Building Institutional Competence in Brazilian Biotechnology:

Some theoretical and empirical remarks

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FIRST DRAFT

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1.Introduction

During the last twenty years, Brazil has been developing a respectable knowledge in biotechnology research developing a few products and services in this area. Technological opportunities have also increased since Brazil entered the GENOMA international network by sequencing the bacteria present in orange trees (Xyllela) and cancer research (Nature: July2000)[1]. Scientific based knowledge and academic competence do not appear to be obstacles to the development of biotechnology in this country. Furthermore, Brazilian government has been trying to stimulate biotechnological firms establishing new rules of the game have been improving the institutional framework in very recent years.

This paper seeks to indicate some elements to an alternative analysis that values important characteristics of the activities surrounding biotechnological activities - mainly in the so-called biotechnology industry. It will be organised in terms of the following issues:

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1. the considerations about the convenience of using the building blocks device in order to define and understand how biotechnology is evolving in a new industry;
2. a brief reflection upon the new financial institutions that have been representing solutions to the problem of funding biotechnology activities and firms in underdeveloped countries;
3. a description on the Brazilian R&D institutional endeavour to find new market opportunities and develop new capabilities in agriculture biotechnology.

2. Introducing Biotechnology

The commonly used definitions of biotechnology taken from OECD (1989) are:

Classical biotechnology - Refers to the traditional technologies that have been used for thousands of years in the production – based mainly on experience;

Modern biotechnology - A science based development of the classical biotechnologies, a development that started in the 19th century;

Biotechnology competence approach - Technologies that have developed from the late 1970s including genetic engineering and cell fusion.

The emergence of biotechnology since the second half of the 1970's definitely cannot be treated in a conventional and linear way, in which a scientific discovery is followed by the upsurge of differentiated biotech products. Biotechnological activities suppose now the development of important class of *feed-backs* between the productive sector (pharmaceutical and agribusiness, for example) and specialised firms. Using advanced biotech procedures and protocols these firms give rise to a new class of network amongst different sectors and industries. Together they represent a complex combination expertise, capabilities and proficiency. However, they are also giving rise to transaction costs, especially the contractual costs. Governance problems can occur between the specialised firms and their suppliers and the presence of adverse selection on the relation between new specialist and the incumbent firms of pharmaceutical industry. [2]

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[1] Brazil was the third country to achieve a whole DNA sequence (Xylella squence) in 2000 even before France and other European Contries.

[2] See see Meyer and Nickerson (1998) and Pisano (1997).

Very often, the technological and scientific communities orient themselves by “guided empiricism”, resorting to science only when they face “bottlenecks” on the innovative process. When the investigation program in biotechnology is designed, these questions are taken into account from the beginning, creating an anticipation power that implies in choices, expenditure and investment decisions in the long run, and on the formulation of intervention strategies for the creation of new institutional designs. However, in congregating distinct forms of knowledge, agents of different nature, interests, and horizons of expectation, biotechnology demands a compatible approach, not only with the architectural complexity of its programs, but mainly with its flowing quality.

Biotechnology is an interdisciplinary dominion. Biotechnology can be been defined as a robust block of knowledge and information, which combines already existing research protocols and methodologies with new scientific concepts derived from distinct disciplines such as genetics, molecular biology, *proteomics*, functional *genomics*, and biochemistry. This definition holds a great potential for new combination and interaction with other technologies and academic fields such as the ones representing computer science and information technologies (See Fonseca, M.D.;Silveira; J.M.,Bonnacelli & Salles Filho,S.:1999 and Fonseca and Silveira, 2001).

The genetic information-based matrix characterises a particular combination of technological protocols and scientific procedures. They also work as a sort of *guide-post* (see Sahal, 1980) for those companies and organisations which are engaged in R&D projects. Together, they represent *a benchmark* for entrepreneurs who are engaged in the gene-hunting race. However, that matrix is a conforming context where no economic basis has yet been established - neither the payoff, nor the rules of behaviour of economic agents.

Basic biotechnological research is still very expansive even for big companies and the uncertainties associated to the development of new products make risks untenable. These uncertainties shall be summed with regulatory problems that are due to the core definitions of the trade agreements, property rights issues, as also to the discussions about the ethical and commercial implications of genetically modified organisms and cloning.

