INSTITUTE FOR DEFENSE ANALYSES

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Executive Summary

Background

Industrial and innovation policies are designed to give a country a competitive advantage in a particular industry or sector. Some countries have made significant leaps in industrialization and technological advancement in the last two decades by strategically combining sustained investments in research and development (R&D), infrastructure, and human capital with policy frameworks that support nascent industries through tax breaks, export support, and access to capital and markets. Other countries follow a less rapid and more organic path to industrial growth. In all cases, socio-economic, cultural, and political factors influence how effectively a country is able to capitalize on its natural advantages, be it raw materials, population, or market size.

This project examined the national innovation system of Brazil based on the premise that a country's innovation system is a lens through which to understand other important issues, including those of interest to the intelligence community.

Brazil's industry is globally competitive in sectors which either derive from its abundant natural resources (oil and gas, agriculture), or were developed to preserve and protect them (aircraft and remote sensing). Innovation in other sectors is hindered by the government's protectionist policies, and this may pose a risk to Brazil's economic security in light of China's growing trade relationship with the country as well as the region.

Although Brazil has the strongest science and technology (S&T) workforce in South America, industry is not highly innovative according to many objective measures. The country's economic growth appears to rely on Brazil being integrated into the global supply chains of other countries, primarily China, and less on the maturation of a national innovation strategy. If that is true, Brazil's reliance on other countries, especially China, could lead to security concerns not only for Brazil and other South American countries but also for the United States.

Tasking

With the goal of understanding better how different countries implement innovation policies, the Office of the Director of National Intelligence asked the Institute for Defense Analyses (IDA) to examine the industrial and innovation policies of South Korea, Russia, and Brazil. A team of IDA researchers reviewed the literature and interviewed experts to provide an overview of the political, economic, demographic, and other factors that are brought to bear on each country's industrial and innovation policies, relative to other countries.

This report documents the outcome of this examination for Brazil. It examines

- Drivers behind Brazil's innovation goals;
- Mechanisms Brazil uses to execute its innovation policies aimed at achieving those goals;
- Trends that indicate the effectiveness of the mechanisms and policies;
- Socio-cultural characteristics that could affect success or failure;
- Primary partners in Brazil's innovation activities;
- Implications of Brazil's innovation policies for the United States, particularly U.S. national security; and
- Future vision relative to how changes in innovation policies translate to threats and opportunities for U.S. national security, innovation, and economy.

This report also looks at the national innovation system of Brazil to determine the goals of its innovation policies and to measure its success in meeting those goals in comparison with other countries of interest to the intelligence community.

Brazil's National Innovation System

Brazil's national innovation system is relatively young compared to similarly sized economies. Brazil's gross domestic product (GDP) is the seventh largest in the world, behind the United States, China, Japan; leading European Union countries; and ahead of Russia and India. Brazil has legislated on S&T development since the 1930s when several industrial sectors important from a national security perspective, such as oil and gas extraction, mining, and automotive and aircraft manufacturing were established as statist monopolies under a military regime.

It was not until Brazil had moved towards democracy in the 1980s and gradually opened its markets to trade that the government turned its attention to economic competitiveness. The first major funding program targeting innovation went into effect in 1999; since then, several policies and strategic plans have been implemented that target both specific technology sectors as well as the framework conditions that support innovation.

Going by commonly accepted indicators, innovation in Brazil, particularly in the private nonstate-supported sectors, is low compared to that of peer countries. Brazil ranks 64th in the World Economic Forum's Global Innovation Index, behind Mexico and Russia, due to a complex but interrelated set of conditions. Despite this low ranking, Brazil leads other South American countries in the S&T arena with a strong manufacturing sector and an economy that accounted for close to 60% of the region's GDP in 2011. Brazil's policymakers face the challenge of making the transition from regional dominance towards global competitiveness, and deepening the Brazilian industry's integration with global supply chains, particularly in light of China's growing trade relationships in South America.

Government's Role in Innovation

Brazil has leveraged its rich and plentiful natural resources to build strong S&T-driven sectors with state support. Recent examples are the development of its biofuels industry and research into pre-salt oil reserves. Some industry leaders in these sectors are Petrobras (oil and gas), Embrapa (agriculture), and Embraer (aircraft manufacture), and private multinational companies include Vale (mining), Volkswagen do Brasil (automotive and biofuels), Halliburton and Schlumberger (oil and gas) and General Electric (equipment/machinery).

Public funding for research has steadily increased over the past decade from 1% to 1.17% of the GDP, slightly lower than in Russia and China but the highest among Latin American countries. Increased research funding has translated to a steady increase in the number of publications; however, patenting rates in Brazil remain significantly lower than in peer countries.

The government's efforts at fostering innovation in the Brazilian economy are fairly recent and have had mixed success to date; on the one hand, total undergraduate degrees granted have more than doubled in the past decade, with similarly significant trends seen in post-graduate degrees attained, an outcome of an education push by the Lula and Rousseff administrations. On the other hand, a cultural bias towards pure research and a historical mistrust of the military have traditionally diverted the majority of qualified S&T researchers to academia, where they have little interaction with industry, a trend that policies have not been able to impact thus far. As a result, industry-university linkages are poor, and publicly funded research is by and large not accessed or exploited by industry. This, in turn, also negatively impacts industry's capacity to engage in R&D-based innovation.

The high cost of doing business in Brazil known as *custo Brasil* is a barrier to starting and growing new businesses and arises from high tax and interest rates, excessive bureaucracy, rigid labor laws, and inefficient infrastructure. Critics of the Brazilian government say the profusion of uncoordinated policies announced in recent years have been ineffective and added to the existing structural defects in the economy for creating an environment that discourages business investment.

Industry's Role in Innovation

Innovation in the business sector in Brazil, outside of the state-supported industries that are S&T leaders, is primarily through the acquisition of foreign technology that is adapted for developing products for local and regional markets. As the South American economy, Brazil's in particular, has grown in the past decade, strong customer demand has enabled Brazilian companies to grow regionally without necessarily becoming more innovative or globally competitive. Companies are unmotivated to push the boundaries of technology, despite having a skilled and efficient engineering workforce. This reticence results in part from Brazil's tradition of state-supported industrial development.

In addition, the Brazilian government's response to macroeconomic shocks that could increase vulnerability to global competition (such as currency appreciation resulting from trade surpluses) has been to implement short-term protectionist measures to benefit local companies. Thus, Brazilian firms perceive that the government will continually defend the domestic industry, and this provides a disincentive to invest in long-term R&D and innovation strategies. Business investment in R&D is low, and companies typically operate in vertical supply chains, and are not well integrated into horizontally integrated (and globally distributed) supply chains of multinational corporations, a disadvantage compared to Southeast Asian countries.

Brazil's increasing trade with China and China's increasing trade with other countries in Latin America are growing concerns as policymakers recognize that short-term tariffs and taxes do not provide a long-term solution for a noncompetitive domestic industry.

Summary and Conclusion

While Brazil's national innovation system is young, two areas of particular weakness in framework conditions are human capital for S&T and research-industry linkages. The quality and extent of science, technology, engineering, and mathematics (STEM) education has been low compared with STEM education in peer countries, and Brazilian businesses have complained about the lack of qualified personnel in STEM fields. In the past decade, however, an aggressive push from successive governments has resulted in overall improvements in education, and numbers of STEM graduates have doubled between 2000 and 2010 and are continuing to climb. Trends in other countries show that efforts to build human capacity take 10–15 years to show impact. In that context, Brazil is positioning itself well for the future.

A combination of culture and skewed policy has historically diverted over three quarters of PhD recipients to academia, where they conduct basic research in alignment with the needs of the domestic industry at large. The private economy (outside the biggest state-supported sectors), in turn, has largely not exploited public R&D resources to its benefit. Thus, basic research is not being transitioned out of the universities. Recent laws address this problem, but again, it may take a decade or more for them to have impact.

Innovation in Brazil today is largely tailored to the needs of local and regional consumers rather than the global market. Despite this, Brazil is a regional leader with a growing economy that dominates the South American region and a strong manufacturing sector. State involvement in industrial policy is significant, and Brazil has historically implemented protectionist policies to support local manufacturers, providing a disincentive for them to be involved in global supply chains or push the cutting edge of technology. Industries have grown without necessarily becoming competitive beyond the needs of the regional consumer. China's growing trade relationship with Brazil and, perhaps more importantly, other countries in South America could eventually pose a threat to Brazil's economic security.

Contents

1. Introduction

A. Background

Industrial and innovation policies are designed to give a country a competitive advantage in a particular industry or sector. Some countries have made significant leaps in industrialization and technological advancement in the last two decades by strategically combining sustained investments in research and development, infrastructure, and human capital along with policy frameworks that support nascent industries through tax breaks, export support, and access to capital and markets. Others follow a less rapid and more organic path to industrial growth. In all cases, socio-economic, cultural, and political factors influence how effectively a country is able to capitalize on its natural advantages, be it supply of raw material, large population, or market size.

B. Tasking

With a goal of better understanding how different countries implement innovation policies, the Office of the Director of National Intelligence asked the Institute for Defense Analyses (IDA) to examine the industrial and innovation policies of Brazil.

C. Approach

This project addresses the following broad questions:

- What are the emerging trends in Brazil's innovation system?
- What are the challenges to advancing the innovation system?
- What are the possible transformative innovation events?

To answer these questions, a team of IDA researchers reviewed the literature and interviewed experts on Brazil to develop an overview of the political, economic, demographic, and other factors that are brought to bear on Brazil's innovation policy, relative to other countries. The themes addressed in this report are:

- Drivers: What are the factors behind Brazil's innovation goals?
- Mechanisms: How is Brazil executing its innovation policies?
- Trends: Have any of the mechanisms or policies been effective?
- Socio-cultural influence: Are there socio-cultural characteristics that might accelerate or inhibit Brazil's ability to execute its innovation goals?

- Partnerships: Who does Brazil view as key partners?
- Future vision: Looking to the future, how do changes in innovation policies translate to threats and opportunities for U.S. national security, innovation, and economy?

From discussions with experts and the literature, the team collected data along the following dimensions:

- Education policies and policies to attract talent
- Focus and level of research and development (R&D) spending, with emphasis on emerging or high-risk technologies
- Business innovation and avenues for technology commercialization
- Intellectual property rights, trade policy, and investment climate
- Focus on national security

Chapter 2 provides an overview of Brazil's innovation system. Following the premise that a country's endowments are primary components of a national innovation system, the chapter describes how Brazil, given its abundant natural resources, benefits from revenues and foreign investment that help leverage those resources. It also provides historical context and describes how Brazil's geography and natural resources—the source of much of the country's economy and wealth—have shaped its innovation trajectory.

Chapter 3 discusses Brazil's economy in terms of trade and the institutions involved with science and technology (S&T). Chapter 4 examines the framework conditions that support innovation. Chapter 5 examines the policies, strategic plans, and initiatives supporting S&T-based innovation that have been implemented in recent years.

Chapter 6 discusses the role of business in the national innovation system, highlighting recent transnational collaborations and investments, and Chapter 7 shows quantitative trend data on the impacts of government policies on innovation outputs. Chapter 8 examines some factors that are important for Brazil's continuing success in innovation and the challenges that lie therein. These findings are examined in the context of how Brazil adapts in an ever-changing environment and its effect on innovation. Chapter 9 provides a summary of findings and conclusions, including strengths, weaknesses, opportunities, and threats identified as a result of this project.

2. Brazil's National Innovation System

A. Background

A national innovation system emerges from the belief that a nation's technological capabilities are its primary source of competitive performance and that these capabilities can be built through national action (Nelson 1993). A nation's innovation system is shaped by how the nation leverages its endowments—natural resources, culture, history, geography, and demographics—through policies that create a thriving market-oriented (firm-centric) economy and accelerate the transition of new technologies, processes, and services to the market (Branscomb and Auerswald 2002). The core of a nation's innovation system, then, are its endowments and how government and industry leverage these endowments—the nation's government through policy investments, incentives, and, regulations and industrial firms through strategies, investments, and training.

For this report, we define innovation as the introduction of a new or improved product, process, model, or service in any field that produces a new advantage or value, and is either widely disseminated into the market or influences the market such that economies are impacted (OECD 2005). Stone et al. (2008) point to the presence of innovation in new or improved products, processes, experiences, or business models, which covers a broad spectrum of business activity. Innovation is often spoken of as an interconnected system because it is not limited to science and technology but can cross into many fields, such as business practices, design, and services. By definition, innovation requires successful transition into the economy.

The concept of a *national* innovation system was proposed in the 1990s by economists such as Freeman (1995), Lundvall (1992), and Nelson (1993). These and other economists attempted to explain the relationship between a nation's investment in science and technology and its economic development. By contrast to an innovation system in general, a national innovation system is made up of primary actors whose relationships and interactions foster innovation within a nation.

B. Elements of a National Innovation System

Figure 1 shows the interconnections between the three primary components of a national innovation system—endowments, government leverage, and industry leverage—and illustrates their influence on each other.

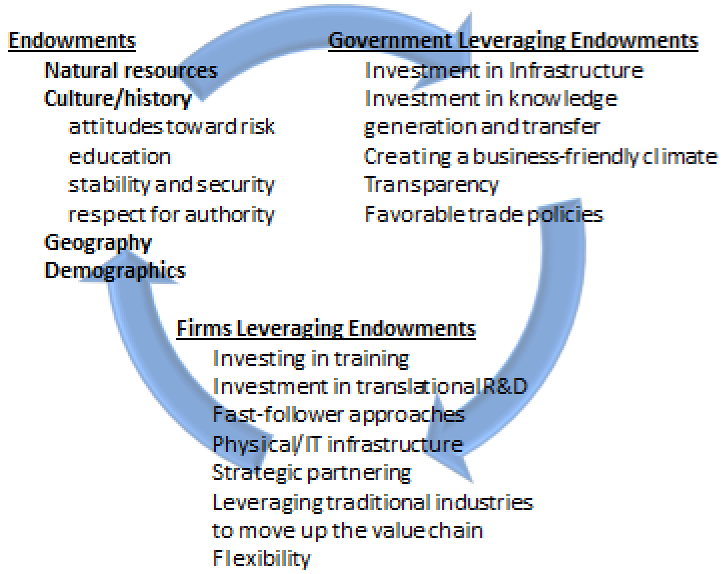


Figure 1. Core Components of a National Innovation System

A national innovation system also encompasses many innovation "pipelines," which are strategies for advancing innovation to industrial output. Such strategies are not necessarily linear. These pipelines aim to create a healthy innovation ecosystem through functional policies that guide primary actors to foster innovation.

National governments may have a range of motives for pursuing innovation. Chief among them is economic development to increase national wealth and prosperity via the creation of new products and services and, in turn, high-paying jobs. Endowments such as a nation's size and natural resources provide comparative advantages and drive conscious decisions to develop and sustain economic strength in certain areas. Brazil has leveraged its natural resources to develop strong industrial sectors in oil and gas, agriculture, and biofuels, and the state-supported research centers established in these areas helped establish an S&T research network in the country. Innovation is, in large part, driven by external competition, thus putting firms at the forefront of a nation's innovation system. Businesses leverage external resources such as research conducting institutions (universities and laboratories), government investments in education and training, policies and regulation that nurture industrial growth, and networks and partnerships that enable a firm to enhance its value in the supply chain.

C. Brazil's Endowments

Brazil's history, natural resources, size, diversity (geographic, ecological, and demographic), and growing educated middle class have shaped its innovation evolution. The government has historically designed policies to develop strong industrial sectors and continues to do so. Examples include recent development of its biofuels industry and research into pre-salt oil reserves. A strong manufacturing base and a skilled engineering workforce have made Brazil the South American region's S&T leader.

Brazil's programs are attempting to respond to structural barriers to innovation that include macroeconomic conditions, especially high interest and tax rates and restrictive labor laws. In addition, Brazilian companies have been buffeted from global competition by a history of protectionist government policies, and they believe that the government will continue to protect them from competition through import substitution, which further reduces incentives to innovate.

D. Historical Context

Brazil's lack of capacity for science, technology, and innovation has been influenced by its history. Despite adopting a constitution in 1891, Brazil oscillated between authoritarian and military rule throughout the period from 1930 to 1984.[1] During this time, Brazil underwent a long process of industrialization as the government developed statist monopolies, including well-known companies such as Petrobras in the oil and gas sector and Vale in the mining sector. Other sectors were also developed through a combination of import substitution and export promotion policies, including manufacturing in the automobile industry, and agriculture Although the Brazilian government lacked a central innovation policy throughout this time, it indirectly supported research and development (R&D) investments through public universities, human resources, and infrastructure that were important to industrial growth (Rodríguez, Dahlman, and Salmi 2008). Select macroeconomic events influencing science, technology, and innovation policy in Brazil since the 1930s are shown in Figure 2. As Brazil moved towards democracy in the 1980s and gradually opened up its markets to trade, the government has focused on stabilizing the economy and fostering growth and competitiveness in the industry.

