From catching up to the technological frontier: Challenges in the governance of knowledge

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"Perhaps a crux of success or failure as a society is to know which core values to hold on to, and which ones to discard and replace with new values, when times change…. Societies and individuals that succeed may be those that have the courage to take those difficult decisions, and that have the luck to win their gambles".

Diamond, J. COLLAPSE. How societies choose to fail or succeed. 2005.

ABSTRACT

'Catching-up' is the achieving of technological parity to the state-of-the-art or international standard. As the technological frontier is always moving ahead, catching-up seems to be an endless process, with falling behind a constant possibility. An alternative path is leapfrogging to the technological frontier. When an industry in a country is said to be at the leading edge, it is expected to define its own frontier. The first part of this article aims to discuss, in the light of the challenges posed by the twenty-first century, the concepts of catching-up, technological frontier, and knowledge.

The main hypothesis proposed herein is the following: Brazil is at the technological frontier of low-carbon tropical agriculture, and the Brazilian Agricultural Research Corporation, EMBRAPA *(Empresa Brasileira de Pesquisa Agropecuária)* plays a leading role in this process. Leadership at the vanguard of any agricultural technological frontier is a hard post to keep. The several possible ways of organizing research point to different

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forms of doing science and technology. Collaborative knowledge platforms are the main example to be mentioned, and EMBRAPA may point to a few remarkable experiences: (i) the Brazilian Consortium for Research and Development of Coffee (CBP&D/Café or Consórcio Café) which congregates more than sixty different institutions; (ii) Consortium for Soy Genome Studies (Genosoja) is more recent, coordinated by *Embrapa Soja* and the (iii) Inter-University Network for the Development of Sugarcane Industry, or Ridesa *(Rede Interuniversitária para o Desenvolvimento do Setor Sucroenergético)* - just to mention a few but important successful experiences.

These are some examples of ongoing collaborative innovation – open, with the contribution of users, using hard science, generating technological spinoffs, and mixing different intellectual property solutions - with huge consequences for the future. The second part of this article aims to examine the governance of knowledge in these research platforms – knowledge networks and markets – a necessary, but not sufficient, condition to keep Brazilian agriculture at the forefront of agricultural innovation.

This article is based on bibliographical research and focal interviews with key EMBRAPA actors.

Theoretical and conceptual inspirations

The first challenge that presents itself pertains updating the concept of technological catching-up,[3] given the new context we live in the twenty-first century. Synthetically, one may suggest the following reflection.

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[3] 'Catching up' refers to the principle that countries with relatively low technological levels are able to exploit a backlog of existing knowledge and therefore attain high productivity growth rates, while countries that operate at (or near to) the technological frontier have less opportunities for high productivity growth. ["A New Empirical Approach to Catching Up or Falling Behind", by Bart Verspagen, in *Structural Change and Economic Dynamics*, vol. 2, no. 2, 1991] It is regarded as the achievement of technological parity, or equivalence to international "state of the art" standards. It is a process that tends to occur in a concentrated form within a limited timeframe, and is followed by high economic growth rates with increased productivity, and international competitiveness both for whole industries and isolated companies. Quite aside from the concept of historical catching-up, there is also the concept of technological catching-up, with which we deal here.

The most important references about Catching-Up are: Gerschenkron, A. (1960); Abramovitz, M. (1986); and Hikino, T. and Amsden, A. in Baumol, J. Nelson, RR & Wolff, E. (Editors), (1994). See also Nelson, R. R.; Mazzoleni, R.; Cantwell, J.; Bell, M.; Hobday, M.; Von Tunzelmann, N.; Metcalfe, S; Henry, C.; Odagiri, H. (2006). Two recent theses on the subject may be cited, Bastian, E. (2008) and Rego, E. (2014). Antonio Barros de Castro was the author responsible for the introduction of this approach to interpret the Brazilian industrial development as a catching-up process, in contrast to the prevailing interpretation in the ECLA (Economic Commission for Latin America) tradition, a synthesis of which may be attributed to Tavares, M.C.

Unlike in the recent past no single clear, outstanding technological pathway seems evident at present, until a higher standard is firmed. The concept of secondary innovation,[4] where countries experiment with and pursue different technological trajectories following their vocations and capabilities,[5] renders the concept of catching–up somewhat indeterminate – after all, catch up with what? A single clear map to be followed by industries and countries doesn't seem available anymore. If such a path existed, it would not necessarily be the countries with the highest per-capita income to "show the less-developed an image of their own future."[6]

So-called "superior" technologies must also meet objectives that lie outside the traditional technological universe: considerations regarding sustainability, the preserving or not wasting of natural resources; avoiding harm to the health and life of persons and animals; meeting objectives of social inclusion; respecting or taking into account traditional

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(1973), whereby Latin American industrialization was essentially an import-substitution process. See, in this regard, Castro, AB and Proenca, A. Velloso, JPR (Coordinator) (2001) and Castro, AB (2003). The collection of papers presented by Castro, A.B., at the National Forum may be read in Velloso, J.P.R., and Castro, A.B., *Brazilian Development from Geisel's to Our Time*. The article "Renegade Development: Rise and Demise of State-led Development in Brazil", in Smith, W. *et al* (Organizer), Miami: Transaction Publishers, 1993, takes a step forward and discusses the role of conventions and shared beliefs in the interpretation of the most recent period the Brazilian economy. The latest version of this article is in Castro and Castro (2012).

[4] Based on the notions of "technological paradigm" and "technology trajectory" by Dosi (1982), secondary innovation introduces a new insight on this topic. Before consolidating a technological standard in an industry product, or process developing countries may explore alternative routes according to their capabilities. A company may acquire a given technology from a developed country, absorb the knowledge via technology transfer agreements with companies from developed countries, and improve it, exploring the possibilities of a new trajectory. See Wu, X .; Ma, R .; Xu, G. Secondary Innovation: The experience of Chinese Enterprises in Learning, Innovation and Capability Building. National Institute for Innovation Management, School of Management, Zhejiang University, Hangzhou. 2011

[5] The concept of "dynamic capabilities" was introduced by David Teece (1998), but its roots are found in the literature on the Resource Based View. The dynamic capabilities translate into the ability of sensing and sizing the market, alluding to Schumpeterian concepts of "competitive advantage", which may be considered a consequence of unique innovations. Innovations, in turn, help understand other organizational and business processes of integration, learning, reconfiguration and transformation, position (localization), imposition capability ("review"), reproducibility and imitability in organizational process. The Resource-Based View has as precursors Penrose, E (1957) and Chandler, A. (1967), and emphasizes competitive advantage related to the ownership of scarce, but relevant and difficult to imitate assets, such as knowledge. See in Foss, N.J., "Resources, Firms, and Strategies: A Reader in the Resource-Based Perspective". (1998) which concentrates this literature's main contributions.

[6] Marx, K., *Capital: Critique of Political Economy*. 1867; the version used herein is Marx, C. *El Capital. Critica de Economía Política*, *Fondo de Cultura Económica*, México – Buenos Aires, Quinta edición, F.C.E. 1968: "The country that is more developed industrially only shows, to the less developed, the image of its own future." Preface to First German Edition of Capital (1867). China is perhaps the best example of leapfrogging. See in Proença, A .; Habert, C .; Aredes, M .; Camargo Jr., S. S. (2011): "Technology and Competitiveness in Basic Sectors of the Chinese Industry: a Case Study. Cooperation Agreement 008/2010 - SAE / UFRJ Agreement, 1st Action Line. Final Technical Report. Available at: www.sae.gov.br/wp-content/uploads/RelatórioFinalVolume1.pdf

knowledge belonging to tradition-rooted cosmologies; all these considerations will be present in defining what technologies are considered superior, in present-day society and in the near future[7].