Biotechnology cannot be understood without the contribution of the established bio-techniques which have been helping producers to improve in productivity and quality. On that account, the biotechnology stock of knowledge does not cease to develop in new sources of information, new disciplines and new forms of capabilities and fitness. Such a sophisticated and complex puzzle requires a further advanced understanding. We think that the concept of the building blocks affiliated to the study of complex systems and emergence (see Holland, 1998) could unveil the mechanisms and principles behind the biotechnology puzzle.[3]

We believe identifying technological opportunities in market oriented economies is not only an issue of dealing with scientific expertise and technological capability but also a matter of handling specific financial tools for R&D. We can immediately identify a first big problem in the underdevelopment of the capital markets determining difficulties to capture funds and implement mechanisms of co-ordination of these markets. Additionally, we found another obstacle in the supervision of property rights and patents - also considered a pre-requisite for fund raising. At last, the patent contends amongst developed and underdeveloped countries can increase the risks and uncertainty already present in the biotech business recently.

Meanwhile, considerations about financial and regulatory issues have not disrupted some institutional solutions that gave support to the process of structuring the blocks of knowledge in biotechnology in the developed countries. The role of basic research in USA and Europe was reinforced by centralised institutions which are engaged in co-ordinate funding and regulatory recommendations, as well as planning programs for representing biotech companies in the government. In countries like Brazil, the consolidation of the biotech business depends, first, on the definition of similar rules (to the developed

[3] The concept of subassembly developed by Simon (1969) present strong similarity with the concept of emergnce and complex systems.

countries) of the game and, second, on the common acceptance of the institutional parameters defined in the international bodies and private corporations.

It is quite unlike that regulating trade, licensing cloning and other essential processes of life -including the institution of biodiversity protectionism - can be satisfactorily managed in the next few years. The discussion of these issues embodies an immense potential for a conflict where business companies, firms, governmental and academic agencies, non-governmental bodies and lobbies are the main actors. In the next session we will catch-up with some theoretical considerations about the convenience of using the building blocks device in order to define and understand how biotechnology is evolving in a new industry.

3. Building organisations as blocks of competence: some theoretical condiderations

What are the main properties and mechanisms that enable the formation of building blocks? There are few basic ideas and principles that can help us to model complex situations. The building blocks mechanism improves our capacity to break a complex structure down into parts using a wide variety of combinations that are neither arbitrary, nor deterministic[4]. It was developed basically by Holland (1985) an Arthur (1999). This approach supplies an important analytical expedient in the discovering of regularities and patterns emerging from a situations as those in which there are *systems with multiple elements adapting and reacting to the patterns they have created* (Arthur 1999). The distinctive final combination is not known *ex-ante* and depends on the selection of a more vastly varieties of alternatives structures.

From a methodological point of view, building blocks result from a heuristic process of search. However, the process of search depends also on the selection and continual creation of variety (see Nelson and Winter, 1982 and Metcalfe, Fonseca and Ramlogam, 2002). Running with few institutional parameters, variation and selection offer a good

[4]They provide a way of extracting recurrent features from the perpetual novelty that attends systems exhibiting emergence.

explanation not only how novelties are generated and introduced in the systems, but also how selection eliminates specific classes of structures and individuals.[5]

Additionally, the methodology behind the scene is based on the notion of the *adaptive* a*gents.* Dwelling in complex environments, these agents are rule (or routines) followers, entities of bounded rationality rather than agents of perfect rationality (Simon,1986 and Arthur, 1999).

Though initially rules should be simple, and even limited, they can be enlarged with minor alterations, creating distinctive levels of aggregations to add more hierarchical heights. However, as we enlarge the scope of the rules followed by agents, they reveal some recurrent patterns of interactions[6]. Existing routines and rules trigger the search for new rules. Innovation, the outcome of this process, rises from the comparison and combination between the new and the old rules. Adaptive agents are continually scrutinising the environment, using a repertoire of already tested rules and procedures, while adapting themselves to their surroundings. In this fashion, an individual agent is compelled to explore its environment competently, using its best attributes, advantages and capabilities. Observes that this is also a process of aggregation of experience, expertise, proficiency, skills, ability, know-how and capabilities. By means of selection, or simply competition, new interactions between agents could emerge as new blocks of competence. At the end of the day, rules mature in knowledge.

In very simple terms, aggregation can be defined as a *natural* technique to constructing models discerning what is relevant from which aspects of the problems must be ignored (Holland, 1998). By means of aggregation we can create scenes never seen before by combining and recombining things. The main difference with traditional approaches succeeds from the categories that are re-employed and can be decomposed into familiar

[5] Selection explains how casual interactions created by individuals develop into more regular patterns that represent characteristics better suited to their survival and growth. This is also the way by which competitive agents vary in characteristics that convey (selective) significance to these groups. See Metcalfe,1998 and 2000 and Metcalfe, Fonseca and Ramlogam (2002)

[6] In terms of modelling, rules can be represented by transition functions and a strategy as a sequence of rules. For a resume of these agents models see Fonseca &Zeidan (2002).

categories, like building blocks. Additionally, aggregation can reveal highly adaptive agents becoming new and superior agents- they evolve to **organisations**. The definition of the limits of the boundaries of an organisation is facilitated by the existence of mechanisms that allow ignoring certain details, focusing in others. At the same time they create identities making selective interactions easier. They also help to create a basis for specialisation and co-operation[7]. When a tangled network of interactions had developed between agents, this can also be defined as be defined as an organised complexity if they, collectively, confirm their continuous regeneration[8].

