Challenges and Perspectives on the Chemical Industry in Brazil

Jose M. Pinto
Praxair Inc.

Brazil has one of the world's largest chemical industries, but that industry faces major challenges in an increasingly competitive global economy.

Brazil's chemical industry is the largest in the Southern Hemisphere and the eighth largest in the world, with revenues in 2009 totaling US$103.3 billion.* Despite its large size, however, it faces increasing trade deficits — the value of imports is nearly three times that of exports — which result from demand growth and insufficient investment in the sector. Furthermore, growth projections for the Brazilian economy over the next 10 years point to major short- and long-term challenges for the chemical industry.

This article briefly reviews the history of the chemical industry in Brazil and discusses its major feedstocks. The chemical industry, as defined by Brazil's National Economic Activity Classification *(1)*, includes the segments listed in Table 1 *(2)*, but excludes the petroleum refining and biofuel production sectors. The largest segment, industrial chemicals, produces basic raw materials used in the chemical industry, and includes petrochemical products, other organic products, and inorganic products such as chlorine and alkalis, industrial gases, and intermediates for fertilizers. Figure 1 illustrates the distribution of industrial chemical plants and petrochemical complexes as of 2009.

Until the early 1990s, the development of Brazil's chemical industry was mostly state-controlled and driven by a policy of substitution of imports in favor of domestic industry. The period from 1950 to 1990 can be divided into three main phases, as discussed in the following sections. In the last 20 years, the scenario has changed dramatically as the Brazilian economy experienced significant macroeconomic and institutional changes.

* All dollar amounts throughout this article are U.S. dollars.

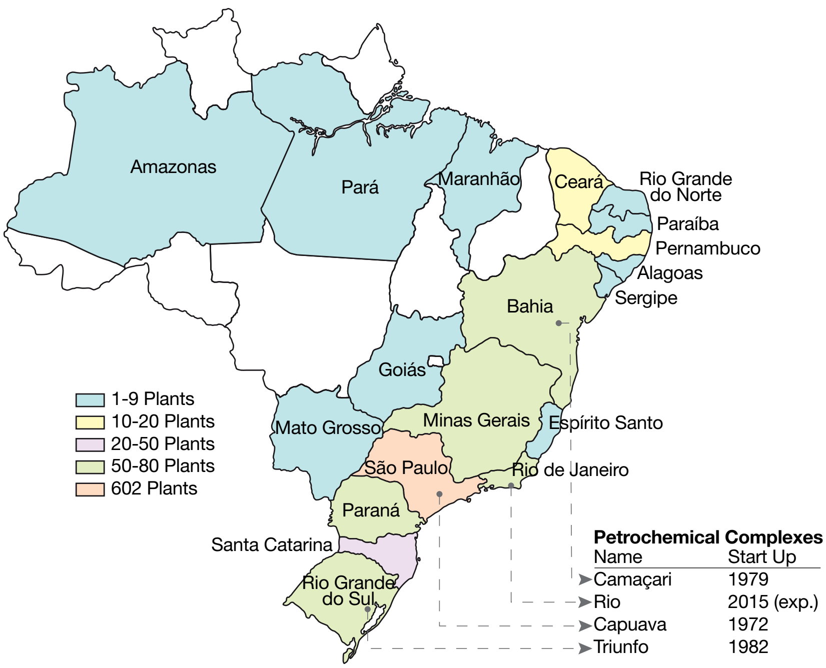
Phase I: Rapid expansion (1950–1968)

The rapid expansion of the Brazilian economy after World War II created a large demand for finished products (paints, solvents, waxes, lubricants, detergents, etc.). Several newly built chemical plants were subsidiaries of multinational corporations, including Mobil and Esso, which entered the market to commercialize such products as motor oils and lubricants. Most of the plants were established in the state of São Paulo, and initially operated with imported raw materials (*e.g.*, styrene, polyethylene, nylon, polyester). While a few domestic firms invested in the intermediate and finished products sectors, most had modest market presence and technological development.

