in situ*. Raw materials have a much lower value/weight ratio than processed materials. An example of optimising the whole value chain in terms of investment is the type of fishing boat-factory that does the processing and packaging on the ship itself while it takes it to port. Similar process designs can extend to other industries, including a trend towards more flexible equipment and processes that are not so dependent on economies of scale, which are one of the factors for locating processing plants near the points of use rather that near the production sites.[6]

On the other hand, recycling and materials recovery are also likely to increase, further reducing the demand for the basic ores. Since the source of recoverable materials would be near intense consumption, these processes are less likely to be located near the original production sites. But high specialisation in handling of such materials may give an advantage in some of those cases.

All these trends need to be connected for their analysis with the impact of the environmental challenge on the patterns of production and consumption. That is probably the most transcendental contextual factor driving innovation in products, processes, logistics and business models. Its impact is felt from the demand side as a shift in consumer preferences, from the policy context side as a growing set of regulations and economic (dis)incentives and from the supply side as increased risk and costs (including rising insurance premia). This implies that pressure will be high for redesigning products and processes to use diminishing amounts of energy and materials and to eliminate waste. These pressures will confront resistance both from the traditional consumers in the developed world and from the emerging masses of new consumers that follow that lifestyle as their aspiration. The outcome is unpredictable but monitoring the trends will be important for all involved.

The consequences of all this are contradictory. A strategy based on natural resources the demand for which may be increasing, but at a diminishing rate, is risky. On the other hand, applying a differentiation strategy to meet the requirements of environmentally friendly production and consumption patterns opens a technological opportunity space that could be exploited to advantage as a countervailing force.

It should be clear from this discussion that strategic and policy innovation must respond to the changing geopolitical context. Even more, that anticipation of the trends in globalisation, in production strategies and in government policies across the world will be an essential ingredient of the design of a development path in the current circumstances.

5. Conclusion: NR-based networks as core of a development strategy for Latin America – Potential, requirements and risks

This paper has shown that it is time to overturn the old ideas about the potential of natural resources for development. The established truths were based on the conditions that prevailed under the mass production paradigm which dominated until about the 1970s. The ideas that were

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[5] Our focus here is on natural resources, so the many possible trends stemming from these circumstances will not be discussed here. For instance, optimisation of transport costs can lead to a relocation of the bulkier and heavier part of the off-shore production sites to closer locations and (together with environmental and organic shifts in demand) to the revival of a range of local fresh produce activities around cities.

[6] In the case of minerals or other extractive resources, the exhaustion of sites is another factor for not locating the capital intensive processing plants in situ.

valid then, were not true at the end of the 19th Century and are no longer true now. Windows of opportunity for development are a moving target and success comes to those that take advantage of them on time (Perez 2001).

The ICT revolution has been radically transforming the opportunity space since the 1980s. Globalisation, network organisations, outsourcing, off-shoring, market segmentation and other changes in company structures and strategies lead to a completely different context and a different set of possibilities. The rise of Asia and the incorporation to the market system of the so-called second world have accelerated the rhythm of growth in demand for energy, food and raw materials to the point of straining the limits of resources and leading to the expectation of rising prices. The threat of global warming and of other environmental concerns have modified the requirements of both producers and final consumers and are likely to lead to regulation and taxes that will further change demand specifications and shape the direction of innovation. All these transformations are having a profound impact on the possibilities open to natural resource producers.

A new potential is there to be exploited for growth and development, but it will require concerted efforts with intelligent guidance on the part of government. It is an opportunity for a limited time, demanding intense technological efforts and, as any other opportunity, confronting strong competitors and facing challenges and risks (Perez 2001).

The potential: Natural resources can be a platform for a development strategy

Recent events have revealed that what was seen as an advantage of manufacturing itself was in fact an advantage of innovative production. Mature manufactures which depend on ubiquitous, highly codified technologies are also suffering from a process of "commoditisation" and are as vulnerable to downturns as the lower echelons of NR networks being just as likely to have decreasing margins (Singer 1975, Kaplinsky 1993, 2005 and 2009). It is the rents from innovation (technological, organisational and marketing) that give the real profit advantage –be it in fabricated products, services or specialised materials–.

We have focused on the driving forces of technological dynamism in natural resource production. We have held that the valid unit of analysis is the network, encompassing from equipment producers, R&D and other services, through raw materials production and all the processing industries and down to packaging and distribution. It is thus a complete system of production, innovation and marketing that is seen as forming the relevant set of dynamic interacting agents.

The forces driving innovation in such networks come from the growth in volume of market demand, from its increasing segmentation into specialised and customised niches, from the opportunities opened by S&T advances and finally, from the changing geopolitical and socioeconomic context, including the changes in behaviour of global corporations and governments and the environmental constraints.