The second reflection recognizes a change in the way science is done, impacting the governance of knowledge and redefining the forms of coordination both within and among companies, hitherto privileged loci for innovation.[8] Concepts such as open innovation,[9] user innovation[10], and the existence of innovation platforms, knowledge networks and markets[11] were absorbed by the literature on innovation, but must be reconsidered in the

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[7] If this is accepted as true for certain sectors, in the case of agriculture these requirements become even stronger. A glance at agriculture reveals the existence of at least three strains or tensions in Brazilian reality: the "´peasant" viewpoint held by land-redistribution movements, markedly ideological, wherein the issue of unequal access to resources is more important than the their use; the "productionist" viewpoint, held by agribusiness, which pursues enabling farming income; and the "sustainability" viewpoint which pursues environmental protection, low fossil fuel use, and agro-ecology, which may or may not be accompanied by cosmologies which emphasize religious and spiritual dimensions, present for instance, in movements of the Pachamama type (mother earth, a deity related to the earth, fertility, motherhood, and femininity) or shamanic traditions, increasingly valued and studied in mainstream science.

[8] Schumpeter (1961) in *Capitalism, Socialism and Democracy*, pointed to the "domestication" of innovation within companies, subordinating the introduction of innovations in the economy to the reduction of an increased revenue from the technologies still in use, as one cause for capitalism to be overcome - not for its failures, but exactly for its successes.

[9] "We propose the following definition of open innovation, in hopes of unifying future work in this area: open innovation is a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with each organization's business model. These flows of knowledge may involve knowledge inflows to the focal organization (leveraging external knowledge sources through internal processes), knowledge outflows from a focal organization (leveraging internal knowledge through external commercialization processes) or both (coupling external knowledge sources and commercialization activities)." Chesbourough, H. "Open Innovation: A New paradigm for Understanding Industrial Innovation". In *Open Innovation, Researching a New Paradigm*. Oxford University Press. 2006, the latter containing the advances in the 'open innovation' approach Chesbrough H.; Vanhaverbeke, W.; West, J. *New Frontiers in Open Innovation*. Oxford University Press. 2015.

[10] "An innovation is "open" in our terminology when all information related to the innovation is a public good – non rivalrous and non excludable …. It differs fundamentally from the recent use of the term to refer to organizational permeability. (Baldwin and Von Hippel, 2011:1400). Von Hippel, E. Democratizing Innovation. MIT Press. 2005. User innovation was proposed by Von Hippel (1988, 2005, 2010) as an alternative model to the dominant view in management that innovation results from activities of producers and managers. In this model, users are not "consumers" of products created by "producer" firms, but instead are empowered (often as "self-manufacturers") to create their own products and services. The users may be individuals or firms — either focused solely on their own needs, or collaborating in communities to share their creations. User innovation thus has three key premises: users have unique ("sticky") information about their needs, when enabled they will create solutions to those needs, and they may freely reveal their results to others (Von Hippel, 2010). a publicação mais recente contendo os avanços da abordagem "inovação derivada do usuário" em Chesbrough H.; Vanhaverbeke, W.; West, J. New Frontiers in Open Innovation. Oxford University Press. 2015.

[11] The OECD released "Knowledge Networks and Markets", for expert discussion. For more information see http://www.oecd.org/innovation/inno/knm.htm.

assessment of technological catching–up processes. In fact, processes involving knowledge, learning, and innovation are currently being thoroughly renovated.[12] These changes are not taking place only in the companies, universities, and research institutions responsible for innovation. "New types of organizations, hybrids composed of markets and corporate networks – knowledge networks and markets – are emerging. In these new types of organizations, knowledge is both proprietary and fragmented across multiple entities. It is also incorporated into intangibles assets,[13] whose value they seek to seize." (Teece 2002) "These intangible assets are marketed under different forms and in emerging market structures."[14]

However, not all leading-edge knowledge must be appropriated – it may also circulate freely, through cooperative research and innovation networks, such as through open genetic maps and code databases, wikis such as Wikipedia, and under "creative commons" and "science commons" licenses, which pursue alternative intellectual property regimes with important implications for the governance of knowledge. In this sense, the creation and dissemination of knowledge soars far ahead of policies and regulations, which have not kept pace with the accelerated change in both the real and virtual worlds of innovation. The implications for catching–up processes do not seem to have been fully thought out or clarified yet.[15] Potential for even faster catching-up is present if developing nations would build specific institutional mechanisms to fully exploit several deliberately provided catching-up mechanism and tools, including 'science commons' by research institutions and researchers, WIPO's free services for developing nations by local patent office and inventors, and the systematic search for expiring patents by manufacturing companies. Also, the development of graduate programs in Reverse Engineering would expedite the assimilation of technologies, which could then be incrementally developed into

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Knowledge networks and markets are arrangements which govern the transfer of various types of knowledge, such as intellectual property, know-how, software code or databases, between independent parties across the economy. The OECD's KNM project studies existing and emerging knowledge allocation mechanisms and their impact on knowledge creation, dissemination and use. The assessment of the economic significance of KNMs informs an evidence-based approach to science and innovation policy making." *op. cit*., page 2.

[12] "The changes alluded to are the products not only of new technological regimes, such as described in Coriat and Weinstein (2002), but, especially, the result of changes in institutions, organizations, and governance structures that accompany them". Burlamaqui, Castro e Kattel 2012:xvi.

[13] Possas, M. (1999) draws attention to "the presence of intangible assets, based on experience, knowledge, networking, and market image" (Possas, 1999, p. 120).

[14] Burlamaqui, Castro e Kattel (2013)

[15] Stressing this point is justified insofar as EMBRAPA's innovation platforms are an object of study herein.

novel variants. One unforeseen consequence that may be suggested is that technological "catching-up" is indeed an ongoing, in fact endless process, where innovations may arise from mutable architectures in substantial institutional arrangements, and therefore may not configure a clear objective to be achieved, while "leapfrogging" is always a possibility that collaborative innovation may, or may not, engender.

Therefore, R&D activities are expanding in connectivity through the development of technological platforms that facilitate the management of distributed innovation activities among companies and innovation networks,[16] involving manifold entities. This new *organization of innovation*, it would seem, brings about several advantages and could prove more efficient than the centralized/hierarchical alternative, in being capable of mobilizing larger and more widespread resources for innovation. In this sense, competition between alternative technological routes - used by countries engaged in secondary innovation – may be enabled through, among other factors, a reduction in the bureaucratic costs associated with centralized research and development processes. These alternative forms, OECD suggests, require a "strong glue" to empower denser flows of knowledge among players. This structure for governance of knowledge would be the aforementioned knowledge networks and markets.

Knowledge networks and markets may be defined as (not necessarily) soft infrastructures, instruments and mechanisms to facilitate the development of innovation clusters, based on open innovation concepts, the trade of inventions made in universities and, in the Brazilian case, Technological Innovation Centers (NIT, *Núcleos de Inovação Tecnológica*) after the passing of the Innovation Law.[17] Arrangements that govern the transfer of several types of codified knowledge include patents, know-how, codes, databases, and others, that circulate among independent parties, facilitating its accessibility, usefulness and tradability. The participants of Knowledge Networks and Markets ("KNM")

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[16] Eric Von Hippel first coined the term *distributed innovation* to describe a system in which innovation emanates not only from the manufacturer of a product but from many sources including users and rivals. Over the years, systems of distributed innovation — so-called business ecosystems — have become increasingly prevalent in many industries. These entities generally encompass numerous corporations, individuals, and communities that might be individually autonomous but related through their connection with an underlying, evolving technical system.

[17] The Brazilian "Innovation Law" or *Lei de Inovação*, Law 10.973, of Dec 2, 2004, is available in Portuguese at http://www.planalto.gov.br/ccivil_03/_ato2004-2006/2004/lei/l10.973.htm

are universities, companies (particularly start-ups), government agencies, even individual researchers and innovators (applying a very broad concept of innovation).[18]

KNMs may be characterized primarily by their objectives: to circulate (share and trade) intellectual property rights, whether through patents, databases, research results of virtually connected teams, copyrighted and protected material in general, knowledge and trade secrets, among others; organizing the joint production of new knowledge, to the extent that such contracts are complex and difficult to monitor; in short, circulate (share and trade) existing knowledge - which may depend on organizing new markets where this exchange may take place.