Table 1. Revenue of Brazil's chemical industry, as defined by Brazil's National Economic Activity Classification (which excludes the oil refining and biofuel production sectors). *(2)*

Segments	Revenue, U.S.$ billions			Overall Growth 2000–2009
	2000	2005	2009	
Industrial Chemicals	22.8	39.1	48.3	112%
Pharmaceuticals	6.7	9.2	15.9	137%
Personal Care, Cosmetics	3.4	5.5	11.6	241%
Fertilizers	3.0	5.3	9.8	227%
Crop Protection	2.3	2.5	6.3	174%
Soaps and Detergents	2.5	4.0	6.1	144%
Paints	1.5	1.9	2.8	87%
Fibers	NA	NA	1.0	NA
Other	1.4	2.0	1.5	7%
Total	**43.6**	**69.5**	**103.3**	**137%**

Copyright © 2011 American Institute of Chemical Engineers (AIChE)



▲ **Figure 1.** Industrial chemical and petrochemical plants are concentrated on Brazil's east coast.

The startup of an oil refinery in Cubatão, on the outskirts of São Paulo, in 1955 boosted the domestic availability of feedstocks. This had a multiplying effect on the number of plants, including facilities operated by Union Carbide (polyethylene), Celanese (carbon black), Koppers (styrene), Borden (methanol), and Rhône Poulenc (acetone and isopropanol).

Phase II: Building the chemical infrastructure (1968–1975)

By the late 1960s, the development of the petrochemical sector came into focus. In 1968, a new state-owned company — Petrobras Química S.A. (Petroquisa) — was formed. The private sector's participation in the petrochemical industry was limited, with the exception of a few subsidiaries of multinationals that built plants for thermoplastic resin production.

This phase coincided with the so-called Economic Miracle — the period during which Brazil's economy experienced its most rapid growth. Besides the formation of Petroquisa, the state offered subsidized credit from the Brazilian Development Bank, imposed tariffs on chemical imports, and set attractive naphtha prices (both imported and from state-controlled oil refineries).

The first petrochemical complex was established in 1972 in Capuava, São Paulo, and was anchored by a plant that produced ethylene from naphtha. The private sector participated in the complex by establishing partnerships with Petroquisa and multinational companies. This tripartite model later became the basis for the second petrochemical complex (Camaçari, in the state of Bahia). Examples of companies that emerged from such partnerships included Politeno (Suzano and Copene from Brazil, and Sumitomo and Itochu Corp. from Japan), and Polibrasil (Pronorte from Brazil, and Shell from the Netherlands). Politeno and Polibrasil are now part of Braskem. Technology transfer occurred through turnkey projects whenever plants were operated by domestic companies.

Phase III: Configuration of the Brazilian chemical complex (1976–1990)

The second half of the 1970s saw the addition of two new petrochemical complexes. The Camaçari complex, in the state of Bahia, integrated vertically the basic first-generation (olefins and aromatics) and second-generation (polymers and intermediates for fibers and detergents) petrochemical sectors with those of the third generation (plastics, acrylic fibers, elastomers, disposable packaging, etc.). As noted earlier, this complex followed the tripartite model.

In parallel, the petrochemical complex of Rio Grande do Sul implemented policies aimed at increasing private participation and technology transfer. Petroquisa's role was to mediate the terms and conditions of the negotiations between the domestic and multinational companies. The latter provided the technology, whereas national groups invested their capital.

Although many people feel this approach led to only marginal participation by national groups, it provided the starting point for technological development in the third-generation petrochemical sector. Moreover, domestic firms were involved in the detailed engineering and construction of new plants. This aspect favored the growth of a local capital goods industry as part of the technological development of the chemical industry.

In the mid 1980s, there was significant progress in the first- and third-generation segments, but significant gaps existed in the second-generation sector. The government later adopted policies that created direct markets and import tariffs for intermediates, particularly those for the pharmaceuticals and specialty chemicals sectors.

Privatization and consolidation (1990–present)

As part of a major government reform, state-owned companies were privatized through public auctions. In the case of the petrochemical industry, private groups bought shares in Petroquisa. The National Privatization Program did not define the objectives of the new system; rather, it established

 Copyright © 2011 American Institute of Chemical Engineers (AIChE)

that the market should determine the composition of the new enterprises through synergies identified by private investors. Thus, the chemical industry went from a state-controlled system to a privately controlled one.

