

New Order and Progress

Development and Democracy in Brazil

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Petrobras in the History of Offshore Oil

TYLER PRIEST

In Brazil, long years of patient ant-like work have gone into proving that we have a competent state oil company; that we developed competitive knowledge and technology; that we have a good regulatory regime; that we offer political stability with clear rules without tearing up contracts. We cannot risk losing all this when, hearing the ephemeral song of the grasshopper, we precociously exult about winning a lottery prize.¹

—Giuseppi Bacocoli, *retired chief geologist, Petrobras*

At the beginning of the 21st century, Brazil suddenly found itself blessed with stupendous new oil wealth. The heralded November 2007 announcement by the Brazilian national oil company, Petrobras, of an estimated 7.5 billion-barrel oil discovery in the “pre-salt” sediments of the deep ocean Santos Basin, the Tupi field, appeared to provide the missing piece of the puzzle that would turn Brazil into a true oil power, if not a world power.² President Luiz Inácio Lula da Silva called the discovery *o bilhete premiado*, a winning lottery ticket. In September 2010, Petrobras completed a \$70 billion stock offering to finance a \$225 billion investment program for the country’s new pre-salt oil. “It was not in Frankfurt, nor in London, nor in New York,” Lula boasted. “It was in São Paulo, in our green and gold Bovespa, that we consecrated the greatest capital-raising in the history of world capitalism.”³

The exultation over the Tupi prize, renamed “Lula” (see Figure 3.1) after the outgoing president, seemed to confirm a national cultural prophecy.⁴ Political elites in Brazil had always believed the country possessed hidden oil riches. So certain were they that in 1953 they created a state-owned oil company, Petrobras, incubated under the slogan, “*o petróleo é nosso*” (the oil is ours), even before there

Santos and Campos basins part of new focus on presalt resources

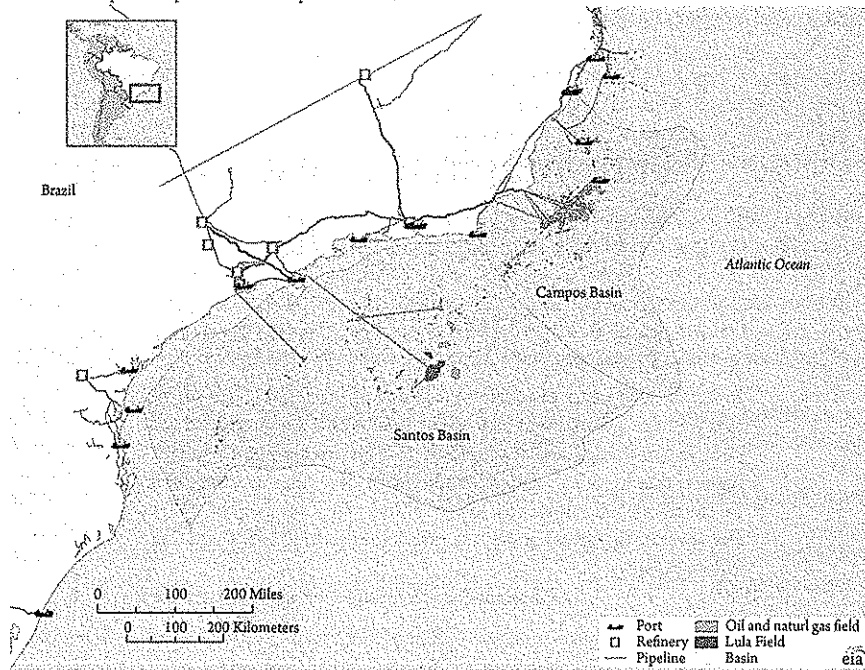


Figure 3.1 Campos and Santos Basin Offshore Oil and Gas Fields and Infrastructure.

Source: US Energy Information Administration, <http://www.eia.gov/todayinenergy/detail.cfm?id=13771>.

was any oil to claim. Like in many other nations, the Brazilian oil industry was born in a wave of nationalist fervor. But the objectives and results were different. Other state-owned oil companies (or national oil companies, NOCs), such as Mexico's Pemex, Venezuela's PDVSA, or Norway's Statoil, were created to manage large oil reserves previously discovered by foreign companies, and to develop these reserves for export. Petrobras, by contrast, started off with an overriding imperative to turn Brazil into an oil producer in order to meet rising consumption at home.

This basic difference is rarely highlighted in the literature on NOCs, which concentrates on comparing the relative competencies of these companies and their complex relationship to the state.⁵ Such perspectives are important, but they often fail to place NOCs in the proper comparative, global, and historical context. The most apt comparison to Petrobras, in this regard, is not Pemex, PDVSA, or Statoil, but Shell Oil, the U.S. subsidiary of the international oil major, Royal Dutch Shell. During the postwar period, the long-range mission of Shell Oil, similar to Petrobras but exceptional among other competitors, was domestic self-sufficiency in oil. Shell Oil pursued this goal by investing in technology and pushing exploration into ever-deeper waters offshore.⁶

Likewise, Petrobras's founding mission to achieve Brazilian self-sufficiency in oil bred into the organization a unique technological orientation and a focus on doing what successful international oil companies (IOCs) did, which was search for oil. Early permutations of oil nationalism in Brazil, however, often inhibited this objective. Only when depoliticized by the military regime in the 1960s and 1970s did Petrobras achieve enough decision-making autonomy to rededicate itself to oil exploration. As the nation's petroleum dilemma became more serious beginning in the late 1960s, the military regime's support of frontier offshore projects permitted the company to keep upstream technical teams in place and concentrate on long-range exploration objectives. The oil price shocks and foreign supply crises of the 1970s forced Brazil to double down on this oil-import substitution strategy, which, fortunately for the nation, resulted in world-class deepwater discoveries in the Campos Basin during the 1980s.⁷

By the early 1990s, Petrobras had become an aggressive investor in offshore technology, an instrument for self-sufficiency in oil, and an internationally competitive state-owned enterprise. As Brooks and Kurtz (chapter 2) point out in this volume, the story of Petrobras contradicts assumptions about the inevitability of the "resource curse," which is the paradoxical notion that oil wealth often leads to national economic stagnation and political dysfunction.⁸ Natural resource endowment, Brooks and Kurtz argue, is not merely a "gift of nature," but the product of technological capacity and human capital, which are "crucial to escaping the putative resource curse."