The spread of ICT and the advances in biotech and materials science have radically changed the capacity to innovate in minerals and biological products and processes. Market segmentation has made it possible to target relatively small specialised markets with tailored products. This move from "remedial" innovation (destined to overcome the difficulties in comparison with the best lands and mines) to aiming at new qualities and new product markets has profoundly changed market conditions for the natural resource networks. Something similar has happened downstream where metallurgical and chemical processes have moved from bulk standardised products to an increasing number of specialised niche products. This widening of product variety is what has been denominated the "decommoditisation" of natural resource markets.

The instability of export prices is not likely to disappear but due to the limits on resources, the volatility would tend to occur at higher levels. This would be aided by the fact that the prices of special niche foods or materials are much more stable because the smaller markets to which they cater are willing to pay a premium for the special qualities, creating conditions of semi-monopoly.

Yet what makes this a particularly interesting window of opportunity for developing countries is the changed attitude of global corporations and the increased negotiating power provided by geopolitical competition.

Global corporations are hyper-segmenting their activities and distributing them in networks of allies and suppliers. They are learning to take advantage of local talent and capabilities for R&D and innovation and they are also increasingly outsourcing activities to local specialised KIBS (knowledge intensive business services). This practice was initially displayed by fabricating companies but it is gradually being adopted by mining and agricultural ones.

China is using its sovereign wealth fund to invest in other continents with a view to securing access to natural resources (eventually, so will India). This gives resource rich countries a much greater negotiating power with all investors. And the possibilities of succeeding in fostering more local participation, better conditions, and downstream processing are all the greater given the environmental imperatives and the modern network structures and alliances.

Strength can be obtained, not only from achieving good negotiating outcomes but from the capacity for achieving dynamic synergies within local networks. Furthermore, the variety of resource endowments across the Latin American countries can provide the conditions for regional networks of collaboration.

The requirements: Role of the State and embedded autonomy

Disenchantment with the power of the market to allocate resources with the efficiency needed to support a development strategy has spread as the 2008-2009 recession forces governments to intervene private institutions to stabilise the economy. In Latin America, this disenchantment pre-dates the recession as the region experienced low levels of growth and the weakening of their welfare systems at the height of the structural adjustment years (1990s). With public support for a greater role for the State, this is an ideal moment for governments to promote policies to support innovation in any sector of the economy.

This ushers the possibility of a new type of industrial policy, not based on a series of macroeconomic instruments as during the 1990s but a new type of industrial policy, one that is based on encouraging innovation in specific industries by offering direct support and incentives. Those who remember the era of Import Substitution Industrialisation policies (ISI) in Latin America may think that this suggestion sounds familiar but the ‘new’ industrial policy is neither ISI-based nor solely concerned with controlling macroeconomic variables (*à la* Washington consensus). Rather, it is based on the lessons from diverse successful experiences around the world (including Latin America), is usually based on some form of consensus building but does not follow a single rigid set of prescriptions because it is largely context specific and process-centred. Rodrik (2006) calls this way to reconsider industrial policies: ‘self-discovery’.

‘Self-discovery’ is not a wholly original notion, other authors have spoken about ‘finding your own way’ (Schmitz, 2007) and Gerschenkron argued that ‘the idea that every development case should be based on the same set of preconditions was a classic example of historical determinism’ (Hobday, 2003:294). In sum, each country needs to develop a strategy based on its own resources, experiences and allegiances in a competitive environment that is constantly changed by the choices taken by other countries and companies.

However the point we think should be emphasised from Rodrik's proposal is his insistence in purposefully setting up a permanent *process* in which public sector and business actors interact (not at arm's length but also avoiding exerting unduly influence on each other) over long periods of time, even if the final results of such cooperation are not pre-established. The objective is to create mechanisms of collaboration among the agents for decision-making, information-sharing and the promotion of innovation. Rodrik (2006) calls this consensus-building framework 'embedded autonomy'.

Several examples in this paper have highlighted the importance of long-term collaboration across the private sector–government divide for innovation. In the case of Eucalyptus (Box 6), the experience of intense cooperation among in-company scientists, publicly-funded technological institutions and policy makers over the years proved to be crucial for the world-leading innovations achieved by Brazilian pulp and paper companies. A similar story was revealed in the case of Coffee in Colombia (Box 3) but an interesting contrast was offered by the South African case and their mixed fortunes with the promotion of Eucalyptus Saligna, hindered by a lack of cooperation and trust between private sector actors and government agencies and between the firms themselves (See Morris 2001 for a detailed account).

Embedded autonomy does not require all ties between the private sector and State organisations to be formal, they can also be informal as long as they allow or facilitate the generation of new earning and learning streams/initiatives by complementing each other's lack of information and/or capabilities. Once the process of collaboration is established, following a 'portfolio approach' maximises the opportunities for the State to give differentiated support to several initiatives and reduce or increase the level of support as the initiative 'graduates' and no longer needs help or if it fails to live to its potential. Accepting that there will be some failed experiments is part of the process, one that may be politically controversial in democratic governments but key to increasing the chances of finding the next 'Champion NR network' similar to those created around Chilean Salmon, Brazilian Eucalyptus and Ethanol, Argentinean Soya and so on.

Where to start?