On the supply side, KNMs include monetary incentives (including public funding), reciprocal access, reputation-building, networking, and prestige accrued for acting on behalf of the public interest. On the demand side, KNMs enable different access conditions: restricted (research clubs and networks); paid open access; free open access, as in Wikipedias or Scielo, for instance.[19] Governance occurs at a *micro* level, the companies and organizations participating in the consortia; at "*meso*" level, the networks and market structures; and at *macro* level, the mechanisms and instruments that govern the production, use, circulation and proprietorship (rights, protection) of knowledge.[20]

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[18] This concept does not apply solely to the innovations in the so-called 'more conventional' industries. One application that may not have been thought under the KNM concept, in the creative economy, could be the business model introduced by the YouTube platform to "monetize" video uploads and other distributed. See the excellent presentation in Portuguese of this business model by Pedro Misukami, *Centro de Tecnologia e Sociedade, Fundação Getúlio Vargas*, "The Digital Culture and New intermediation Processes". There is also a lecture by the author on the new Brazilian internet legal framework at https://www.youtube.com/watch?v=qiOd_owiv6w.

[19] Other relevant criteria for thinking a KNM typology would include: who are the members, how do they interact, what are their governance mechanisms, and how is the KNM internally coordinated.

[20] It seems useful to clarify two recent concepts in the governance of knowledge. The first may be attributed to Nicolai Foss and other researchers in this line, presented in Foss, N.J. and Michailova, S. (2009) Knowledge Governance, Processes and Perspectives, which is business-focused. The other consideration was explored by Burlamaqui, Castro and Kattel, cited above, in which the governance of knowledge refers to policies and regulations that encourage the production, circulation, distribution / use and protection of knowledge. In other words, the concept is located at the macro level. In this regard, the very notion of knowledge would benefit from a distinction between knowledge in general - restless and agitated - as per Stanley Metcalfe, and organizational knowledge, which even when not codified, is shared throughout by the company or organization and thus can be coordinated. Also see Tsoukas, H. (2005) and Tsoukas, H., Mylonopoulos, N. (2004).

Types of Knowledge Network and Market structures according to the OECD:

1. IP Marketplaces – these include mechanisms for the trade or sharing of intellectual property rights protected by IPRs, especially patents. The goal is to "marry" buyers and sellers of patents, bundling several related complementary patents as a pool, reducing their transaction cost. Brazilian Innovation Law created the NITs to perform this role, as a license market, to transfer technologies produced in universities and public research organizations.

2. Collaborative Innovation - includes certain modes of outsourcing, awards and contests, research alliances, public-private alliances for innovation, open source communities.

3. Knowledge Platforms - databases, expertise, collaborative research platforms, joint ventures, which may be closed, more or less closed, or open, governed by contractual agreements. Their boundaries are not clear, as they may lie in more than one category

4. Trade Mechanisms: clearing houses, patent auction houses, licensing markets, brokers, specialized Internet portals such as YouTube, music and video streaming and download portals, university technology transfer offices, such as iBridge, a portal that discloses university inventions, which are of interest to researchers, among other forms that exist today or are still to be invented.

5. Other mechanisms: patent pools in open or closed collaboration networks, non-commercial patent pools and patent funds (including humanitarian funds run by large companies that buy and provide patents, such as the French government, or foundations including the Bill and Melinda Gates).

Industrial and technological innovation policies, competition regulation, intellectual property regimes - which are the result of the work of patent offices, intellectual property litigation courts, the diplomatic corps of countries that operate in global governance organizations with some degree of influence on international IP, Intellectual Property, and competition regulation legal frameworks, are institutions that comprise the new innovation ecology and its governance.

Therefore, the concept of 'knowledge management' has weakened before the entanglement of dimensions, actors and policies. The term 'knowledge governance' seems better suited and closer to the multiple realities of the knowledge economy - which includes not only the scientific and technological frontier but also, for example, the subtleties and

complexities of the creative economy. Organizational knowledge, in this same manner, cannot be strictly managed, because a company's dynamic capabilities may lead technological trajectories in novel, not always foreseeable, paths. In this sense, the technological perspective, even though fundamental to envisage frontiers, pathways and trends, may not account for the windows of opportunity which companies pursue and would exploit, even though breakthroughs, but arise only unexpectedly.

Before examining EMBRAPA's knowledge platforms, some study findings are worthy of note, gleaned in 2012 and 2013 during our interviews with the top management.

It may be said that there was a shared belief, or structured consensus, that EMBRAPA considered itself as being on the leading edge, or technological frontier, of low carbon tropical agriculture; moreover, the company believes they actually define it. In this sense, the internal, national and international institutional arrangements, the strategic design, research infrastructure, new recently inaugurated research units, the LABEX (Overseas Virtual Labs), the organization in macro-programs – in short, their entire internal knowledge governance system - reinforced this viewpoint. Their result assessment methodology itself requires a new metric capable of revealing the dynamics of an agricultural system with these characteristics. Tensions between disparate objectives, such as social inclusion, a profitable high yield, and sustainability, seemed intertwined under a single strategic orientation, that of low carbon tropical agriculture. The company performs technology foresight and has ample trust in its leading position among countries with similar agriculture.[21]. Their organizational structure is shown in Figures 1 and 2.

[21] The same cannot be said today, but neither is there evidence otherwise.

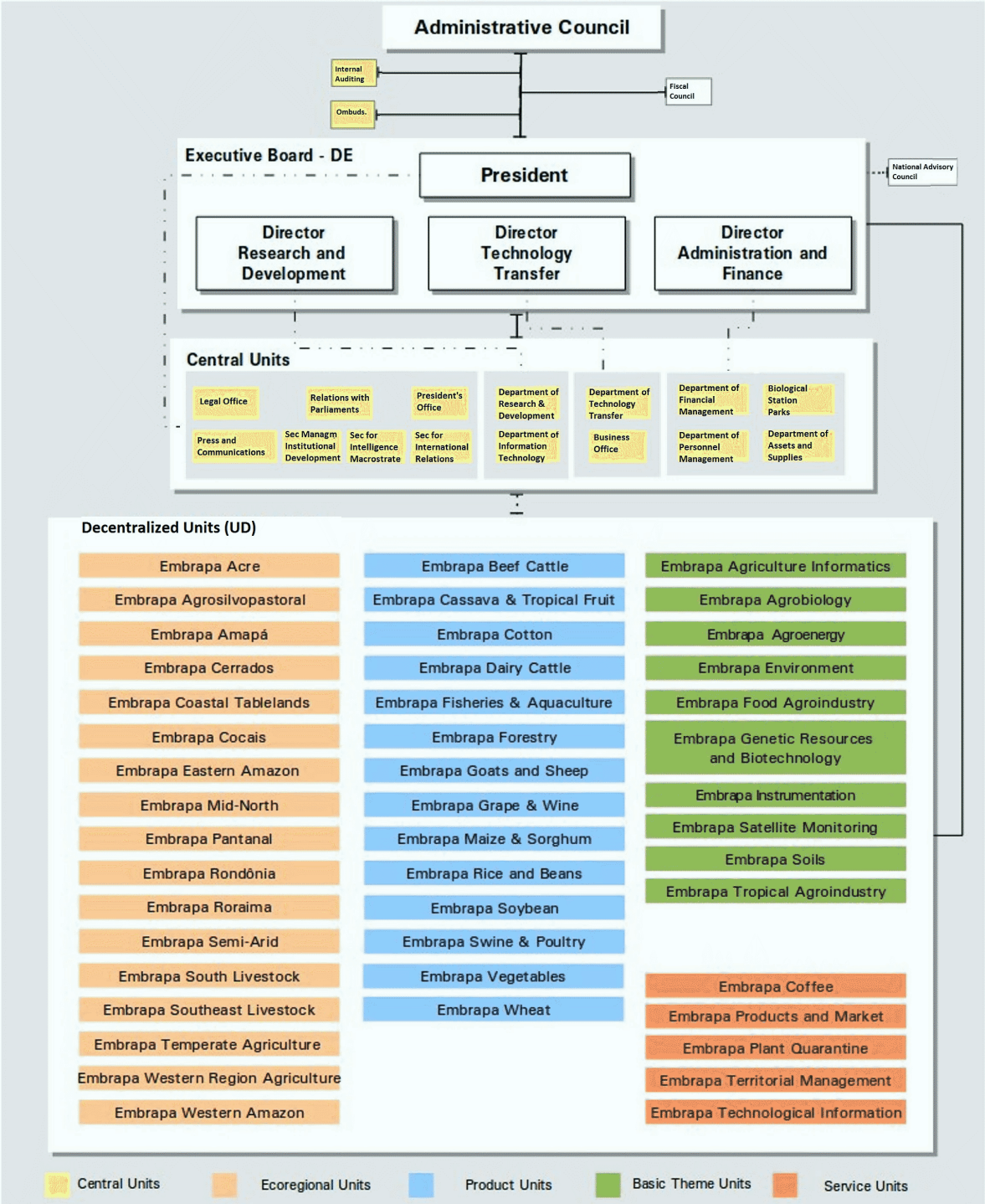

Figure 01 – Embrapa Organizational Chart, 2014
Source: Embrapa, 2014.