Petrobras's ability to discover and develop large offshore oil fields, however, was not the result of indigenous innovation or invention. From its founding in 1953 to the great discoveries of the 1980s, the company relied on a constant infusion of outside geological, geophysical, and engineering expertise. To extract offshore oil, Petrobras borrowed concepts tested elsewhere and tapped into a mature, global oil-services industry by hiring contractors in all aspects of operations. Brazil's success in finding and producing oil did not depend on preexisting domestic industrial capacity and a virtuous cycle of forward linkages, as Brooks and Kurtz assert, but rather on Petrobras's determination to adapt techniques and ideas fashioned abroad and import the expertise, equipment, and services needed to do the job.

This essay contributes to scholarship on the political economy of NOCs by revealing the largely unacknowledged role of multinational oil service companies, contractors, and consultants in the creation and maintenance of an otherwise nationally controlled oil sector.⁹ Once deepwater discoveries were made offshore Brazil, cooperative research and development through joint industry projects, involving many of the same contractors operating in both the deepwater Gulf of Mexico and Campos Basin, enabled Petrobras to bring them on

production. The creation of Brazilian industrial capacity to support upstream oil development thus came *after* discovering large reserves, not prior to it, and by participating in international technological networks, not operating independently from them. In a departure from past experience, Brazil's recent pursuit of a more ambitious oil-driven industrial policy, relying on a rapid and graft-ridden build-up of domestic capacity in shipbuilding, offshore fabrication, and refining, has succumbed to corruption and mismanagement. The challenge for the Brazilian oil industry going forward is to preserve the technocratic legacy of Petrobras while resisting the temptations to exploit newfound oil abundance in ways that undermine it.

A historical analysis of Petrobras, in the context of the larger offshore oil industry, is thus critical for informing discussions about the precarious state of Brazilian oil. Building on other historical studies of offshore oil and drawing on research in trade and technical literature, this essay reconstructs the development of Petrobras's offshore capabilities through five phases: first, the formation of Petrobras and its initial exploratory efforts during the Second Republic; second, the push in offshore exploration under the military; third, the uneven progress of the offshore campaign in the 1970s; fourth, the move into deep water in the late twentieth century; and, fifth, the technological achievements and political uncertainties of the current era.

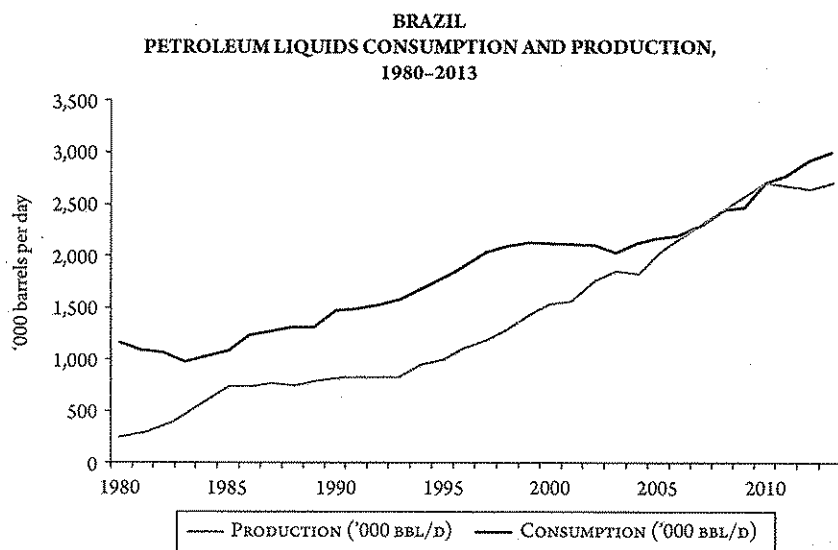


Figure 3.2 Brazilian Petroleum Liquids (Crude Oil plus Natural Gas Liquids) Consumption and Production, 1980–2013. Source: US Energy Information Administration, International Energy Statistics, <http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=54&aid=3>.

O Petróleo é Nosso: 1934–1964

The Brazilian government's assertion of broad powers over oil occurred during a period of nationalist ferment and political struggle. In April 1938, following years of propagandizing by Brazilian nationalists against foreign oil trusts and a month after Mexico nationalized foreign oil investments, Brazilian military leaders persuaded President Getúlio Vargas to decree the creation of the Conselho Nacional de Petróleo (CNP), Brazil's first state oil monopoly. The CNP commandeered Brazil's first oil discovery, a minor deposit near the city of Lobato, in the Recôncavo Basin of the Northeast state of Bahia, instilling national pride in the CNP and, by extension, the national government.¹⁰

Despite the lack of equipment and spare parts to fully develop the discovery, the nationalist crusade in oil continued. After the war, nationalists and military leaders rallied behind the slogan of "*o petróleo é nosso*" ("the oil is ours") and continued to outmaneuver other politicians, derisively labeled *entreguistas* (sell-outs), who favored alliances with foreign oil companies. During Vargas's second presidency (1950–1954), the military prevailed on him to transform the CNP into the state-owned company, Petróleo Brasileiro S.A. (Petrobras), authorized by Law 2004 of October 3, 1953. In August 1954, following the news that his lead bodyguard had been linked to an assassination attempt against his chief political rival, Carlos Lacerda, and facing calls for his resignation, President Vargas put a bullet through his own heart, leaving a suicide note in which he alleged that "a subterranean campaign of international groups joined with national groups" had tried to prevent the creation of Petrobras. Although the details of this campaign were never uncovered, the drama sowed the seeds of mistrust toward foreign capital that shaped the ensuing politics of oil in Brazil.¹¹

Despite such mistrust, Vargas's successors (José Café Filho and Juscelino Kubitschek) did not completely close off the oil sector to outside influence. Law 2004 maintained the federal monopoly over the extraction, refining, and transport of oil, thus prohibiting foreign capital from developing oil for their own profit. However, international oil companies were allowed to participate in wholesale distribution and retail sales of petroleum productions. More importantly, the law did not prevent Petrobras from contracting with foreigners for services such as geophysical exploration, drilling, and the building of refineries.¹²

The early growth of Petrobras and the Brazilian oil industry relied heavily on foreign equipment, education, and expertise. Foreign companies built refineries and terminals and provided the technical training to run them.¹³ The most pressing concern for the company, however, was to find oil in Brazil. Looking for a skilled professional to organize the company's exploration department, Juracy Magalhães, the first president of Petrobras, enticed Walter K. Link, chief

geologist for Standard Oil of New Jersey (1947–1953), forerunner to Exxon, to come out of semi-retirement and lead the effort.¹⁴