Since most Latin American countries have a long history of natural resource production and exports, there is already an accumulation of experience and expertise in those traditional products (Copper in Chile, oil in Venezuela, meat in Argentina, coffee in Colombia, etc.) To varying degrees, there is usually a significant number of trained engineers, R&D capabilities, a certain network of suppliers, including capital goods, and in most cases the development of processing industries downstream. There are also in most cases connections with export clients as well as varying levels of knowledge regarding market requirements. These sectors are thus likely to be the most promising when considering an NR-based strategy. The objective in these cases is to build the consensus vision among all the stakeholders, to aim for a bold innovation strategy, while intensifying the network links domestically and internationally, promoting the development of local knowledge intensive services and engaging in intelligent and informed negotiations with whatever global corporations are involved. The goals of such a strategy would also need to be complemented with a clearly focused and intensive educational effort.

However, there are many other resources in each country that are either under-exploited or not even recognised as such. Each part of the territory needs to identify its potential through an exercise in "self-recognition" and in this process it is likely that national and local governments or other agents, private or international, could play a major role.

Government experience in such promotion processes has been building up. Even after the demise of the ISI model, industrial policies were not totally abandoned in Latin America (and

they have been key to most of the successful Asian cases). The late 1980s and the 1990s saw a proliferation of 'contained' industrial policies aimed at local industries in smaller geographical areas or industrial clusters. These policies became known as *cluster promotion* or *cluster development policies* (See Nadvi and Schmitz, 1999, for a collection of cases from the developing world). In Brazil industrial clusters were called APLs or 'Arranjos Produtivos Locais'.

Successful industrial clusters or APLs in Latin America tend to exhibit the type of behaviour described as 'embedded autonomy' described by Rodrik (2006) and several of them happen to be based on Natural Resources like the examples (in boxes) presented in this paper. One clear recommendation would be to start by working with those regions and institutions where this type of arrangement already exists while at the same time invest in creating these conditions and behaviours in other regions where NR-based networks can develop.

The expertise of Latin American institutions (such as Corfo in Chile and SEBRAE, Instituto Euvaldo Lodi and the Federation of Industries in Brazil CINDE and CAMTIC[7] in Costa Rica, the regional CONACYTs in Mexico and others) in cluster/APL promotion can be used to identify and promote the appearance of 'embedded autonomy' behaviour in NR-based networks.

Thus a strategy to foster technological dynamism in NR natural resources may be constructed in several networks and at different levels, i.e. local, regional (meaning sub-national or clusters), national and even supra-national (since NR networks may cross over national borders). It is also important to note that development strategies can be designed or co-designed by other actors besides national governments, including the private sector and, of course, such international organisations as the IADB (Inter-American Development Bank) ,UNIDO (the United Nations agency specialised on industrial organisation), ILO (International Labour Office), GTZ (German Development Agency) and many others that have already acquired useful experience in this task.

Towards the late 1990s and in the first decade of the 21st century, industrial promotion strategies based on the locality were also complemented by strategies aimed at strengthening these clusters linkages with other actors located in other countries that had strong ties to the industries located in developing countries. These new strategies aimed to use a 'Value Chain' approach in order to reduce inefficiencies along the chain and/or improve the local industry's earning prospects by facilitating the industry's acquisition of new technological, organisational and marketing capabilities that would allow them to upgrade their position in global value chains vis-a-vis the global lead firms coordinating such chains. Humphrey and Navas-Aleman (2009), reviewed best practice in value chain promotion projects led by international donors and development agencies in Latin America and other developing regions. These strategies tend to involve global lead firms, local industrial champions in developing countries and their support institutions (e.g. local governments, NGOs, donors, etc). The Chilean salmon industry, for instance, owes part of its success to the financial and technical support provided by international agencies during the first years of the industry (Maggi, 2007)

Both cluster/APLs and value chain approaches have been used in Latin America to strengthen industrial networks in both the fabrication and processing industries (including those working with natural resources). These sub-national regions where NR-based industries have already successfully experimented with competitiveness promotion strategies in collaboration with local governments, technology institutions, universities and so forth would provide ideal settings to start a strategy such as the one suggested in this paper.

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[7] CINDE is a prívate institution in charge of attracting FDI to Costa Rica. CAMTIC is the Chamber for information technologies and is very active in the country.

The possibility of working at these different levels cannot be emphasised enough. Policy makers that are aware of these possibilities and build on the previous local successes of cluster/APLs policy implementations may achieve 'quick gains' from a development strategy based on NR-networks that would have powerful demonstration effects for other regions, both sub-nationally and supra-nationally.

The risks: Missing the boat and intrinsic perils

The biggest risk of all is one of timing: Just as the Asian story cannot be repeated because the micro-electronics related opportunity space they exploited came and went, the current opportunity with the processing industries in relation to natural resources is here now and will also pass.