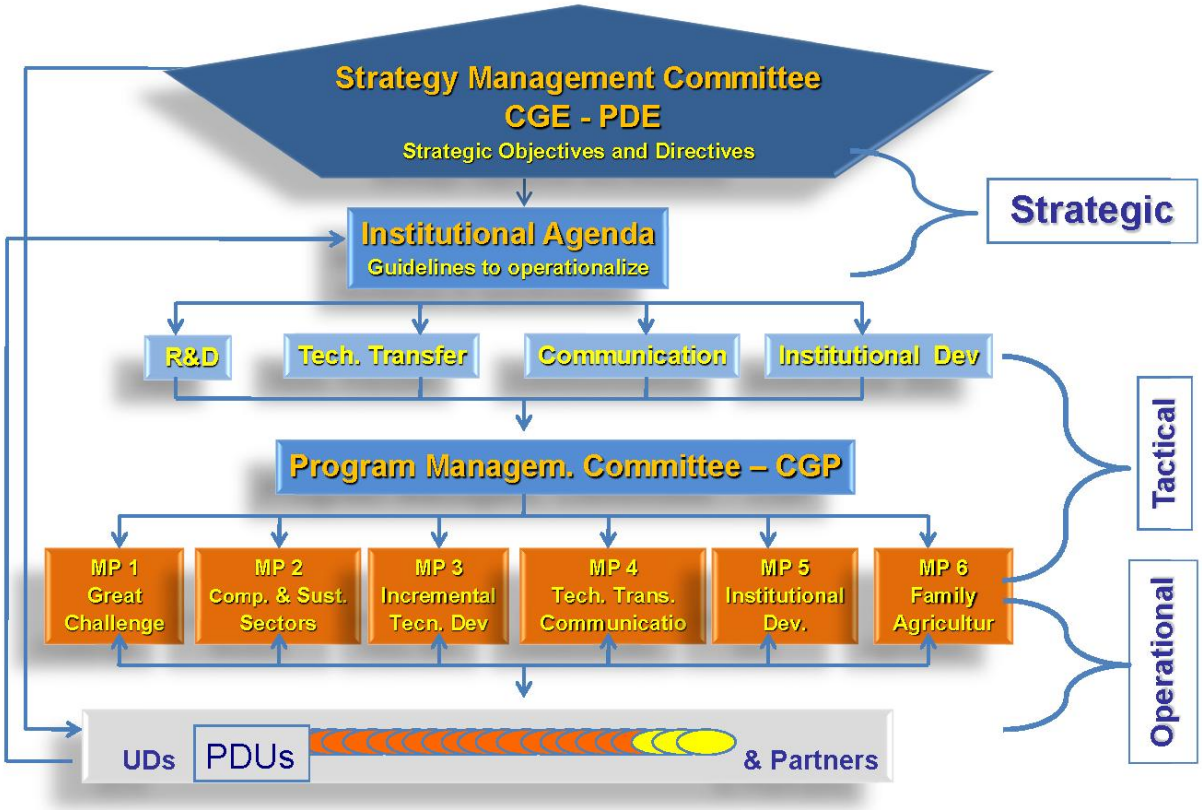

Figure 02 - Embrapa Internal Organizational Chart, Macro-programs

Source: Embrapa

Governance of Knowledge - Coffee, Soy and Sugar Cane[22]

EMBRAPA has played a catalytic role in placing Brazil at the cutting edge of low-carbon farming. Leadership in any agricultural frontier, as we know, is not an easy place to hold. The new forms of organizing research suggest different ways of doing science and technology. The collaborative knowledge platforms are the main example worthy of mention, and Embrapa has the governance (as coordinators) of a few remarkable experiences: the Eucalyptus Genome National Research Project Network (Rede Genolyptus); (ii) the Brazilian Consortium for Coffee Research and Development (CBP&D/Café or Consórcio Café), joining over sixty institutions;[23] (iii) and the Citriculture Defense Fund (Fundecitrus), just to mention a few important successful experiences. These consortia will be discussed here below.

The Brazilian Consortium for Coffee Research and Development (CBP & DC), coordinated by *Embrapa Café*, features the larger political and institutional organization and was founded in 1997, whereas the National Consortium for Soy Genome Studies (Genosoja) is more recent, coordinated by *Embrapa Soja*, and was founded in 2007 in order to identify and functionally characterize the soybean genes that act in the plant's physiological processes. The consortium is a form of organization set up by Embrapa to establish partnerships with other national and international public and private institutions, to remain abreast the governance of knowledge regarding the soybean culture. These two consortia represent, to some extent, the present structure for governance of knowledge in these sectors, where Embrapa is a great reference.

Unlike other cultures where the EMBRAPA's presence has always been marked, the company did not maintain a thematic unit specifically dedicated to sugarcane research

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[22] According to Ministry of Agriculture data the Brazilian coffee crop yield was of 49.15 million (60-kg) bags (2013/2014); the sugarcane yield was 633.7 million metric tons (making Brazil the largest world producer); the 2013/2014 soybean crop was 30.17 million metric tons.
http://www.wattagnet.com/articles/17264-brazil-2013-2014-soybean-crop-up-from-previous-year e
e http://revistagloborural.globo.com/Noticias/Agricultura/noticia/2015/08/safra-brasileira-pode-ser-de-208-milhoes-de-toneladas.html

[23] Regarding coffee and soybeans, we find Technical Committees (TC) organized by Embrapa, through the Embrapa Coffee and Embrapa Soy units. These consortia are quite different from one another in goals, and in composition of public and private actors, implying in different knowledge governance conditions for the research in the two areas. The Coffee TC has a larger participation of private actors and gave rise to the Embrapa Coffee unit, which has coordinated the consortium for about fifteen years. The Soy TC started more recently, by initiative of Embrapa Soy unit researchers from, and had a more focused and specific goal: mapping the soybean genome.

until recently, when the Embrapa Agroenergy unit was created, wherein among a few other energy crops sugarcane is the foremost asset. Embrapa therefore established a partnership with the Inter-University Network for the Development of Sugarcane Industry, or Ridesa *(Rede Interuniversitária para o Desenvolvimento do Setor Sucroenergético)*, to expand the action of Embrapa Agroenergy and strengthen their research capabilities. Ridesa takes the approach of a technological consortium, bringing together materials, intellectual resources, and infrastructure, focusing on the research of national sugarcane cultures. Ridesa was founded in 1991 and its coordination is carried out by its comprising universities, under a public institutional arrangement.

Brazilian Coffee R&D Consortium[24]

The Brazilian Consortium for Coffee Research and Development brings together over 50 research institutions and is coordinated by Embrapa, having emerged in the mid-1990s in response to the challenges faced by the culture in face of the market opening with the end of the barrier clauses of the International Coffee Agreement (ICA) and extinction of the Brazilian Coffee Institute (IBC). The institution's creation was considered an innovative proposal, because it intended to integrate coffee culture research activities, something which did not exist at the time, being initially composed by ten founding institutions.[25] Soon after the formation of the consortium, *Embrapa Café* was created as a decentralized unit to coordinate the research demands among the participant institutions. The Coffee Program Support Service (SAPC) was founded on August 30, 1999 in Brasilia, and became known by synthetic name *Embrapa Café*. More than an institutional arrangement for

[24] The TC aims to bring together human resources, laboratories, and physical and financial institutions, for the design and execution of research activities on behalf of all areas across the coffee production chain, in the main Brazilian coffee producer states: Minas Gerais, Espírito Santo, São Paulo, Paraná, Bahia, Rondônia, Rio de Janeiro, Pará, Acre, Amazonas, Goiás and the Federal District. The research developed by the TC covers the entire production chain, from production, processing, through trade and consumption, including consumer health. See http://www.sapc.embrapa.br/. See also ISSN 1678-1694 November 2012 Consortium Management System Coffee Research: Corporate Governance, in http://ainfo.cnptia.embrapa.br/digital/bitstream/item/86766/1/Sistema-de-gestao.pdf

[25] Namely: *Empresa Baiana de Desenvolvimento Agrícola (EBDA), Empresa de Pesquisa Agropecuária de Minas Gerais (Epamig), Instituto Agronômico de Campinas (IAC), Instituto Agronômico do Paraná (Iapar), Instituto Capixaba de Pesquisa, Assistência Técnica e Extensão Rural (Incaper), Empresa de Pesquisa Agropecuária do Estado do Rio de Janeiro (*Pesagro – Rio*), Universidade Federal de Lavras (*UFLA*), Universidade Federal de Viçosa (*UFV*),* aside from Embrapa and the Ministry of Agriculture.

corporate management, a Research Networking platform was underway, and a structure capable of building consensus within a coalition of the manifold interests involved in an arena of utmost importance for Brazilian agribusiness[26].