Although the appointment of a top official from the Standard Oil “trust” was controversial with nationalists, Link headed up “the most extensive petroleum exploratory program ever conducted by a major company.”¹⁵ He sent young Brazilian scientists, typically people who had graduated from the prestigious Escola de Minas, to American universities for schooling in petroleum geology. Link also brought in foreign geologists and geophysicists to work for Petrobras and train Brazilians to take their place. Graduates of the program then moved on to assignments in surface mapping or seismic crews headed by Americans. In conjunction with this effort, Petrobras sponsored the creation of a geology department at the Universidade de Bahia, near the first oil discoveries, and other Brazilian universities later followed suit.¹⁶ “A job in Petrobras,” writes Adilson de Oliveira, “became a prized outcome for young graduates, and placement and progress within the company’s technical ranks, as in the military, was competitive and based on merit rather than decided through personal connections.”¹⁷

Between 1954 and 1960, the Petrobras exploration department (DEPEX) spent \$300 million on an ambitious program to explore most of Brazil’s Paleozoic sedimentary basins. At the end of his contract in 1960, Link resigned from Petrobras and submitted his final report to the company president. Summarizing the disappointing results of the exploration program, the *Relatório Link* cast doubt on the prospect of finding large oil deposits in most areas of the Brazilian mainland. The only onshore basins favorable for oil finds, the report advised, were the Recôncavo, the Tucano (just north of the Recôncavo), and the coastal strip of Sergipe. Future exploration, the report advised, should focus on these basins. Link also presciently expressed more optimism about oil prospects offshore along the nation’s continental shelf, where DEPEX had only shot just a few, sparse seismic lines. He recommended more intensive seismic work offshore, which did not happen until 1967. Finally, he urged that Petrobras prepare for the possibility of continued failures in domestic exploration by seeking an assured source of oil from abroad.¹⁸

When leaked to the press and disclosed to the Chamber of Deputies, Link’s report elicited denunciation from radical nationalists. Newspapers and politicians vilified Link as a “saboteur” of Petrobras’s drilling program and a “tool of the imperialists” who had been sent to derail Brazil’s oil ambitions. During the next several years, they repeatedly invoked his name as a warning of the nefarious forces plotting to exploit Brazil’s oil wealth. Under President João Goulart (1962–1964), fears of “Linkism” led to a growing radicalization and politicization of company management. Goulart increased Petrobras’s control over the oil industry by nationalizing the remaining private refineries at the behest of striking labor unions, asserting a monopoly over oil imports, and entering into oil products distribution, formerly reserved to international oil companies.¹⁹

Oil exploration also suffered. Petrobras continued drilling in the Middle Amazonia region, by many accounts, simply to prove that Link had been wrong about the interior’s oil potential. The company embarked on a course not to discover if Brazil had abundant oil reserves, but to prove the foregone conclusion. Any new discovery—most of which were in the Recôncavo Basin—was unduly hyped as evidence that self-sufficiency was just around the corner, an impulse that echoes into the present day. Yet the drilling failures continued to outweigh the successes. The role of Petrobras was “to confirm the myths about Brazil’s oil—that it was abundant and that ‘the trusts’ were eager to exploit it—rather than to investigate them.”²⁰

O Petróleo No Mar: 1964–1974

Without minimizing or justifying the oppression that followed, it is fair to say that the coup of April 1964 rescued Petrobras from internal political conflicts and revived the technocratic ethos within company ranks. The new military government removed hostile labor leaders and managers, rescinded the decree nationalizing the private refineries, and allowed private investment in petrochemicals.²¹ The Petrobras monopoly over the extraction and supply of oil remained, however, and exploration picked up again in 1967 with a redirected focus on Brazil’s coastal plains and continental shelf. Not only had this been one recommendation of the Link Report (no longer as harshly criticized as before), but breakthroughs in offshore technology coming out of the Gulf of Mexico and the gathering interest in the North Sea provided new motivation for pushing offshore in Brazil. By the early 1960s, the commercial development of three fundamental technologies dramatically propelled oil companies into deeper waters: floating drilling, subsea well completions, and digital seismic surveying, processing, and interpretation.²² The oil operators in the Gulf of Mexico had fostered a thriving industry of contractors in each of these areas, whose technical expertise could be hired to jump-start offshore development elsewhere.²³ Production from the Royal Dutch Shell’s and Esso’s massive Groningen gas field off The Netherlands’ North Sea coast, beginning in 1963, raised expectations about hydrocarbon potential further north and set off a wave of exploratory drilling in the UK sector of the North Sea.²⁴

Such developments generated interest in Brazil. Led by chief geophysicist Wagner Freire, Petrobras pursued state-of-the-art exploration technologies and expertise. The company had increased its exploration budget in 1967 by 37 percent, in response to mounting imports, and ordered an ambitious program of analog seismic surveys along its coast, covering 4 million square kilometers. To support this effort, in June 1968, Freire supervised the installation of an analog

seismic processing center in Rio. After contracting with the US firm Western Geophysical, to begin running digital surveys, he then followed up on this project, only six months later, by opening an advanced digital processing center using new IBM 360 mainframe computers. Petrobras began to assimilate industry advances in geophysical exploration.²⁵

That same year, 1968, Petrobras drilled its first significant offshore wells in the Espirito Santos and Sergipe-Alagoas Basins, contracting with Zapata Offshore's jack-up drilling vessel, the *Vinegarroon*.²⁶ At this time, the geological knowledge of Brazil's open marine sediments was minimal. Unlike the Gulf of Mexico, where the sedimentary rock sequences onshore continued far onto the outer continental shelf, Brazil's offshore sediments were quite different than what was found onshore, due to the rifting in the South Atlantic 130–150 million years ago that separated the continents of South America and Africa.²⁷

The first well drilled in 50 meters of water off Espirito Santos was dry, but it confirmed salt features associated with oil production found in the Gulf of Mexico. The *Vinegarroon* then moved north to Sergipe-Alagoas, where in September 1968 it made a significant discovery in the Guaricema field, located in 30 meters of water off the delta of the São Francisco River. The field was in a thin sandstone layer later determined, significantly, to be a "turbidite" (see below). The Guaricema discovery, Petrobras's first true offshore find, initiated an intensification of marine seismic data acquisition, leading to a cluster of other small but important commercial discoveries during 1969–1970 in the same basin at Caioba, Dourados, and Camorim.²⁸