Today, the Brazilian chemical industry consists of a few privatized companies, and these are not fully integrated from a value chain standpoint. Despite consolidation, Brazil's chemical industry has not been able to satisfy internal demand. The market has increasingly been supplied by imports, which creates increasingly larger trade deficits. Several reasons explain this deficiency — from insufficient investment to the lack of raw materials, and the global shift in supply by realignment of multinational companies, as discussed in the next section.

The chemical industry today

With 2009 sales of $103.3 billion, the Brazilian chemical industry's contribution to the country's gross domestic product (GDP) is estimated at 2.6% *(3)* — a larger relative contribution than that of the U.S. chemical industry (2% of U.S. GDP) *(4)*. Brazil's chemical industry is the third-largest sector of the country's manufacturing base, with 11.2% of total manufacturing revenues; the food and beverage sector is the largest (16.4%), followed by the oil refining, coking, and ethanol production sector (12.4%). In 2009, Brazil's chemical industry employed 394,000 people, 70% of whom worked in the finished product sector.

Table 2 *(5)* lists the largest Brazilian chemical companies (in terms of sales revenues). Braskem is a good example of the restructuring of Brazil's petrochemical industry by building economies of scale and scope, as well as integrating the value chain horizontally and vertically. Braskem accounts for 71% of Brazil's installed ethylene capacity, 67% of its propylene capacity, 47% of its polyethylene capacity, and 53% of its polypropylene capacity. In 2010, Braskem acquired Quattor Petroquímica S.A.

Petrobras returned to the petrochemical arena in 2007 through a process of consolidation, by which it acquired 25% of Braskem and 40% of Quattor, among other companies. More importantly, Petrobras is the main investor in a fourth petrochemical complex — COMPERJ, in the state of Rio de Janeiro, which is expected to start operation in 2015.

Exports of Brazilian chemicals in 2009 were valued at $9.0 billion, while imports were $25.8 billion, down from the record high of $34.7 billion in 2008 (Figure 2). Chemicals accounted for 20% of the total $127.6 billion worth of goods imported and 7% of the $153.0 billion exported in 2009 *(2)*. Argentina, Paraguay, and Uruguay bought 22% of Brazil's exports ($2.3 billion), while the U.S., Canada, and Mexico were responsible for 21% of exports ($2.2 billion). The European Union was Brazil's largest chemical supplier, with imports of $8.4 billion.

Table 2. Largest Brazilian chemical companies by sales. *(5)*

Rank	Company*	Segment	Sales, US$ millions
1	Braskem	Industrial Chemicals	10,485
2	Quattor	Industrial Chemicals	2,620
3	Heringer	Fertilizers	1,909
4	Oxiteno	Industrial Chemicals	1,310
5	Fertipar	Fertilizers	1,016
6	Ultrafertil	Fertilizers	958
7	Medley	Pharmaceuticals	919
8	Rio Polimeros	Industrial Chemicals	799
9	Fosfertil	Fertilizers	752
10	Ems Sigma Phrama	Pharmaceuticals	727

* Braskem acquired Quattor in 2010

The petrochemicals sector is the largest segment of Brazil's chemical industry, with revenues of $48.3 billion in 2009. Brazil currently consumes 10 million tons of naphtha per year, some 40% of which is imported. Natural gas is an important alternative source of raw materials, with the chemical industry accounting for about 45% of all the natural gas consumed by industry in Brazil. Of that, some 30% is used as feedstock.

Of 3,266 commercial chemical products (including pharmaceuticals) used in Brazil, 79% (2,589) were imported in 2009 *(3)*. Potassium chloride accounts for by far the largest share, accounting for 8% of the total ($2.06 billion).

Approximately 22% of Brazilian imports came from inorganic chemicals, 22% from organic chemicals, 22% from pharmaceutical products, 13% from resins and elastomers, and 20% from all other segments (based on the value of the chemicals in U.S. dollars). Also in 2009, 21.9 million tons of chemical products were imported and 11.9 million tons exported — with an average unit price of $1,190/ton for imports and $873/ton for exports. This indicates that Brazil exports chemicals of lower technological content than those it imports.