Maybe the most pervasive characteristic of building blocks formation is *diversity*. Put in very simple terms, the idea of *diversity* is connected with the enduring appearance of novelties and innovations[9]. However, diversity can be also related to some regular characteristics of its individual elements –agents and organisations, which are supporting structural transformation. If one of these elements disappears, the pattern of interactions re-establishes itself in a different way. To be more exact, diversity unfolds when these elements or agents are removed from its context, creating a gap in the structure which *naturally* respond with a stream of adaptation; the result might be the introduction of new agents filling the gap[10].Accordingly, we can say that diversity is the product of progressive adaptation (Holland, 1995: 29).

Returning to economics province we should add that the emergence of new economics structures and new patterns of competition is a direct extension of hierarchical social institutions. Hierarchy is still an extremely important element in aggregating agents and organisations since it helps to maintain the web of social relations built in the past (Foster,2000). Commons (1934) had also provided intuitive observations on the institutional nature of hierarchies. In depicting the economic system as a complex web of interactions in an explicit contractual setting, Douglas North (1996) have also provided brilliant reasoning on the same topic when he state that institutions represent humanly

[7] Tag is also a building block mechanism. They help people to create standards, as labels ans trademarks.
[8] An o*rganised complexity* exists if the constituent elements of an organisation engage in interactions whose direct outcome is the construction of other elements and other associations (Fontana & Buss, 1996).
[9] It is also related to the scope for variety (see Fonseca, 2000).
[10] Holland (1999)

developed constraints supporting interactions between social actors providing social and political context in changeable environments.

At one hand, institutions are also of important as they help to shape the emergence of new interactions and modes of behaviour. On the other hand, institutions could ease the emergent patterns of conduct to develop into competitive strategies, inducing co-ordination and occasionally co-operation between agents. According to Metcalfe (2000) selection processes in capitalism are essentially market-based processes and the role of markets is to co-ordinate different activities. Institutions, norms and conventions depict a counterpart. At On the other hand, the major role of institutions in a society is to reduce uncertainty by establishing a stable (but not necessarily efficient) structure for human interactions. We could add that institutions provide a social and political context to rules and routines for the developing of strategies, by inducing co-ordination ate the level of organisations.

4. Institutional Framework for agriculture biotechnology: the role of networks[11]

Some economists, like Taxler (1999), have considered the Brazilian option to incentive public and private investment in biotechnology a serious mistake. For them, it would be better to invest in means for technology transfer, profiting with the existing country' research network to adapt technologies coming from abroad. It is our solid opinion that they do not take in account the complexity of biotechnology development, mostly the importance of local development in basic research. For example, the rapidly and successful assembly of GENOMA network in Brazil was very important to channel efforts to go further, to study structural proteins chains (*proteomics*) and functional *genomics*. To understand this story and other cases of biotech success it is necessary to understand the institutional incentives created in the last years.

[11] This section describes Brazil's public research efforts pointing to the institutional contributions from the Brazilian government – at federal and regional level to build an adequate institutional framework to biotechnology development in the country in the last decade.

In a country facing serious budget constraints and macroeconomics uncertainties like Brazil, developing these blocks of competence should be impossible without the institutional opportunities created by the Brazilian government to R&D based biotechnology firms.

About 300 biotechnological companies has been created in Brazil since the 1990's, originated from a diversification processes carried out by companies already established in the market or governmental research institutions.

The future of new biotech firms in Brazil is still dependent on adequate e clearly established institutional arrangements. In spite of the development of scientific and technological skills, creating and sustaining start up biotech firms in Brazil still remain in the experimental phase. One of the reasons is that Brazilian venture capital is still incipient while the budget that would finance R&D activities in Brazil are small. Other issue is related to regulating GMO food and cloning research activities in Brazil.

On the other hand, biotechnology trajectories are closely related to the capacity to create new biotechnology firms and guarantee the uprising of we called "biotechnology market", i.e., a minimum level of biotechnology input-output relations. The Enterprise-University links and mostly the Research Institutes – enterprise links are required to incentive the development of sustainable biotech market in Brazil.

Biotechnology activities suffered an explosive upraising during the second half of the nineties, demanding new institutional tools to spur local R&D, mostly 'in house' research. Traditional sources of biotechnology financing are inadequate, because has been focused on scientific sponsorship only. The lack of adequate property rights legislation is another obstacle to universities spin off towards biotechnology enterprises.

