Vertical Integration in a Lean Supply Chain: Brazilian Automobile Component Parts*

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Abstract: Brazil's automobile component parts industry shows that vertical integration and scale economies endure within flexible production systems. Recent neoliberal economic reforms propelled vehicle assemblers to adopt flexible modes of production and subcontract component manufacturing. However, transactional hazards in supply chains escalated as first-tier subsystem assemblers had to rely on small, opportunistic, and inefficient parts makers. Large tier one suppliers purchased existing parts makers and invested in greenfield facilities to service both new flexibly organized vehicle assembly plants in southern Brazil and Argentina and restructured assembly plants in the traditional automobile complex of São Paulo. We focus on Dana Corporation, Bradesco Bank, and British Tyre and Rubber Corporation—firms that assemble chasses, engines, and body subsystems, respectively. These companies dominate their segment of the parts industry, delivering subsystems to a growing network of flexible vehicle assembly plants throughout Brazil. Large-batch parts production, subsystem assembly by a few major multinational tier one suppliers, and ownership consolidation underscore the continued role of vertical integration and scale economies in automobile production chains.

Key words: automobile components, Brazil, tier one suppliers, trade policy, vertical integration.

A dominant theme in the analysis of industrial restructuring investigates shifts from traditional mass production to more flexible industrial systems (Piore and Sabel 1984; Gertler 1988; Harvey 1988; Scott 1988; Sabel 1989; Storper and Scott 1989). Scholars often acclaim the automobile industry for leading a general transition from organized to fragmented capitalism (Schoenberger 1987; Hoffman and Kaplinsky 1988; Womack, Jones, and Roos 1990). Many studies that investigated the increasing flexibility of vehicle production stressed the adoption of flexible machines to reduce scale economies, the emergence of corporate alliances to support flexible interfirm relations, the use of just-in-time (JIT) delivery of parts to lower costs and improve efficiency, and the growth of flexible labor relations to restrain trade unions and implement multitasking (Womack, Jones, and Roos 1990; Law 1991; Streeck 1991). Furthermore, to speed the rate of vehicle production and reduce costs, auto-

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mobile assemblers now subcontract the design, engineering, and production of components to suppliers of major vehicle subsystems. Those *tier one suppliers* play a decisive role in flexible industrial systems, designing components, supervising subcontractors, assembling individual parts into component subsystems, and managing JIT production networks (Linge 1991; Chappel 1994, 1996; Anderson and Holmes 1995).

This study of the Brazilian automobile component parts sector corroborates a global industrial trend of the 1990s—the disintegration of some stages of production and parallel vertical integration of others (Ó hUallacháin 1996, 1997). We use the transaction cost theory of the firm to interpret the organizational, technological, and territorial strategies of Brazil-based tier one suppliers. Investigating three major component subsystems—chasses, engines, and bodies—we document the emergence of vertically integrated subsystem manufacturers. Tier one suppliers faced a common dilemma once Brazil-based vehicle assembly firms adopted flexible manufacturing practices in the early 1990s: how to produce and deliver major vehicle subsystems composed of parts procured from subcontractors noted for poor quality, unreliability, limited production capacity, and low levels of technological innovation (Shapiro 1994; Addis 1996; Banco Nacional de Desenvolvimento 1995a, 1996b). First-tier suppliers removed contractual hazards in the supply chain by vertically integrating component production and subsystem assembly. That altered the geography of Brazil's automobile component parts sector. New centers of parts production developed as first-tier firms, servicing new assembly plants in southern Brazil and Argentina and those in the traditional automobile complex of São Paulo, purchased parts makers and invested in greenfield facilities (Aby-Azar 1996a; Banco Nacional de Desenvolvimento 1996b).