A democratic government was established in 1984; subsequently the Federal Government promoted privatization, trade liberalization, and macroeconomic stability during the 1980s and 1990s to encourage foreign direct investment (FDI) and economic growth. The Real Plan[2] introduced a new currency in 1994 that was followed by restrictive monetary and fiscal policies and high interest rates.

Policies during this time period, known as the "two lost decades," discouraged investments in the industrial sector but stabilized inflation and economic growth (Cassiolato et al. 2010). As Brazil begin to attract significant foreign direct investments

[1] After World War II, Brazil experienced a wave of democratization and held presidential elections in 1945. However, a military regime returned to power from 1964 until 1984.

[2] The Real Plan (*Plano Real*) was a set of measures taken in 1994, during the Presidency of Itamar Franco, to stabilize Brazil's domestic currency in nominal terms after a string of failed plans to control inflation.

and domestic companies struggled to compete, the government began to recognize the importance of innovation and productivity growth to economic growth.

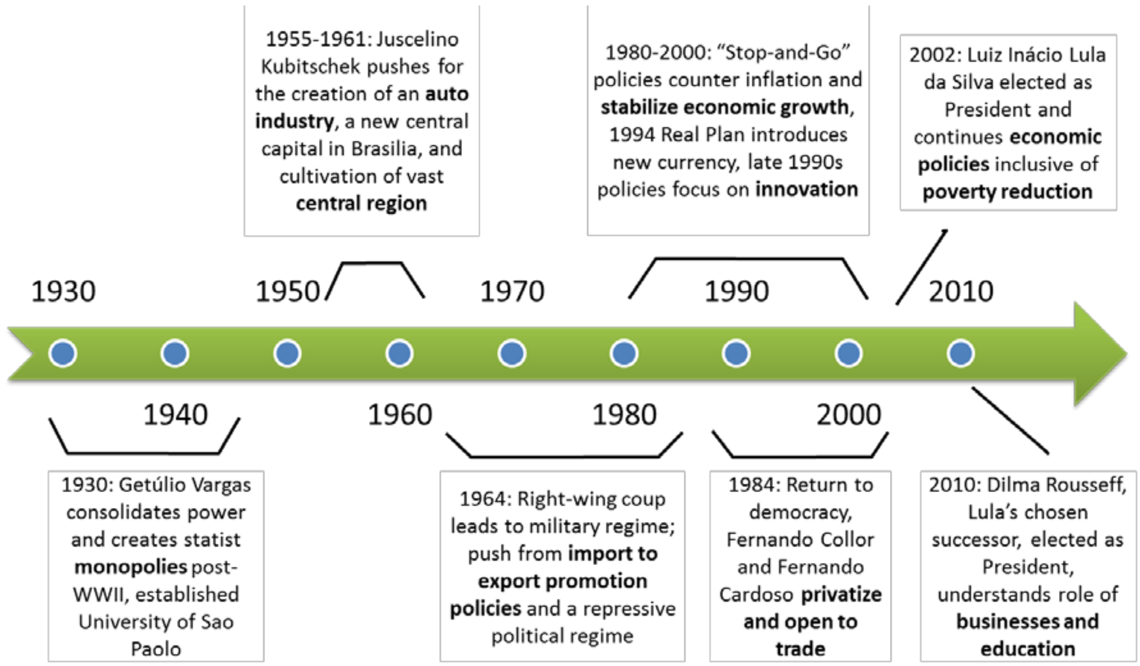


Figure 2. Select Governments and Macroeconomic Events Influencing Science, Technology, and Innovation in Brazil from 1930 to 2010

E. Geography and Natural Resources

Brazil is one of the most geographically, ecologically, and demographically diverse countries in the world and the biodiversity of its rainforests are a source of national pride. The majority of the country's economic activity occurs in the southeast region, which includes the cities of São Paulo and Rio de Janeiro (Figure 3). This region accounts for almost 40% of Brazil's total population and has the highest living standards in Brazil, although with significant pockets of poverty (IBGE 2012). Brazil lacks both a major coastal roadway and a major national rail network. Only the southeastern part of the country around the city of São Paulo has a relatively modern and integrated urban infrastructure.

Industrial activity is concentrated in the southeastern and northeast regions, along the coast. The northern region is predominantly Amazon forest, which covers approximately half of the country. Brazil contains more than 60% of the Amazon Rainforest, which makes up 40% of the world's remaining tropical rain forests. Much of the arable land in Brazil lies in the southern and central-western regions, where farmers plant sugarcane, coffee, and, more recently, soybeans through the efforts of Brazil's Agricultural Research Corporation Embrapa (Fishlow 2011).

Source: Brazilian Institute of Geography and Statistics (IBGE 2012).

Figure 3. Brazilian States and Regions

3. National Economy

A. Overview

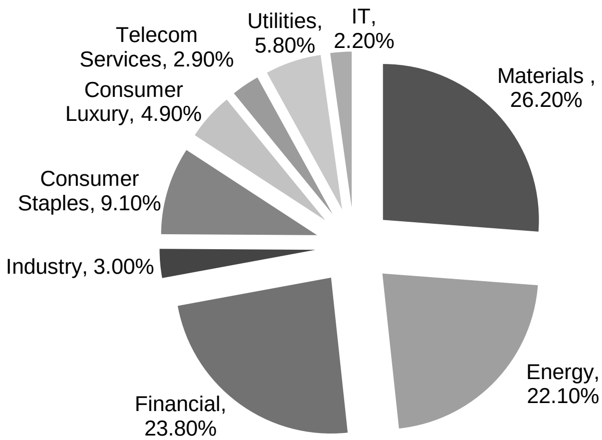
Brazil's economy is the largest among the Latin American nations. It has the sixth largest economy by nominal GDP in the world, and is one of the fastest-growing major economies in the world with an average annual GDP growth rate of over 5%. While Brazil's economy could be characterized as inward looking, it has a moderately free-market economy and is one of the top destinations for foreign direct investment globally. Brazil's economy breakdown by sector is shown in Table 1.

Table 1. Brazil's Economy Breakdown by Sector

Sector	Share of GDP	Share of Labor Force
Agriculture	6%	10%
Industry	66%	19%
Services	28%	71%

Source: CIA World Factbook.

Brazil's economy benefits from a strong manufacturing base supported by a wealth of natural resources and commodities, including oil and gas, minerals, and agricultural products. Its industrial sector, considered the largest in South America, manufactures automobiles, automobile parts, machinery and equipment, textiles, cement, computers, aircraft, steel and petrochemicals, and consumer durables. Figure 4 shows the main market sectors based on stock market representation.



Source: MCSI Brazil Index

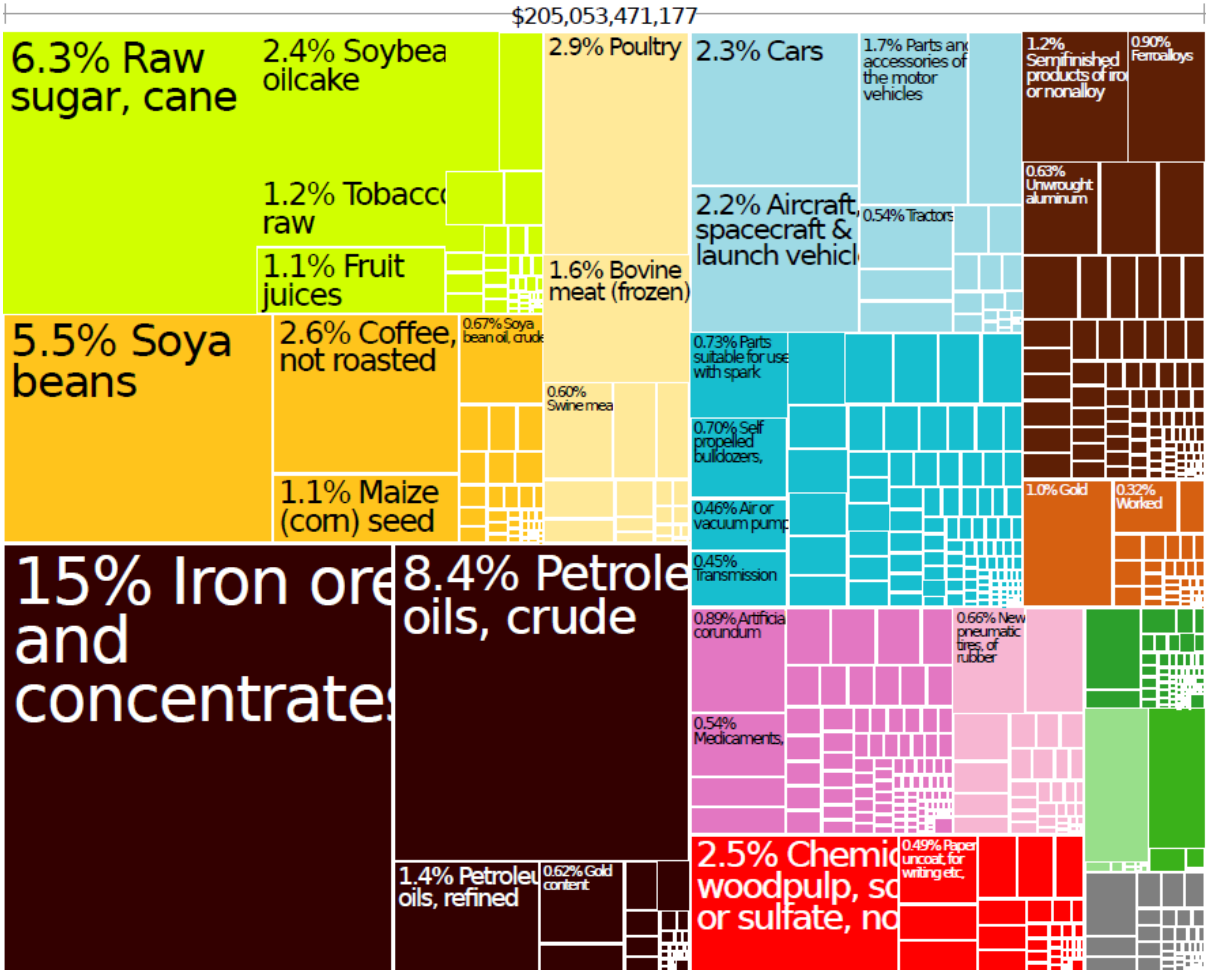
Note: Commodities (Materials + Energy): 48%.

Figure 4. Breakdown of Brazil's Economy

B. Trade

Brazil's main trading partners are China, the United States, and Argentina. Figure 5 shows the main exports of Brazil. Since the mid-1990s, natural resource–intensive industries have experienced a significant increase in the share of industrial output in comparison with more technology-intensive sectors, such as the manufacture of electronic, communication, medical, and transportation (including aeronautical), equipment (Cassiolato et al. 2010). This growth, observed particularly in the commodities, agriculture, and oil and gas sectors, has supported large trade surpluses, resulting in currency appreciation and external debt pay-down.

Macroeconomic conditions resulting from currency swings have traditionally had a strong influence on Brazil's economic policies; as a result, strategic plans for advancing innovation are sometimes countered by short-term protectionist trade policies to help local firms that suffer the impacts of currency appreciation. This aspect of Brazil's economy is discussed in more detail in Chapter 6.



Source: Economic Complexity Observatory, MIT Media Lab and the Center for International Development at Harvard University, http://atlas.media.mit.edu/.

Figure 5. Brazilian Exports, 2012

C. S&T Leadership Sectors

Within South America, Brazil is the S&T leader; it has established global leadership in select sectors that leverage its natural resources such as agricultural research, deep-sea oil production and energy, and in sectors that are reflective of national security concerns (space and remote sensing and aircraft manufacture). These sectors and with their roles in establishing Brazil's innovation driven economy are described briefly in the following subsections.

1. Agriculture

Agricultural production has historically played a vital role in Brazil's technological development and agricultural competitive advantage. The creation of Embrapa, a state-owned company affiliated with the Brazilian Ministry of Agriculture, in 1900 and its national research centers in the 1970s stimulated technological development of new crops specific to the soil and climate conditions in Brazil (Martha and Filho (eds.) 2012).[3] One of the major innovations from Embrapa is the development of soybeans for tropical climates making Brazil the second largest producer globally (Hall et al. 2011). Embrapa also helped to make the biofuels sector globally competitive by improving sugarcane, an efficient ethanol crop, production and yield per hectare (Hall et al. 2011; Martha and Filho (eds.) 2012). The successes and continued technological demands in the agriculture sector also lead to the birth of the biotechnology sector in the 1970s (Martha and Filho (eds.) 2012).

2. Oil and Gas

The oil and gas sector has historically been and continues to be a major industry in Brazil. Domestic energy consumption is a key security issues, and Brazil has met its goal of attaining net-zero oil imports down from importing 70% of its needs in the mid-1980s. Petrobras, Brazils' leading oil producer, was established in 1953 as a state-owned company, and while its monopoly ended in 1998, it continues to be awarded the majority of oil concessions accounting for 95% of Brazil's total oil production (DOC 2011). In 2010, Brazil's proven oil reserves area was estimated to be 12.9 billion barrels, mostly sourced from offshore fields, and it ranks sixteenth globally in proven oil reserves and ninth in oil production (DOC 2011).

Deep-water discoveries by Petrobras have led them to refine technologies appropriate for offshore and deep-water drilling. Currently, Petrobras operates about 20% of the world's deep-water production (Organization of the Petroleum Exporting Countries (OPEC) 2010). In 2006, the discovery of oil in the pre-salt layers located at depths of 2000 meters brought the need for a new generation of technologies for oil and gas production for which Petrobras will be the designated operator in partnership with a consortium of members (DOC 2011).

Petrobras invests heavily in R&D, and these investments have increased about 50% since 2000 ($160 million to $1.5 billion in 2011). Its R&D funding also supports a technology center in Rio de Janeiro, six experimentation centers, and infrastructure or other joint projects with universities and research institutions (Petrobras 2011).

3. Aircraft Manufacturing

Brazil's aircraft industry began in the 1960s with the establishment of three state-owned aircraft companies, including Embraer (which was privatized in 1994) and the Aeronautical Technology Institute (*Instituto Tecnólogico de Aeronáutica*, ITA) in the

[3] Also see Embrapa's website at http://www.embrapa.br/english.

1950s to provide training in areas of interest to Brazil's Aeronautical Command.[4] Embraer was created to provide transportation for monitoring and accessing Brazil's vast stretches of relatively isolated territory. Currently, Embraer is regarded as one the world's top aircraft companies alongside Boeing and Airbus and is a leader in mid-sized aircraft (Sanchez 2009). While the firm does not compete with Boeing (Embraer's largest airplanes are barely as big as Boeing's smallest ones), it has since 2012 begun collaborating with Boeing on research in aviation biofuels and composites for aircraft design. ITA and Embraer partnered in 2000 to develop a professional master's program, which serves as a pipeline of aeronautical and aerospace engineers to meet Embraer's human resource demands (Rizzi and de Andrade 1992).

4. Space and Remote Sensing

Brazil has leading capabilities in satellite and remote sensing technology, motivated by the need to monitor and access its vast, forested hinterland. Its longstanding partnership with China, the China-Brazil Earth Resources Satellite (CBERS) program, has led to successful satellite and launch systems technology, which Brazil now plans to sell to Europe and Russia (Shiro 2008).

Overall, Brazil's competitive assets include an abundance of natural resources, growing domestic commercial market, well -developed financial market, and diversified domestic business sector.

[4] See ITA's website, http://www.ita.br/.

4. Innovation Governance Structure and Framework

Brazil’s leadership since the mid-1990s has been crucial to the integration of innovation into national policies. Although S&T issues have not necessarily played an influential role for the public during the election cycles, experts interviewed indicated that S&T policies were at the forefront of national policies in the da Silva presidency and for current President Dilma Rousseff, who has helped the Brazilian public and business community gain a deeper understanding of the importance of innovation to the country’s economy.[5]

A. Governance Structure for Innovation Policies

Brazil’s governance framework for the implementation and coordination of S&T and innovation policies is complex and ministries and agencies are consolidated along three functions: coordination for science and technology, coordination for trade and commerce, and public research centers. Table 2 lists the entities involved in setting priorities and implementing S&T and innovation policies.