The familiar Brazilian optimism that greeted these discoveries was tempered internally by concerns about the economic viability of high-cost offshore operations. General Ernesto Geisel, who had taken over the presidency of Petrobras in 1968 with the understanding that the Minister of Mines would not interfere with his management of the company, had supported the move into offshore exploration, but his main strategy was hedging against the absence of big domestic oil strikes. Taking advantage of falling international oil prices in the late 1960s and early 1970s, he shifted the company's focus toward downstream investments carried out by the subsidiaries, Petrobras Distribudora (oil products marketing), Petrofertil (fertilizers), and Petroquisa (petrochemicals, involving domestic and foreign private investors). Geisel also created Braspetro, an E&P subsidiary to explore for oil overseas, finally acting on one of the chief recommendations of the Link Report.²⁹

This new strategic orientation risked the drive for domestic oil self-sufficiency. On the eve of the Arab oil embargo of 1973, oil accounted for 45 percent of the nation's entire energy consumption, and 80 percent of its oil demand was met by imports, 65 percent of which came from the Middle East. Rapid national economic growth in the late 1960s had raised Brazil's crude oil import bill, which,

after the OPEC price increases, spiked from \$1 billion in 1972 to \$4.9 billion in 1974. As General Geisel moved from the boardroom of Petrobras to replace General Emílio Garrastazu Médici as president of Brazil in 1974, the country faced immense economic pressure to reduce dependence on increasingly expensive, imported oil. Borrowing heavily in the new petrodollar market to finance the country's economic development program, Geisel promoted the development of nuclear power plants, the expansion of hydroelectric power, and the initiation of a sugar cane ethanol fuel program. At the same time, the Geisel regime spurred Petrobras to step up domestic exploration, with its sights now firmly set on offshore prospects.³⁰

Passo a Passo: 1974–1980

In the 1970s, offshore exploration on the edges of the Atlantic Ocean benefitted a revolution in geophysical surveying. The commercialization and spread of digital seismic technology, pioneered largely by Dallas-based GSI in the early 1960s, provided geophysicists with a vast increase in the amount and resolution of subsurface data. As digital seismic gained industry acceptance and as a new generation of digital computers emerged, geophysicists acquired ever-improving tools to visualize offshore geology. The greater economies of scale achieved in surveying offshore (where there were no troublesome landowners or topographical features with which to contend) meant that the increase in marginal cost of digital equipment over analog was smaller than on land. The higher volume of data acquired offshore was ideal for digital data processing and brought offshore geology into clear focus in ways that it did not on land.³¹

After Petrobras's Guaricema discovery, the company stepped up its acquisition of marine seismic data, most of which was processed in Houston. The particular results of the Campos Basin, southeast of Rio de Janeiro, where Petrobras began exploration in 1971, yielded higher quality records than many other places and indicated the existence of likely oil-bearing structures associated with salt features. The high expectations, however, were severely tested at first. The first eight wells drilled by Petrobras came up dry. Searching for a solution, the Petrobras exploration department discussed their frustration with geologists from the French oil company, Elf-Aquitaine. By the mid-1970s, most geologists accepted that Brazil's eastern continental margin had split off from West Africa during the breakup of the supercontinent Gondwana starting some 150 million years ago. The sedimentary rocks off Brazil's southeast coast looked a lot like those that Elf-Aquitaine had worked in to develop oil along the coast of West Africa. The Elf geologists suggested that Petrobras drill deeper, into Albian-age carbonates, where they had enjoyed success. On the ninth well, after some

technical difficulties, Petrobras drillers finally discovered oil in an Albian carbonate prospect called Garoupa. This well in 394 feet (120 meters) of water and 62 miles (100 km) from shore made the first commercial discovery in the Campos Basin.³²

Still, the Geisel government lacked confidence in Petrobras's technological capabilities to capitalize on the discovery. In a high-profile 1975 television announcement designed to preempt nationalist criticism, Geisel demanded that Petrobras sign risk-service contracts (*contractos de risco*) with foreign oil companies to assist exploration. Under such an arrangement, IOCs would assume the financial risk of searching for oil and be reimbursed a share of revenues earned in case of a discovery, with Petrobras taking over as the sole operator. The IOCs would earn nothing if drilling came up empty.³³

The response by foreign companies was tepid at first, but after contract terms were loosened in 1977, they leapt at the opportunity. By 1980, they had invested \$1.2 billion, but with little success. Petrobras officials, who had opposed the risk-service contracts, determined which offshore areas would be offered, and the IOCs complained that the acreage they received lacked potential. In the view of Petrobras, the IOCs did not have the requisite understanding of Brazilian geology to succeed. Whatever the case, the entry of a degree of foreign competition perhaps motivated Petrobras shift its investment budget to the upstream sector and redouble its efforts offshore.³⁴

Petrobras pressed to develop its Campos Basin discoveries in an unorthodox way. Garoupa and other subsequent discoveries in the general vicinity, such as Namorado and Enchova in less than 200 meters, were relatively medium-sized fields by world standards. Driven by the desperate need to replace oil imports, whose price had more than quadrupled since 1973, the company searched to shorten the time to get the fields on production. Installing traditional fixed platforms, like most operators were doing in the Gulf of Mexico, would have required four to eight years of development and an inordinate amount of fixed capital investment for fields of that size. This Petrobras and Brazil could not afford.³⁵

Fortunately, there were floating production solutions available that could speed up development. These had evolved from the fundamental concepts pioneered by Shell Oil in the early 1960s. The rapid dissemination of new ideas and approaches received a boost beginning in 1969, when the first annual Offshore Technology Conference (OTC) took place in Houston. The OTC became a key forum for publishing and exchanging technical information, thus loosening the secrecy surrounding companies' research efforts and rallying the industry behind a shared sense of technological purpose. It made possible drilling and production technologies that evolved in particular offshore environments to be applied elsewhere.³⁶

Petrobras adopted production concepts pioneered in the North Sea and the Mediterranean Sea to bring its Campos Basin finds on production. In 1977, at Enchova, Petrobras deployed an "early production system," comprised of a semi-submersible production facility and subsea wells successfully demonstrated by a small US independent, Hamilton Brothers, to produce the first oil from the North Sea. Two years later, following a precedent set by Shell España in the Eastern Mediterranean in using a converted tanker to gather oil, Petrobras began operating the world's second floating, production, storage and offloading facility (FPSO), the *P.P. Moraes*, to develop the Garoupa discovery. Garoupa was a much more trying project than Enchova, suffering one technical setback after another (complications with wellhead chambers, the production tower, downhole safety valves, etc.). This resulted in long delays and contributed to the escalation in Campos Basin development costs, but Garoupa established a vital learning curve for Petrobras.³⁷