This analysis of Brazil's tier one automobile suppliers clarifies the roles of scale economies and public policy within flexible production systems. Though early studies of automotive restructuring argued that flexible production favors the exploitation of scope economies (Schoenberger 1987; Hoffman and Kaplinksy 1988; Womack, Jones, and Roos 1990), later analyses noted the persistence of scale economies throughout the industry (Dicken 1992; Anderson and Holmes 1995). We confirm that mass manufacturing guided the restructuring of Brazil's automobile component parts industry. Tier one suppliers risked producing costly subsystems if manufacturers in the component chain did not exploit economies of scale. In Brazil, restructuring also highlights the industrial and territorial reorganization of industries that follow the radical alteration of a state's trade strategies and industrial development policies. A decisive switch from protectionist to free trade principles drove changes in the industrial organization and location of automobile production. As demand and vehicle production surged, tier one suppliers internalized production, dislodging a network of 2,000 small and medium-sized subcontractors. Small family-owned companies are rapidly declining in number and few will survive in the 21st century (Banco Nacional de Desenvolvimento 1996b; Cintra 1996).

Investigating tier one suppliers in Brazil also broadens our understanding of passenger car production beyond the well-documented manufacturing complexes of North America, Europe, and Japan. Although the growth of automobile production has slowed in those areas, significant expansion has occurred in developing countries, particularly Brazil and Argentina (see Fig. 1) (Choi and Parolini 1996; Carvalho 1997). Finally, the Brazilian automobile industry is amenable to the type of analysis needed to prove theories of industrial restructuring and regional adjustment. The activities of tier one parts producers are widely documented owing to their strategic role in the economy. We concentrate on three large tier one supply groups—Dana Corporation, Bradesco Bank, and British Tyre and Rubber Company. Interviews with cor-

porate officials and industry analysts in Brazil and the United States yielded insights into corporate strategy and public policy. Documents filed with Brazilian and United States regulatory agencies, trade publications, and reports deposited in specialized automotive archives in São Paulo and Belo Horizonte provided ample data for our analysis of restructuring.

Transaction Cost Theory and Flexible Automobile Production

Transaction cost theory seeks to understand how the nature of incomplete contracts governing exchanges between firms molds the ownership of successive stages of production. Williamson's (1975, 1985) transaction cost approach to industrial organization explains why companies, when faced with incomplete contracts, will vertically integrate production. Contracts are agreements between buyers and sellers that stipulate the quantity, quality, timing, and duration of exchanges. Williamson centered his analysis on the ability of contracts to regulate the exchange of goods and services across technologically separable sequences. Contracts are incomplete if, at the time of their conception, the parties do not acknowledge, comprehend, or anticipate each eventuality that may affect future exchanges, and if they cannot agree on the necessary adjustments for unforeseen events. Contracts also become hazardous when transactions depend on specific assets—investments that cannot be redeployed to alternative users or uses except by a loss of worthwhile value. Asset specificity takes various forms: employees with specialized individual skills, employee teams with collective expertise, dedicated machinery with designated functions, and fixed capital too cumbersome to move. Once companies make specific investments, interfirm exchanges may break down, as those assets create bilateral dependency between organizations, spurring opportunistic bargaining. Frequent exchanges, combined with uncertainty about the behavior of trading partners and specialized assets, aggravate the hazards of incomplete contracts.

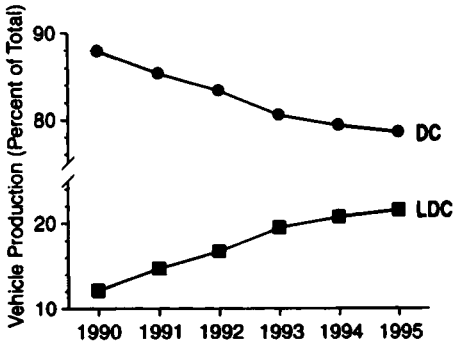

Figure 1. Percentage of the world's automobiles produced in developed (Belgium, Canada, France, Germany, Italy, Japan, Sweden, United Kingdom, United States) and less developed (Argentina, Brazil, China, India, Mexico, Spain, South Korea, Taiwan, Thailand, Turkey) markets, 1990–1995. *Source:* Associacão Nacional dos Fabricantes de Veículos Automotores (1996).

Transaction cost theory holds that institutional arrangements govern all contractual exchanges. It interprets how trading associates select, from the class of feasible organizational choices, ownership forms that best safeguard transaction-specific investments at the lowest cost. Depending on the circumstances surrounding transactions, certain institutional structures work better than others. In spot markets, which have many buyers and sellers, autonomous parties may shift partners without cost. That is the case with raw material commodities markets, which avoid opportunism because products are standardized and alternative buyers and sellers are easily identified. In a market with few participants, where exchanges depend on specific assets, parties protect themselves from the opportunistic behavior of trading partners by vertically integrating sequential stages of production.