Government support for the sustainability of innovation and scientific programs at the agriculture biotechnology is of great importance to the creation of biotechnology companies. In Brazil, the public sector is particularly significant in areas where private capital has a more fundamental role in other countries. The Brazilian government plays a considerable part in the development of biotechnology through investments in agricultural research and plant biotechnology, as well as through the support of public institutions.

In 1985, the Ministry of Science and Technology, MCT, was created to oversee federal programs in science and technology. The responsibilities of this central body include co-ordinating, supervising, and controlling science and technology activities as well as implementing national policy on Bio-safety. Other government agencies involved in the biotechnology sector include the Ministry of Development, Ministry of Health (including Oswaldo Cruz Foundation, Fiocruz), Industry and Commerce, the Ministry of Education, Ministry of Agriculture and the Ministry of the Environment, which includes IBAMA. While favourable, the involvement of so many actors must be carefully co-ordinated if inefficiencies and conflicts, such as a case between the MCT and IBAMA over transgenics, are to be avoided (Silveira, Fonseca & Dal Poz, 2001).

An important feature of the research and even production projects biotechnology in Brazil is the large number of relevant institutions involved[12]. Through various programs, the Brazilian government has focused its support on risk alleviation, risk being a great deterrent to investment in the field of biotechnology. This type of support is crucial for the creation of a critical mass of companies in the field. For example, FAPESP , the State of São Paulo Research Foundation - created in the year 1998 a program known by PIPE (*Pesquisa Inovadora em Pequenas Empresas*) which provides financial assistance for research in small companies of up to 100 employees.

At same time, Central government has also implemented three important assistance programs for R&D in biotechnology. These programs focus on building human capital and encouraging co-operative projects between universities and companies. Support for these

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[12] This feature is not necessarily good. Sometimes it is a sign of a lack of co-ordination and a waste of scarce resourcesfunds available in a country like Brazil. Assouline *et. al*.(1999) studying the institutional framework of the countries in Europe have found a great variance in the combination between non- centralised forms of control of strategic decisions in S&T and sources of biotechnological funds. For example, GB biotechnology system has mix between private and governmental base. In other European countries the role of the state is still greater.

programs comes from public, federal organisations including the CNPq (Conselho Nacional de Desenvolvimento Cietífico e Tecológico), FINEP (Financiadora de Estudos e Projetos), CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior), and EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária). The main programs are:

a) PADCT – Assistance program for scientific development, created by the Brazilian Government in 1984 for the purpose of stimulating science and technology in strategic areas;

b) RHAE – Program for building human resource capacity in strategic areas, created in 1986 by the MCT and supported by CNPq;

c) National Program of Biotechnology and Genetic Resources, a MCT initiative that encourages the participation of biotechnology related sectors with an interest in socio-economic development. Objectives include creating a favourable environment for up and coming companies and accelerating technology transfer of goods and services.

The scientific support to biotechnology in PADCT - where biotechnology represents about the 15 percent of the total financed in all areas – is of US$ 42 million (5 years program) a modest amount, but significant in relation to the total expenses in R&D in the country. The Biotechnology Program launched by the MCT, in the year 2000, anticipates US$250 million in resources for biotechnology in the next two years. The financing of the first *Genoma* Project costs US$32 million in two years, congregating almost 200 researchers and over 40 laboratories, matching “knowledge blocks” from bio-computer science up to studies of molecular protein structure and using the Laboratory of *Síncroton Light* of the National Research Council (CNPQ) going very beyond a simple gene sequencing.[13]

[13] Brazil has acquired prominence in the scientific field when constituting the *Genoma* Network, initially in the State of São Paulo, an experience that is being multiplied in new networks financed not only by FAPESP, but also by the Federal Government. More recently, Brazilian researchers and venture capital sponsored firms (Allelyx) has established some contracts with an association of wine producers of California and with a Belgian company, Crop Desing). Part of this success, as we had seen above, is based on research public efforts. Taxler (1999) has pointed that for agricultural based countries like Brazil is more important to create adequate means to adapt foreign technologies, coming from developed research centre like USA. From our

Such assistance programs attest the current government's commitment to developing the national biotechnology sector, and illustrate its interests in linking technology advancement to economic growth. The government's undertaking is particularly significant since, research capacity in Brazil is high but lacks a critical mass of experts in the field needed for sustainable progress. Thus, "government funding programs" focused on human capital are of strategic importance. Over the past few years, Brazil has established appropriate public institutions and organisations to support its biotechnology sector.

4. Biotechnology in Brazil : Agriculture and agribusiness

Brazil is considered to be one of the main agricultural research centres of developing countries, along with India and Mexico. Following Taxler (2000) classification, Brazil is a Super Nar´s). As an additional advantage, Brazil has the possibility to count on its own institutions, whose budget is not tied to those of international institutions, like the International Agricultural Research Centers chain, supported by FAO and other Multilateral Organisations.