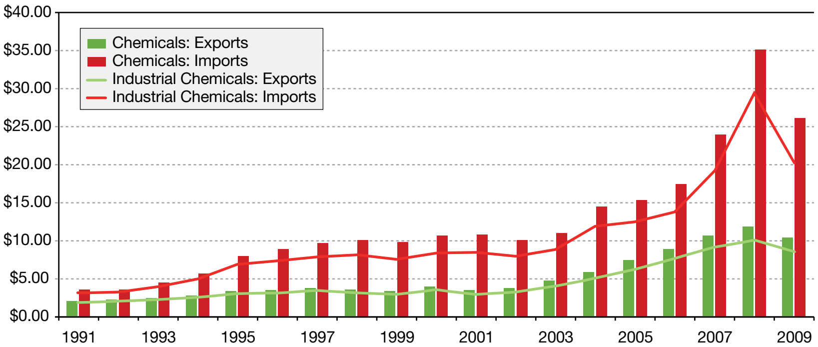
Overall, environmental and productivity trends are improving in the chemical industry. CO_2 emissions were 312 kg/ton of product in 2009, which represents a 46% decline since 2001. Over the same period, water consumption decreased from 9.22 m^3/ton of product to 6.29 m^3/ton. Total energy consumption fell from 420 kWh/ton of product to 363 kWh/ton *(2)*.

Beyond the chemical industry: feedstocks

Three feedstocks are becoming increasingly important to Brazil's chemical industry: crude oil, natural gas and ethanol.

The recent discovery of hydrocarbon fields in the pre-salt

Copyright © 2011 American Institute of Chemical Engineers (AIChE)



▲ **Figure 2.** Brazil's chemical exports in 2009 were valued at $9.0 billion, while imports were $25.8 billion, reflecting Brazil's growing trade deficit. Source: Brazilian Chemical Industry Association (ABAQUIM).

layer of the deep ocean off Brazil's southeast coast is promising, because the fields contain large volumes of light crude. The country's proven reserves doubled from the pre-2008 level of 14 billion barrels of oil equivalent (BOE). Furthermore, estimates indicate potential reserves in the pre-salt layer of 70–100 billion BOE *(6)*.

Pre-salt oil reserves are located 6,000 m below sea level, of which 2,000 m is the thickness of the pre-salt layer. Efforts to recover this oil face several technological challenges related to the thickness of the pre-salt layer, the stability of wells due to the layer's physicochemical properties, the need to remove hydrocarbons from carbonaceous rocks (as opposed to removal from arenites, for which the technology is well developed), and the high operating temperatures and pressures under large concentrations of CO_2 that is associated with the hydrocarbons.

Despite these challenges, oil production — currently at 2.0 million BOE/d — is projected to reach 3.9 million BOE/d in 2014 and 5.4 million BOE/d in 2020, and most of this will come from the pre-salt fields. Total investment during the 2010–2014 period will amount to $118 billion, of which $33 billion will be spent on the pre-salt reserves. In addition, between now and 2014, the downstream sector will invest $37 billion to expand the capacity of two refineries as well as construct four new refineries. Refining capacity will increase to 3.0 million bbl/d in 2014 and 4.0 million bbl/d in 2020, from the current 1.8 million bbl/d.

Domestic natural gas production will increase from 28 million m^3/d in 2008 to 71 million m^3/d in 2013, mostly from pre-salt fields *(7)*. Gas imports from Bolivia are contracted to remain at approximately 25–30 million m^3/d until 2019. Imports of liquefied natural gas (LNG) — from two plants currently in operation (producing a total of 21 million m^3/d) and a 13-million-m^3/d plant forecasted to open in 2013 — will help meet the country's increased demand. In 2009, demand was 55 million m^3/d, and it is estimated to reach 135 million m^3/d in 2013. Natural gas for industrial use currently accounts for 22 million m^3/d, 25% of which is used in the chemical industry (mostly as feedstock for urea and methanol production).