Early accounts of flexible automobile production underscored the pliable nature of interfirm linkages and considered vertical disintegration the norm (Hoffman and Kaplinsky 1988; Womack, Jones, and Roos 1990; Law 1991; Dicken 1992). However, flexible production systems, especially in developing economies, are fraught with transactional hazards. Tier one suppliers, in particular, must develop specific technical expertise, invest in dedicated assets, and share design and engineering information with assorted parts makers—who can easily divulge that knowledge to competitors. Statistical analyses showed that the greater the engineering effort needed to develop a particular automobile component, the more likely a company will internalize production. Monteverde and Teece (1982) found a positive relationship between engineering effort and the likelihood of internalization in their analysis of General Motors and Ford's component procurement policies. Similarly, Masten, Meehan, and Snyder (1989) found that Chrysler, Ford, and General Motors were more likely to produce in-house parts that required specific design or manufacturing expertise.

We show how the shift to flexible automobile production in Brazil increased transaction costs, causing tier one suppliers to integrate vertically. Vehicle assemblers in Brazil increasingly rely on first-tier suppliers to design, assemble, and deliver zero-defect subsystems—all the while demanding price reductions. Given their lack of confidence in the engineering and management abilities of local firms, Brazil-based tier one suppliers chose to vertically integrate successive production stages to exploit scale, control costs, assure quality, and protect proprietary knowledge from opportunistic subcontractors (Banco Nacional de Desenvolvimento 1995a, 1996b). Beyond strict vertical integration, large tier one suppliers extended their control of component production by purchasing partial ownership stakes in some parts companies and entering equity joint ventures with others. Tapered and hybrid integration enabled those firms to stipulate the equipment subcontractors must purchase, allocate production quotas among multiple parts plants, and establish component prices. That is similar to strategies Japanese firms use to combat transaction costs inherent in automobile production (Kenney and Florida 1993; Reid, Solocha, and Ó hUallacháin 1995). In summary, internalization reduced the hazards of incomplete contracts that might have crippled the flow of goods in a component assembly system undergoing restructuring.

Restructured Automobile Production: Flexibility and Global Localization

Throughout much of this century, firms manufactured automobiles under a rigid mass production system, allowing companies to achieve substantial cost reductions (Womack, Jones, and Roos 1990). Assemblers manufactured at least 2 million vehicles a year to exploit scale economies, and component makers emphasized large-batch production (Dicken 1992). Dedicated assets and scale economies permitted little variation in processes and products and stipulated rigid relationships between assemblers and suppliers. Assemblers sought short-term contracts with parts manufacturers, based upon cost and not quality. Component suppliers used exact specifications provided by assemblers, had no role in the design process, and competed with other firms to manufacture identical parts. Firms rarely acknowledged design and manufacturing flaws until they sold vehicles, and quality suffered (Hoffman and Kaplinsky 1988; Womack, Jones, and Roos 1990). Although geographic proximity between assemblers and suppliers was the rule in the earliest days of automobile production, distance increased as transportation networks improved and firms sought low-cost labor at home and abroad (Schoenberger 1987; Rubenstein 1992).

The system thrived in the expanding market for new cars following the Second World War. Nonetheless, by the 1970s consumers tired of the lack of variety and poor quality of mass-produced vehicles. Western manufacturers faced the choice of developing new processes and products or losing market-share to Japanese producers (Sinclair 1983; Abernathy, Clark, and Kantrow 1984). Most auto makers in the United States and Europe embraced the Japanese system of flexible or lean manufacturing to regain competitive advantage. Lean manufacturing combines the best elements of both craft and mass production—emphasizing flexible firms, technologies, labor relations, and products. Flexible firms use nondedicated machinery to produce differentiated vehicles that fill market niches. Workers trained in multiple tasks and participating in quality enhancement significantly improved quality. Flexible interfirm relations eased externalization of parts production (Womack, Jones, and Roos 1990; Law 1991).