[5] Discussions with experts. See the appendix.

Table 2. Select Government Ministries, Agencies, and Public Research Centers in Brazil Involved in Coordinating Science, Technology, and Innovation

Ministry, Agency, or Research Center	Year Created	Purpose
Coordination for Science and Technology		
National Council on Science and Technology (*Centro Cientifico Tecnológico*, CCT)	1996	Defines science and technology priorities and coordinates policies
Ministry of Science, Technology and Innovation (*Ministério da Ciência,Tecnologia e Inovação*, MCTI)	1985	Implements science, technology, and innovation policies
Studies and Projects Financing Agency (Financiadora de Estudos e Projetos, FINEP)	1965	Funds basic research through reimbursable and nonreimbursable funding
National S&T Development Council (Conselho *Nacional de Desenvolvimento Científico e Tecnológico*, CNPq)	1951	Funds graduate and post-graduate programs and scholarships
Post-graduate Development Agency (*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior*, CAPES)/Ministry of Education	1951	Coordinates post-graduate scholarships
Coordination for Industry and Commerce		
National Industrial Development Council (*Conselho Nacional de Desenvolvimento Industrial*, CNDI)	2005	Defines industrial development priorities and coordinates policies
Ministry of Development, Industry and Foreign Trade (*Ministério do Desenvolvimento, Indústria e Comércio Exterior,* MDIC)	1960	Responsible for policy development of industry, trade and services
National Bank for Economic and Social Development (*Banco Nacional de Desenvolvimento Econômico e Social*, BNDES)	1952	Provides R&D financing for the private sector
Brazilian Industrial Development Agency (*Agência Brasileira de Desenvolvimento Industrial*, ABDI)	2004	Promotes industrial policies by providing support services to industry
National Institute of Intellectual Property (*Instituto Nacional da Propriedade Industrial*, INPI)	1970	Manages the intellectual property rights system
Public Research Centers		
Oswaldo Cruz Foundation (*Fundação Oswaldo Cruz*, FIOCRUZ), Ministry of Health	1900	Responsible for health research, development of health technologies (e.g., vaccines and equipment), and dissemination
Agricultural Research Corporation (Embrapa)/Ministry of Agriculture	1900	Responsible for agricultural research and technology transfer to regional centers
Center for Management and Strategic Studies (*Publicação do Centro de Gestão e Estudos Estratégicos*, CGEE), Ministry of Science, Technology and Innovation	2002	Responsible for providing research, policy advice, and coordination to the ministry

In addition, Brazil's individual states have significant autonomy over their S&T policies and have created their own funding agencies and university and research institutions (Rodríguez, Dahlman, and Salmi 2008). For example, the São Paolo Research Foundation (*Fundacáo de Amparo á Pesquisa do Estado de São Paulo*, FAPESP), established in 1960, is one of the largest state funding agencies in Brazil (NSB 2012). FAPESP receives funds through a 1% tax on the state's total tax revenue and in 2011 received more than $600 million to distribute through research grants, scholarships, and special programs, such as for specific sectors, technological innovation, and small businesses.

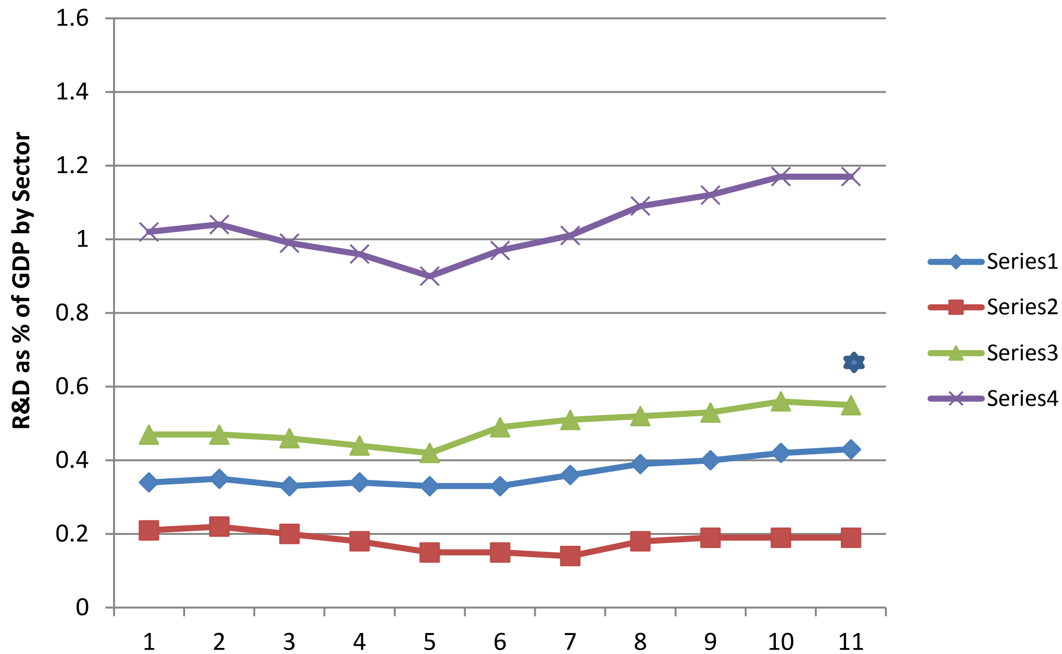
B. Institutional Support for Innovation: Inputs to Innovation

1. Government Funding of R&D

R&D intensity is used as an indicator of an economy's relative degree of investment in generating new knowledge. The goal for most countries is to spend at least 3% of GDP on R&D, although emerging economies generally spend less (NSB 2012).[6] As shown in Figure 6, Brazil's R&D expenditure as a fraction of GDP, at 1.17%, in 2009 grew substantially in the past decade, with the private sector contributing slightly less than half (NSB 2012).[7] Private R&D in Brazil remains relatively low compared to the Organisation for Economic Co-operation and Development (OECD) average of 2.3% (OECD 2011), although it is the highest among Latin American countries. One economist stated, "This is remarkable when you consider that 30 to 40 years ago there was almost no infrastructure for scientific research" (Bound 2008).

[6] For comparison, Brazil's R&D intensity is 1.16% (2008), Russia's is 1.24% (2009), India's is 0.76% (2007), China's is 1.70% (2009), and South Korea's is 3.36% (2008) (NSB 2012, appendix table 4-43).

[7] For comparison, the contribution of the business sector to R&D intensity for Brazil is 43.9% (2008), for Russia is 26.6 % (2009), for India is 33.9% (2007), for China is 1.70 (2009), and for South Korea is 75.4% (2008) (NSB 2012, appendix table 4-44).



Note: The R&D/GDP ratio (2009) is 1.17%. The private sector contributes 0.55% and the government (federal + state) contributes 0.62% (MCTI 2012d).

Figure 6. R&D as a Fraction of GDP, Total and by Sector

2. Education and Workforce Development

The management of Brazil's education system is tiered, with municipalities responsible for basic education, states responsible for secondary education, and primarily the government responsible for higher education. Brazil has achieved universal basic education in the recent past, although quality varies across regions and socioeconomic divisions (Koeller and Gordon 2009; Sennes Undated). Recent educational reforms began in 1995 under the Cardoso government and were expanded upon by Lula.

In terms of quality, the system is variable, with top universities in the south and southeast ranked in the top 200–300 globally and relatively few highly ranked universities in the other regions, despite leaders earmarking 30% of research funds for these poorer states (Regalado 2010). Table 3 profiles the top five universities in Brazil today.

Table 3. Brazil's Top Five Universities

Name	World Ranking	Research Strengths	Industry Collaboration	Notes
University of São Paulo, São Paulo	139	Molecular biology, genetics, medicine, nuclear energy research	—	Ranked 1st in Latin America;75,000 students; >25% of Brazilian publications
State University of Campanias (Unicamp), near São Paolo	228	Molecular biology, information and communications technology (ICT) research clusters	IBM, Lucent, Samsung, Motorola, Dell	Ranked 2-3 in Latin America; 17% of Brazilian publications; 10% of PhDs
Federal University of Rio de Janeiro, Rio de Janeiro	333	Engineering, energy, mathematics	CENPES Petrobras Research Center	Also known as University of Brazil; 9% of Brazilian research output
Technological Institute of Aeronautics, San Jose dos Campos		Aerospace engineering	Embraer, Brazilian Air Force, Avibras	Small (100 students/year); admission exams are the most competitive in the country
National Institute of Telecommunication, Santa Rita do Sapucai		Telecommunications electronics, IT, computer science	Has given rise to over 120 high tech enterprises[2]	Hosts biannual International Workshop on Telecommunication in Rio de Janeiro

Source: U.S. News and World Report, Top World Universities.

Note: CAPES performs a triennial ranking of all graduate programs in the country, based on number of faculty members, dissertations and theses, journal publications, and other types of publications. Each academic program receives an overall score of 1–7. These data are available at: http://www.capes.gov.br/component/content/article/44-avaliacao/4355-planilhas-comparativas-da-avaliacao-trienal-2010.

Interest in STEM education is known to be limited at the university level in Brazil, and post-secondary enrolment in STEM has been in a slow decline there over the past decade. Recent S&T and innovation-related policy actions have not been able to reverse this trend. Brazil suffers from a shortage of scientists and engineers employed in the private sector, as the vast majority of PhD holders seek careers in academia. Academia traditionally remains a highly favored destination for qualified students because of a cultural bias towards pure research. Of an estimated 200,000 researchers in Brazil in 2008, less than 10% were employed in industry (Sennes Undated). By comparison, universities and colleges in the United States employed 45% of all graduating doctoral students as of 1999 (NSB 2002).

The formal education system has in the past placed little weight on developing job skills, relying on on-the-job training beyond the basic skills acquired through formal education (OECD 2005). Thus, many Brazilian firms spend significant time training employees despite the high labor turnover, which reduces incentive to provide training. In many cases the firms are making up for skills that should have been acquired in secondary school (Rodríguez, Dahlman, and Salmi 2008).

3. Research-Industry Linkages

A key weakness in Brazil's innovation system is the gap in university-industry interaction and collaboration, caused in part by companies' lack of involvement in R&D-driven innovation and the dearth of doctoral-level researchers in industry. Academic researchers are disconnected from activities related to commercialization and innovation, and they typically collaborate with industry over short-term consulting projects and training, not long-term collaboration. As a result, transitioning of technology and R&D outputs from public research institutes is limited, as neither side is incentivized to do so, and policies mandating the establishment of technology transfer offices at universities have not had much success thus far in bridging this divide. Government policies have attempted to incentivize industry to hire post-doctoral researchers by paying half their salaries for the first 3 years (European Commission (EC) 2010). The impact of this is not yet known.

This disconnect is borne out in the low rates of patent applications by Brazilians at the domestic patent office as well as the U.S. Patent and Trademark Office (USPTO) and other international patent offices. The Brazilian patent office (INPI) granted 2,000–6,000 patents each year between 1998 and 2011, with 70–80% granted to non-Brazilian residents.

5. Innovation Policies and Initiatives

A. Impact of Recent Governments

The leadership of Brazil's federal government since the mid-1990s has emphasized the integration of innovation into national policies. It was under the Cardoso presidency that large-scale innovation funding first appeared in 1999 and was directed solely to university and research institutes. Substantial increases in federal R&D spending (from 0.33% to 0.43% of GDP) occurred over 2003–2010 under President Lula, when the government expanded its S&T policy to support both academic research and private sector productivity and innovation.[8]

As Brazil begin to attract significant foreign direct investments in the early 2000s, the broader S&T support for industry coincided with the creation of new policies and funding instruments centered on promoting innovation, with the intent of helping domestic companies compete with foreign competition. Brazil's state-owned and -run institutions in petroleum (Petrobras), aeronautics (Embraer), and agriculture (Embrapa), were privatized or partially privatized in the 1990s.

A major part of Brazil's prioritization of innovation is the role played by the Financier of Studies and Projects (*Financiadora de Estudos e Projetos*, FINEP), a public firm under the Brazilian Ministry of Science, Technology and Innovation (MCTI), established to mobilize S&T research in the public, private, and nonprofit sectors. FINEP serves as a bank, issuing loans to the private sector for innovation-related projects through the National Fund for Science and Technology. Brazil's banking sector has also developed and matured as a result of aggressive reforms in 1988 and 1994–1995 that supported modernization and regulation of the banking sector. These reforms have encouraged foreign banks to invest in Brazil, which increased competition and lowered interest rates (Roett 2011).

Two of Brazil's largest ongoing funding instruments are the Sectoral Funds for Science and Technology and the Economic Subvention Program. A recently initiated plan, the Action Plan on Science, Technology and Innovation for National Development (PACTI) addresses key deficiencies in previous policies, particularly those related to industrial investment in R&D and industrial capacity for engaging in R&D-based innovation activities. This section briefly describes the innovation-related policies that have gone into effect since 1999; a summary is provided in Table 4.

[8] Discussions with experts. See the appendix.

Table 4. Brazil's Significant S&T and Innovation Policies Since 2003, Purpose and Implementation Barriers

Year	Policy	Purpose	Implementation Barriers
1999	Sectoral Funds for Science and Technology	Funds science, technology, and innovation in 15 thematic areas	• Funding limited to universities and research institutes • Solely managed by MCTI
2003–2006	Industrial, Technological and Foreign Trade Policy (*A Política Industrial, Tecnológica e de Comércio Exterior*, PITCE)	Aims to grow exports, promote innovation capacity in firms, regional development, and capital goods; targets specific priority areas	• Does not create a governance structure • Created by MDIC but depends largely on MCTI funding instruments to execute
2005	Law of Goods	Provides fiscal incentives to firms conducting R&D and hiring graduate students	• Does not address longer-term strategies of firms in the productive sector • Targets those that would invest in R&D without fiscal incentives
2006*	Law of Innovation	Public-private partnerships for technology commercialization	• Lack of funding (initially) by MCTI to implement the law
2006^	Economic Subvention Program	Provides grants for innovative projects provided directly to firms; targets strategic sectors	• Lack of coordination and opposition among agencies • Solely managed by MCTI through FINEP
2007–2010	Action Plan for Science, Technology and Innovation for National Development (PACTI)	Coordination of national innovation system and increase private R&D spending	• Lack of transparency in developing targets • Several targets, including R&D expenditures, not met
2008–2010	Production Development Policy (PDP)	Increasing exports and small businesses; provides direct funding to 25 strategic sectors	• Created by MDIC, uncertain how well it strengthens MCTI and MDIC relations • Short-term goals coincide with election cycle • Development of goals lack transparency, some targets are merely projections of current trends
2011–2014	Greater Brazil Plan	Promotion of domestic industry (via increased protectionist measures)	• Newest policy, too early to see impacts • Carries over many of the same and unmet targets from PITCE and PDP

B. Laws and Policies Facilitating Innovation

In 1999, the sectoral funds for science and technology were created to fund innovation and S&T development in cross-cutting areas, such as infrastructure, and specific sectors, such as petroleum, energy, and agriculture. From 1999 to 2012, these funds distributed about $6.4 billion to finance more than 30,000 projects throughout Brazil (Ministry of Science 2012d). Implementation of the funds was initially considered to be misguided in some aspects; although the funds aimed to increase university-industry cooperation, funding was provided directly to the university or research institute, not the firm (Koeller and Gordon 2010), giving universities a disproportionate advantage in attracting talented researchers. Direct allocation of funding to firms was not legislated until the Law of Innovation was passed in 2004.

The Industrial, Technological and Foreign Trade Policy (*A Política Industrial, Tecnológica e de Comércio Exterior,* PITCE), introduced in 2003, is a multiagency initiative whose mandate goes beyond R&D promotion to include broader economic and industrial goals, such as expansion of trade policy. The PITCE has defined its priority areas along three themes: horizontal actions (innovation and technological development, exports, industrial modernization, and institutional environment), strategic sectors (software, semiconductor, capital goods, and pharmaceuticals), and future activities (biotechnology, nanotechnology, and renewable energy). To date, its effectiveness has been dampened by coordination challenges and dissent among the various participant agencies.

The goal of the Law of Innovation was to increase the private sector's access to public S&T resources and expertise via mechanisms such as public-private partnerships, technology transfer offices, and streamlined licensing and intellectual property allocation processes. The Law of Goods expands existing R&D tax credits to businesses, a strategy designed to increase Brazil's competitiveness in attracting investments from global R&D conducting companies.