Sugar-cane-based ethanol has been produced on a large scale in Brazil since the late 1970s. Production costs in 2009 were in the $30–35/bbl range — significantly lower than the costs of producing ethanol in the U.S. and other regions *(8)*. In 2009, Brazil produced 0.45 million bbl/d of ethanol, while the U.S. produced 0.70 million bbl/d, mostly from corn, with production costs in the $44–48/bbl range. Together the two countries account for about 88% of worldwide ethanol production.

Ethanol is widely used in Brazil as fuel, in both hydrated and anhydrous (blended with gasoline) forms. All of Brazil's gasoline contains ethanol, with blending levels varying from 20% to 25%. In addition, more than half of all cars in Brazil can run on 100% ethanol (E100) or an ethanol-gasoline mixture. In the U.S., there is no federally mandated minimum ethanol content in gasoline, although some states enforce a 10% threshold (E10). On a volume basis, ethanol's share of the transportation fuels market is 50% in Brazil and 8% in the U.S.

Approximately 5% of Brazil's total ethanol production is industrial-grade ethanol, of which half is consumed in pharmaceutical manufacturing and the other half in food and beverage processing. Despite modest consumption, forecasts indicate 60% growth until 2015, due to the diffusion of the ethanol-based chemical industry *(9)*. For example, Braskem recently inaugurated a polyethylene plant that uses 8,000 bbl/d of ethanol as feedstock, approximately 1.8% of the total domestic production. Dow Chemical and Solvay also announced "green" plants for polyethylene and polyvinyl chloride (PVC) production, respectively. In the U.S., industrial consumption of ethanol is approximately 4% of total production, with 61% used as solvent and 39% as an intermediate; the food and beverage industry uses 1% of the total production.

Final thoughts

Preliminary data indicate that sales revenues of Brazil's chemical industry in 2010 increased significantly from those in 2009 (+29.0%) and surpassed the pre-crisis levels of 2008 (+6.6%), with growth in all segments *(2)*. Moreover, the trade deficit surpassed $20 billion in 2010.

Despite its size, Brazil's chemical industry has few integrated chemical supply chains, in contrast to the highly diversified chemical industry worldwide, particularly in developed countries. For instance, Brazil's petrochemical industry focuses on first- and second-generation products such as thermoplastic resins, but several organic chemicals

Copyright © 2011 American Institute of Chemical Engineers (AIChE)

and resins must be imported. In segments such as fertilizers, crop protection, and pharmaceuticals, local production is limited, and internal demand is fulfilled mostly by imports.

The combination of strong dependence on imports and the low value of exports represents a major bottleneck in the growth of the Brazilian economy, as well as a source of vulnerability. Likewise, growth projections for Brazil's economy in the near future (on the order of 7% annually) pose significant challenges to the chemical industry.

Brazil must expand the level and diversity of its manufacturing base, for example, by increasing production of intermediates for fertilizers, pharmaceuticals, organic products, and resins. With relatively few products accounting for a significant portion of imports, investment in the manufacturing of products such as potassium chloride, urea, and resins, or even in value chains such as acrylics, would considerably reduce the chemical industry's trade deficit.

In the petrochemical industry, competition from raw-materials-rich mega-complexes in the Middle East, as well as from Asia with its growing economy, will be intense. Today, Brazil's main challenges are the relatively small size of its companies and the insufficient availability of raw materials. To address the former, the sector has undergone considerable consolidation and integration, as well as the return of state investment via Petrobras. Raw material availability may be boosted by alternative sources — mainly natural gas — and, most importantly, by investments in refining and deep-sea exploration.

Several major chemical industry expansion projects have been announced recently. In the industrial chemicals sector, \$21.4 billion will be invested in projects expected to start up in the 2011–2015 period *(10)*. Despite these significant numbers, the Brazilian Chemical Industry Association (ABIQUIM) estimates that this investment is not nearly enough to overcome the current trade imbalance, much less to meet expected growth over the next decade. Estimates of required investment levels are in the range of \$87–167 billion between now and 2020.