In addition, Latin America is not alone in being able to exploit this space. The opportunity is there for resource rich countries anywhere. Competition could come from Russia, Kazakhstan, Africa, Indonesia, Malaysia and others. Since each natural resource is different and its distribution on the planet highly uneven, there are usually only a few major potential suppliers and possible competitors. The importance of quick adoption of this sort of strategy is in the synergies created by early mover advantages. Once the highly competitive climate is created in a country with the availability of high-tech services, trained personnel and knowledgeable suppliers, more and more investors are attracted, transaction costs are reduced and the original advantages multiply. Experience in negotiation increases the dynamic conditions and if the companies in the country establish a reputation as trustworthy suppliers, clients tend to give them priority. There is a path-dependent character to the "hot spots" of growth in the global economy.

Furthermore, this strategy can also serve as insurance for the future. There is a high likelihood that the next technological revolution will be based on some combination of biotechnology, nanotechnology, bioelectronics and new materials. All these areas happen to be related to a mastery of the deep structure of natural resources. At present, most countries, be they advanced, emerging or developing are trying to position themselves in those technologies. The current development opportunity is thus also ideal for Latin American countries to get ready to take full advantage of the next technological revolution.

For all these reasons, it is imperative to generate a sense of urgency amongst policy makers and industrial leaders to accelerate the establishment of linkages and cooperation around a development strategy based on the technological dynamism of NR based networks.

The second major risk is to be unable to tackle Latin America's social inequalities with a development strategy that focuses on innovation in NR-producing and processing industries which are not labour-intensive. In this sense, the 'Vision' proposal presented by Perez (2008) acknowledges the need for a 'dual strategy' which includes support for high-end, world-leading innovation in NR based networks in tandem with sustainable, organic, environmentally friendly, culturally sensitive and location specific projects to generate income generation in a 'bottom-up' manner (with activities such as eco-tourism, niche agriculture, customised services, etc.)

Environmental concerns comprise another set of issues which could be seen as a risk in a strategy based on natural resources. There could be a backlash against the use of natural resources because of [a] the danger of exhaustion of the non-renewable resources, [b] the increasing threat of global warming [c] the destruction of ecosystems (as in the case of the Amazon forest - See Vera-Diaz et al, 2009 about a road project to facilitate soya plantations in the Brazilian states of Amazonas and Para) [d] the threat of serious pollution of air and water (as was recently the issue in the controversy about the Uruguayan project for a paper mill on the margin of Rio de la Plata) and [e] the fear of the unpredictable consequences of technological advances (such as GM crops). All these concerns are valid and are likely to become

characteristic of the political and business climate of the next decades as well as of national and international public opinion. Any resource-based strategy will have to take them centrally into account.

An additional risk from this strategy is that of being seen as 'apolitical' by policy makers, the type of approach or thinking that uses technology to explain the world and ignores the political economy realities that may well hinder the establishment of a strategy like the one we propose in this paper. This critique would most likely come from those policy makers that have been influenced by the 'Resource curse' literature. Ironically, the 'curse' literature could also be rejected as 'atechnological' for not acknowledging how the new technological paradigm has changed the conditions in which a development strategy based on natural resources could be deployed. Ideally, policy makers should not have to choose between full awareness of the political or the technological contexts but to surmount the 'blind spots' of both perspectives by aiming to analyse and understand the technological and political opportunities (as well as barriers) to design, test and roll out a viable strategy. This understanding should be enhanced by systematically identifying empirical evidence about the conditions that make innovation more likely in NR networks in the Latin-American context.

Finally, there are challenges and risks that remain from past conditions. Price volatility for the commodity segments of both the raw materials and their processed products cannot be avoided, although it may occur at higher prices. The technological rents of some of the productivity (as opposed to product) innovations may not be reaped by the originators. The Dutch disease may continue to affect the potential for investment and the export competitiveness of other sectors in the economy. Corruption will still be present as a possibility, especially in the countries with a less developed democratic system and a public sector that is more politicised, less stable and less technical. Finally, there will always be conflicts of interest where achieving a positive-sum game will become the principal challenge.

To sum up, in this paper we have argued that the conditions that condemned natural resources as low tech and a poor platform for a development strategy are changing significantly. The possibility of innovating actively across the value network around each of the natural resources of each country is open and the market conditions are favourable. What we argue is that natural resource production and all its linkages upstream, downstream and laterally conform an innovation space that is ready for exploitation and that the probable trends in the global economy will do nothing but expand that space. Of course, successful strategies are still to be designed and tested and all agents need to be aware of the many risks to be confronted along these relatively untested paths.

Yet, all strategies have drawbacks and risks. The risks increase if they are not recognised and if the adequate safeguards are not incorporated into the strategy. But the greatest risk of all is for Latin American countries to let a rich development opportunity pass them by.