The Brazilian Coffee Institute, created in 1950, was closed in 1990 and the institutions that worked with coffee felt a need to ensure the continuity of research activities that were being carried out. These institutions' interest stimulated the creation of the Coffee Policy Board (CDPC, *Conselho Deliberativo de Política do Café*) in 1996, a collegiate body under the Ministry of Agriculture, in order to decide on policies for the coffee industry.[27] The Coffee TC, or Technical Committee, is a unique and unprecedented experience in the country and abroad, integrating scientific, teaching and rural extension institutions which are traditional players in the generation of knowledge and transference of technologies in an integrated manner to the various segments of the coffee agro-industrial chain. According to Mirian Eira, the consortium represents institutions

> *"…gathered under a model that is pluralistic, democratically participative, coordinated at the national level, and decentralized in execution. The result of this union is hundreds of research activities and technology transfers, which involve over a thousand professionals among researchers, teachers, extension workers, grant-funded scholars, students and interns. All the research work is focused on customer needs - farmers, traders, government and consumers. This concentrated research effort has expanded the bases for the evolution of the Brazilian coffee business ."(Embrapa,* 2012)[28]

Embrapa Café is in charge of the strategic management and programing of the coordinated, manifold research programs in order to sustain the technological innovation process and, according to an official document, sustainably develop the productive chain of Brazilian coffee. Research funding is provided by the Coffee Fund, Funcafé.

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[26] In the 1950s the first institute with the mission of addressing coffee appeared, the Brazilian Coffee Institute (IBC, *Instituto Brasileiro do Café*). Created with the purpose of setting a policy for the sector, coordinating and controlling strategies, from production to internal and external trade, the IBC provided technical and economic assistance to coffee producers and promoted studies and research on behalf of the coffee culture and trade. The Institute managed a Coffee Economy Defense Fund (Funcafé), established in 1986 with funds from a contribution quota over exports. The Fund financed crop production and culture research – and at times also strived to act as supply-side regulator as small "coffee OPEP".

[27] The Council has the purpose of deciding the public policies for coffee production, trade, export and marketing, as well as establishing agronomic and market research programs to provide technical and commercial support to the development of the coffee agro-industrial chain (Embrapa, 2012).

[28] The Consortium is responsible for the design and implementation of the National Program for Coffee Research and Development, which enables projects and mobilizes over 1300 researchers and extension workers. This program acts as the scientific and technological arm of the Ministry of Agriculture and the Coffee Policy Board.

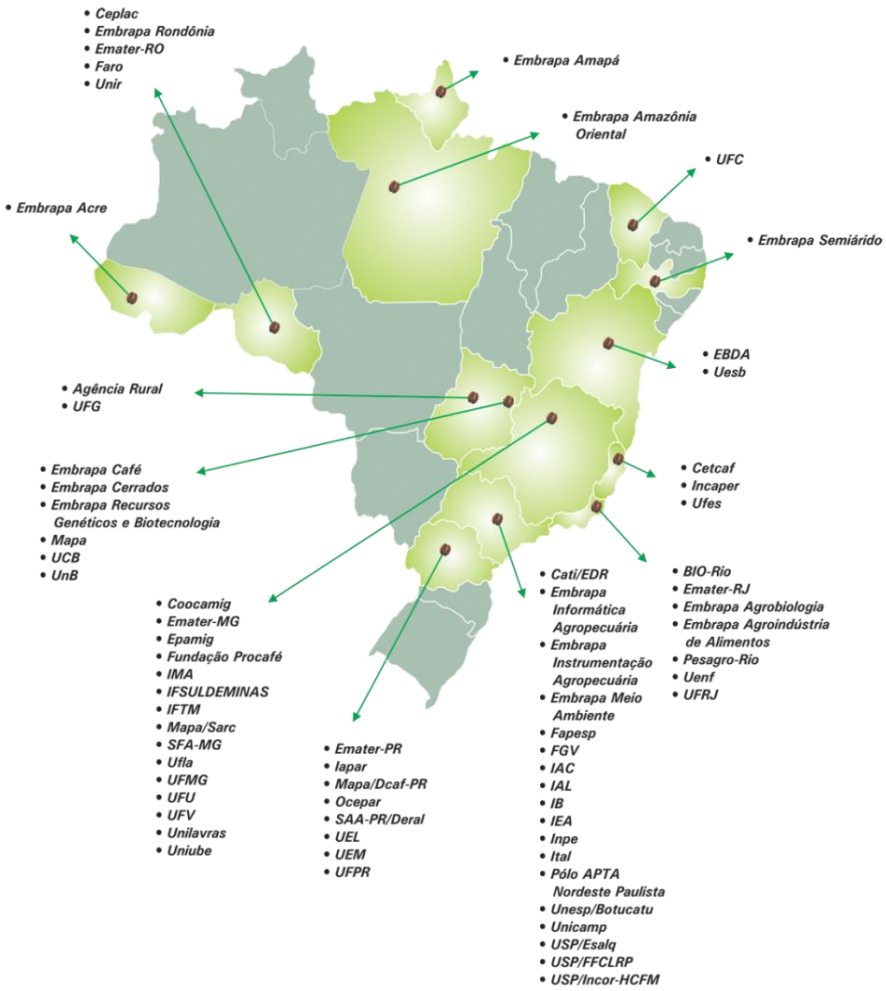

Figure 03 – Participant institutions of the Coffee Research Consortium.
Source: www.consorciopesquisacafe.com.br

Developing this consortium enabled establishing formal, effective channels for scientific and technological exchange among the consorted institutions in a dynamic systematic. The TC replaced an informal, individual model with an institutionalized, collective research model on behalf of the coffee industry. After the construction of this institutional arrangement, fundraising from outer sources external to Funcafé already reaches 50% of the total Fund resources.[29]

[29] In 2011, Funcafé made available to the national coffee culture R$ 2.44 billion for funding, modernization, and productivity enhancement for coffee farming, processing, and export; research development; and

The Consortium has achieved several technological accomplishments, to wit:

- Genetic improvement, new cultivars with higher yield and quality potential;
- Biotechnology studies, genetic mapping based on DNA markers, characterization of nucleotide modification markers from the Coffee Genome Project database. This project raises Brazilian coffee to a position of world leadership in coffee genetic research;
- Multiplication of materials of high agronomic value in bioreactors, evaluation under field conditions, biofactories with large seedling production capacity;
- Forestation of coffee plantations: characterization and assessment of technologies, practices and husbandry of agro-systems with wooded coffee crops; the ecophysiological, edaphic and phytotechnical impact of shading, consequences of association with other cultures regarding sustainability, evaluation of cultivars, organic materials and other plants as sources of fertilizing nutrients, for the sustainability of coffee agroecosystems;
- Coffee irrigation: improvement of irrigated coffee production systems, definition of technologies for preferential use in irrigation, fertigation in different production systems; competitiveness and sustainability
- Organic coffee: design of a standard system for the production of organic coffee, assessment of novel coffee fertilization management systems focusing on nutrition, health and soil protection;
- Conilon (commonly known as Robusta) coffee production technologies: improving the production process and cultural practices to increase yield and sustainability;
- Sizing of the national coffee park, GIS technologies, encouragement of Geographical Indications and Indications of Origin to promote the sustainable production of coffee in the various territories;
- Climate change: strategic studies of possible technological solutions to maintain productivity and mitigate the effects of climate change on coffee production;
- Nematode control: studies on the genetic variability of nematodes and establishing culture husbandry practices for their biological control in infested areas.