These projects encouraged Petrobras to accelerate development in the Campos Basin. By the end of 1977, the company had contracted for 26 offshore drilling vessels, the largest concentration anywhere in the world. Several discoveries were made, bringing the total number of fields in the Campos Basin, by 1980, to eight. Like Enchova and Garoupa, the fields started up with early production systems, followed by permanent production platforms, initially ordered from in Europe, to be installed out to 200-meter depths. The first platform, a \$15 million steel jacket slated for the Namorado field and built for Petrobras by J. Ray McDermott's Ardersier Scotland yard, sank as it was being towed by barge across the Atlantic. Petrobras then scrambled to have subsequent platforms built in Brazil by foreign contractors such as Heerema and Micoperi. Development costs ballooned to \$3 billion for eight fields with approximately 630 million barrels of recoverable oil, a respectable amount but not nearly enough to offset declining oil production onshore and at the same time supply an expanding portion of Brazil's growing oil demand.³⁸

By the end of 1980, Brazil's oil supply situation looked even gloomier, due to a major setback in Petrobras's efforts to obtain and secure a dedicated source of foreign oil. In 1975, the company's foreign exploration and production (E&P) subsidiary, Braspetro, had made a monumental discovery at Majnoon in Iraq. With 12 billion barrels of recoverable oil, Majnoon was a "supergiant" field, one of the largest discovered anywhere in the world during the last half of the twentieth century. Under the terms of its risk contract with the Iraq National Petroleum Company, Braspetro was entitled to import a portion of the new production at a discount from world prices. After the Brazilian company submitted a development plan, however, the Iraqi government unfavorably altered the terms, canceling the risk contract and substituting an engineering services contract. Through a series of complex negotiations, the Brazilian government

then agreed to provide weapons, light armor, and natural and lightly enriched uranium to Iraq, in exchange for an assured supply of oil that would meet half of Brazil's imported petroleum needs over a 13-year period. But in September 1980, when war broke out between Iran and Iraq, the Iranian army occupied and sabotaged Majnoon. The Brazilian economy, which had become dependent on Iraqi oil, now sustained a major shock, amplified by yet another sharp rise in world oil prices.³⁹

Águas Profundas: 1980–1996

As the Brazilian administration of João Baptista de Oliveira Figueiredo introduced programs to find energy substitutes for petroleum (sugar cane alcohol fuel, hydroelectric, and nuclear power), the petroleum outlook for the country began to turn around. Production from the Campos Basin grew past 300,000 barrels per day by the end of 1982, raising hope that Petrobras might even achieve its 1985 target of 500,000 b/d announced in 1979. Such hope was bolstered, at least internally, by enticing prospects in deep water (*águas profundas*), typically defined as water depths greater than 1,300 feet or 400 meters.⁴⁰

The intensive geological and geophysical work sponsored by Petrobras to develop sedimentological and stratigraphic models of the country's continental margin revealed promising clues to buried petroleum in deep water. In 1975, Petrobras had resumed sending geophysicists to foreign universities for advanced degrees and exposure to the latest work in petroleum exploration. The company also brought that expertise directly to Brazil. During 1973–1980, Petrobras contracted with L. Frank Brown and William L. Fisher, Jr. from the Texas Bureau of Economic Geology to help piece together the geological history of Brazil's offshore basins. In anticipation of exploring in deeper waters, where the high risks and costs of a failure placed a premium on accurate geological information, Petrobras needed a much better picture of the subsurface. Combining "the fortuitous and parallel advance in geophysics and basin-analysis," and integrating seismic data with a limited amount of well data, Brown and Fisher's "seismic sequence stratigraphy" concepts, which evolved from work usually credited to Exxon, helped model Brazil's shelf-slope-basin depositional systems and identify possible deep-sea sandstone reservoirs as turbidites.⁴¹

Turbidite sandstones were so named because they had been deposited when ancient rivers had channeled massive volumes of sediment underwater by means of turbidity currents onto the continental margin, where they settled in expansive depositional fans. Emerging geological theory indicated that turbidite reservoirs in deep water could be potentially large and continuous, and unusually coarse-grained and porous, due to the sifting of the sands carried by the

turbidity currents over long distances. They also might be more tightly sealed and under higher pressure. Shell had drilled a number of oil discoveries along the edge of the Gulf of Mexico shelf in similar rocks. Petrobras, likewise, had struck oil in turbidites in almost all its offshore basins, including its first offshore success at Guaricema.⁴²

Although the Brazilians had identified deepwater prospects by 1980, they could not test them until 1984. Regional maps based on a widely spaced seismic survey performed in 1972 revealed the presence of large structural features in the deepwater Campos. Using the revolutionary method of "bright spot" seismic interpretation, developed in the early 1970s by Shell Oil and Mobil Oil, Petrobras geophysicists had found strong indications of hydrocarbons on the seismic record.⁴³ Yet, there were few drilling vessels in the world rated for great water depths, and the daily rates for those few in operation were prohibitively expensive. Petrobras was cash short at the time, after the Ministry of Finance forced the company to subsidize the price of oil products to control spiraling inflation. Upon Shell Oil's demonstration of the viability of deepwater drilling with the *Discoverer Seven Seas* drillship, which made a major discovery for that company in October 1983 in the Gulf of Mexico (Bullwinkle), contractors built or modified rigs for deep water and day rates came down. Rapidly falling oil prices and suspended drilling programs by many offshore operators contributed to the slackening of the drilling contractor market. In 1984, Petrobras then hired a French-owned (Foramer), dynamically positioned drillship, *Pélerin*, to begin drilling wildcat wells out to 1,000-meter water depths.⁴⁴