Box 1: Transformations in the mining industry - from enclaves to knowledge-intensive clusters

The mining industry has recently experienced a major transformation with enormous implications for the enclave model which predominated in the past. Its model of production has moved from a highly integrated to a highly de-integrated one, where key knowledge services, that used to be conducted within the large mining companies, are now outsourced. Every step of the mining process can now be outsourced. Entire activities that were performed in the past within large global mining companies are now conducted by independent firms (Urzua, 2007). As a consequence, a new sector of specialised knowledge intensive mining services providers (SKIMS) has emerged. These are not pure knowledge intensive providers; they incorporate highly specialised services, capital goods and equipment and consumable input such as chemicals, all of which are high-tech given the increasing knowledge intensity of the mining industry. Knowledge produced for serving this industry therefore is being applied to other industries generating important positive externalities and multiplier effects (Walker and Jourdan, 2003). The experience of Bell Equipment from South Africa is an excellent example of this knowledge migration, which has been called lateral migration in the literature. This company, which started producing self-loading trailers to manage cane cutting in the mining sector, moved to produce machineries with similar principles for the agricultural, forestry and sugar industries (Kaplinsky and Mhlongo, 1997, Walker and Jourdan, 2003), which are exported to the rest of the world.

This transformation has opened up opportunities for new actors –including those from NR-rich emerging economies- to become global providers of high tech services to the industry. The case of SRK consulting from South Africa is an excellent example. This company started as a service provider for the Anglo American company and has now turned into a global provider of advice and solutions for earth and water resource industries. Just for mining they offer services from exploration through feasibility, mine planning and mine closure.

SKIMS are now key for the success of the mining business. Mining global corporations are therefore committed to develop world class SKIMS suppliers. BHP Billiton Metals Base for instance, in facing the unprecedented increase in demand of copper has implemented a very ambitious supplier development programme in Chile, which aims to support a selected group of service providers in their movement from production and adaptation capabilities to the development of capabilities to design and carry out R&D at the frontier. They have currently 3000 suppliers in Chile, a few of which are able to export. The aim of this programme is to select and develop between 250 and 500 suppliers, with potential and commitment to become world class providers, to transform their current operational capabilities into capacities to develop new specialised knowledge and services which can be exported worldwide (Interview with BHP Billiton Metals Base).

Box 2: The de-commoditisation of NR based products: the case of wine

Wine can hardly be considered a new/emerging industry. It has been produced for thousands of years and until very recently was considered a typical example of a traditional, mature and non dynamic industry, characterised by low innovation and a very simple production process based mostly on tradition rather than on new knowledge ("it simply required collecting and pressing grapes and storing the juice in barrels until it ferments" Archibugi, 2007)). However, very recently several forces changing at the same time have combined to dynamise this industry to an extent before unimaginable. As pointed by Smith (2007): wine is one of the few products "whose recent history includes long-term growth in world trade, substantial foreign direct investment, rising unit values, positive income elasticity of demand in the OECD world, sustained technological change and quality improvements, and success by new producers that include developing countries"

The two more obvious forces of change have been demand and knowledge.

The demand of wine has moved from valuing only price and quantity to valuing quality and variety (Giuliani, 2007). In the wine markets nowadays "..differences in taste are so valued by consumers that a vintage bottle of wine can be a luxury or positional good, as expensive as a diamond" Archibugi (2007). This shift in consumption patterns is clearly reflected in the trade statistics which show that while during the last 30 years the total volume of wine produced is declining the total value of production in increasing (Smith, 2007).

Knowledge regarding the several mechanisms underlying wine production has also improved substantially during the last 20 years or so. These improvements have favoured wine producers in two main ways. First they have opened innumerable opportunities for experimentation and the development of new tastes, and second, they have allowed them to reach degrees of control over the production process before unimaginable. For instance, advances in genetic by improving understanding of wine structure and different *terroirs* have allowed the design of new tastes, even within the same vine variety, a similar effect has been produced by improvements in the chemistry and bacteriology fields, which by helping to understand the process of fermentation have allowed producers to have greater predictability of wine quality (Giuliani, 2007, Smith, 2007). Developments in the ICT field have favoured the process of canopy management by helping to take decisions with respect to intervention in the vineyard, and the use of new materials in tanks have helped both the vinification and clarification processes.

These changes, by introducing new rules of competition, have opened a window of opportunity for several regions in the developing world, in Latin America and Africa, to gain increasing portions of the world market, by not only closing the gap with existing producers in France and Italy, but also in many cases creating completely new trajectories using their advantages as latecomers.

Box 3: De-commoditisation of NR products: the Coffee industry

Coffee was the perfect example of a commodity until the end of the 1990s. Until then, it was generally thought that differentiation strategies could not be applied to a product which is grown in the developing world, which suffered from volatile prices, inelastic demand and was sold in bulk to global roasters and toasters that would brand the product themselves and receive the rents linked to marketing, organisation and distribution.

However, changes in the demographic structure in several developed countries (greater longevity leads to several generations with different tastes to co-exist), the increasing purchasing power in emerging economies (e.g. China) in conjunction with a new preference for exotic, certified origin, organic and even luxury items has created the type of segmentation in the market that opens opportunities for greater differentiation within so-called commodities such as coffee and even for producers located in the developing world (e.g. Jamaican 'Blue Mountain' coffee; Ghana's 'Fairtrade' coffee).