JIT parts sourcing is central to flexible automobile production. JIT obligates parts suppliers to produce precise numbers of components and deliver them at the exact time needed. Because assemblers employing just-in-time systems do not permit warehousing, parts suppliers must guarantee zero defects in each shipment and forge close organizational ties with assemblers (Law 1991; Linge 1991). In the United States, JIT altered the geography of automobile production, favoring spatial agglomerations of parts suppliers and vehicle assemblers (Schoenberger 1987; Rubenstein 1992; Kenney and Florida 1993; Reid, Solocha, and Ó hUallacháin 1995; Ó hUallacháin and Reid 1997). Flexible production and JIT also radically altered ownership in automotive production chains. Vehicle assemblers subcontracted parts production to tier one suppliers to reduce costs. That enabled assembly firms to focus on core skills—designing, assembling, and marketing finished vehicles—rather than supply chain management. Tier one suppliers assumed the responsibility for designing and assembling entire subsystems, supervising multiple tiers of subcontractors, and JIT delivering their subsystems to assembly firms (Chappel 1994; Klier 1994).

Automobile assemblers also responded to growing competition by establishing world car programs. Global production initially sought to maximize scale economies by creating a single car for multiple markets. World car programs of the 1970s were mere extensions of existing rigid mass production systems. Assemblers manufactured component subsystems, including transmissions and engines, at select facilities and shipped them long distances to plants that assembled mechanically identical cars, cosmetically altered for consumers in North America and Europe. Assembly firms quickly abandoned those initial world car programs because standardized vehicles did not satisfy middle-class consumers (Sinclair 1983; Dicken 1992).

The global car strategy recently reemerged to serve the rapidly growing markets of Asia and Latin America, where consumers are less discerning. Automotive assemblers are expanding their worldwide production capabilities, manufacturing identical cars on multiple continents, and procuring components locally. Those cars are small, fuel efficient, and inexpensive, unlike previous models that targeted more fickle middle-class consumers. Installing flexible production methods and exploiting scale economies underlay recent successes at global expansion (Chappel 1994; Chew 1996; Choi and Parolini 1996). Automobile assemblers also consolidated the number of vehicle platforms. Volkswagen, for example, reduced the number of its platforms from 16 to 4 (Chew 1996). General Motors reduced platform variety from 14 to 7, assembling an identical *Opel* model in Latin America, Asia, Africa, and the Middle East (General Motors 1995). Fiat produces its *Palio* class in Brazil, Argentina, India, China, Turkey, Morocco, and South Africa (Fiat 1997).

The trend toward global cars for developing markets altered the organizational

structure and geography of component production. Assembly firms increasingly rely on tier one suppliers to produce component subsystems. To hasten design, engineering, and manufacturing cycles and to ensure quality, assembly firms require suppliers to JIT service international assembly facilities from geographically proximate facilities (Chew 1996; Choi and Parolini 1996). Tier one suppliers unable to deliver subsystems in multiple regions risk losing long-term global contracts tied to the life of a vehicle (Klier 1994; Chappel 1996). Only the largest tier one suppliers possess the financial and technological capabilities needed to become global suppliers. Internalizing parts production has proven the best way for Brazil-based tier one suppliers to guarantee quality and manage supply relationships among many vehicle assembly plants (Banco Nacional de Desenvolvimento 1996b).

The Brazilian Automobile Industry: Background

In 1919, Ford Motor Company opened the first automobile assembly line in Brazil (Ferro and Venosa 1985). Other multinationals, including General Motors, Mercedes Benz, and International Harvester, soon followed. They used few local materials, mostly assembling component "kits" imported from the United States (Shapiro 1994). Following the Second World War, the Brazilian government continued its policy of unrestricted imports of vehicles and parts. However, in 1956, the government—facing a severe balance of payments crisis—imposed high tariffs on vehicles and components and established domestic content laws. By 1960, cars had to contain 95 percent domestic parts content. Realizing the potential of the Brazilian market, some assembly firms, including General Motors, Ford, and Volkswagen, expanded their operations in Brazil (Ferro and Venosa 1985).