Its position as an "*excellency centre*" in vegetal genetic breeding is related to the role of EMBRAPA, the US$ 250 million/year budget federal agency. There is some regional centres of great importance, like the APTA network which is in charge of the agribusiness institutional research in the most developed state, the state of São Paulo (SP). This network includes IAC, IB, ITAL, among others, FAPESP is the most important funding agency at the state level, is pushing all the GENOMA network in Brazil. In a smaller degree, there is a small group of expert co-operative associations ("co-operativas") developing research projects related to the sugar-cane business, Copersucar, the soya and other seed grain, Coodetec, a US$ 8 million agency. The latter is responsible for the diffusion of varieties of soybeans in the Centre and in the South of Brazil. This very efficient Research Centre.[14]

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point of view, Taxler (2000) do not foresee technological opportunities opened by the exploitation the interactions between *germoplasm* and local features of climate and soil.

In spite of its remarkable results, agricultural biotechnology is developed in Brazil in several levels that are not necessarily articulated in hierarchic form. Commodities commercialised by agribusiness are founded upon a mature technology, sometimes in conflict with ampler objectives of productivity increase, quality gains and environmental conservation. Sometimes biotechnology threatens important incumbents in some consolidated agribusiness fields; in other cases, its impacts causes sharp market concentrations, as happens in the field of citrus matrix producers in the Estate of São Paulo. These sources of potential conflicts claim for an adequate framework to define the role of different biotechnology relevant players.

According with our theoretical point of view, agriculture biotechnology clearly supplies an example that the conception of the innovative process demands a broader vision than the one supplied by the theories of innovation. The idea that some aspects of scientific knowledge relate themselves in a complex way with a set of institutional aspects, which are not necessarily virtuous or, on the other hand, antagonistic, is verified in the requirements for its consolidation. At the same time they incorporate the results of the increasing sophistication of the innovative process from biotechnology, the innovations, a lot more incremental, present slower patterns of diffusion, in average, than in the areas of animal and human health. In the agricultural sector the innovation results present a very varied pattern of diffusion,, from the producer to the consumer, something that rarely happens in the sectors of human health.

The diffusion of biotechnological innovations happens in two basic forms, recovering the previous analysis:

a) By the use of cellular culture techniques or applied knowledge of biology for plague and disease control, diagnosis' kits construction, use of micro-organisms to improve the fertility conditions of the system soil-plant (*Micorrhizal*), techniques whose diffusion depends crucially on institutional arrays and producers to become effective;

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[14] See also Massola(2002) According this author, this very efficient Research Center benefits with the spill over coming from a very intense agriculture research network in the South and Southeast Brazil.

b) By the use of biological markers and in the future of bio-computer science to speed up the process of vegetal genetic improvement and micro-organisms;

c) By the generation of innovations using techniques of recombinant DNA, *proteasis* blockade and directing techniques of the expression of certain desirable features.

The first item allows the fast sprouting of micro and small companies of local or regional base, that necessarily must be supported by research institutions as well as by diffusion programs supported by public or private institutions (co-operatives, associations of producers).

Activities mentioned in the second item are internalised by large companies and by public research institutions, with an exception being average sized companies. The level of appropriation (and rate of return) is a subject of great importance in this case, as well as the relationship between conventional breeders and top biotechnological innovators.

The third item is very close to the previous one. It is related to difference within certain protocols which can be used by public organisations or public-private alliances. They aim to treat specific problems, as a nutritional enrichment of a variety, tolerance to plagues by intervening in the pathogen/host relationship or the reproductive pattern of the pathogen (for example, the research by Dr. Marcos Castro on potatoes, made at ESALQ-University of São Paulo).

The governmental bodies have established scientific and technological network of support to help the emergence of small biotech companies in Brazil. This network includes labour training (RHAE, of the MCT), support to international consultants (CNPQ) and technological transference (Universities and mainly key research institution, as EMBRAPA and institutions of the APT network - State of São Paulo). In consequence, a new group of *especialists* firms have emerged on the production of *inoculants*, plants and matrices without viruses, firms of diagnose (diagnosis kits), of artificial insemination and vaccines services, which are not capable of developing in house research.

Finally, in the seed market, contractual forms were established for the diffusion of improved seeds between seed companies and Embrapa (for example, Unimilho, for diffusion of corn hybrids -about 10% of the hybrid corn market in Brazil). They are an important institutional tool for the establishment of agreements of diffusion of genetically modified seeds or innovations originated at multinationals.

This complex scenario admits, therefore, an institutional redesign and the promotion of varied forms of development of contractual activities involving small companies, public institutions and even great corporations, in an environment that is at the same time competitive and co-operative.