Colombia is by far the most successful developing country regarding differentiation and upgrading in the global value chain of coffee at a large scale (Giovanucci *et al*, 2002; Reina *et al*, 2007). This success is easily observable when coffee retailers over the world highlight the Colombian origin of their product as a synonym of high quality. The Colombian Coffee brand 'Juan Valdez' is tipped to become one of the Global Brands of the next five years by Wolff Olins, the consultants that created the London 2012 Olympics logo and the Product Red Campaign (Wiggins, 2009).By emphasising the soil, climatic, harvesting and processing specificities that make their coffee of superior quality, Colombia invested in an aggressive marketing strategy to take advantage of the increased consumption and demand for higher-priced 'specialty' coffees in the US, Europe, China and India (Reina et al, 2007).

The National Federation of Coffee Growers initially worked in partnership with large branded companies (Nestle, Volcafe, Starbucks and others) in order to promote the origin of their coffee. Without abandoning its partnerships, Colombia has ventured on its own and opened boutique coffee shops in the US, Europe and Japan where the Colombian brands 'Café de Colombia' and 'Juan Valdez' are recognised.

The best marketing strategy cannot be sustained over time if the product does not measure up to the public's expectations every time they consume it (Tybout and Calkins, 2005) and Colombian coffee is one of the most consistent performers in the coffee world.

This quality consistency has required efforts in each and every stage of the value chain from price and quality negotiations with international input suppliers (providers of fertilisers, fungicides, herbicides), distributors and retailers to intensive efforts to create new varieties of coffee by Colombian biotech innovators (i.e. Creation of the 'Colombia' coffee variety, a disease-resistant, highly valued *Arabica*).

Differentiation in Natural Resources may require both types of innovations: technological *and* those in the area of marketing. The close interaction and cooperation between the Colombian Science and Technology system(*) , local coffee producers and their support institutions such as the National Federation of Coffee Growers has made Colombia the leading site for technological and marketing innovation in the Coffee industry.

(*)Note: Colombia holds the highest number of PhDs specialised in the Coffee industry and their research within CENICAFE and other S&T institutions in Colombia and abroad (IFPRI in the US and CIRAT in France) is continuously transmitted to coffee producers via a large extension service paid for by the producers contributions (Interview with Julian Garcia-Cardona, ex-officer of the National Federation of Coffee Growers of Colombia and current Doctoral Researcher at the Institute of Development Studies, Sussex, UK)

Box 4: The Agricultural sector in Argentina - From 'chacras' to knowledge intensive networks

The agricultural sector in Argentina, which was until fifteen years ago dominated by the 'chacareros' (farmers) - who owned the land and machineries and centralised most of knowledge and decisions - has recently transformed into a complex network involving a number of new actors, several sectoral interdependences, and a rate of technological change which has no precedents. This network includes now, in addition to the owners of the land; the "contratistas" - new players who do not have land but own machinery and knowledge and rent the land to organise agricultural production -; large MNCs (and some national companies) in the business of GM seeds, herbicides and fertilisers, machinery producers (mostly local), national institutions of S&T (such as the national institute for agricultural technology, INTA), investment funds, etc. Hence, the evolution of the sector no longer depends on the centralised decisions of a single actor, the *chacarero*, but on the interactions between these several actors, who share decisions, knowledge, risks, via markets, medium term contracts and trust (Bisang et al, 2008).

Several transformations occurring in parallel contributed to this transformation of the agricultural sector from integrated units to complex networks, namely, the emergence of a new actor, the professional contractors; the knowledge intensification of production; the massive diffusion of agro-chemicals and transgenic seeds; the expansion of the agricultural frontier; the rapid diffusion of 'precision agriculture', etc (Bisang, 2008). However, the most dramatic change in the 1990s, that interacting with all the other transformations explains this new network configuration of the agricultural sector, was the massive adoption in Argentina of the radically novel Zero Tillage (ZT) technology. 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. This had enormous implications for both the agricultural sector itself and for its suppliers.

In narrow terms, ZT involves planting crop seeds in previously unprepared soil. However, more broadly it involves a complete farm management system covering planting practices, plant residue management, weed and pest control and other activities through to harvesting. In Argentina, as elsewhere such as in Brazil, it has also been closely associated with the use of genetically modified seeds that are resistant to herbicides. It is therefore a technological 'package' that requires the close integration of several components. Moreover, a particularly important feature of this package is that it is very sensitive to ecological conditions, and its individual component parts require substantial integrated adaptation for small variations in local conditions (Ekboir, 2003). Interestingly, therefore, the technology (or management system) encourages networks of close collaboration by farmers, professional contractors, scientific and extension institutions, suppliers of biotech and chemical products (seeds, pesticides and herbicides) and suppliers of the machinery, in particular the specialised seed planters, sprayers and equipment for residue management (see Box 5).

Box 5: 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, Ekboir, 2003). 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.