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promotion and marketing in the domestic and foreign markets, as well as the improvement of living conditions for rural workers (Embrapa, 2012).

It is worthy of note that the actions are concentrated in the areas of biotechnology, eco-physiology, biotic stress response, genetic improvement, disease prevision system, harvesting improvements. But studies also emphasize sustainability issues, such as climate change, pest bio-ecology, development of sustainable production systems, optimizing the use of water. A third emphasis, not listed in the priorities above, but which is reported elsewhere, pertains the demand-side - such the importance of the beverage's quality, expressed through research on gourmet coffees, on the one hand, and the effects of coffee on human health, on the other - both the positive effects, such as reducing depression, coronary heart disease and prevention of degenerative diseases, and the negative ones generated by excessive consumption.[30]

Embrapa Soy and the Genosoja program[31]

The National Soybean Genome Studies Consortium, Genosoja, comprises Brazil's participation in the International Soybean Genome Consortium, ISGC, formed in 2007 by 25 research groups around the world from the US, China, Japan, Korea and Brazil.

Genosoja is led by Embrapa Soja, funded by CNPq, and involves more than nine institutions in the country. The Brazilian consortium aims to provide the national counterpart to the ISGC, contributing with studies focusing on tropical reality. More specifically it deals with mechanisms to enhance the plant's conditions of development in Brazil, ensuring resistance to disease and drought, among other issues.

Commercial soy production in the country began in the 1960s, when the culture became an option as a summer rotation crop to alternate with the wheat crop, contributing

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[30] "Few people know that coffee is a nutraceutical beverage (nutritional and pharmaceutical), richer in minerals that sports drinks, containing vitamin B (niacin), that caffeine is safe in the dose contained in 3 or 4 daily cups (up to 500 mg/day) and which stimulates attention, concentration, memory and classroom learning. In addition, coffee contains chlorogenic acids, natural antioxidants, which form the appropriate process of roasting of quinic acids, and which help prevent depression and its consequences (smoking, alcoholism, drug abuse and suicide). The daily and moderate consumption of coffee by adults can help combat depression, the fourth leading cause of death in the world today, and which may become the second most important in 2020, according to the World Health Organization, after myocardial infarction. Therefore, a good way to avoid depression and its consequences, as well as myocardial infarction, is the daily and moderate consumption of coffee". See (in Portuguese) in http://www.sbicafe.ufv.br/handle/123456789/3383. Also see (in Portuguese) http://www.abic.com.br/publique/cgi/cgilua.exe/sys/start.htm?sid=279 on the effects of coffee in the prevention of Parkinson and Alzheimer.

[31] The information presented here was collected from the CNPq Research Groups directory, at http://dgp.cnpq.br/buscaoperacional/detalhegrupo.jsp?grupo=00925014BKW6DN.

to an increased production of pork and poultry. Skyrocketing soybean prices in the world market and prompt sales of the Brazilian crop during the American offseason period in the 1970s spurred investment in technology to adapt the culture to Brazilian conditions. In 1975 the *Embrapa Soja* unit was created in Londrina, Paraná, dedicated to the "*tropicalization"* of the soybean culture, enabling allowing the legume to be planted in low latitudes. The result was a revolution in the world soy market making of Brazil one of the largest world producers, only behind the US.[32]

Embrapa Soja is a national and international reference in soybean research, and has developed pioneering technologies such as soil and fertility management - having introduced the biological fixation of nitrogen in the soil through the Rhizobium bacterium[33]; proper crop management under different Brazilian ecosystems; the integrated management of pests and weeds; the biological control of the velvetbean caterpillar and green stinkbug, the most important soy pests, and others (*Embrapa Soja*, 2012). The Genosoja consortium was founded in 2008 and comprises a specific research group in CNPq, bringing together over 50 researchers[34].

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[32] "The importance of certain structuralizing agro-industrial chains that work as both driver and showcase – such as soy, orange, and poultry, whose consequences far outweigh the effects of catching up. As an example, soybean expansion is mentioned in the 1970s, promoting land redistribution enabling medium and small producers in the South, especially through the production of soybeans and wheat on the same agricultural calendar. In addition to allowing the effective pairing (catching up) with the United States and Argentina, it shifted the agricultural frontier to the Midwest and Northern Midwest states, dramatically increasing Brazilian yield potential. It managed to solve technological problems created by the expansion of the frontier, cheapened production and fostered the creation of an intermodal transport network, before this nonexistent, reducing costs. Research on Brazilian soybean focused on the biological fixation of nitrogen in the soil, reducing the use of fertilizers, enabling sustainable and continued expansion. Soy, through the combination of the bean-bran-oil and bean-feed-meat chains, contributed for the industry to offer more diverse and sophisticated foods, not merely more competitive but able to meet the new consumer demands (functional foods, GM versus traditional versus organic). In this sense, it enabled the domestic agro-food system for growing international competition. Finally, the development of new products and processes made of soy (soy ink, biodiesel, traceability, labeling) configure a new technological frontier". Castro, A.C. (2007), page 297. Regarding agricultural catching-up and the competitiveness of the agro-industrial soy chain, see Castro, A.C. (1996, 2009, 2010, 2011, 2012).

[33] See in Döbereiner, Johanna - *The Importance of Nitrogen Biological Fixation for Sustainable Agriculture*. Johanna Döbereiner, a researcher at EMBRAPA CNPAB in Seropédica, Rio de Janeiro, pioneered nitrogen fixation research through the Rizhobium, bacteria found naturally in association with legumes such as soybeans. This feature of Brazilian soy not only places this research in a position of leadership but, above all, represents an unprecedented economy in production costs afield.

[34] Among the participating institutions in -Genosoja are Embrapa Genetic Resources and Biotechnology (CENARGEN, Brasilia, Distrito Federal), State University of Campinas (Unicamp, Campinas, São Paulo), *Universidade Estadual Paulista Julio de Mesquita Filho* (UNESP, Botucatu , São Paulo), Federal University of Pernambuco (UFPE, Recife, Pernambuco), the Federal University of Rio Grande do Sul (UFRGS, Porto Alegre, Rio Grande do Sul), the Federal University of Viçosa (UFV, Viçosa, Minas Gerais) the Federal

Figure 04 - Institutions participating in the Soy Genome Consortium.
Source: www.scielo.br/scielo.php?pid = S1415-47572012000200001 & script = sci_arttext # fig1

The Genosoja consortium provides the exchange of information, technology, and knowledge generated on the soybean crop, benefiting not only the members of the consortium but also the entire scientific community that conducts soybean research, the main commodity in Brazilian agriculture. Project objectives focus on the identification and functional characterization of the genes involved in important physiological processes[35]. In this sense, the Genosoja consortium's studies endeavor to better understand the molecular mechanisms of plant, in order to enable the development of technologies that lead to new alternatives in the control of the main problems that limit the culture's exploitation, such as biotic and abiotic stresses, through structural and functional genomics, transcriptomics, and proteomics studies.

The Genosoja consortium is the country's counterpart in the international soybean genome consortium which joins Brazilian, American, Korean, Chinese, and Japanese

University of Rio de Janeiro (UFRJ, Rio de Janeiro, Rio de Janeiro), and a private partner, the Central Cooperative for Agricultural Research (COODETEC, Cascavel, Paraná).