In late 1984, news reverberated through the world oil industry of two major discoveries drilled by the *Pélerin*. In September, the drillship struck oil in a well located in 293 meters of water. The field, named Albacora, contained commercially recoverable resources of more than 600 million barrels (4.5 billion barrels in place), nearly equivalent to all the oil discovered in the Campos Basin up until then. Even more stunning was the discovery three months later, in December 1984, of the world-class Marlim field, containing 2.3 billion barrels of commercial oil (6.7 billion barrels in place). These were company-maker fields (see Figure 3.3 for reserve growth history). Ramping up drilling with a fleet of leased drillships and semi-submersibles, Petrobras achieved a string of sensational discoveries: South Marlim in 1987 (1.9 billion barrels); Barracuda in 1989 (700 million barrels); Caratinga (400 million barrels), East Marlim (300 million barrels), and East Albacora (1.2 billion barrels) in 1994; and the biggest of them all, Roncador (2.7 billion barrels), in 1996.⁴⁵ "The oil is there," Petrobras president, Ozires Silva, beamed in 1986. "And all Brazil needs is the proper technology."⁴⁶

To achieve this, Petrobras embarked on an unprecedented multi-billion dollar industrial mobilization. The technological hurdles were formidable, while

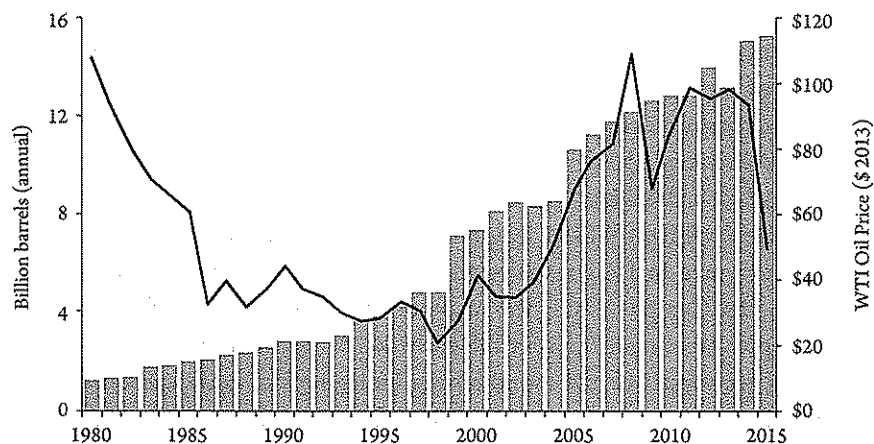


Figure 3.3 Brazil, Crude Oil Proved Reserves, 1980–2015. Source: US Energy Information Administration, International Energy Statistics, <http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=54&aid=3>.

the sheer scale of mobilization—manpower, resources, and infrastructure—nearly matched the technological challenges. In order to bring Albacora and Marlim on line, Petrobras created an in-house R&D program, called PROCAP (*Programa Tecnológico Empresarial de Desenvolvimento em Exploração de Águas Ultraprofundas*) coordinated by the company's research center in Rio de Janeiro, Centro de Pesquisas e Desenvolvimento (Center for Research and Development, CENPES), but which enlisted Brazilian and foreign universities, technology centers, engineering consultants, suppliers, and associated industries. The six-year (1986–1992) PROCAP program aimed to establish production *capacitação* (“capability”) in waters 1,000 meters deep. Fixed platforms like Petrobras was installing in the shallower reaches of the Campos had a maximum depth of about 400 meters. Beyond that, production facilities had to be designed to float or bob in the water. Shell Oil was leaning toward tension-leg platforms to support its development of recently discovered deepwater reserves in the Gulf of Mexico. PROCAP researchers studied this alternative, but based on experience with early production systems, they selected the FPSO and semi-submersible concepts, combined with subsea wellheads, for its deepwater fields.⁴⁷

Deepwater production was more than a simple extension of experiences in shallow water. Among other innovations, it required complex subsea wellheads and manifolds, mooring and anchoring systems, flexible-pipe production risers, horizontally drilled wells, and remotely operated vehicles (ROVs) to take the place of divers in assisting installation and maintenance—all with an attendant escalation of risks and hazards. While Petrobras geared up for deep water, it continued to develop its Campos fields in shallower water, installing fourteen

platforms between 1983 and 1989. To meet impossible deadlines and get on with the job, as well as satisfy political demands to invest and employ locally, the company cultivated an expanded Brazilian oil services and capital goods sector. Labor had to be recruited and trained on a crash basis.⁴⁸

Such a massive undertaking required a new level of organizational coordination. Petrobras thus created a new regional unit, E&P-BC (Campos Basin Exploration and Production), headquartered in the coastal city of Macaé, Rio de Janeiro state. Macaé rapidly became the bustling onshore support center for Campos Basin developments. By 1990, E&P-BC had 4,600 employees, 60 percent working offshore. Six years later, it employed 6,700 people, with the same percentage working offshore. In 1996, the Campos Basin had 28 platforms (14 fixed, 14 floating) producing an annual average production of 610,000 barrels of oil and 11 million cubic meters of natural gas per day. Working offshore for Petrobras were 17 drilling vessels (14 leased, 3 owned), 52 support vessels, 42 oil tankers, and 17 helicopters. Infrastructure included 3,950 kilometers of flowlines, pipelines, and umbilicals to gather and transport oil and gas to refineries in Rio de Janeiro, São Paulo, and Minas Gerais.⁴⁹

Industrial and technological mobilization depended on partnerships with oil service companies, consultants, and universities beyond Brazil. Petrobras continued to contract out most of the drilling, well services, fabrication, installation, and diving/subsea engineering. In doing so, it solidified strategic alliances with foreign suppliers of high-tech services and equipment, such as the French firm, Coflexip, maker of flexible pipes and risers, the San Francisco-based FMC Technologies and Norwegian Aker Solutions, manufacturers of subsea wellhead equipment, National Oilwell Varco, the Houston-headquartered provider of drilling, lifting, and servicing equipment, and another French firm, Comex, which performed diving and ROV work.⁵⁰ As PROCAP came to a close, the company joined the pioneering joint industry program “Deep Star.” Initiated in 1991 by oil major Texaco, Deep Star brought together a group of eleven offshore operators to fund contractor-generated R&D that addressed “technical issues that are barriers to economically viable deepwater production.”⁵¹ The Deep Star consortium, of which Petrobras was the only NOC member for many years, organized projects on a two-year cycle (as of 2015, Deep Star is in its twelfth phase) and marked the emergence of multinational service companies as the major source of deepwater technology development.⁵²

By the late 1990s, Petrobras appeared to be handling the technological and organization challenges internally and through its multinational collaborations. The company competed with Shell Oil's projects in the Gulf of Mexico to break the world depth record with each new facility installed. In 1997, Brazilian oil production surpassed the psychological benchmark of 1 million barrels/day and was well on the way to providing national self-sufficiency in the not-too-distant future.