PLA S.A., a leading company in the segment of self-propelled sprayers exemplifies very well the promising trajectory followed by some of these companies. PLA started as a private family company in 1975, and became a public company in 1995. At the moment it has 400 employees and is positioned 546 in the ranking of Argentinean companies with respect to sales. In the early stages the company produced a varied range of machinery, equipment and parts. However, in the 1990s it became specialised in agricultural implements, in particular: sprayers and planters. In these products, the company has been able to develop world leading innovations, which have received twenty national and international awards. Its more innovative products are: different types of self-propelled sprayers (e.g. interseeders and sprayers controlled by computer and satellite), and several systems for variable dosage of herbicides and fertilizers. As a result of these innovations in the sprayers segment PLA is the leader in Argentina with 30% of the market. But the company does not only serve the Argentinean market. Recently, it has started to internationalise to other countries in Latin America. PLA has opened production plants in Brazil, Paraguay, Uruguay and Bolivia, with the purpose of serving these countries. It also exports to distant locations such as Russia, Ukraine, Kazakhstan, and South Africa. In this last group of countries the company has exclusive distribution points, which also provide after-sales service and are used to identify the specific requirements of demand.

Box 6: Eucalyptus from the 'Global South': changing the innovation landscape in the global forestry, pulp and paper industries.

Eucalyptus is not a native tree from the Americas but of Australia. However, South America has become the home of the largest Eucalyptus plantations in the world as well as the most productive (Flynn, c.2003; Figueiredo, 2009). This was due to supportive local governmental policies favouring plantation in order to ensure self-sufficiency (initially- back in the 1920s-1940s) as well as increasing exports (later –from 1970s onwards) when endangered tropical hardwoods began to be protected.

In the case of Brazil, the high productivity and quality of pulp and paper derived from Eucalyptus have made Brazil one of the world leaders in this type of product. This leadership has not been a 'natural consequence' of long term investment but the result of targeted efforts to strive for breakthrough innovations (of the world-leading type), and the support via informal (but highly responsive) links with public agencies even across different models of policy making (by the military, by civilians, import-substitution style, 'Washington-consensus' based, etc) (Figueiredo, 2009).

Before the 1960s, it was thought that good quality pulp for paper could not come from Eucalyptus but Brazilian researchers (in-company and at universities and technological centres) developed the best trees that would produce the best pulp for paper. Looking for the best seeds (sometimes imported), preparing the best hybrids and experimenting with propagation via cloning instead of traditional means they ended up creating a genetic pool of excellence within the Eucalyptus population in Brazil. In 1984, the Brazilian firm Aracruz received the prestigious Marcus Wallenberg Prize (from Sweden) after creating trees that were fungus resistant and could be propagated clonally. In 1997, Aracruz took the lead again (ahead of Canadian and Scandinavian firms) by developing and patenting a totally chlorine-free process to bleach eucalyptus pulp making it not only better for the purposes of making paper but also environmentally-friendly (Figueiredo, 2009).

Regarding innovation in woodboards, Brazilian interior designers are introducing Eucalyptus to any design that previously required a tropical hardwood (Flynn, c.2003). Eucalyptus can take any type of finishing after its drying process has been completed to specifications and Brazil has developed innovative ways to dry, varnish and finish Eucalyptus wood, even when the trees are relatively young (10 years old). The name 'Brazilian Mahogany' (Mogno Brasileiro) has been coined to refer to these new uses for treated Eucalyptus and it is marketed (correctly) as a Forestry Stewardship Certified (FSC) wood, which is also attractive for customers in Europe, Japan and the United States.

Other countries that have extensive Eucalyptus plantations and uses for this renewable wood are Chile, Argentina and Uruguay. In Chile, global corporate giant (and Chilean owned) Masisa has diversified its production of woodboards by including Eucalyptus to its list of planted woods (along with Pine) that are used for solid boards and for particleboard which require chippings.

In South Africa, a particular species of Eucalyptus (E. Saligna) has been used to export wooden furniture from renewable sources to European markets, but their fortunes appear to have been more mixed than in the South American experiences. Morris (2001) explains the institutional challenges (weak local cooperation between public and private actors) that prevented collaboration between the different actors in the Saligna value chain. It could be argued that any early NR based development strategy will need to start by identifying the locations where policy networks (including private and public actors) have been cooperating or if these are not available, the first step should be to foster trust and better flows of information within the network.

Box 7: Biotech networks: knowledge about specificities and cost structure advantages furthering local innovation.

Biotechnology in Latin America has a strong track record of specialisation in agricultural products and those of animal origin. This specialisation has been traced back to the mid-1990s when international companies developed innovations around seeds and vaccines aimed at the region's markets but needed the knowledge of local companies and scientists in order to adapt new products to local specificities such as particular species, types of soil, climate and so forth.

This in-depth knowledge about local specificities provides opportunities for Latin American companies or scientists to complement and fine tune the technological packages developed by international companies. These opportunities may be part of an alliance or they may be identified independently by locals when international companies leave some parts of the business unattended (purposefully or not). In addition, Latin-American companies have taken up new technological opportunities both downstream and upstream in biotech networks, often in other industries such as food and drink processing (Bisang et al, 2006 cited in Gutman et al, 2007).