[35] Key objectives include the resistance to diseases, specifically Asian rust and nematodes; tolerance to drought; nitrogen fixation; and bean quality.

researchers and, in this sense, places Brazil at the cutting-edge of soybean research. The soy genome, containing approximately 66000 genes, has already been sequenced by the United States; however, very little is yet known about the function of each gene, and the challenge posed to the international consortium is to discover and map these functions. Therefore participation in this international consortium means, for Brazil, being linked to numerous other labs in the world researching the soy genome and its local specificities.[36] Prior to the establishment of the Genosoja Consortium, a consortium for the study of the soybean rust disease had been created at the Ministry of Science and Technology with support from the Ministry of Agriculture. With the creation of a technological platform for study of the soybean rust, focusing on phytopathology, genetics and biopathology, the consortium was funded by the Brazilian Innovation Agency, FINEP (*Financiadora de Estudos e Projetos*) from 2004 to 2010. After the soybean gene sequencing was made available, the challenge became finding out and mapping the gene functions, in Brazilian and international research.[37] Once the genes responsible for characteristics that improve the soybean yield have been spotted, research now aims to select some of these genes for deeper study to attain better understanding of the molecular mechanisms that will effectively enhance the soybean culture yield. The Genosoja Consortium is divided into components, including the management and treatment of different aspects of the soybean genome (Benko-Iseppon, Nepomuceno and Abdelnoor, 2012):

- **Project management** – organization, meetings, integration, research reports;

- **Structural Genomics** - includes research on genomic physical architecture; analysis of gene-rich clusters; comparison with wild relatives of the Glycine genus; synteny and indication of regions important for ressequencing; identification of single nucleotide polymorphisms (SNPs) important for mapping as predictive markers.

- **Transcriptomics** - the largest research group, responsible for different approaches to the regulation of gene expression, using several strategies to access transcripts addressing different challenges, both biotic (Asian rust, *Phakopsora pachyrhizi*; CPMMV, *Cowpea mild mottle virus*; nematodes, *Meloydogyne javanica* and

[36] "The Genosoja will be very important for the development of new cultivars related to these characteristics, not only for the members of the consortium, but for the entire scientific community working with the soybean crop, since all the data generated will be publicly released after the end project" (Agronline, 2012).
[37] The Consortium Genosoja began funded by with CNPq with a R$ 6 million grant and a R$ 2 million counterpart from the Embrapa Network for Soy Genome Studies (Regesoja).

Pratylenchus brachyurus) and abiotic (hydric stress). Strategies include: a) subtractive cDNA; b) SuperSAGE; c) microRNA libraries; d) cDNA sequences of roots infested with *M. javanica* nematode, compared to a stressed control;

- **Proteomics** – profile of soybean proteins, low mass proteins, and identification of peptides and protein-protein interactions;

- **Expression testing (transgenic)** – testing for transgene expression after transcriptomics and proteomics results: valuable genes are being transformed.

- **Bioinformatics** – the Genosoja database; tools that integrate project data, comparison with sequences available in other public research databases.

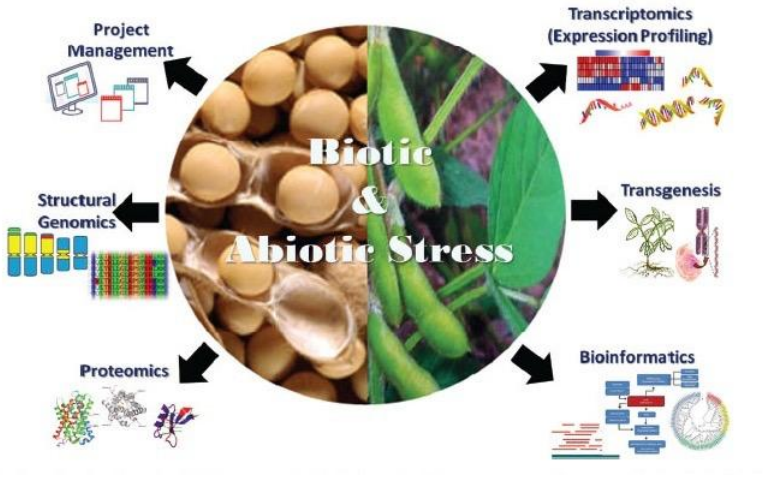

Figure 05 - Functional organization of the Genosoja Consortium.
Source: www.scielo.br/scielo.php?pid = S141547572012000200001 & script = sci_arttext # fig1

If on one hand the Genosoja has a specific role within soybean genetic research, for the purpose of which aggregating several different Brazilian research institutions, on the other it is coordinated by *Embrapa Soja*, which runs several other partnerships in soybean research. In this context, Genosoja is inserted in a broader collaborative platform, managed by *Embrapa Soja*.

Ridesa and Embrapa Agrobioenergy[38]

The Brazilian federal government had a rather timid performance regarding sugarcane, especially after the decommissioning of the National Program for Sugarcane

[38] Information from <http://www.ridesa.com.br/?pagina=home>.

Improvement (Planasucar)[39] in the early 1990s when its activities were merged into Ridesa (Furtado, 2008)[40]. Ridesa is a successful example of networking for the technological development of the sugarcane seed. This public-private partnership joins over 300 sugar, ethanol and energy companies and nine Brazilian federal universities.[41]

Ridesa was established in 1991,[42] located in the areas where previously functioned Planasucar, from which they inherited infrastructure facilities including offices and research stations, and staff including university professors.

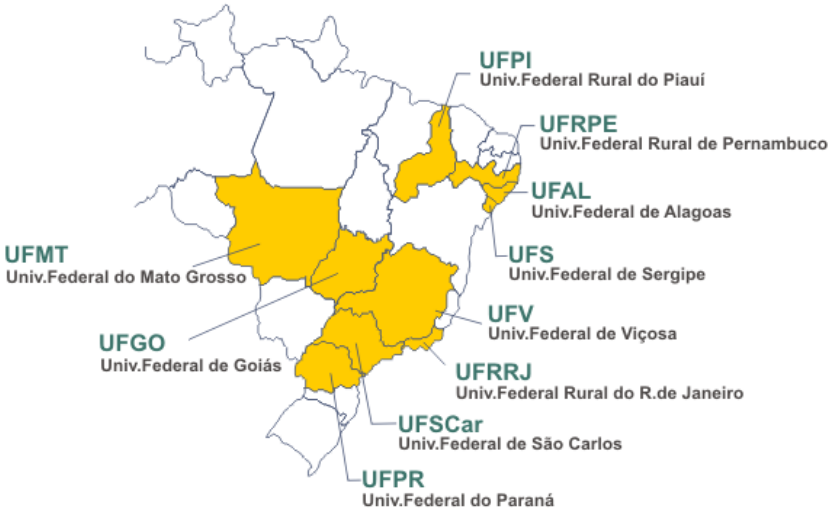

Figure 06 - Participant organizations of Ridesa.[43]

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[39] The National Program for Sugarcane Improvement (Planalsucar) maintained 30 research stations across the country, and made a significant contribution to the improvement of the sugarcane yield in the Northeastern states (Furtado, 2008).

[40] It is notorious however that the main research center in Brazil focusing on sugarcane is the Sugarcane Technology Center (CTC, *Centro de Tecnologia Canavieira*), a private institution. To learn more about this institution, as well as other groups that invest in sugarcane research, see Vieira Junior, Buainain, Silveira and Oliveira (2009).

[41] Considering the Ridesa addresses exclusively sugarcane research, is would be of interest for Embrapa Agroenergy to partner up with this network, to enhance their own cane research program.

[42] Initially through an agreement signed by seven Federal Universities: Federal University of Paraná (UFPR), Federal University of São Carlos (UFSCar), Federal University of Viçosa (UFV), Rural Federal University of Rio de Janeiro, Federal University of Sergipe (UFS), Federal University of Alagoas (UFAL) and Federal University of Pernambuco (UFPE).

[43] In 2015 Ridesa completed 24 years. The organization involves 31 research stations in the states with most sugarcane crops: Paraná, Mato Grosso, São Paulo, Goias, Minas Gerais, Rio de Janeiro, Sergipe, Alagoas and Pernambuco. The network also develops research in experimental areas through nine federal universities, usually at graduate level. These universities emphasize the Sugarcane Genetic Improvement Program (PMGCA, *Programa de Melhoramento Genético da Cana-de-açúcar*), which maintains the RB sign to identify their cultivars, and already released 65 new and improved cultivars. In 2004, Ridesa added the Federal University of Goiás and in 2007 the Federal University of Mato Grosso, strengthening its research structure, creating three new experimental stations for the *cerrado* biome, one located in Goiânia (GO) by UFG, and another in Cuiaba (MT) by UFMT. A third experimental station in Capinópolis (MG) by UFV was

Source: http://pmgca.dbv.cca.ufscar.br/htm/pmg/histor.php

Ridesa is responsible for cloning sugarcane seedlings from seeds produced in their germplasm bank, which gathers over two thousand genotypes including cultivars used in the country, clones, and different species imported from different sugarcane regions in the world. The cultivars branded "RB", formerly produced by Planasucar and currently by Ridesa, have a good reception and it is estimated that they are grown on more than 50% of the sugarcane crop area in the country, perhaps up to 70% of the crop area. The data presented by Ridesa (2012) reveal the ample scope of the technological results achieved in sugarcane culture research, and the importance of the partner institutions.[44]

Embrapa Agroenergy

The resumption by the Brazilian government of sugarcane research through Embrapa was a recent move, and takes place within a paradigm shift within the company, namely addressing the research of biomass production for energy and not only for food production.[45] This new guideline is due to the current scenario of energy scarcity caused by the "end of the Fossil Fuel Era" due to the dwindling of oil, coal and natural gas reserves (Embrapa Agroenergy, 2008: 07).