The Economic Subvention Program is the main policy instrument for the Brazilian government to distribute R&D funds directly to the private sector. The program has almost doubled its total funding and number of awards since 2006, which was when it became active. Some funding trends are shown in Table 5. While most projects funded in the initial cycles have achieved their goals, revisions to the program have recognized the need for funding areas (beyond research) that are essential for bringing products to the market, such as technology development and marketing.

Table 5. Economic Subvention Program Funding, Grants, and Targeted Strategic Areas from 2006 to 2010 (latest year data were available)

Year	Funding (US$M)	Grants	Minimum Funding per Grant (US$K)	Strategic Areas
2006	140	145	140	3 areas: horizontal actions, strategic sectors, and activities bearing future perspectives
2007	210	153	240	5 areas: ICT and nanotechnology, biodiversity, biotechnology and health, strategic programs, biofuels and energy, and social development
2008	210	206	480	6 areas: ICT and nanotechnology, biotechnology, health, strategic programs, biofuels and energy, and social development
2009	210	260	240 (small) 480 (med & lg)	Same 6 areas as in 2008
2010	240	No info.	No info.	Same 6 areas as in 2008 and 2009

Source: FINEP website, http://www.finep.gov.br//fundos_setoriais/subvencao_economica/subvencao_economica_resultado.asp?codSessao=8&codFundo=24 and (Ministry of Science 2012b).

Note: Conversion of Brazilian real (R$) to U.S. dollars (US$): R$1 = US$0.48.

The Action Plan for Science, Technology and Innovation for National Development (PACTI) and the Productive Development Policy (PDP) were instituted in 2007 and 2008, respectively, to improve coordination of S&T and innovation governance across the various government agencies. The PACTI addresses key weaknesses in the innovation framework, such as lack of industry investment in technological R&D, lack of scientists and engineers employed in the private sector, and limited avenues for commercialization of publicly funded research.

C. Strategic Plans Addressing Innovation

In addition to innovation laws, the Rousseff administration recently implemented three overarching strategic plans that investing more than R$33 billion in targeted sectors. While the laws address longstanding structural problems, experts state that the Rousseff administration, for better or worse, has made the defense of domestic industry and markets an explicit goal (Monteiro 2013). While this stance has been justified by the fact that industry is increasingly unable to compete, it leaves industry more vulnerable in the long run to an influx of imports, particularly as the Brazilian currency appreciates and Brazil's trade relationship with China (described in Chapter 6) grows.

The recently instituted *Greater Brazil Plan (Brasil Major)* attempts to address the challenges that Brazil has faced historically when implementing innovation policies.[9] With the slogan "Innovate to compete, compete to grow," the plan is envisioned as a countermeasure to the increase in imports due to the appreciation of the Brazilian real and is focused on the development of domestic industry in 25 sectors and growth in exports (MDIC 2011; MCTI 2012a).[10] While the goal is largely to increase innovation and competitiveness, the *Greater Brazil Plan* relies on greater trade protectionism measures to promote domestic industry and exports through local content requirements, increased investments in the domestic industry (from 19% to 24% of GDP by 2014), and increased import taxes.

Critics call out the array of subsidies, taxes, and trade-related measures to boost domestic innovation as translating into short-term relief for local industry from foreign competition. In August 2012, one year after the announcement of the *Brasil Major*, the Brazilian National Confederation of Industries, which represents Brazil's manufacturing sector, published a poll of 800 manufacturers across all sectors. The poll found that more than 75% of Brazilian companies interviewed said the plan had no impact on their business. Low private sector participation and lack of regional heterogeneity are some of the implementation issues (Brazil-U.S. Business Council Undated).

The Ministry of Science, Technology, and Innovation (*Ministério da Ciência, Tecnologia e Inovação*, MCTI) initiated the Greater IT policy to build and enhance the country's information, communications, and technology infrastructure to meet the accelerating demand for social media and e-commerce.[11] The goal is to develop public-private partnerships to invest in 150 start-ups, develop 50,000 new professionals, and promote strategic areas. However, given the Rousseff administration's focus on protection of domestic industry and markets, reservations have been expressed about achieving the plan's stated goals of promoting entrepreneurship and competitiveness (Accioli 2012).

Finally, the Business Innovation Plan (*Plano Inova Empresa*) was announced in March, 2013 to stimulate private sector investment in innovation, an acknowledged gap in previous innovation policies (Monteiro 2013). The plan is expected to attract upwards of R$33 billion from the government to stimulate R&D in industry, with a specific emphasis on promoting applied research (to re-balance the current situation of too much basic research and too little application development).

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[9] Worth about R$ 60 billion (US$35 billion and 1.5% of GDP), the plan extends tax and procurement related preferences to the pharmaceutical and biopharmaceutical, telecommunications equipment and infrastructure, semiconductors and automotive sectors.

[10] See *Brasil Maior* (Greater Brazil) webpage, "Greater Brazil Plan Helped the Country Weather the Crisis, Says Fernando Pimentel," http://www.brasilmaior.mdic.gov.br/noticia/index/institucional/id/1813.

[11] See *TI Maior* (Greater IT Policy) webpage, http://timaior.mcti.gov.br.

Impact of Long-Term Protectionist Policies on Brazil's IT Sector: A Case Study

Brazil's IT industry provides an informative case study on the long-term effects of protectionist policies on growth and competitiveness. Brazil has been legislating on Information Technology since 1984; initial legislation was aimed at developing the country's nascent IT sector, and placed restrictions on imports, trade in IT-related goods and services, while providing financial incentives to locally funded companies. IT laws were amended in 1991 and subsequently in 2001 and 2004, extending incentives to all Brazilian companies in the IT sector, regardless of the origin of their financing (Marsiglia Law Firm 2013).

In 2010, a study was conducted by the University of Campinas (Unicamp) at the behest of the Brazilian Ministry of Science and Technology, analyzing the impacts of legislation on the performance of the IT sector between 1998 and 2008 (Accioli 2012). Unicamp found that the total income of beneficiary companies nearly quadrupled, productivity grew 42% more than in companies without incentives, and investment in R&D increased 30%. However, this did nothing for Brazil's position in the global market. In 2008, according to the OECD and the United Nations, Brazil ranked 27th among IT exporters—just as it had in 1998. In those 10 years, the Unicamp study pointed out, while Brazil's annual exports doubled from US$1 billion to US$ 2 billion, South Korea's shot up from US$34 billion to US$114 billion and China's from US$26 billion to US$79 billion. According to Brazilian experts, policies to encourage local content in the IT industry do not promote global competitiveness, as evidence, they point to Brazil's inability to sell its electronics other than in the domestic market.

D. Science and Technology Initiatives

Brazil is making strategic investments in S&T, which aligns with its shift in policy in the late 1990s to fund public and private university-industry partnerships. Traditionally, Brazil funded basic research at universities, but there is growing interest and realization of the need to move science and technology from the laboratory to the marketplace. Brazil funds 16 sectoral funds in S&T, and the most recent policies highlight the following 11:

- The Amazon
- Agri-science
- Biodiversity
- Biofuels
- Biotechnology and nanotechnology
- Climate change
- Energy (electrical, hydrogen, and renewables)
- Health
- Information and Communications Technology (ICT)
- Oil, gas, and minerals
- Space, nuclear, and defense.

The policy allocates a small percentage of the taxes paid by key industries to R&D projects selected by a public committee. Two-thirds of Brazil's investment (R$1.1 billion)[12] are allocated to joint ventures between universities and the private sector. These funds have had the positive impact of intensifying R&D at Brazil's established companies but have also redistributed resources to less developed regions.

[12] Equivalent to about US$690 million.

6. Business and Innovation

Innovation depends on the ability to move new science and technologies to the market. Going by commonly accepted indicators, business innovation in Brazil is comparatively low due to a complex but inter-related set of conditions including the high cost of investment and doing business, the lack of qualified personnel, and the low business interest in R&D-based innovation. Private investment in R&D (0.55% of GDP in 2010) is, and has been, relatively low in Brazil compared to OECD averages and is concentrated in larger companies.

Additionally, compared to peer countries, Brazil's sustained focus on S&T-based innovation and competitiveness is relatively young, as it was not until Brazil moved towards a democracy in the 1980s and gradually opened its markets to trade that the government regained focus on stabilizing the economy and increasing competitiveness in industry. Since then, while Brazil has experienced consistent growth in its S&T and industrial base, the translation of S&T to innovation has not kept pace.[13] Sectoral funds for science and technology were created to fund innovation and S&T development in cross-cutting areas, such as infrastructure, and specific sectors, such as petroleum, energy, and agriculture. As the first policy instrument to commit significant funding to S&T-based innovation, the funds have distributed about $6.4 billion to 30,000 projects throughout Brazil since inception in 1999. More recently, PACTI[14] addressed some of the underlying challenges such as low industry investment in R&D and lack of scientists and engineers in industry; however, strategic planning in Brazil can be hindered by short-term protectionist measures in response to macroeconomic shocks, which decreases firm interest in innovation.

Brazil is, however, strong in several S&T-driven sectors. Examples of domestic industry leaders are Petrobras (oil and gas), Embrapa (agriculture), and Embraer (aircraft manufacture), and private multinationals include Vale (mining), Volkswagen do Brasil (automotive and biofuels), Halliburton and Schlumberger (oil and gas), and General Electric (equipment/machinery). Often many of these innovative companies are linked together in production chains, such as Halliburton, Schlumberger, and GE supporting Petrobras in deep-water oil and gas exploration R&D.

This chapter discusses selected indicators of business innovation as well as the many factors that impact business innovation.

[13] Discussions with experts. See the appendix.

[14] The Action Plan for Science, Technology and Innovation for National Development (PACTI) and the Productive Development Policy (PDP) were instituted in 2007 and 2008, respectively, to improve coordination of S&T and innovation governance across the various government agencies.

A. Business Climate Measures in Brazil

A well-known fact about doing business in Brazil is *custo Brasil*, defined as the additional expense of goods due to insufficient infrastructure, inflexible labor laws, high taxes and interest rates, and an "excessively onerous bureaucracy," makes doing business difficult (Lopez-Claros and Mata 2010). It currently takes 119 days to start a business, which is the fifth longest wait in the world (World Bank 2012).

Table 6 shows the top obstacles to innovation reported by company respondents according to a World Economic Forum survey. In recent years the lack of qualified personnel has increased in relative importance while availability of financing has decreased, presumably as a consequence of increased government support for financing innovation-related activities (Sennes Undated). Tax rates are widely cited as the largest barriers to business development (WEF 2013). During the 2000s, the Brazilian government increased its spending, raising the tax rate to about 70%, which was a disincentive to private sector investment (World Bank 2012, 2013; Rodríguez, Dahlman, and Salmi 2008).[15]

Table 6. Most Problematic Factors for Doing Business in Brazil

Factor	Percentage of Responses
Tax regulations	18.7
Inadequate supply of infrastructure	17.5
Tax rates	17.2
Inefficient government bureaucracy	11.1
Restrictive labor regulations	10.1
Inadequately educated workforce	7.4
Corruption	6.0
Access to financing	3.9
Foreign currency regulations	2.1
Insufficient capacity to innovate	1.8
Crime and theft	1.0
Policy instability	0.9
Poor public health	0.8
Poor work ethic in national labor force	0.6
Government instability and coups	0.5
Inflation	0.3

Source: From a set list of factors, respondents were asked to select the five most problematic for doing business in their country and to rank them between 1 (most problematic) and 20 (World Economic Forum (WEF) 2013).

B. Innovation Occurs Primarily by Technology Adaptation

Brazil has a history of state-supported industrial development, which has produced many of its technologically leading firms; the government's strategy is to develop companies through incentives and subsidies, gradually reducing the government's role in ownership and management

[15] Discussions with experts. See the appendix.

as the firm becomes successful. Brazilian firms perceive that the government will continually help them be competitive and ensure economic growth.[16] For firms, this perspective has a negative influence on their willingness to invest in the kinds of high-risk, high-payoff, long-term strategies required for R&D and innovation, resulting in low involvement in R&D-based innovation in the larger private sector.

Available data show that the majority of innovation occurring in Brazil today is by technology acquisition from foreign companies. Such innovation is not positioned for global competitiveness but rather for adapting and developing products for local and regional markets (Reddy 2011). With the exception of the natural resource-based sectors, Brazilian firms are seeking to learn through copying for short-term gains rather than investing in and producing true innovations to meet societal demands.[17] On the other hand, technology adaptation, in combination with a strong manufacturing base and effective engineering workforce, has made Brazil the indisputable the regional leader in S&T-based sectors, the maintenance of which relies on consistent investment and support from the state.

A significant characteristic of Brazil's industrial sector is the relative disconnect from global supply chains relative to other growing economies with a strong manufacturing base. The few multinational corporations performing R&D-based innovation are not connected to the majority of micro, small, and medium enterprises that serve only the domestic or regional market (Melo and Rapini 2012; Sennes and Filho 2012). The disadvantage of this lack of connection has been exacerbated in recent years by the impact of Chinese companies on Brazilian local industry. Research conducted by the Brazilian National Confederation shows that competition from Chinese products now affects one in four Brazilian industrial companies, with the impact being proportional to the size of the company. Industries most affected by this competition are automotive, machinery and equipment, footwear, medical and precision equipment, and computing and communication hardware. An example of this is the growing investment by Chinese low-cost IT manufacturer Foxconn in Brazil, putting the Brazilian IT manufacturing and retail businesses at a disadvantage (Standing, Chang, and Hung 2011). The relative vertical integration, high cost of business, and mid-technology levels of Brazilian industries puts them increasingly at a disadvantage to the fragmentation of global supply chains and economies of scale that China and other Southeast Asian countries have used to their advantage to capture global market shares in high-technology sectors. In response, Brazilian companies are beginning to take countermeasures by integrating with parts of the Chinese supply-chain, both in the form of foreign direct investment and trade relationships; other actions involve investment in quality and cost reduction (Deloitte Touche Tohmatsu 2012).

[16] Discussions with experts. See the appendix.

[17] Discussions with experts. See the appendix.

C. Protectionist Measures in Response to Macroeconomic Conditions

Brazil's natural resource wealth is a defining factor for the country in many ways, not the least of it being that Brazil's economy is susceptible to swings in the global commodities and energy markets. Large trade surpluses in these sectors in the recent past have resulted in currency appreciation, and the government's response to macroeconomic swings has historically been to implement short-term protectionist measures such as local content requirements and high tariffs to benefit local companies.

In September 2012, the Rousseff administration raised tariffs for 100 products applied to all of their trading partners (exceptions being where they have trading agreements in place[18]) (MercoPress 2012).[19] These policies are supported by various organizations, including the Federation of Industries for the State of Sao Paolo,[20] that are vocal about their stance to protect Brazil's markets and promote protectionist measures.[21] In an industrial base that traditionally has a strong reliance on acquisition of technologies, this provides a further disincentive for firms to engage in innovation and, in turn, reduces the overall demand for highly qualified S&T personnel in industry.

However, the increased global competition and imports continues to threaten local supply chains, and the government faces challenges on how to balance the often conflicting competitiveness and protectionist interests (Rodríguez, Dahlman, and Salmi 2008). In recent negotiations that alleviate the downside of the protectionist measures, Brazil has reached agreements with foreign manufacturers such as BMW, who have a local presence, allowing flexibility in local content requirements[22] if the companies are willing to invest in R&D in Brazil.[23] This appears to be similar in nature to measures implemented by the other BRIC countries, particularly China.

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[18] Discussions with experts. See the appendix.

[19] Brazil can have a low actual tariff rate of about 0% or 5% with an allowed bound rate of up to 35%. Under the most favored nation principles of the World Trade Organization, Brazil can implement the tariff across all trading partners. However, by raising the tariff rate for certain goods, the government can target specific sectors and trading partners (Discussion with Fussell and Young).

[20] The Federation of Industries of the State of São Paulo (Fiesp) is the largest professional association of Brazilian industry, representing about 130,000 industries in various sectors, distributed in more than 130 unions (http://www2.fiesp.com.br/.)

[21] Discussions with experts. See the appendix.

[22] BMW requires that their motors be Bavarian-made, which incurs a high sales tax compared to auto manufacturers whose operations are fully Brazil-based.

[23] Discussion with experts. Also, see International Council on Clean Transportation (ICCT 2013).