Cost advantages have also spurred innovation in biotech networks. The lower availability of financial resources that often characterises innovation endeavours in developing countries has incentivised low-cost innovations which fit local conditions and may not be viable for international companies with a higher cost structure looking for more standardised solutions, with larger economies of scale.

Bortagaray and Sutz (2008) illustrate how these factors play a role in biotech innovation with an example from Uruguay: A local biotech company developed a vaccine against a common cattle disease, Leptospira, which is the main cause of abortion in bovine cattle. Since there are numerous varieties of the pathogen and it mutates quickly, there are no economies of scale for an international company to engage in developing a general vaccine. This opportunity was taken by the Uruguayan biotech firm which hence developed a cost-effective approach to a) detect the specific variety of Leptospira affecting a number of cattle and b) quickly producing a tailored vaccine for each mutation.

Local actors are also learning how to deal with the challenges of negotiating a mutually beneficial alliance with international companies in biotech. Gutman et al (2007) report two cases of successful innovation processes in the Argentinian dairy probiotic sector. The first case describes an alliance where the local partner managed to negotiate excellent terms with its international ally (a former division of Monsanto) and the resulting product (a probiotic cheese branded as Ilolay) is currently in the process of being patented by the local company. The second case consists of a three-way alliance between a local company (Sancor), a TNC (Christian Hansen) and a local S&T institution (Cerela-Conicet) for the successful development of a new type of bio-milk with probiotics. The alliance proved successful from the innovation point of view and although the Argentinian firm could not appropriate as much of the returns as the ILolay case, they gained very valuable experience on the type of processes that would eventually allow them to lead their own alliances and innovation networks.

Other examples from biotech innovations in Latin America where local specificities and cost advantages provided opportunities for local innovation in biotech are: Chilean vaccines for Salmon (Maggi, 2007) and the Mexican creation of the widely demanded Hass avocado disease-free variety (Carbajal et al, 2008).

Box 8: Nano-materials for the processing industries

Nano Dispersions Technology Inc. is a small high-tech company developing nano-materials for various processing industries, located in the City of Knowledge, a Science Park in Panama. It is an association of high level engineers from Venezuela, Japan and the USA, with a strong global network of researchers.

The business model does not involve selling the products they develop but rather making alliances with the producers or users and/or licensing the technology. In this way, they can concentrate on their main areas of expertise as high level researchers and engineers: from the product development stage to the scaling-up of the production process to a marketable size.

Among the nano-materials licenses they are commercialising one can find what is apparently a very simple product but with an enormous potential impact: a nano-dispersion of calcium carbonate. This is one of the most widely used "commodities" in industry, with applications in the paper industry, in paints, coatings and plastics, as well as in food, in pharmaceuticals and in toxic combustion emissions abatement.

Under established patterns of treatment, calcium carbonate has a relatively coarse granular structure that limits the applications, for instance in a paint or coating, because it can lead to cracks or breakage. The nano-dispersion treatment brings the grains down to nano-particle sizes, conveying a new texture to calcium carbonate suspensions. This new nano material, used as a component in coatings, imparts anti-crack, anti-scratching properties to the coated surface. As a component in the manufacture of plastics, the mechanical strength is improved to make harder, more resistant materials. Further, the technology being developed implies a significant reduction in process complexity and costs, with potential positive impact on the prices of food or medicines that contain calcium carbonate.

And this is only one of several similar products with significant prospects as specialised industrial inputs that are being developed by the company.

Source: Interview with G. Núñez, President of NanoDT, Inc., Panama City

Box 9: Differentiating products using location-specific advantages – Jamaican Blue Mountain Coffee

"Jamaican Blue Mountain coffee is a premium product, with Japanese consumers prepared to pay up to $20 per cup. Its growers have been able to escape the severe price pressures that have characterised the industry, particularly in recent years. As the CEO of the Jamaican Coffee Board observes: 'Blue Mountain coffee prices are not subject to the factors of supply and demand that affect other commodities. The price is fixed. This is useful in those times when coffee prices are low because of over-supply'. In early 2002, Blue Mountain coffee sold at $6-8,000/tonne compared to the London market price for arabicas of around $1,200/tonne. Not surprisingly, other producers, in Cuba and Kenya, have attempted to grow smuggled Blue Mountain beans in similar growing conditions. Whether the exact growing conditions and agronomic practices have been difficult to replicate (the Jamaican coffee industry's view), or whether it is the unique reputation and mystique of Jamaican origin coffee that affects consumer tastes (the view of competitors and many industry observers), the special characteristics of Jamaican Blue Mountain coffee endure. Most importantly, from the perspective of other growers and policy, it is the single-origin nature of the product's image that enables this particular set of growers to gain from product rents."

Source: Extracted from Kaplinsky and Fitter 2004, p. 19

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