Import restrictions were a boon to the local parts makers. They guaranteed high profits, provided few incentives to cut costs or improve quality, and encouraged opportunistic price gouging of assemblers during peak demand periods. In response, vehicle assemblers internalized some of their parts needs to avoid dependence on poor-quality locally produced components. By the late 1960s, Brazil's largest assembly firms—General Motors, Ford, and Volkswagen—produced more than half of their components internally (Scarlato 1987; Shapiro 1994; Addis 1996). They particularly internalized forging, engine assembly, drive train components, and body work. A thriving component sector made an assortment of other parts. Parts companies soon consisted of two factions: a foreign controlled group of approximately 100 large firms, which shipped 80 percent of its output directly to assemblers; and a 2,000 strong network of small and medium-sized businesses, which produced replacement parts, filled emergency orders for assemblers, and exported. The latter group directly shipped approximately 40 percent of its output to vehicle assemblers in Brazil (Ferro and Venosa 1985; Scarlato 1987; Shapiro 1994).

In 1981, at the onset of a severe economic downturn, finished automobile production in Brazil declined dramatically, and recession persisted throughout the following decade (see Fig. 2). However, with a captive market, vehicle assemblers had little incentive to improve quality, introduce new models, or lower prices. Although component parts production initially expanded in the 1980s, owing to a devalued currency that favored exports, by 1990 that sector was also in decline (Ferro and Venosa 1985). In the period 1989–92, the annual value of gross sales of automobile component parts dropped from 16 to 10 billion U.S. dollars (Sindicato Nacional da Indústria de Componentes para Veículos Automotores 1996). Decline in finished vehicle and parts production caused politicians and industry experts to

question the very survival of Brazil's automotive industry (Kamm 1994).

Following his election in 1989, President Fernando Collor de Mello began to transform the Brazilian automobile industry. Pursuing a neoliberal economic policy, Collor opened Brazil's market to imports; reduced tariffs on assembled automobiles, component parts, and production equipment; and cut sales taxes. Assemblers immediately lowered car prices by 22 percent (Kamm 1994; Associacão Nacional dos Fabricantes de Veículos Automotores 1996). Following Collor's lead, President Itamar Franco pressed home reforms by enacting the Carro Popular, or "Popular Car," program, which further lowered sales taxes on small cars. Popular cars, which include Ford's *Fiesta*, Fiat's *Palio*, and General Motors' *Corsa*, are adaptations of world car designs. Additional legislation enacted in 1993 and 1995 struck a trilateral bargain between the state, automobile companies, and organized labor. The government further reduced sales taxes on cars and tariffs on parts and production machinery, vehicle assemblers deepened price cuts, and trade unions moderated wage demands (Associacão Nacional dos Fabricantes de Veículos Automotores 1995). Automobile production grew rapidly, and by 1996 popular cars increased their market share to 63 percent of all automobiles sold in Brazil (Demasi 1997).

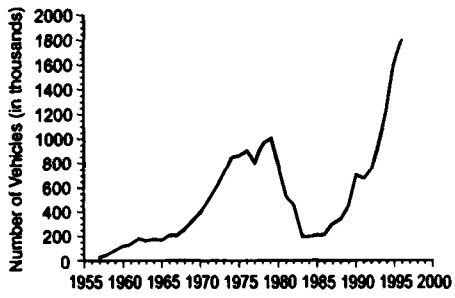

Figure 2. Number of vehicles produced in Brazil, 1957–1996. Includes passenger cars, sport utility vehicles, and commercial vehicles. *Source:* Associacão Nacional dos Fabricantes de Veículos Automotores (1996).

By signing the MERCOSUR free trade agreement with Argentina, Uruguay, and Paraguay the Brazilian government intensified restructuring within the industry. MERCOSUR eliminated many long-standing trade barriers and encouraged regional economic integration within the Southern Cone—a 200 million strong consumer market with an annual gross national product of $1 trillion (Carvalho 1997). Abolishing trade barriers on flows of components and vehicles allowed assemblers and tier one suppliers to coordinate production, exploit scale economies, and eliminate duplicate facilities in Brazil and Argentina (Banco Nacional de Desenvolvimento 1995b).