Reforma e Contrarreforma: 1997–Present

Despite the magnitude and significance of the Campos Basin oil development, it was overshadowed by the even more momentous political transition in Brazil from military dictatorship to democracy. Military rule ended in 1985. The country adopted a new constitution in 1988, and the following year Brazilians elected their first government by direct popular ballot since 1960.

Along with democratization came proposals to liberalize or privatize state-owned industries, including Petrobras. One goal was to reduce the federal government's fiscal deficits. The other was to attract foreign IOC investments and enlist their assistance in evaluating the country's petroleum potential to a much greater extent than Petrobras could accomplish on its own. In 1995, Congress passed a controversial law ending the company's oil monopoly by retaining for the government the right to allocate concessions for oil exploration and allowing other companies to compete with Petrobras on bidding for and developing leases. In 1997, Congress created the Agência Nacional do Petróleo (ANP) to auction lease blocks, contract the licensing of exploration to winning bidders, and regulate all activities across the oil sector. Reforms also included a partial privatization of Petrobras. In 2000, company shares were sold to private investors and listed on the New York Stock Exchange. To appease nationalists, who opposed privatization, the government retained a majority of the company's voting shares.⁵³

After witnessing Petrobras's run of success in the deep water, international oil companies adjusted their exploration strategies and investment portfolios to include Brazil. In particular, they were interested in what Giuseppe Baccocoli calls the "Three Sisters": the Santos, Campos, and Espírito Santos salt-turbidite basins.⁵⁴ Along with the deepwater Gulf of Mexico and West Africa (Gulf of Guinea and offshore Angola), Brazil now became the third leg of the deepwater "Golden Triangle."⁵⁵ First access to Brazilian oil for outside firms came through a "farm-out" program with Petrobras. In the so-called licensing "Round 0," the ANP awarded Petrobras 115 exploration blocks and 282 production and development blocks. The company then turned around and offered farm-outs, in which Petrobras assigned part of its interest in a block or blocks to another company in exchange for fulfilling specific conditions for developing the property. The farm-out program resulted in a number of exploration and production joint ventures and partnerships. Then, from 1999 to 2007, the ANP held eight annual licensing rounds, allocating more than 500,000 square kilometers to sixty oil companies. The licensing rounds were enticing to foreign companies, seeming to offer a relatively level playing field for everyone and, in some basins, acreage that had never been explored.⁵⁶

While the new entrants gained a foothold and enjoyed some exploration success, Petrobras maintained a de facto monopoly upstream.⁵⁷ It commanded unrivaled access to information, both geological and political. It enjoyed long and close relationships with suppliers and service companies, both domestic and foreign. The petroleum reforms, however, also altered the governance of Petrobras, as Musacchio and Lazzarini detail in chapter 5, introducing a new degree of transparency in accounting and corporate governance needed to gain investor confidence. The company reorganized into business units, each measured on performance. It reinvented itself as an international oil company, expanding aggressively abroad, where it could apply its hard-won project management skills. Its new financial strength allowed for the upgrading of refineries to process heavier crudes and the diversification into new projects with petrochemicals, renewable energy, and natural gas.⁵⁸

Petrobras's bread-and-butter remained the deepwater offshore at home. During 1993–1999, it completed another program of *capacitação*, PROCAP 2000, to take oil production into 2,000 meters of water, followed by PROCAP 3000 in 2000 to extend capabilities another 3,000 meters. In 2001 the company received the Offshore Technology Conference's Distinguished Achievement Award for a second time in recognition of the "outstanding advancements to deepwater technology and economics in the development of the Roncador field."⁵⁹ In an ironic tragedy, just before Petrobras accepted the award, the massive *P-36* semi-submersible floating production unit on its way to the Roncador field suffered a mechanical failure and gas explosion, killing eleven people before sinking in 1,300 meters of water. This was a clear reminder that offshore rewards could be offset by the heightened risks of developing increasingly complex technologies and equipment for moving into deep water.⁶⁰

During the early 2000s, other kinds of risks accumulated to tip the balance further. For the new entrants, investments in Brazilian oil fell short of expectations, due to low exploration success, small average field size, lower oil quality, and increasingly "uncompetitive" fiscal terms compared to the two other legs of the Golden Triangle.⁶¹ Petrobras, too, saw its success rate with new exploration decline. Production nevertheless continued to trend upward thanks to the development of reserves discovered earlier, finally reaching the goal of national oil self-sufficiency in 2006 at an average 2 million barrels/day (see Figure 3.2). Then in 2007, as *New York Times* reporter Larry Rohter put it, "with the price of oil hovering near \$100 a barrel, came the stroke of extraordinary good fortune that seemed the most compelling proof of the saying that God is Brazilian."⁶² Petrobras's Tupi discovery appeared to right the risk-reward balance of deep water.

A Canção do Gafanhoto

How can a historical perspective on Brazilian oil help explain the significance of the Tupi (now Lula) discovery and the likely future trajectory of the Brazilian petroleum industry? In answering the question, we can draw three broader lessons: first, regarding the limits to “bonanza” developments when “knowledge, not petroleum, is becoming the critical resource in the oil business”; second, about the difficulties of insulating state-owned enterprises from partisan political competition; and third, concerning the corresponding risks induced by natural resource booms in late-developing countries like Brazil.⁶³

First, the Tupi discovery was not merely a stroke of miraculous luck, as the “winning lottery ticket” metaphor implies, nor was it the fruit of petroleum liberalization and privatization. Rather, the opening of this new petroleum frontier was the result of ongoing work of Petrobras geologists and geophysicists in rhythm with the march of innovation in the global oil industry and whose legacy can be traced all the way back to the creation of DEPEX under Walter Link. The geological decryption of the Santos Basin was a long-time coming. It actually started with Shell Oil’s discovery of the Merluza gas field in 1979, one of the few successes of the 1970s *contracto de risco* program and another example of the importance of foreign participation in Brazilian oil development.⁶⁴ A major breakthrough happened in the late 1980s and early 1990s, when geologists pieced together the geological evolution of the Cabo Frio fault zone, the major structure that separated the Campos and Santos Basins. They then identified and mapped major “structural highs” sealed by a thick salt layer in deep waters of the Santos, a vivid indicator of possible petroleum accumulations. The growing digitally driven power and sophistication of exploration geophysics—from 3-D seismic imaging, to wide and multi-azimuth seismic data collection, to new processing algorithms like reverse-time migration, all first applied in the Gulf of Mexico—eventually enabled geophysicists to correct for distortions of sound signals through the salt layer and reveal the treasure beneath.⁶⁵

Second, the military government laid the groundwork for these discoveries. Had the 1964 coup not occurred, argues Peter Smith, “it seems inevitable that the company would have become a ‘political football.’”⁶⁶ Instead, it was insulated from political competition and given a technocratic structure and ethos that, at least until recently, distinguished it from its regional counterparts, such as Pemex and PDVSA, which were routinely exploited as sources of cash for ruling parties. Petrobras was organized as a company driven to find oil in a country, unlike Mexico and Venezuela, which did not yet have any. The Brazilian military not only had the latitude to depoliticize Petrobras, but was compelled by strategic and economic imperatives to achieve a level of technical sophistication unattainable by its regional counterparts.