Brazil's growing trade relationship with China

China's increasing demand for commodities and raw materials has led to a growing trade relationship with Brazil. In 2009, China replaced the United States as Brazil's largest trading partner, and the two countries have established tighter economic ties and interdependency. China now appears to be within the top five of Brazil's foreign investors and estimates for the magnitude of China's foreign direct investment in Brazil range from $4.5 billion to $35 billion (Kushner 2012). (The exact magnitude of China's investment and the magnitude relative to the rest of the world are difficult to assess. According to Ernst & Young (2012), data quality is poor, partially because China's FDI is routed through financial centers such as Hong Kong, the Cayman Islands, and the British Virgin Islands.) Brazil is purchasing manufactured goods and electronics from China to bolster its growing industry, infrastructure projects, and telecommunications networks. China's imports from Brazil primarily consist of commodities (soy, oil, wood, and iron); however, imports of manufactured goods, particularly cars, are increasing (Kushner 2012; CBBC 2012).

As Brazil's trade relationship with China has accelerated, fears of Chinese goods flooding the market is one of the drivers behind the Brazilian government's recent promotion of protectionist measures ranging from tariff hikes to local content requirements. Recent Chinese investments in the Brazilian auto sector show significant impacts on the sector's auto supply chain, which is at the heart of Brazil's industrial structure (CBBC 2012). As Brazil has seen an influx of Chinese-made cars, the Rousseff administration has increased taxes on cars with less than 65% local content, taking the tax on some imported models to 55% on top of import tariffs (Cassiolato et al. 2010; Kliman and Fontaine 2012). Discussions with experts (see appendix A) indicate that tariff hikes on auto equipment have affected Chinese investments in the auto sector, forcing some companies to exit the Brazilian market. One expert said, "if Brazil could raise tariffs only on China, they would." In the long term, rather than continue to implement protectionist measures, or acquiesce in loss of domestic manufacturing capability in competitive industries, Brazil will move towards managed trade with China, at least in some sectors (*The Economist* 2012).

D. Foreign Direct Investment

Multinationals have several motivations for investing in Brazil, most notably access to the large Brazilian market and the Common Market of the South (*Mercado Común del Sur*, MERCOSUR).[24] Compared to India and China, Brazil has a longer tradition of multinationals and a fairly consolidated industrial base, both advantages for foreign direct investment (FDI) in innovative activities (Sennes Undated). These drivers have led to FDI in Brazil reaching $67 billion in 2011 (5% of world FDI), up from an average of $24 billion in the previous decade (World Bank 2012). Table 7 shows a breakdown by sector of FDI in Brazil.

In a recent survey of companies, more than half of the respondents expressed interest in establishing or expanding work in Brazil and over three-fourths think Brazil will improve in attractiveness over the next 3 years on the strength of its highly consumer-oriented middle class,

[24] The MERCOSUR is an ambitious economic integration project that includes the founding members Argentina, Brazil, Paraguay, and Uruguay. In 2008, Venezuela, Chile, and Bolivia became associate members. Peru, Ecuador, Colombia, and Mexico have expressed interest in joining. MERCOSUR's goal is (MercoPress 2013):

> to increase the efficiency and competitiveness of its member economies by opening markets, promoting economic development in the framework of a globalized world, improving infrastructure and communications, making better use of available resources, preserving the environment, generating industrial complementation and coordinating macroeconomic policies. Achieving a common external tariff is one of the main goals of the block.

its natural resources, and its global demand for commodities (Ernst & Young 2012; Kearney 2010). However, while investors believe that Brazil will be a leader in oil and gas in the next 10 years, few foresee Brazil being a leader in innovation (Lustosa 2011). The investors' primary recommendations are to improve technical skills, build innovation capacity and diversify sectors, and promote Brazil's regions (Ernst & Young 2012).

Table 7. Top Sectors in Brazil Attracting FDI Projects

Top 15 sectors by FDI projects

Rank	Sector	Number of projects		Share in 2011	Change 2011 vs. 2010	Jobs created 2011	Value (US$m) 2011
		2010	2011				
1	ICT	69	105	21%	52%	17,724	14,780
2	Manufacturing	47	94	19%	100%	21,822	4,678
3	Business services	29	53	10%	83%	2,043	687
4	Retail and consumer products (RCP)	41	44	9%	7%	23,051	6,872
5	Financial services	20	35	7%	75%	2,464	600
6	Mining and metals	18	35	7%	94%	45,778	18,965
7	Automotive	31	33	7%	6%	16,327	6,034
8	Chemicals	30	32	6%	7%	5,956	1,677
9	Transport and logistics	17	17	3%	0%	2,689	725
10	Equipment	11	16	3%	45%	7,519	375
11	Real estate, hospitality and construction	17	12	2%	-29%	4,075	969
12	Cleantech	13	11	2%	-15%	7,165	4,290
13	Energy	4	8	2%	100%	3,517	2,047
14	Life sciences	15	8	2%	-47%	752	108
15	Aerospace	4	4	1%	0%	284	110
	Total	366	507	100%	39%	161,166	62,916

Source: Ernst & Young (2012).

E. Access to Capital

Brazil's banking sector has undergone changes in the past two decades to improve access to capital; however, the equity market is still young, and governance rules for raising capital through public markets for startups and growth industries are still evolving. In insecure macroeconomic times (common in Brazil over the past 30 years), early stage capital and financing for less certain ventures can be hard to come by—according to the Global Entrepreneurship Monitor, most businesses in Brazil start with less than US$5,000, and Brazil has the second lowest rate of informal investors among all countries in the GEM (infoDev 2010).

Despite recent growth in FDI and private equity (Sennes Undated) (infoDev 2010), access to capital, especially early stage funding, is mixed. A relative scarcity of exit opportunities and relatively long maturation periods continue to hamper venture capital growth in Brazil (Ernst &

Young 2012), while the availability of venture capital varies across regions, with slightly better situations in São Paulo and Rio de Janeiro, which have benefitted from university leadership connecting researchers and entrepreneurs to networks of investors such as the Gavea Angel Network (infoDev 2010).

F. Intellectual Property

Brazil adopted the 1995 World Trade Organization's Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) in 1996, which created a baseline for intellectual property in Brazil. Patent activity in Brazil, while low by global standards,[25] has grown slowly since 1999, resulting from both economic growth and improvements in Brazil's intellectual property system. Much of the patenting activity is driven by foreign firms conducting R&D in Brazil. America's Whirlpool Corporation holds the first place in patent applications in Brazil (Article One Partners 2011). While protection of intellectual property has improved in Brazil, the country is still ranked 75 out of 144 countries in terms of patent protection (WEF 2013, 116).

[25] Brazil had 250 patents granted by the U.S. Patent and Trademark Office (USPTO) of the over 4.5 million granted in 2010 (Regalado 2010; Ministry of Science 2012d). While this number is more than double what it was 10 year earlier, it is still an exceedingly low fraction (0.01%) of the USPTO totals given Brazil's share of global GDP (3.5% in 2011).

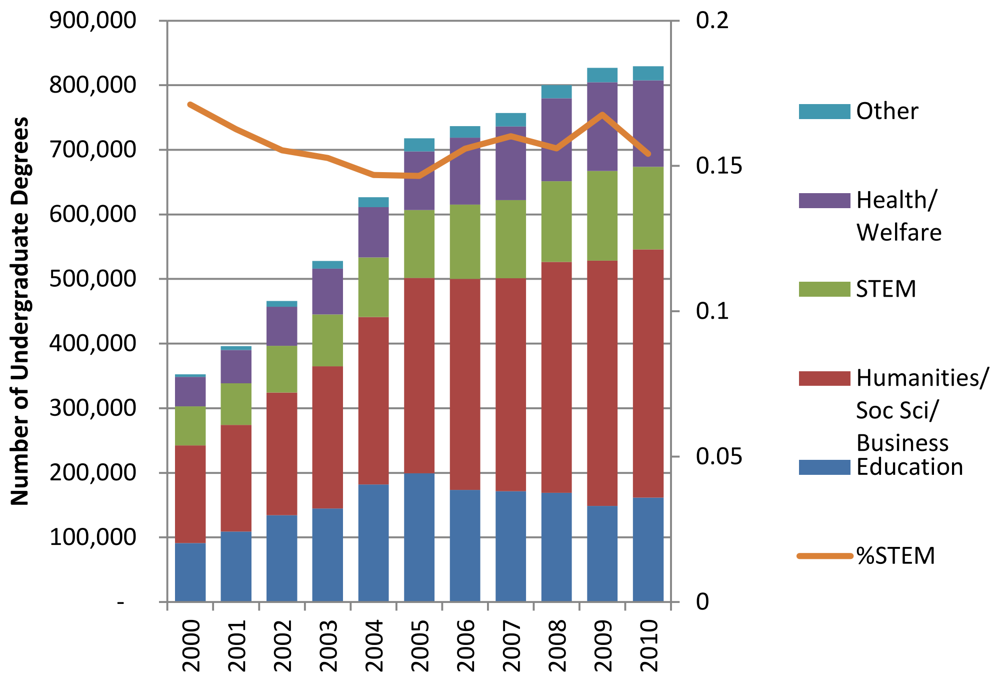
7. Impact of Policies on Innovation Indicators

Innovation is today a central component in Brazil's recent S&T and industrial policies. However, many of Brazil's innovation strategies and policies are fairly new and, thus, it may be too soon to assess significant and direct outcomes. Additionally, it was not until 2007 that policies began integrating measurable goals and targets and thus it is not surprising that many of these short-term goals have not yet been met given the financial crisis and short time horizon of implementation.

Several aspects of Brazil's historical development, geography, governance, and institutions affect both its overall business competitiveness and its potential for innovation. Like all countries, Brazil has relative strengths (including a strong manufacturing base, government support for innovation, and immense natural resources) and weaknesses (high taxes, protectionist trade policies, corruption, inefficient labor markets, and still developing intellectual property rights) in its innovative potential. Being a relatively young country, many of these factors are still in flux as evidenced by the change from a historical lack of attention to innovation to strong support over the last 15 years. Further, these recent innovation policies have often been designed specifically to improve or correct aspects of these underlying factors.

A. Growth in STEM Education

The Lula and Rousseff governments have made education a priority in Brazil, and enrollment in post-secondary education has expanded in the past decade given large funding increases under programs such as the Federal University Expansion and Restructuring Program. Figure 7 shows the total granted undergraduate degrees, which more than doubled over a decade from 350,000 in 2000 to over 800,000 in 2010 (Ministry of Science 2012b, 2012c). Enrollments are heavily biased toward the south and southeast regions of Brazil, which constitute 16% and 54%, respectively, of graduates. Sao Paulo alone represents 32% of undergraduates (Ministry of Science 2012b, 2012c).



Note: The term %STEM represents the fraction of STEM degrees, including math, science, and computing; agriculture and veterinary science; and engineering, manufacturing, and construction (Ministry of Science).

Figure 7. Undergraduate degrees granted by Brazilian institutes of higher education by field of study.

Similarly significant trends can be seen in post-graduate education. In 1998 Brazil granted only 2,800 PhDs and 12,000 master's degrees, but these numbers have grown to 7,700 PhDs and 39,000 master's, more than doubling the number of doctorates and tripling the number master's degrees (Figure 8 shows PhDs by field of study).

While attainment of higher education has sharply increased, the proportion of STEM degrees granted decreased at all levels, from 17% to 15% at the undergraduate level,[26] 60% to 55% at the master's level, and 71% to 63% at the doctoral level (MCTI 2012b, 2012c). *These data confirm expert input that despite recent government increases in funding for higher education, there have been no policy actions specific to supporting STEM education, which are essential for driving innovation in private enterprise* (Sennes Undated; NRC 2010).

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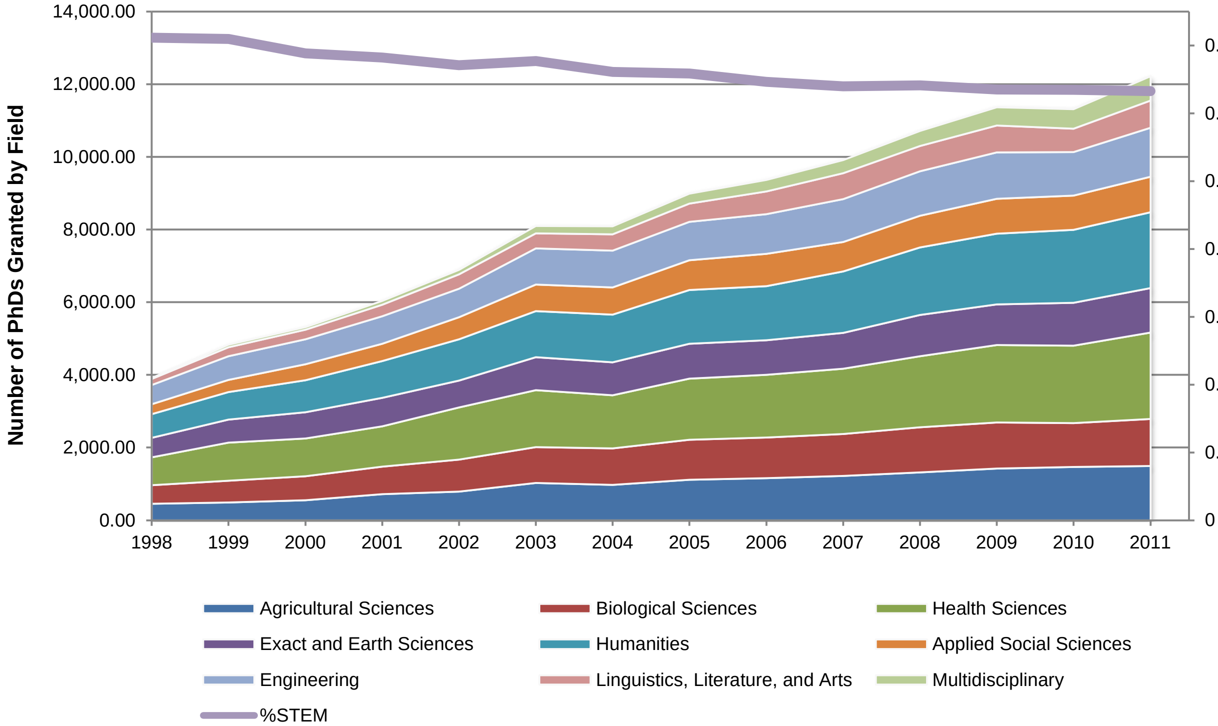
[26] For comparison, the proportion is 39% in China, 31% in Germany, and 24% in Japan (ABDI 2010).



Note: STEM includes agricultural sciences, Biological, Exact/Earth Sciences and Engineering.

Figure 8. Number of PhDs Granted by Brazilian Institutes of Higher Education and Fraction of STEM Graduates

While the increase in overall researcher numbers is impressive, the numbers of graduating scientists and engineers is considered insufficient for the country's developmental needs (National Research Council (NRC) 2010)and Brazil has a long way to go before catching up to peer countries Russia and China in researcher intensity (i.e., number of PhD researchers per million population). Russia today has approximately 3,000 researchers at the PhD level per million population; China has 1,200.[27] Brazil's researcher intensity is about 700, on par with that of Turkey and Argentina (when comparing across countries with roughly similar geographic size and population).

B. Workforce Development for an Innovation Economy

One of the largest weaknesses of the Brazilian innovation system continues to be the lack of opportunities afforded to researchers in industry after graduation (Sennes Undated; Rodríguez, Dahlman, and Salmi 2008; Koeller and Gordon 2010). The number of PhD researchers in Brazil has almost doubled in the decade from 2000 to 2010, which is on par with numbers of PhD researchers in Argentina and Turkey.

As Figure 9 shows, although the number of postgraduates has increased over the past decade, nearly all of these postgraduates have gone into academia. The number of researchers in private

[27] Comparable numbers for India were not available.

industry actually declined while the number in academia increased by more than 140% (Ministry of Science 2012c). In contrast, in the 1973–1999 timeframe, the United States saw a 230% increase in doctoral researchers entering the private sector while academic researchers in the same period doubled (National Science Board (NSB) 2002). Increased support for graduate education and improved academic standards has not translated into integration of graduates into industry (National Research Council (NRC) 2010).