Current planning efforts in the private sector, in the form of the National Pact of the Chemical Industry *(11),* identify several factors that inhibit investment — namely, feedstock availability and price, tax reform, logistics infrastructure, technological innovation, and credit. Other analyses *(12)* emphasize the need for improved raw material availability (*e.g.*, by eliminating the cycling in natural gas prices), continued investment of Petrobras in the chemical industry, and taxes and tariffs to protect the local industry and attract foreign investment.

Given the enormous challenges faced by Brazil's chemical industry, coordinated action from the private and public sectors will be required to mitigate its structural deficiencies. CEP

Literature Cited

1. **Instituto Brasileiro de Geografia e Estatística (IBGE),** "National Economic Activity Classification," ISBN 978-85-240-3970-6, www.ibge.gov.br/home/estatistica/economia/classificacoes/cnae2.0/cnae2.0.pdf (accessed July 7, 2011), IBGE, Rio de Janeiro, Brazil (2007).
2. **Brazilian Chemical Industry Association (ABIQUIM),** "Brazilian Chemical Industry — Outlook," www.abiquim.org.br/english/default.asp (accessed July 7, 2011).
3. **Bastos, V. D., *et al.*,** "Recent Performance of the Trade Balance and Growth Limits of the Chemical Industry," *BNDES (Brazilian Development Bank) Setorial,* **32**, pp. 397–432 (2010).
4. **Bureau of Economic Analysis (BEA)**, U.S. Dept. of Commerce, "Measuring the Nation's Economy: An Industry Perspective: A Primer on BEA's Industry Accounts," www.bea.gov/industry/pdf/industry_primer.pdf, BEA, Washington, DC (2011).
5. "The Largest and Best Companies in Brazil," *EXAME*, http://exame.abril.com.br/negocios/melhores-e-maiores (accessed July 7, 2011), São Paulo, Brazil (Apr. 2010).
6. **Costa, R. C., *et al.*,** "Challenges and Perspectives in the Oil and Gas Sector," in "Brazil in Transition," ISBN 978-85-87545-37-4, Além, A. C. and F. Giambiagi, eds., *BNDES Setorial*, Rio de Janeiro, Brazil (2010).
7. **Confederação Nacional da Indústria (CNI)**, "The Industry and Brazil — Natural Gas: A Proposed Policy," ISBN 978-85-7957-054-4, CNI, Brasilia, Brazil (2010).
8. **Bastos, V. D.,** "Ethanol, Ethanol-Chemistry and Biorefineries," *BNDES Setorial,* **25**, pp. 5–38 (2007).
9. **Milanez, A.Y., *et al.*,** "Perspectives for the Brazilian Ethanol," *BNDES Setorial*, **27**, pp. 21–38 (2008).
10. **DeMarchi, M.,** "Industrial Chemicals," Chemical Industry Annual Meeting, www.abiquim.org.br/enaiq2010/apr/DeMarchi.pdf (accessed July 7, 2011), Brazilian Chemical Industry Association (ABIQUIM) (2010).
11. **Brazilian Chemical Industry Association (ABIQUIM)**, "National Pact for the Chemical Industry," www.abiquim.org.br/pacto/Pacto_Nacional_Ingles.pdf (accessed July 7, 2011), ABIQUIM, São Paulo, Brazil (2010).
12. **Rocha, C. F. L., *et al.*,** "Investment Perspectives in Basic Feedstocks," Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil (2009).

JOSE PINTO is Senior R&D Manager in the Advanced Control and Operations Research Group at Praxair, Inc. (39 Old Ridgebury Rd., Danbury, CT 06810; Phone: (203) 837-2391 ; Email: jose_m_pinto@Praxair.com), where he is responsible for the Business Optimization and Analytics team. He holds a BS from the Univ. of São Paulo, an MS from the Federal Univ. of Rio de Janeiro, and a PhD from Carnegie Mellon Univ., all in chemical engineering. He has published more than 100 papers in peer-reviewed journals in the areas of planning, scheduling, and supply chain optimization; process operations; process synthesis and design; and mixed integer optimization. Prior to joining Praxair, he was a faculty member at the Univ. of São Paulo and the Polytechnic Institute of New York Univ.

Copyright © 2011 American Institute of Chemical Engineers (AIChE)