5. Competitive Patterns and Concentration in the Seed Markets

The great deal of Brazilian biotechnology is to incentive the raise of small and medium sized enterprises. Biominas foundation estimates a relevant number of 340 biotechnology firms in Brazil, the majority in health fields. In agriculture, three issues are still on the spotlight, and they are highly correlated:

a) a high level of market concentration in seeds markets, mostly hybrid corn, soybeans and horticultural seeds; b) Intellectual Property Rights and bio-diversity issues and; c) bio-safety regulation.

As we saw above, a major part of the diffusion of the innovations is associated with the market of improved seeds. More than 80% of this market is represented by three or four cultures of agricultural importance: soy, corn, cotton and rice. There are and some few targets of research either, such as the introduction of tolerance genes to herbicides, resistance to pathogen and less often, the improvement of the nutritional qualities of the products.

The interest in Brazil is in the fact that it is the biggest market of Latin America, (more than 50% of the total) and the fifth world market, with a sum of USS 1.2 billion. According to Taxler (2000), a market characterised by the necessary adaptation for tropical varieties process where, even in the mentioned sectors, the world leaders need to establish agreements of co-operation and contracts with firms and Brazilian institutions.[15]

Recent Acquisitions in Brazilian Seed Market (1997-2000)

Buyer	Companies Acquired	Products
Monsanto	FT-Pesquisas e Sementes	Soy
	Sementes Hatã	Soy
	MAEDA	Cotton
	Sementes Agroceres	Hybrid Corn (former leader)
Singenta	Zeneca (and Limagrain)	Hybrid Corn
Bayer(Agr-Evo)	Granja Quatro Irmãos	Rice
	Sementes Ribeiral	Maize/Soy
DuPont	Pioneer	Maize/Soy
	Dois Marcos Melhoramentos	Soy
Savia (La Moderna)	Asgrow	Horticultural (former leader)

Source: Caltelli & Wilkimsoni (2000) and interviews with firms made by the authors of the article.

Concentration in the seed industry has been happening at an international level and resulted in domination by the five largest multinational seed companies which are: a) DuPont, Monsanto, Novartis (Singenta), followed by Aventis (Today Bayer) and Savia. (Silveira, Fonseca e& Dal Poz, 2001).

In the current seed sector, Monsanto has been an active player. For starters, it owns Calgene, Delta & Pine, and Dekalb Genetics Corp which was the second largest seed company in the US and active in Brazil through Braskalb. Between 1997 and 1998 Monsanto invested around US$ 6 billion in global biotechnology, research, and acquisitions. In 1996, it adopted soy-breeding projects and began to purchase companies in Brazil including Parana Company, FT-Sementes, and in 1997 the plant division of Agroceres, the largest research and Seed Company in Brazil. While Embrapa still dominates the seed market in soy, Monsanto represents about 18%. With the support of

[15] The market of seeds of horticultural crops (around USS 50 million only in Brazil) is a separate sector, where the imports fulfill an important backing role. Savia S.A has the local market monopoly in horticultural seeds in Brazil. . This firm is a branch of the world leader firm, La Moderna, from Mexico.

some agencies of the Brazilian government, Monsanto introduced “Roundup Ready” transgenic soy, but opposition to GMO’s stood as an obstacle to the commercialisation of this seed.

Brazil is one of the most competitive agriculture producer countries in the world and investment in research by public sector has been very successful (Ávila, 2002; Geopi, 2000).

However, as happened in Pesticide and Fertilizer, multinationals has been pursuing a narrow path and imposing a global technological standard with negative impact on agricultural commercial balance, regarding our financial fragility. To find new organisational forms to develop biotechnology, stressing its creative destruction feature (for example, by the diffusion of Methods of Integrated Pest Management- IPM) is mandatory. The improvement of Intellectual Property Rights legislation in this field, since 1997, is a pre-condition to strengthen biotechnological research.

6. The Institution of Property Rights in Brazil

Regarding the importance of plant breeding to agriculture, Brazil’s public sector has been a vital player in basic research necessary for innovation. Technologies developed in this way have been either subsidised, or free to the public. With the introduction of modern biotechnology, however, it has become evident that State funding alone cannot satisfy research requirements. Since 1995, after the introduction of trade agreements, agricultural research institutions in Brazil have begun to pay closer attention to their Intellectual Property Rights (IPR) and pursue returns on their investments. Brazil, like many countries, while still relying on the support of its government, has established IPR systems to reflect the change in technology, and encourage private sector participation.