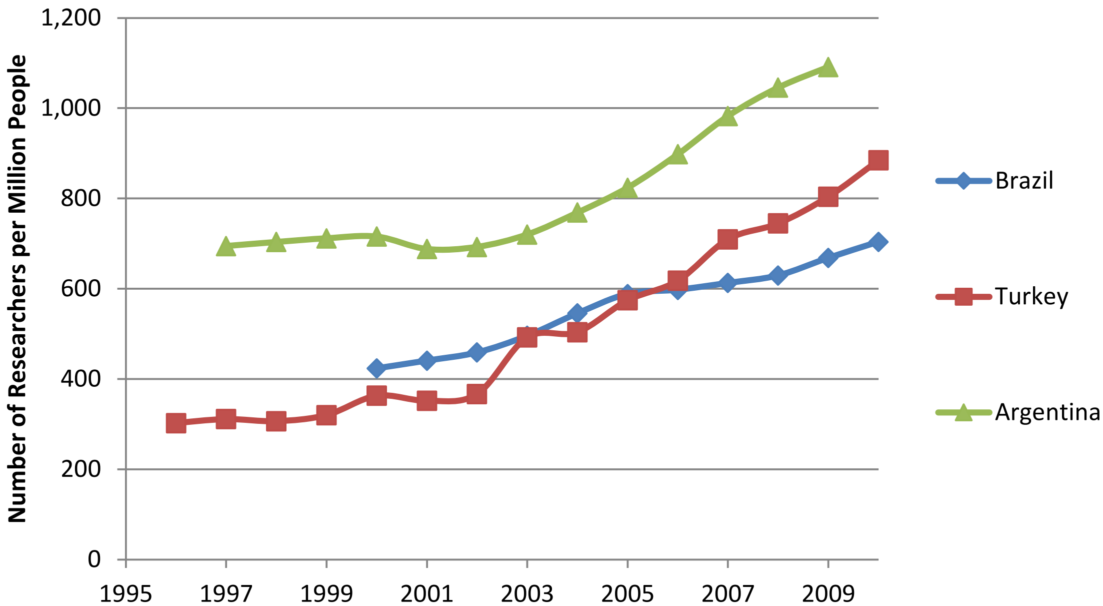
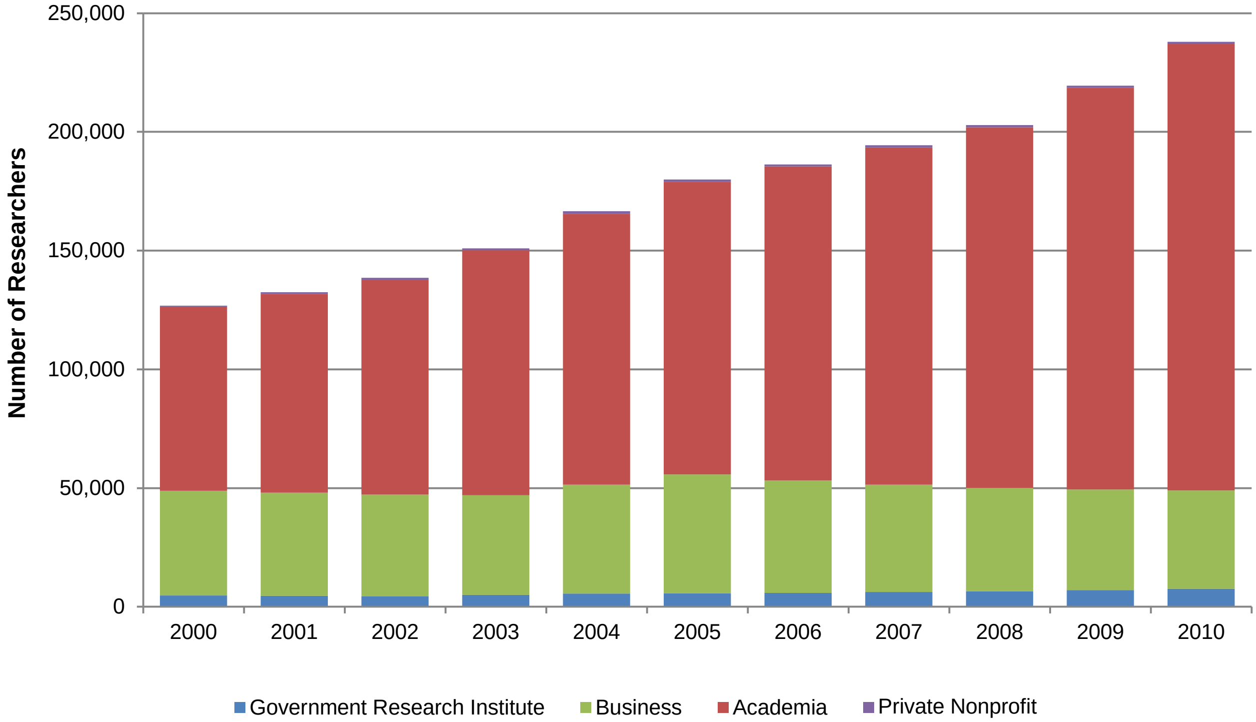


Figure 9. Researcher Intensity in Brazil and Selected Countries

This skewed result can be partly attributed to narrow policy design—public funding for improving university-industry research collaborations instituted in 1999 provided the funds directly to the universities, leaving industry at a disadvantage in as far as attracting talented graduates. As a result, outside of the large multinationals and domestic corporations in sectors where Brazil has demonstrated R&D capability (such as Petrobras and Embraer), industry's ability to compete with academic and public research institutions in recruiting a high-quality researcher cadre is low (Figure 10). In fact, over 90% of industrial researchers hold bachelor's or master's degrees.



Source: MCTI (2012b).

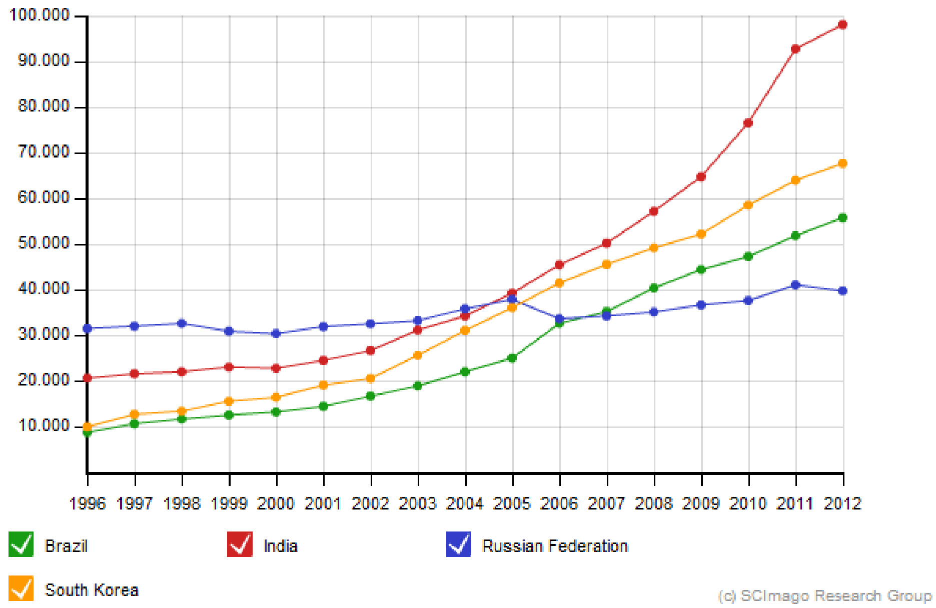
Figure 10. Stock of Researchers by Sector

C. Patent and Publication Rates

The surge of qualified researchers towards academia has had a noted impact on the academic output of Brazilian universities, with peer-reviewed papers published tripling from 13,000 to 43,000 papers, and the total Brazilian fraction of publications increasing from 1.15 to 2.4% (Regalado 2010; MDTI2012b).

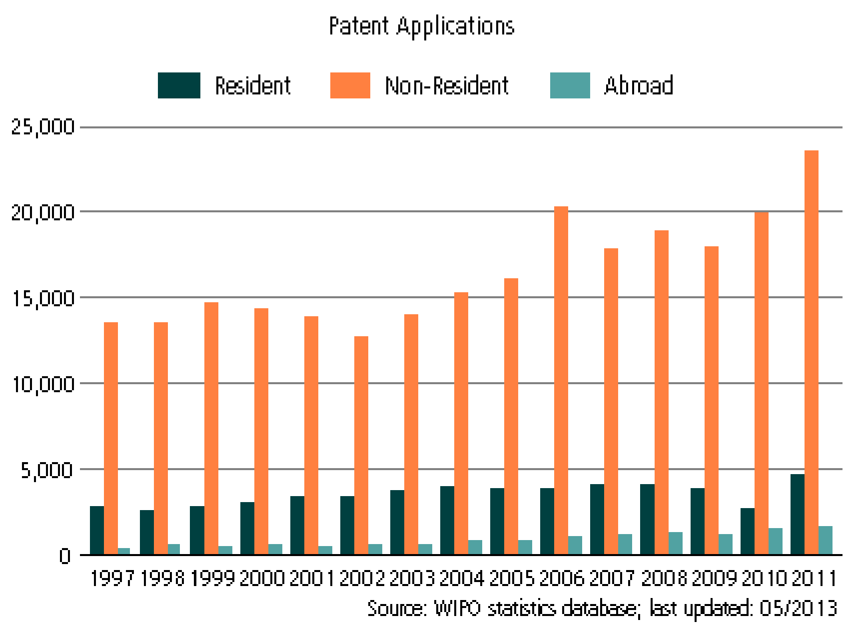
As Figure 11 shows, Brazil ranks among the top five countries for nonresident patent filings as a share of all applications. The Brazilian patent office (INPI) granted 2,000–6,000 patents per year in 1998–2011, and 70–80% of these were granted to non-Brazilian residents.

Figure 12 shows that annual patent applications by residents in Brazil have seen a slow increase from about 2,500 in 1996 to 4,000 in 2010. This rate of patenting by residents is on par with Turkey, Canada, and Spain, but low compared to peer countries. Both China and Russia, for example, produce more than seven times the number of patent applications by residents. The low rate of patenting by domestic companies and individuals can be partially explained by the relative lack of researchers in private industry (40,000 compared to 180,000 in academia), and low levels of technology transition from universities to industry in the domestic ecosystem. In addition, the increase in patents has failed to keep pace with the increase in publications, which is one measure of potential weakness in the commercialization of knowledge.



Source: SCImago Journal & Country Rank, http://www.scimagojr.com/.

Figure 11. Nonresident Patent Applications



Source: World Intellectual Property Organization (WIPO) Statistics database; last updated May 2013.

Figure 12. Total Patents Granted by INPI to Nonresidents and Residents of Brazil

By contrast, patent applications by nonresidents (shown in Figure 13) have increased steadily during the same timeframe, pointing to an increasing presence of multinationals that are conducting R&D.

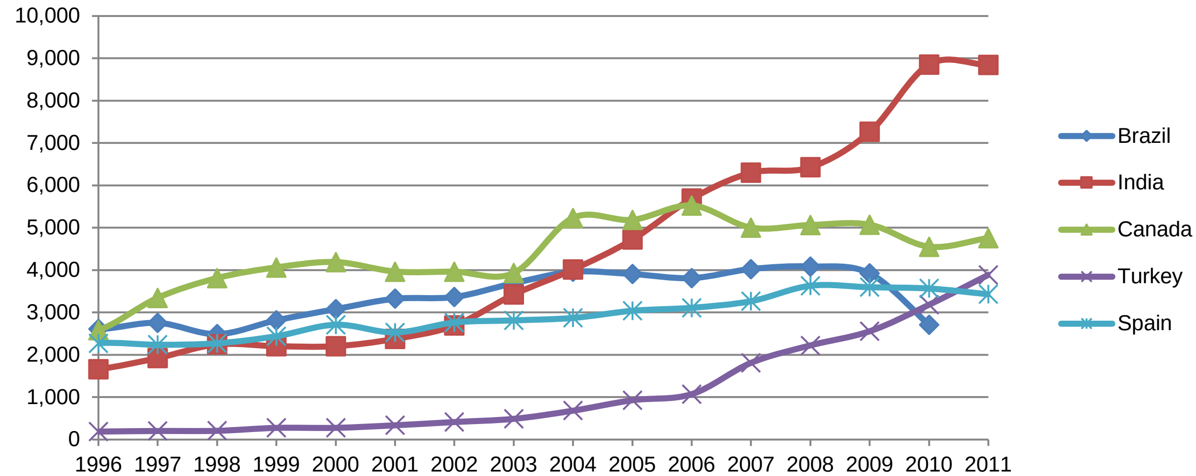


Figure 13. Patent Applications filed by Residents in Brazil and selected countries, 1995–2011

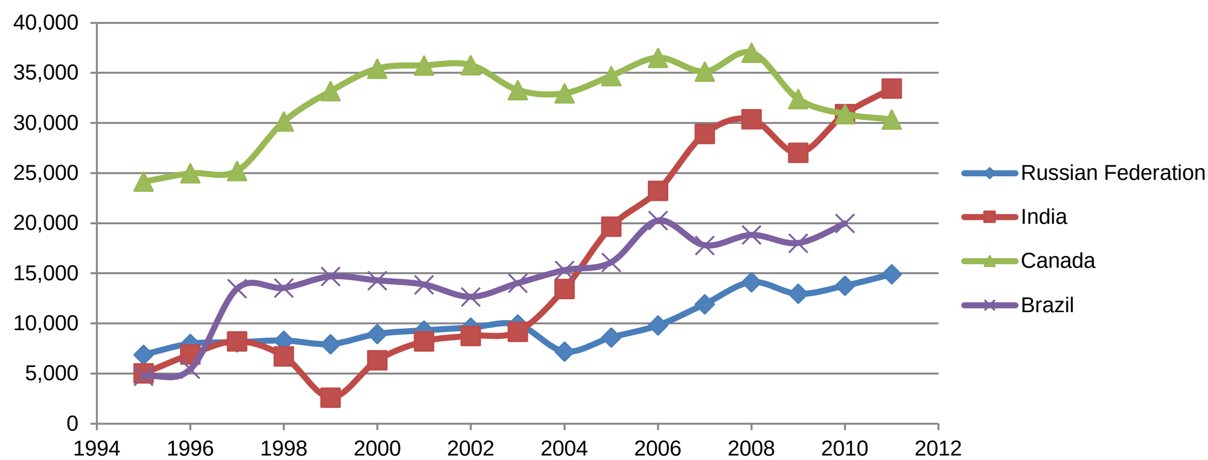


Figure 13. Patent Applications Filed by Nonresidents in Brazil and Selected Countries, 1995–2011

D. Firm Involvement in Innovation

Brazil's manufacturing sector, its second biggest sector after services, accounting for about 30% of the economy, is a strong contributor to its position as the regional economic leader (Brazil's GDP accounts for over 60% of South America's economy). However, R&D-based innovation in the manufacturing sector, and the economy at large, is low with technological sophistication at low- and mid-technology levels. Business expenditure on R&D as a percentage of GDP is at about 48%, lower than most OECD countries.

Using a broad definition of innovation (including the purchase of software or new machinery or even innovations in the marketing of existing products), the 2008 Survey of Technological Innovation (*Pesquisa de Inovação Tecnológica*, PINTEC) shows that 38% of domestic companies reported having performed innovative activities, up from 30% in the first survey conducted in 1998–2000.[28] However, innovation in the vast majority of these companies (84% of product innovations and 94% of process innovations) were *new only to the company rather than being new to the entire Brazilian or world markets*, as shown in Table 8, validating the perception that Brazilian innovation tends to represent only technology transfer rather than global innovation.

Table 8. Proportions of Product and Process Innovations Described as New to the World Market, New to the Brazilian Market, or New to the Company Reporting the Innovation

	Product			Process		
	% New World	**% New Brazil**	**% New Company**	**% New World**	**% New Brazil**	**% New Company**
Tobacco products	8.2%	21.0%	70.8%	9.1%	0.0%	90.9%
Machinery and equipment	6.7%	22.0%	71.3%	0.6%	4.8%	94.6%
Pharmaceuticals	6.0%	27.7%	66.3%	0.5%	7.3%	92.2%
Other transport equipment	5.3%	37.7%	57.0%	1.8%	6.1%	92.1%
Computer equipment	3.9%	25.7%	70.4%	1.0%	13.2%	85.8%
Petroleum refining	3.7%	9.1%	87.2%	3.4%	12.9%	83.7%
Automobiles	3.4%	40.4%	56.2%	0.0%	23.1%	76.9%
Chemicals	2.3%	11.7%	86.0%	1.4%	6.4%	92.3%
Rubber and Plastics	2.2%	14.7%	83.1%	0.1%	4.5%	95.4%
Total	**1.2%**	**14.7%**	**84.1%**	**0.3%**	**5.7%**	**94.0%**

Source: PINTEC 2008, http://www.ibge.gov.br/english/estatistica/economia/industria/pintec/2008/default.shtm .

Note: Data are broken out by sector and organized by the top 10 sectors reporting innovations new to the world market (as a fraction of total product innovation).