In 2006, the Ministry of Agriculture released the National Agroenergy Plan, establishing guidelines for public and private action to generate knowledge and technologies for sustainable production of energy from agriculture and the rational use of

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also opened in 2003. Ridesa manages around 80 sugarcane cultivars, formerly patented in Planasucar's name, today in the name of the member institutions directly responsible for developing the technology (including the UFSCar, UFAL, UFRPE, UFRRJ, UFPR and UFV).

[44] The germplasm or gene bank is located at the *Estação de Floração e Cruzamento da Serra do Ouro* (UFAL), in Murici, Alagoas. It gathers over 2000 genotypes among cultivars used in the country, clones and different species imported from different sugarcane regions.

[45] To Rufino (2006: 82) Embrapa, since its founding in 1974, to avoid duplicating redundant actions and diluting resources, refrained from including in their research program studies on coffee, sugarcane and cocoa, as these cultures already had their own research institutes, namely the Brazilian Coffee Institute (IBC), the Sugar and Alcohol Institute (IAA) and the Executive Committee for Cocoa Farming Planning (Ceplac), under the Ministry of Industry and Trade. With the expiry of the three institutions in 1991, for political reasons and in face of administrative and financial constraints Embrapa had not assumed the duties of generating knowledge and technologies on behalf of these three production chains.

this renewable energy, stimulating the creation of Embrapa Agroenergy, called the National Center for Agroenergy Research (CNPAE).[46]

In the Brazilian agroenergy scenario, the sugarcane culture is a major focus of research. Competition with other institutions previously established for the improvement of this culture could inhibit, according to Embrapa Agroenergy (2008:23), the advance required for agribusiness expansion. Among the opportunities for technological cooperation, the Company proposes to establish a partnership among its units, Ridesa, and other institutions, as a conceptual basis for a new nationwide public program for sugarcane improvement (Embrapa Agroenergy, 2008: 26). The organization of this institutional arrangement would promote the union of institutions working with sugarcane in Brazil and optimize their research, but at this time still represents a significant challenge.

Considering the sugarcane culture, there is a strong demand for the construction of a specific EMBRAPA unit, something also often expressed in debates at the Sectorial Chamber for Sugar and Alcohol, mostly by Northeastern groups.[47] One factor that has spurred demand is that the state of Alagoas is the only Northeastern state without an EMBRAPA unit, yet is the seat of the RIDESA germplasm bank. Throughout the interviews, what we see is that there is, in fact, no internal mobilization for this to occur within EMBRAPA, given that their units prioritize a transversal approach to research topics, which does not point towards building another product-focused unit.

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[46] Embrapa Agroenergy (2008: 9) explains the National Center for Agroenergy Research (CNPAE - Embrapa Agroenergy), was established by Board Resolution 61 of May 24, 2006 (BCA No. 25 of 05.29.2006) as a unit within Embrapa's decentralized structure, to develop and promote innovation and technology transfer. These technologies strive for the sustainability and competitiveness of the bioenergy chains. This is the Embrapa's 41st Decentralized Unit and 38th Research Center, in the category of "thematic center", and with operations across the country. Embrapa Agroenergy involves four working platforms: Ethanol, Biodiesel, Energy Forests, and Byproducts and Residues; the aim is to promote the improvement of raw materials, of biomass conversion processes, and forms of energy obtained, ensuring scientific and technological competitiveness and integration with Embrapa's other capabilities.

[47] Recently the union of sugar producers donated an area next to the UFAL to expand an existent Embrapa experimental crop field. Today this field is run by the Embrapa Tabuleiros Costeiros unit, within the UFAL campus in Alagoas, Sergipe.

Table 01 - Characteristics of institutional arrangements in Technical Committees and Networks for Soybean, Coffee and Sugarcane in Brazil

Characteristics	Soy	Coffee	Sugar cane
Institutional arrangement oriented research	Genosoja / Embrapa Soja	Technological Consortium Coffee / Embrapa Café	Ridesa
Year Consortium or Network Creation	2007	1997	1991
No. Institutions involved	9	+ 50	9
Public institutions involved	Embrapa Soja, Embrapa CENARGEN, UFV, UFRGS, UEP, UFPE, Unicamp, UFRJ, UFPR	EBDA, EPAMIG, IAC, IAPAR, INCAPER, PESAGRO-RJ, UFLA University, UFV, Embrapa and MAP	UFPR, UFSCar, UFV, UFRRJ, UFS, UFAL, UFPE, UFG and UFMT
Private institutions involved	COODETEC (Cascavel, PR).	-	300 companies in public-private partnership
No. Brazilian researchers involved	50	1300	-
Coverage	National and International Genosoja project	National and International	National
Coordination	Embrapa Soja (Londrina / PR)	Embrapa Café (DF)	Switching between the institutions involved
Institutional mechanism for sector policy debate	Sectorial Chamber of the Productive Chain of the Soybean	Coffee Policy Board	Sectorial Chamber of the Productive Chain of Sugar and Alcohol

Source: Sylvia Zimmermann

Preliminary Conclusions

One may justifiably consider Brazil as being on the frontier of low carbon tropical agriculture, and EMBRAPA plays a central role in this process. The historic trajectory that led the country from a technological catching-up process in the 1950s to a leading position today is not the object of this study. Upon assuming the technical vanguard, the country reaps the risks and benefits of defining the frontier. To occupy this leading position the governance of knowledge, through knowledge networks and markets, has been decisive. This is the case of coffee, soy and sugarcane innovation platforms, institutional arrangements geared for the generation of innovation.

These complex structures redefine old concepts, such as catching–up: there is no map to follow, and therefore leapfrogging is the sole alternative; leading countries may be peers or partners; the concepts of secondary innovation, open innovation, and cooperative networks constitute new ways to generate innovation, all of which contribute to the deconstruction of the concept of catching–up.

There is still considerable uncertainty regarding what may be considered "superior innovation", given the need to accommodate tensions previously foreign from the territory of innovation (such as social inclusion and sustainability, for instance). Another insight provided by this discussion is that leapfrogging will depend, on one hand, on strategic choices; and on the other, on conditions to implement these choices.

In a recent article on comparative State capabilities[48], when the institutional architectures for science and technology in Brazil and in China were compared the conclusion was arrived at that "the existence of a structured consensus regarding which industries should be encouraged by the entrepreneurial State, where the technological frontier lies in these industries, and which countries have arrived there, depends on: *i)* the existence of a background of supporting institutions capable of carrying out prospective and retrospective studies, that will actually be considered in decision-making processes; *ii)* a continual exercise technological foresight, subject to periodic review; *iii)* the ability to take into account conflicts of interest, but also to neutralize them after building a structured consensus; and, finally, *iv)* a well-grounded and effective innovation financial system. Two

[48] Castro, A. C. (2015), IPEA.

conditions seem essential to coordinate the countries' modernization process: structured visions of the future, and state capabilities to implement the latter; rather than a continuum of skills and competencies, a variety of decision-making processes on long-term strategies, and coordination in the design and implementation of technological policies."

During an appraisal of these decision-making processes it is important to consider the relation between those who hold decision-making positions, and those who subsidize these decisions - research institutes, think tanks, universities, and others - the institutional rearguard supporting strategic decisions; the existence or absence of effort to achieve this technological vision; governance structures and power relations, when these are assessable; and the presence of conventions, shared beliefs and consensuses behind these visions of the future and influence the direction and choices made.

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