The implementation of IPRs in the agricultural sector, however, poses a challenge to breeders as their access to modern research may be limited by license requirements and delays due to legal procedures. In short, the effects of introducing IPRs in the agriculture sector cannot be ignored. A more appropriate reaction would be to meet international requirement in a way that safeguards national interests.[16]

Under Brazilian legislation, biotechnology inventions are protected for a twenty-year period and must satisfy TRIPs eligibility requirements. Excluded from patents are: discoveries, scientific theories, living beings (except microorganisms), biological processes, biological materials such as genomes and *germoplasmas* of any living organism, as well as all that is found to go against morality and public security.

Plants are explicitly excluded from patent protection and so must rely on other means. In such cases, countries usually do one of the following to satisfy Plant Breeders Rights (PBR) requirements: (a) join UPOV, the international convention of PBRs; (b) adopt UPOV-like terminology but as national law; (c) Develop a new national law. Brazil adopted UPOV 1978 and established legislation reflecting and, at times, even exceeding important UPOV 1991 clauses. This move proves valuable since it accomplishes what patent legislation had set out to achieve, namely stimulate innovative activities and create favourable conditions for foreign investment in the country. Thus, PBR protection, and not patent protection assumes this role in Brazil because of its applicability to plant varieties.

Doing an effort to meet international institutional standards, Brazil developed many legislative changes in a short period of time. Meanwhile, in light of agricultural technology developments and IPR innovations, debates emerged regarding ethical, social, economics and cultural questions. Particularly sensitive issues are ongoing and include the patenting of animals, genetic manipulation, and the human genome. The accomplishment of the Brazilian property laws, *Lei de Propriedade Industrial,* put a lot of passion in the discussions. For the first time, groups of various organisations vocally expressed their concerns and expectations with respect to patenting human life. In response, Brazilian

[16] Between 1980 and 1990, in response to domestic pressures and international forces, the Brazilian government began to implement IPR legislation that led the National Congress in 1991 to establish a project for the creation of an IPR protection law. The resulting Law No. 9,279/96, or Lei de Propriedade Industrial, was approved by National Congress on April 10, 1996 and was ratified without vetoes by President Fernando Henrique Cardoso on May 14 of that year.

legislators have decided to allow patenting for genetically modified micro-organisms only. The development of PBR protection followed.

Prior to national PBR protection, agreements drove relationships between plant breeders and farmers. In the case of hybrids (e.g. maize and sorghum), contracts were enough to protect the interests of both parties. Since the introduction of biotechnology tools, however, finding a trade secret has become simpler. Vulnerable to new competition, the plant breeder must now turn to IPR's for extra protection. This is an example of "creative destruction" and the opening of the windows of opportunities by the use of biotechnology tools. Unlike hybrids, plant varieties developed through gene technology (e.g. soybeans, cotton, wheat) have always relied on IPR protection due to the ease with which they can be propagated. Farmers are therefore more independent, and breeders require protective legislation.

The LPC brought to Brazilian breeders the rights on the new plant varieties protecting these varieties from 15 to 25 years. The Law for the Protection of *Cultivares* (LPC) No. 9,456/97 was published in 28/04/. The LPC is regulated by Decree n. 2.366 of November 5, 1997, which created two administering bodies, The National Commission for the Protection of Cultivars (Commissão Nacional de Proteção de Cultivares), and the SNPC, or National Service for the Protection of Cultivars (Serviço Nacional de Proteção de Cultivares). In addition, Brazil have joined UPOV 1978 in 23/04/ 1999.[25]

Consistent with UPOV, the LPC states that a variety must be homogenous, stable, as well as clearly distinguishable from other varieties and its description made public. The LPC also includes the concept of essential derivative introduced in UPOV 1991, which addresses unfair practices occurring as a result of modern biotechnology. A variety is considered "essentially derived" if it was developed in a way that results in essentially the same genetic structure as the original variety. Assuredly any protected variety may be freely used as a source of initial variation, but as of UPOV 1991, if a resulting variety falls within the concept of essentially derived the authorisation of the first breeder is required[UPOV].

Under the LPC, an essential derivative of a protected variety may be commercially exploited only after receiving authorisation from and paying royalties to the holder of the initial protected variety. UPOV specifies that, permission is not required for the use of a protected variety for experimental, private or non-commercial purposes, or for breeding or exploiting other non-essentially derived varieties. As an optional exception, UPOV allows Members to permit seed saving without obligations within reasonable limits and without compromising legitimate rights of the breeder. Brazil abides by the required exemptions, and acknowledges farmers` rights, a privilege generally granted to certain crops or small farms. The LPC shows its true value here since these exemptions would not be possible under patent rights, which are exclusive and if applied to plants would not permit such access without royalty payments.(Domian, 2002).