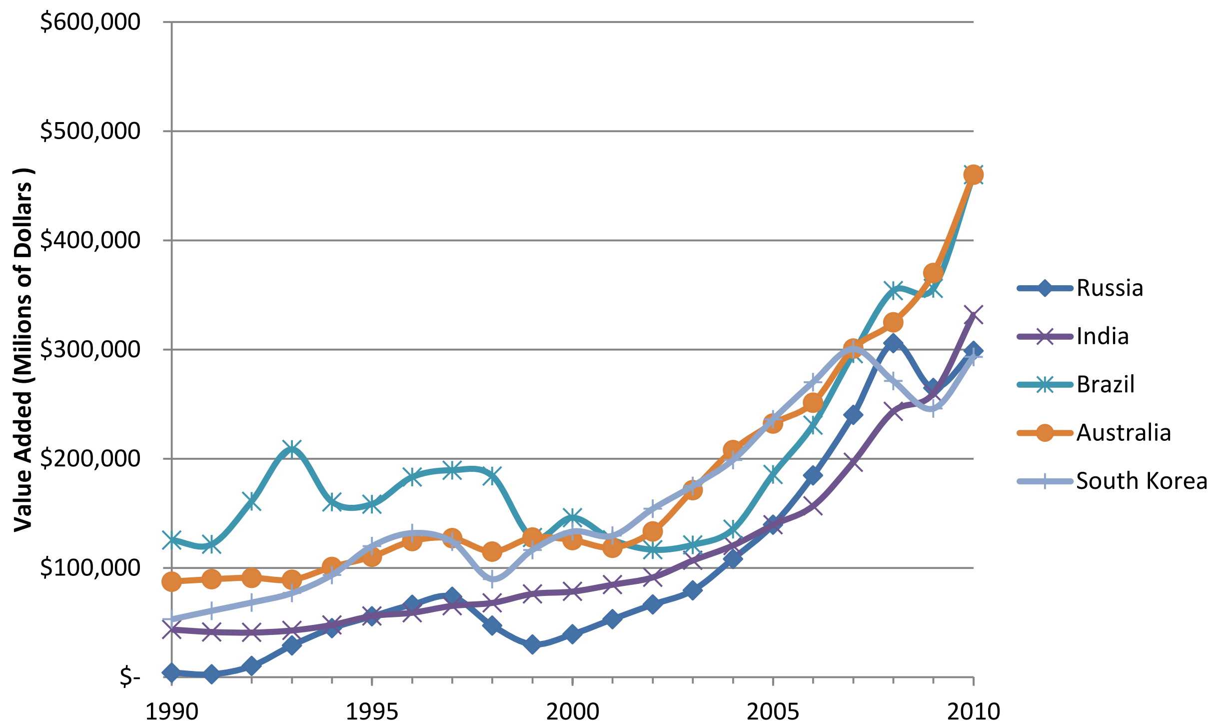
The PINTEC survey data also show that large companies in Brazil tend to be more engaged in innovation than small companies and most small innovative companies tend to be in the supply chains of the large innovative firms such as Embraer, Petrobras, Ford, Gerdau, and others (Rodríguez, Dahlman, and Salmi 2008).

[28] PINTEC has been conducted every 3 years by the Brazilian government since 1998. Results reported here are for over 100,000 businesses for the years 2006 to 2008.

The low incidence of R&D-based innovation in the economy, or innovation resulting in the development and commercialization of new products for the global marketplace, is reflected in the low volume of exports of high-technology goods relative to similar countries. Where Brazil's high-technology manufacturing value added is twice that of Mexico, its high-technology exports amount to less than a seventh of Mexico's (and below India), pointing to a lower participation level in global supply chains.

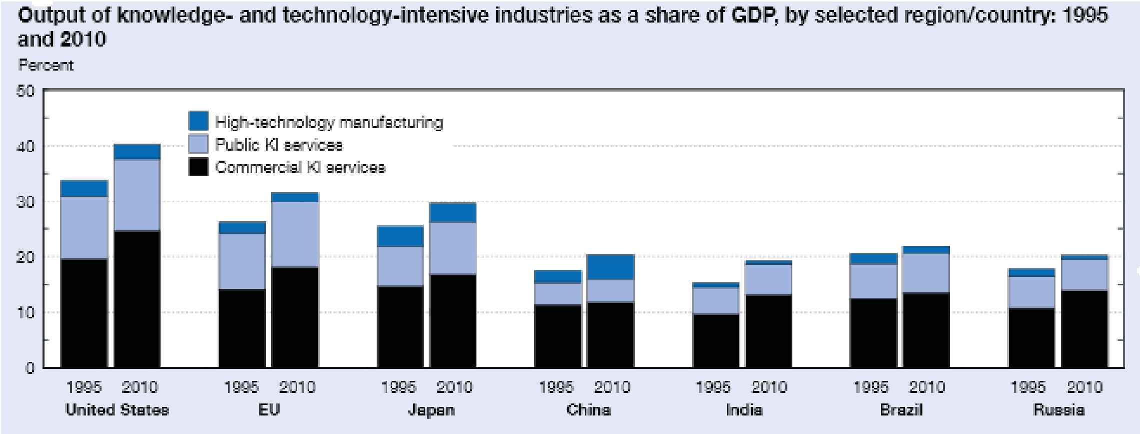
E. Share of Knowledge-Intensive Services and Manufacturing in the Economy

In terms of value added of knowledge and technology-intensive industries, Brazil has grown steadily over the past 15 years, keeping pace with India, Russia, and Australia, as Figure 14shows. However, as Figure 15 shows, the bulk of this increase comes from services such as business, financial, health and education; the share of high-technology manufacturing has fallen during this period.



Source: OECD (2011).

Figure 14. Value Added of Knowledge and Technology-Intensive Industries for Brazil and Select Countries, 1995–2010



Source: NSB (2012).

Figure 15. Change in Output of Knowledge- and Technology-Intensive Industries as a Share of GDP for Brazil and Selected Other Countries, 1995 and 2010

F. Conclusion

Several experts consulted for this project believed that the overall level of innovation has not changed much since implementing the innovation policies, and capabilities to produce technological developments for the national and international markets remains concentrated in few companies.[29] Coordination of policies and funding instruments among various ministries remains a significant concern (Andrade 2009; Peixoto 2011). One expert stated, "New programs and policies are established and implemented weekly, if not daily. This is not strategic and results in a patchwork of policies and strategies. Overall, this makes it difficult for industry to invest in the country."[30]

On the other hand, state support has resulted in a strong manufacturing sector in addition to well-developed resource extraction industries, and Brazil is establishing itself as a regional leader, accounting for 60% of the GDP of South America. The Brazilian economy has generally had steady growth, and innovation, while incremental and noncompetitive at the global level, serves the regional economy well, perhaps serving as a disincentive for the majority of the domestic firms to push the cutting edge of technology.

[29] Discussions with experts. See the appendix.

[30] Discussions with experts. See the appendix.

8. Factors Affecting Innovation in the Long Run

Brazil's innovation ecosystem is relatively young, and experts acknowledge that the overabundance of laws and strategic plans instituted over the past 10–15 years have led to a patchwork of policies with little coordination. However, the government's acknowledgement of outward engagement, both in education and industrial collaborations, as well as efforts to strengthen framework conditions are nascent efforts that are likely to positively affect Brazil's capacity in the future. This chapter describes selected factors that may strengthen innovation in Brazil going forward.

A. Outward Engagement: Global Sourcing of Knowledge

Along with the expansion of funding for higher education and increasing financial aid for students, the Brazilian government is recognizing the value of outward engagement as it seeks to build human capital in the STEM fields. One of President Rousseff's biggest focus areas has been to initiate the innovative Science without Borders (SwB) program to send 100,000 Brazilian students and researchers to top universities in other countries by 2014.

SwB, run in tandem by CAPES (the Post-Graduate Development Agency) and CNPq (the National S&T Development Council) offers one-year scholarships to undergraduates and graduate students for study in science or engineering fields in leading universities. The program works with partners in other countries (currently the United States, Canada, South Korea, Australia, Japan, and many European Union countries) to place students in foreign institutions for one year before returning to Brazil to finish their degree. The program specifically aims to increase the number and quality of students in STEM fields in Brazil while increasing international collaborations in science, technology, and innovation. The government is funding three-fourths of the scholarships and the private sector, the balance. Many experts (including those interviewed for this project) are enthusiastic about the program and the potential benefits to Brazil and the partner countries. One criticism is that lower income students are not well represented, in part because students are required to be fluent in English or another language (Gardner 2011).

B. University-Industry Linkages and Technology Commercialization

Promoting interaction between industry and universities has been a priority of Brazilian innovation policies, particularly in light of the relative dearth of doctoral-level research scientists in private industry compared to academia. Also, public funding typically goes to short-term partnerships instead of producing long-term collaborations,[31] although there are indications that this may be changing[32] Support for these linkages is primarily channeled through the Sectoral Funds, which were partly established specifically to bridge gaps between industry and science and technology institutions (Koeller and Gordon 2010).

Government supported business incubators and technology parks, typically affiliated with a university, have been instrumental in fostering university-industry linkages. The National Program to Support Incubators and Technology Parks launched in 1999 is part of the Action Plan for Science, Technology and Innovation for National Development (PACTI) (infoDev 2010). Today, Brazil has one of the most successful incubation cultures in Latin America (infoDev 2010) with close to 400 incubators in operations, most of them reporting innovation-related activities. A 2012 study by the National Association of Incubators and Small Parks (*Associação Nacional de Entidades Promotoras de Empreendimentos Inovadores*, ANPROTEC) shows that the incubators have graduated over 2,500 enterprises, with revenues of R$4.1 billion and 29,000 employees. On the other hand, most of the incubators grow low-technology enterprises and less than a dozen of Brazil's incubator parks (such as those listed below) are notable for technological innovation (infoDev 2010).

Specific hotspots of innovation mentioned in interviews include:

- **Rio's Technology Park**: This park is located next to the Federal University of Rio de Janeiro, with Petrobras and many of its suppliers playing a major role, given the proximity to offshore oil fields. GE, Schlumberger, Baker Hughes, Siemens, and Halliburton all have a presence there, many brought by a combination of Brazil's recent offshore oil finds and tax incentives (Regalado 2010). The development was brought about by the combination of federal, municipal, and private efforts.
- **Campinas**: A center of innovation on telecommunications and biofuels, Campinas has its roots in the strong research University of Campinas and the Telebras Center for Research and Development in Telecommunications (*Centro de Pesquisa e Desenvolvimento em Telecomunicações*, CPqD). The research hub started in 1976 and was originally located adjacent to the university because of fiber optic research (Reddy). Biofuels grew in Campinas due to advanced researchers in biotechnology, chemical engineering, and proximity to the main region of sugarcane production.
- **Supera**: São Paulo is home to a strong health and biomedical community, with Supera being a prominent incubator. It is located at Universidad de São Paulo's campus, and is

[31] Discussions with experts. See the appendix.

[32] In Sao Paolo, FAPESP has experienced a steep increase in the number and quality of joint project requests, and firms are now pursuing longer term agreements with universities (e.g., up to 10 years). Many of these partnerships are supported through FAPESP's 11 Research, Innovation and Dissemination Centers, in which a center seeks partnerships with a company and focuses scientific research on areas that are relevant for both the researcher and industry. For further on FAPESP's centers, *see* http://www.fapesp.br/en/17.

responsible for 4% of the studies that have been published in Brazil's indexed journals. The incubator provides science and technology infrastructure and consultancy in the areas of biotechnology and medical equipment.

- **Porto Digital and CESAR**: In the city of Recife, Porto Digital (Digital Harbor) is located in a region that was previously underdeveloped but where the city and state government created an IT park (Brito). Porto Digital is home to a successful incubator, The Recife Centre for Advanced Studies and Systems (*Centro de Estudos e Sistemas Avançados do Recife*, CESAR)., which was founded in 1996 by academics from the Federal University of Pernambuco in Brazil's Northeast region to keep the students they trained from heading to the southwest. The Recife cluster now has over 200 companies with an international focus; its three biggest clients for R&D are Motorola, Samsung, and Sony-Ericsson (Bound 2008).
- **Saint Joseph of the Fields (*São José dos Campos*)**: This complex for aeronautics and aviation is the home of both Embraer's headquarters as well as the Aeronautical Technology Institute (*Instituto Tecnológico de Aeronáutica*, ITA), one of Brazil's strongest undergraduate institutions for engineering, particularly aeronautical engineering. Several other aerospace and defense-related research institutes are also located here, dating to the 1950s.

C. Role of Multinationals and International Collaborations

International partnerships are also beginning to play an increased role in Brazilian private innovation as foreign direct investment increases. Experts interviewed reported that the United States and several European Union countries remain the most important investors in Brazilian companies, with China as a major emerging player in raw materials and some consumer markets. In some cases, investments are driven by raw materials supply chains or access to the growing Brazilian market (as most of the Chinese investments seem to indicate; only 3 of 60 projects from 2007 to 2010 were related to R&D (CBBC 2011). In other cases, international partnerships are driven by the global competitiveness and innovativeness of Brazilian companies, such as in aerospace (see sidebar), biofuels and oil and gas.

International Collaborations: the Embraer and Boeing partnership

Embraer and Boeing partnership is one example where Brazilian companies are teaming up with multinational companies within their industries. Embraer and Boeing announced a collaboration for R&D in drop-in affordable biofuels for aviation in March 2012, and a further collaboration on the KC-390 Brazilian Air Force refueling and transport aircraft was announced in June 2012. Both projects are a part of a larger memorandum of understanding to work together on safety, manufacturing productivity, and energy efficiency that was announced in April 2012 during President Rousseff's visit to the United States. An additional collaboration between aviation agencies in both countries to enhance cooperation on airspace management, safety, and airport expansion and construction.

D. Role of Society and Culture in Innovation

Over the past decade, Brazil's growing middle class has driven demand for high-value-added products and services creating pressure for structural and policy reform, including lowering taxes, incentivizing R&D and innovation, and fostering sustainable long-term growth.[33] The government has responded with policies that promote the expansion of medium- and high-technology production and exports, particularly in the auto, mining, and electronics sectors.[34] The growth of the middle class, and the expectation that the state will respond to societal welfare needs may prove to be a driver for progress in innovation policies, if long-term strategy is not undermined by political and business need to respond to swings in short-term macroeconomic conditions.

E. Resistance to Natural Resource Exploitation

Brazil has over one-fourth of the world's plants, animals, and micro-organisms found in natural habitats. Since 1994 the Brazilian government has invested in biodiversity programs, and the Ministry of Science and Technology is supporting the creation of innovation networks to conduct research on Amazonian biodiversity for the development of cosmetics, phyto-pharmaceuticals, and nonalcoholic beverages.

On the other hand, Brazil views its natural resources as patrimony that needs to be carefully guarded.[35] Environmental regulations undergo recurrent changes and are applied across all firms, ignoring efficiency and the costs of compliance across sectors (Cassiolato et al. 2010). Exploitation of biodiversity by pharmaceutical and related companies is heavily regulated, providing a disincentive for private investment in technology development. Brazilian bioscience companies cite inhibitors ranging from lack of clarity and responsiveness from regulatory bodies to a disparity in cost of compliance across sectors, which is not incorporated into regulation (Sennes and Filho 2012; Cassiolato et al. 2010).

[33] Discussions with experts. See the appendix.

[34] Discussions with experts. See the appendix.

[35] Discussions with experts. See the appendix.

9. Summary and Analysis

The following broad trends relate to the initial hypothesis that a country's innovation system is tied to its endowments, relationships, and adaptive strategies. The challenge in examining innovation in Brazil is the number of factors that influence innovation.

A. Geography and Natural Resources Have Shaped Technology Development

Brazil's economic and technological development has been shaped by its geography and natural resources. Initially established by the military, Brazil's traditionally strong industries—oil and gas, agriculture, and aerospace—have enjoyed considerable state support until they were well established, after which point government oversight was gradually decreased. Today, Brazil is globally competitive in extraction of oil and gas (Petrobras), agriculture (Embrapa), and development and deployment of biofuels, which aligns with Brazil's long-term goal of transitioning to alternative energy sources. In these sectors, the country has developed extensive research networks to become a leader in R&D and technological innovation among other South American countries. In the energy area, for example, Brazil has capitalized on its leadership in ethanol consumption to develop a system-level solution for making ethanol available as part of the Brazilian energy matrix. The availability of flex-fuel vehicles (90% of all cars sold in Brazil in 2009) and the provision of gas stations with dual-fuel service demonstrate a capability to institutionalize large-scale system level changes involving several sectors and economic agents (Shikida 2010). These niche technological strengths speak to capabilities that have the potential to serve as a foundation for future innovation.