Recent events, however, appear to have overtaken this comparison. As Lazzarini and Musacchio note in chapter 5, the corporate reforms at Petrobras did not prevent government intervention in oil, and the ANP was too weak to oversee the company effectively, making the president of Brazil and the Minister of Mines and Energy the de facto “regulators.” The Tupi discovery prompted the Workers Party (*Partido Trabalhadores*—PT) governments of Lula and Dilma Rousseff to reduce the relative autonomy that Petrobras had long enjoyed and transform the company into a vehicle for an expansive industrial policy fashioned to consolidate the PT’s political power. The “Buy Brazil” local-content model introduced in 2003 both hamstrung the overly ambitious development plans for the pre-salt discoveries and contributed to the massive money-laundering and bribery scheme run through Petrobras by the PT, the “*petrolão*,” which was uncovered in 2014 by the federal investigation, “Operation Car Wash” (*Operação Lava Jato*). The shocking scale of the *petrolão* scandal, to the tune of \$17 billion in reported graft and overvalued assets, suggests that many of Petrobras’s commercial relationships, at least since 2003, were being driven by political calculations and pay-to-play schemes.⁶⁷

At the same time, the PT reigned in Petrobras’s autonomy and closed off portions of the petroleum sector. After the Tupi discovery, the government suspended offshore licensing rounds for six years as it revised Brazil’s legal and regulatory framework for petroleum. In December 2010, it amended the Petroleum Law of 1997 to create a new state-controlled company, Petrosal, to oversee a new production-sharing agreement (PSA) model for unleased blocks in the pre-salt area. Petrosal approves all operational decisions and manages all government revenue through a new sovereign wealth fund. Furthermore, the new PSAs oblige Petrobras to assume a 30 percent interest and operate all contracts awarded in future bidding rounds.

This is not the first time a Brazilian government has used Petrobras as a tool to achieve larger nationalist designs. In this case, however, the government appears to have transferred too many financial, technical, and operational risks to the company, driving away potential foreign partners and setting off a collapse in the company’s stock price. The government’s grandiose pre-salt development plans, moreover, created tension with the ANP’s local content rules, which required up to 85 percent of equipment and supplies for the oil industry to be nationally produced. This impeded Petrobras’s access to foreign contractors, equipment, and expertise, which had been a critical component of the company’s past success. For example, the rules require drilling vessels to be built in Brazil, but only a small percentage of the sophisticated equipment needed to build those vessels can be obtained domestically. Brazilian labor is also more expensive yet less skilled and less experienced than in East Asia, where most drilling vessels have been built in recent decades.⁶⁸ Problems finally came to a head in February

2015, when Sete Brasil, the Petrobras-associated company charged with managing the construction of 28 new-build drillships, at a cost of more than \$800 million each, missed \$125 million in payments for construction services to Estaleiro Atlântico Sul (EAS), a shipyard formed in the wake of the pre-salt boom, forcing the cancellation of seven drillship orders.⁶⁹

Indeed, critics believe that the risks of the pre-salt program go beyond those assumed by Petrobras and its stockholders and redound upon the nation as a whole. The development of the pre-salt areas proved to be much more technically challenging than anticipated or advertised, and much more costly under slumping crude oil prices. Investing hundreds of billions of dollars in a politically, economically, and environmentally uncertain petroleum future, they fear, neglects and perhaps exacerbates other pressing social and economic problems. The spectacular bankruptcy of the oil and mining empire of the Brazilian billionaire Eike Batista, whose oil company OGX had consisted of a “dream team” of former Petrobras executives and geologists, has served as “a kind of proxy for enthusiasm and then disillusion confronting Brazil’s problem in financing and executing big projects.”⁷⁰

Petrobras faced similarly long odds and seemingly impossible challenges in forging into the deep waters of the Campos Basin, and overcame them to the larger benefit of the nation. Recently, there have been hopeful signs of progress in gradually rising production from pre-salt fields, including output from the first PSA signed with foreign investors (Royal Dutch Shell, Total, Cnooc, and China National Petroleum Corporation) for the Libra field, northeast of the Lula field.⁷¹ The April 2015 announcement of Royal Dutch Shell’s \$70 billion purchase of the BG Group, which has significant investments and partnerships with Petrobras in Brazil, can be read as a show of support for long-term deepwater development there. Furthermore, Petrobras’s five-year program, announced in June 2015, reduces investments in corruption-plagued refineries, lowers overly optimistic crude oil output targets, and refocuses on pre-salt exploration.⁷² The Brazilian energy ministry, meanwhile, drafted plans to ease local content rules, allowing for greater foreign-built oil equipment in offshore development, and to consider possible changes to pre-salt PSA rules that reserve a dominant role for Petrobras in all projects.⁷³

Brazil’s oil strategy is at a crossroads. In recent years, national oil policy has concentrated on subsidizing fuel for consumers, expanding petroleum-linked industry, and rewarding political benefactors, all at great economic and political costs. The pre-salt technical challenges and revelations of corruption that have engulfed Petrobras and destabilized the PT’s political designs may finally compel a return to what worked so well for Brazilian oil in the past. In the words of Giuseppe Bacoccoli, retired chief geologist of Petrobras, this involved the patient efforts of Petrobras “ants” in finding technological solutions to the extraction of

oil. These ants, however, did not arrive at such solutions on their own. They leveraged the knowledge, experience, technology, and innovation of the global offshore oil industry in their pursuit. In order to replicate prior success, Brazilians must resist the “ephemeral song of the grasshopper,” which promises immediate oil-driven national enrichment, but which might lead perilously down a path toward the resource curse.

Notes

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