While IPR systems have focused on encouraging the private sector, public institutions have also begun to realise the importance of exploiting such protection. In general, other countries have been slow to react to this opportunity[6], but Brazil's Embrapa has made some opportune, strategic changes in the face of a transforming economic world. With the introduction of its 1996 "Institutional Policy for the Management of Intellectual Property", Embrapa adapted an internal IPR assistance program. The policy addresses technology transfer and product licensing issues for plant varieties, genes, molecules, and software. Special committees help implement the policy, review requests for in-house IPR protection, and provide assistance for scientists through courses and conferences.

Embrapa has been actively implementing IPR protection for its in-house inventions and seed varieties since the introduction of the LPC. This demonstrates its tendency to behave like a private company while remaining a public institution. Farmers who benefited from Embrapa's improved varieties at minimal costs initially resented the changes since technological innovation was seen as a public good more than a private one. Time has shown, however, that this change serves to expand the seed market and not limit it (Domian, 2002).

Public varieties continue to produce well and now exist alongside protected varieties, which offer good performance and have the advantage of receiving royalty payments. In a country like Brazil where the local industry is strong – in spite of *seed market* concentration, as mentioned before - the benefits of IPR protection are beginning to shine through disadvantages such as price increases. As a consequence of IPR protection, for example the private sector has made more investments in Embrapa projects. Thus, while remaining committed to its objectives, and for the sake of its own success as a public institution, Embrapa resolved to receive returns on products developed in-house (Rodrigues, 1998). Having adopted protection, it is also able to join in national IPR related discussions, and influence the global course of IPR's by participating in TRIPS negotiations. Embrapa's inclusion of an IP system allows it to address important issues such as indigenous knowledge and the implementation of the CBD.

7. Biodiversity and IPR in Brazil

The Convention on Biological Diversity (CBD) is another important form of IPR protection and addresses issues of bio-diversity. Brazil is among the richest countries in bio-diversity. A vast range of plants, animals and microorganisms can be found in Brazil's Pantanal, Semi-arid, Cerrado and Amazon regions (Rodrigues, 19998; Santaniello, 2000).
The CBD works towards the development of fair sharing and preservation of such resources and their products. The idea of equitable sharing is based on interdependence, whereby developing countries provide genetic resources and are in need of modern technologies, whereas developed countries require genetic resources and a market in which to sell their products.(Lesser, 2000).

The industrialized country provides access to technology and intellectual property, and in return, receives access to natural resources. The Convention recognizes that participants in this transaction require protection mostly through patents, PBR, and trade secretes. Under the CBD royalties must be paid to countries and communities that provide raw materials used in production. The CBD is seen as a step in coordinating questions of access, use, and protection of bio-diversity between industrialized and developing countries. It is, however, still in dispute.

Like TRIPS and UPOV, the CBD deals with ownership issues, however it focuses more on genetic resources and less only technologies. Unlike the case of TRIPS and UPOV, industrialised countries have rejected the CBD. The US, for example, while insisting on the importance of harmonising IPR systems among all countries, refused to sign the CBD agreement due to alleged criticisms from the private sector in industrialised countries. While some industrialized countries believe that some sort of regulation should be developed, others feel that genetic resources should be available without regulation. To countries with rich bio-diversity, however, such reasoning gives the impression that so called “harmonization” has more to do with accepting US imposed standards than mutually agreed upon regulations. A member of both TRIPS and UPOV, Brazil seems to be in self-contradiction for having signed the CBD in 1992 and ratified it in 1994.

On one hand Brazil abides by US conditions, yet on the other it upholds its own requirements. Like other bio-diversity countries, Brazil fears a typical scenario in which: foreign researchers acquire information on useful qualities of an indigenous plant used by local communities. The scientists had identified and extracted relevant genes from that plant expressing the desired properties. After that, using advanced laboratory technology, they insert these genes into their own, marketed products. The resulting products then express the desired properties, and can be patented and sold at high prices without recognition for the indigenous knowledge that contributed to the finding.

Such unfair practices bring to question whether local communities should be able to control access to their property, as well as share in the benefits that result from royalty payments on products developed with their assistance. Brazil remains adamant on this point calling for an agreement such as the CBD, but this apparent impasse between industrialised and developing countries continues to be a cause of tension among governments. The Brazilian Government would in fact like to implement its own system of protection.

Brazil recently created The Center of Amazon Biotechnology (CBA), a US$ 12 million applied research center, with the main purpose to give scientific and mostly technological support to Amazon product's development, like cosmetics, tropical food and sources of active ingredients for medicines. It works as a node of a large network, composed by public institutions, local private firms, and University research facilities. Agreements with multinationals are seen as very important in the field of microorganism identification, but there is a lot of concern about the informational asymmetries, once multinationals like Glaxo and Novartis are worldwide leaders in many market segments related to fermentation and pharmaceutical products (CBA, 2001).

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