Brazil's economic development has been uneven, with the south and southeast regions along the coastline being far more developed in terms of S&T-related human capital and the infrastructure and resources needed for innovation-led development. Brazil is also protective of the biodiversity and indigenous cultures that populate the Amazon Basin. As a result, innovation "hotspots" are predominantly concentrated in a small part of the country. A consistent period of strong economic growth has led to a growing middle class, with a large regional spread, and this population's demands for better goods and services may lead to the regional diversification of innovation-related activity in Brazil.

B. Publicly Funded Basic Research Not Exploited by Private Sector

The strong university-industry divide in Brazil has a negative effect on opportunities for R&D-based innovation in the domestic economy. Academia traditionally is a highly favored destination for researchers in Brazil because of a cultural bias towards what is thought to be "pure research" at universities and because of academia's public opposition to Brazil's military dictatorship. Although the number of postgraduates has increased over the past decade (as a result of policies intended to support innovation-), nearly all have gone into academia, with the number of researchers in private industry actually declining while the number in academia increased by more than 140%.

Academics in Brazil has been historically discouraged from collaborating with industry; academics are predominantly funded by the government to do basic research and have little incentive to align their research interests with industry to seek funding. As a result, the transition of basic research outputs to the commercial sector is nearly nonexistent.

The sectoral funds, one of the main innovation-fostering instruments instituted in 1999, were intended to enhance university-industry collaborations; however, the implementation of the policy was initially misguided as funding was provided directly to the university or research institute (not the firms), giving them little incentive to collaborate externally. A major step forward was the passing of the Law of Innovation in 2004, which provided the framework for public resources to be utilized by industry; this allowed the sectoral funds to be opened up to industry. Finally, the recently passed Business Innovation Plan is designed to directly stimulate private sector investment in R&D, and, if effective, could make the private sector more willing to invest in R&D.

C. Patchwork of Policies with Little Coordination

Innovation policies have gained increasing importance in Brazil since the late 1990s, particularly under the Lula and Rousseff administrations. The S&T base is growing rapidly, with a tenfold increase in the number of scientists at the master's and doctoral levels over the past decade and an accompanying increase in number of scientific publications. Laws for improving the framework conditions needed for innovation (improved intellectual property rights, incubators for technology commercialization, and business-university linkages, for example) have been instituted since the early 2000s.

However, there is an overall sense that the innovation policies have stimulated competitiveness and innovation in the private sector as intended. Coordination among the ministries that implement the policies and disburse funding remains a barrier to success. As an expert stated, "New programs and policies are established and implemented weekly, if not daily. This is not strategic, and results in a patchwork of policies and strategies. Overall, this makes it difficult for industry to invest in the country." While the Rousseff administration has attempted to address the gaps from previous policies, focusing increased attention towards education (particularly in STEM fields) and creating a favorable environment for business investment in innovative activities, observers have called out the profusion of policies and strategic directions being pursued as being incoherent and ultimately low in effectiveness.

D. Innovation Focused on Needs of the Regional Market

Innovation in Brazil is predominantly tailored to the needs of the local and regional market. Brazil has global leadership in certain sectors where technological development and innovation draw on domestic R&D capability. Outside of these areas, technology development and innovation occur mainly through technology acquisition and adaptation to the domestic market, and multinational companies that invest in R&D-based activities are disconnected from the majority of the enterprises serving the Brazilian market.

Despite this, Brazil is a regional leader in economic terms; Brazil's GDP accounted for close to 60% of the total GDP of South America at the end of 2011 (Woodrow Wilson International Center for Scholars Undated), and it is the dominant trading partner in the MERCOSUR region. Unlike Southeast Asian countries that have followed an export oriented path to technological sophistication and leadership, Brazil's formal industry has grown without necessarily becoming more competitive in many areas, and companies are unmotivated to push the boundaries of technology (the IT and auto parts industries are examples). Innovation is growing faster in the "informal" sector, such as e-commerce and businesses that can leverage informal peer networks; here, the cost of setting up businesses (in both time and money) is less challenging than in the formal sector, a big advantage for start-ups and smaller businesses.

However, concerns about global competition, particularly from China are forcing Brazilian companies to adapt by breaking out of traditional modes of vertical specialization and integrating with global supply chains, particularly those of Chinese companies. While Brazil will largely continue to focus on incremental technology advances that are nationally or regionally rather than globally competitive, there is growing discussion around adapting to the global fragmentation of supply-chains and ways that Brazilian companies can benefit from it.

E. Protectionist Policies in Response to Macroeconomic Conditions

Brazil has a history of implementing protectionist policies in response to changes in macroeconomic conditions, which would appear to be at odds with its efforts to stimulate innovation-driven growth in the private sector. Brazil has had a strong period of growth following economic stabilization in the 1990s and a strong increase in global commodities exports since then. This has resulted in an appreciation of the Brazilian currency, the real. A decade ago, US$1 bought R$3.5; now it buys less than R$2.3. However, accounting for differences in the level of inflation during these periods, the magnitude of appreciation is actually higher.

This growth has made imports cheaper to the detriment of local industries, prompting the Rousseff administration to make the protection of domestic industry the central focus of its innovation-related plans. In particular, Brazil's fast growing trade relationship with China, which has resulted in an influx of manufactured goods, is the impetus behind Brazil raising taxes based on local content requirements (for example, taking the tax on some imported cars to 55% in addition to tariffs). Both the government and industry tacitly acknowledge that the protectionist trade and tax measures are targeted primarily at China, and while providing short-term relief, they render the local industries further uncompetitive. With the Brazil-China trade on an increasing trajectory for the foreseeable future, the Brazilian government runs the risk of undermining the impact of its innovation strategy, if the impact of Chinese imports on the local market is not managed in a more nuanced manner.

F. Natural Resource Wealth an Advantage for Emerging Industries

Many experts agreed that Brazil continues to be at the forefront of technological innovations in oil, biofuels, and aviation and suggested several emerging areas, such as biodiversity, biotechnology, health, and information technology. There is a long history of biodiversity research and a strong network of research institutions through Embrapa and its research centers. Brazilians demand innovative health products as Brazil's health care system, one of the largest in the world, continues to grow.

G. Future Trends

IDA analysis shows that while Brazil's national innovation system is young, two areas of particular weakness in framework conditions are human capital for S&T and research-industry linkages. STEM education has been low (in quality and extent) compared to peer countries and a main complaint from businesses has been the lack of qualified personnel. In the past decade, an aggressive push from successive governments has resulted in overall improvements in education; STEM graduation numbers are climbing and have now doubled. Trends based on other countries show that human capacity building takes about 10–15 years to show impact; Brazil is positioning itself well for the future.

A combination of culture and skewed policy has historically diverted the majority (over three quarters) of PhDs to academia, where they conduct basic research with little interest in or alignment with the needs of the domestic industry at large. The private economy (outside the biggest state-supported sectors), in turn, has largely not exploited public R&D resources to its benefit. Overall, basic research is not being transitioned out of the universities. Recent laws address this, but again, may take a decade or more to have impact.

Innovation in Brazil today is largely tailored to the needs of local and regional consumers rather than the global market. Despite this, Brazil is a regional leader, with a growing economy that dominates the South American region, and a strong manufacturing sector. State involvement in industrial policy is significant, and Brazil has historically implemented protectionist policies to support local manufacturers, providing a disincentive for them to be involved in global supply chains or push the cutting edge of technology. Industries have grown without necessarily becoming competitive beyond the needs of the regional consumer. China's growing trade relationship with Brazil and, perhaps more importantly, with other countries in South America, could eventually pose a threat to Brazil's economic security. Table 9 summarizes the major characteristics of Brazil's innovation system.

Table 9. Characteristics of Brazil's Innovation System

Innovation Area	Strengths	Weaknesses	Opportunities	Threats
Government	• Commitment to foster innovation through education and industry policies • Incentives to increase R&D investments coupled with policies to support production and entrepreneurship in sectors needed to grow the economy (a mix of R&D intensive sectors and service sectors to meet needs of growing middle class) • Growth of technology parks and incubators	• Policy uncertainty • Corruption, although diminishing • Unclear governance in translating federal policies to regions and states • Lack of monitoring and evaluation in the development of incubators and technology parks • Limited capabilities and development of technology transfer offices (TTOs) • High and regressive taxes • Inefficient intellectual property regime	• Implementation of public policies such as the Greater Brazil Plan (Brasil Major—the most recent innovation plan) • Declining corruption supported by strong government action to increase transparency • World Cup in 2014 and Olympics in 2016 could encourage improving infrastructure	• Lackluster economic recovery • Inability to coordinate across university and government sectors • Inability to coordinate policies across ministries • Lack of focus due to large number of programs • Lack of transparency in setting and meeting targets (lack of evaluation of programs) • Lack of follow-through on international agreements • Weak transportation infrastructure (no coastal highway and major national rail network); aging ports in need of repair • Protectionist and conflicting policies
Industry	• Strong industrial sectors: agriculture, deep sea oil and gas production, aeronautics, biotechnology, remote sensing, chemicals, cement, lumber, iron ore, tin, and steel • Growth of venture capital and angel funds since 2005	• Low R&D investment across sectors • Little growth of publically traded companies • Low venture capital and capital investment • Low patenting rates	• Areas of investment: aircraft, biofuels, autos, ICT, health supplies, electrical power, hydrogen, and renewable energy, agribusiness, biodiversity • International partnerships: space, nuclear, and public safety, weather and climate change • Brazilian Venture Capital and Private Equity Association (ABVCAP), formed in 2000, had led to increase in venture capital funds • Diverse trading partners with China, Europe, Africa, and United States	• Historic disconnect between universities and industry • Slowing of economic growth since 2008 • High tax rates • Inadequate and poor quality of infrastructure, such as ports • Strict labor regulations • Regressive tax system with high corporate and individual taxes • Tax regulations

Innovation Area	Strengths	Weaknesses	Opportunities	Threats
Education	• Commitment to increasing its expenditure on education steadily (3.7% of GDP in 1995 compared to 5.5% in 2009) • Secondary and university education attainment rates are rising • Higher levels of education are rewarded in the labor market	• Enrollment rates in early childhood and primary education among Brazil's 3-year-olds are 32% in 2010 (far below the OECD average of 66%) • Inadequate teacher quality • Poor infrastructure • Lack of continuity of reforms • Low global university rankings • Low but growing rate of formal publications	• Increased number of bachelor's, master's, and doctorate degrees • Science without Borders (SwB)—educate 100,000 students overseas in science, technology, engineering and math	• One in five 15- to 29-year-olds was neither in school nor the labor force in 2009 • Low educational rankings (Brazil ranks 52 out of 64 for reading and 56 out of 64 for math (OECD)
Framework conditions	• Reduction of income inequality; increased growth of middle class • Natural resources (oil, gas, and arable land)	• Low rate of patenting • Reduction in inequality but still high	• Large and growing markets • New organizational models and ways of doing business	• Lack of entrepreneurial culture

Appendix.
Discussions with Experts

Table A-1. List of Experts by Sector

Sector	Expert Name	Affiliation	Date of Discussion
Government/Government Research Institute	Carlos Henrique de Brito Cruz	Foundation for Research Support of the State of São Paulo - FAPESP	Oct 10, 2012
	Lorrie J. Fussel	Brazil Desk Office, Market Access and Compliance, Department of Commerce	Oct 17, 2012
	Braeden Young	Brazil Desk Office, Market Access and Compliance, Department of Commerce	Oct 17, 2012
	Carolina Debs	Embassy of Brazil, Washington, D.C.	Oct 2, 2012
Industry	Kellie Meiman Hock	Brazil/Southern Cone, McLarty Associates	Oct 31, 2012
	Pedro Wongtschowski	President of Ultra and leader of Business Mobilization for Innovation, Brazil	Nov 11, 2012
	Stefan Dobrev	Nestle	Mar 6, 2013
Academic/Think Tank	Paolo Sotero	Brazil Institute, Woodrow Wilson Center	Sep 18, 2012
	Noella Ivernizzi	Universidade Federal do Paraná, Curitiba, Brazil	Oct 11, 2012
	Ana Arroio	Federation of Industries of Rio de Janeiro State - FIRJAN, Federal University of Rio de Janeiro, Economics Institute	Oct 15, 2012
	Ben Ross Schneider	Department of Political Science, Massachusetts Institute of Technology	Nov 7, 2012
	Gail Triner	Brazil Institute, Woodrow Wilson Center, Rutgers University	May 13, 2013
Multilateral Banks and Organizations	Thomas Kenyon	World Bank	Sep 25, 2012
	Barbara Bruns	World Bank	Sep 27, 2012
Industry Incubator/ Technology Park	Eiran Simis	Porto Digital	Oct 22, 2012
Nonprofit	André Soares	China-Brazil Business Council	Nov 2, 2012

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Abbreviations

ABDI	*Agência Brasileira de Desenvolvimento Industrial* (Brazilian Industrial Development Agency)
ANPROTEC	*Associação Nacional de Entidades Promotoras de Empreendimentos Inovadores* (National Association of Incubators and Small Parks)
ARWU	Academic Ranking of World Universities
BNDES	*Banco Nacional de Desenvolvimento Econômico e Social* (Bank for Economic and Social Development
CAPES	*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (Post-graduate Development Agency)
CBBC	China-Brazil Business Council
CCT	*Centro Cientifico Tecnológico* (National Council on Science and Technology)
CGEE	*Publicação do Centro de Gestão e Estudos Estratégicos* (Center for Management and Strategic Studies)
CIA	Central Intelligence Agency
CNDI	*Conselho Nacional de Desenvolvimento Industrial* (National Industrial Development Council)
CNPq	*Conselho Nacional de Desenvolvimento Científico e Tecnológico* (National S&T Development Council)
CPqD	*Centro de Pesquisa e Desenvolvimento em Telecomunicações* (Center for Research and Development in Communications)
DARPA	Defense Advanced Research Projects Agency
EURECA	Enhancing University Research and Entrepreneurial Capacity
FAPESP	*Fundacáo de Amparo á Pesquisa do Estado de São Paulo* (São Paolo Research Foundation)
FDI	foreign direct investment
FINEP	*Financiadora de Estudos e Projetos* (Financier of Studies and Projects)
FIOCRUZ	*Fundação Oswaldo Cruz* (Oswaldo Cruz Foundation)
GDP	gross domestic product
IBGE	*Instituto Brasileiro de Geografia e Estatistica* (Brazilian Institute of Geography and Statistics)
ICT	information and communications technology
IDA	Institute for Defense Analyses
IEA	International Energy Agency
INPI	*Instituto Nacional da Propriedade Industrial* (National Institute of Intellectual Property)
IT	information technology

ITA	*Instituto Tecnólogico de Aeronáutica* (Aeronautical Technology Institute)
MCMM	Ministry of Communications and Mass Media
MCTI	*Ministério da Ciência, Tecnologia e Inovação* (Ministry of Science, Technology, and Innovation)
MDIC	*Ministério do Desenvolvimento, Indústria e Comércio Exterior* (Ministry of Development, Industry, and Foreign Trade)
MERCOSUR	*Mercado Común del Sur* (Common Market of the South)
NRC	National Research Council
NSB	National Science Board
OECD	Organisation for Economic Co-operation and Development
PACTI	Action Plan for Science, Technology and Innovation for National Development
PDP	Productive Development Policy
PINTEC	*Pesquisa de Inovação Tecnológica* (Survey of Technological Innovation)
PITCE	*A Política Industrial, Tecnológica e de Comércio Exterior* (Industrial, Technological and Foreign Trade Policy)
R&D	research and development
S&T	science and technology
SRC	State Research Center
STEM	science, technology, engineering, and mathematics
TNC	transnational corporation
USPTO	U.S. Patent and Trademark Office
WEF	World Economic Forum
WIPO	World Intellectual Property Organization

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14. ABSTRACT

This report examines the political, economic, demographic, and other factors that are brought to bear on Brazil's industrial and innovation policies. The analysis explores Brazil's strengths, weaknesses, opportunities, and threats to show that both governance and socio-economic factors play an important role in determining how well a country is able to use its endowments to create a strong national innovation system. Recent policies suggest the government and private sector leaders in Brazil are transitioning from technology and commercialization-driven research and development (R&D) toward more ambitious, long-term, and transformational science, with emphasis in energy efficiency, space and defense technologies, and high-energy physics. Increasing the government's long-term (technology agnostic) investments in basic science R&D, raising the standards of universities, and emphasizing global collaborations will go a long way toward realizing Brazil's vision for a knowledge-based economy, but only if paired with an increased tolerance for risk taking.

15. SUBJECT TERMS

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