Methodology

In the following sections, we evaluate the strategies of finished vehicle and subsystem assemblers to install lean automobile production systems in Brazil. Our empirical analysis is for the period 1990–97, which captures the effects of trade reforms and a drive by vehicle assemblers to become more flexible. Vehicle assembly firms constructed greenfield plants, outsourced parts production to subcontractors, invested in new technology, adopted JIT parts delivery systems, and curtailed trade union power. Although we explore technological, territorial, and ownership shifts at the assembly level, we emphasize restructuring in the component segment. Differences in the organizational strategies of assembly and parts firms justify this distinction. As a consequence of making the assembly system more flexible, tier one subsystem assemblers cannot produce profitably in Brazil without vertically integrating parts production and exploiting mass production for scale economies. Thus, while vehicle assemblers have become more flexible with the adoption of lean vehicle manufacturing systems, tier one suppliers increasingly rely on traditional forms of organization, including production internalization, ownership consolidation, and exploitation of scale economies.

Our methodology for understanding restructuring in Brazil fuses primary and secondary reports of managers' stated opinions and beliefs, the insights of industry analysts and regional planners, and revealed corporate actions. The opinions and beliefs of selected managers were compiled through personal interviews and by scrutiny of interviews in major trade journals, including the Brazilian publication *Autodata* and *Automotive News* in the United States. Brazilian investment bankers and regional planners provided useful insights into Brazilian automotive history and public policy.

We use the transaction cost theory of the firm to interpret those insights, beliefs, and opinions. This conceptual approach to empirical analysis is challenging, for transaction costs are intangible, ambiguous, and difficult to measure. Asset specificity is enigmatic, and bounded rationality and opportunism are unscalable. Our research design confronts these difficulties in the following manner. By analyzing the opinions and actions of comparable tier one subsystem assemblers facing common make-or-buy dilemmas, we partially contain the influence of fluctuating corporate views on the direction of vehicle assembly technology and demand and uncertainty over government trade and industrial policies. Because the adoption of more flexible systems by vehicle assemblers was clear-cut and tier one suppliers held similar views on the ability of local parts makers to adjust successfully, we can better evaluate strategies of component firms than by examining a lengthier period in which other stimuli and pressures confound empirical analysis.

To detect corporations' actions as revealed through choice we explored corporate reports distributed to shareholders, documents filed with the United States Securities and Exchange Commission, corporations' Internet sites, and press releases. These sources are similar to those used by Anderson and Holmes (1995) in their analysis of the North American automotive parts industry and Krickx (1995) and Ó hUallacháin (1997) in their investigations of the United States semiconductor industry.

Organizational and Territorial Shifts in Automobile Assembly

The Popular Car and MERCOSUR accords revived Brazil's automotive sector. The number of vehicles produced expanded by 295 percent in the period 1989–96, and planned investments by assemblers and parts makers will exceed $18 billion by 2000 (Associacão Nacional dos Fabricantes de Veículos Automotores 1996; Carvalho 1997; Demasi 1997). However, by basing growth on inexpensive cars with low profit margins, assembly firms had to reduce costs substantially. A favored strategy included adopting flexible production methods while intensifying mass production (Banco Nacional de Desenvolvimento 1995a, 1996b). Assemblers stressed capital deepening in existing plants, opening automated greenfield facilities in low-wage locations, externalizing component parts making to tier one suppliers, and demanding just-in-time delivery of parts from subcontractors.

Automobile assembly and component parts production were traditionally concentrated in São Paulo, Brazil's most heavily industrialized state (Scarlato 1987). Multinational firms with long histories of producing passenger cars in Brazil—Volkswagen, Ford, and General Motors—control five large automobile assembly complexes in São Paulo and four engine-transmission factories (see Fig. 3). In 1995, those assembly facilities accounted for 70 percent of passenger cars produced in Brazil (Associacão Nacional dos Fabricantes de Veículos Automotores 1996). Owing to its large assembly base, parts makers produced 87 percent of Brazil's components in the state (Sindicato Nacional da Indústria de Componentes para Veículos Automotores 1996). To establish a flexible system of vehicle production, Ford, Volkswagen, and General

Motors collectively invested some $9 billion to modernize existing plants in São Paulo (Carvalho 1997). They concentrated investments in automated assembly lines that rely extensively on flexible equipment, especially robotic tools (Eisenstein 1996). The São Paulo metropolitan region also attracted new automobile assembly operations. In 1996 and 1997, Toyota and Honda invested some $500 and $600 million, respectively, in state-of-the-art greenfield plants to assemble popular cars (Pereira 1997).

Fiat assembled the remaining 30 percent of passenger cars produced in Brazil in the

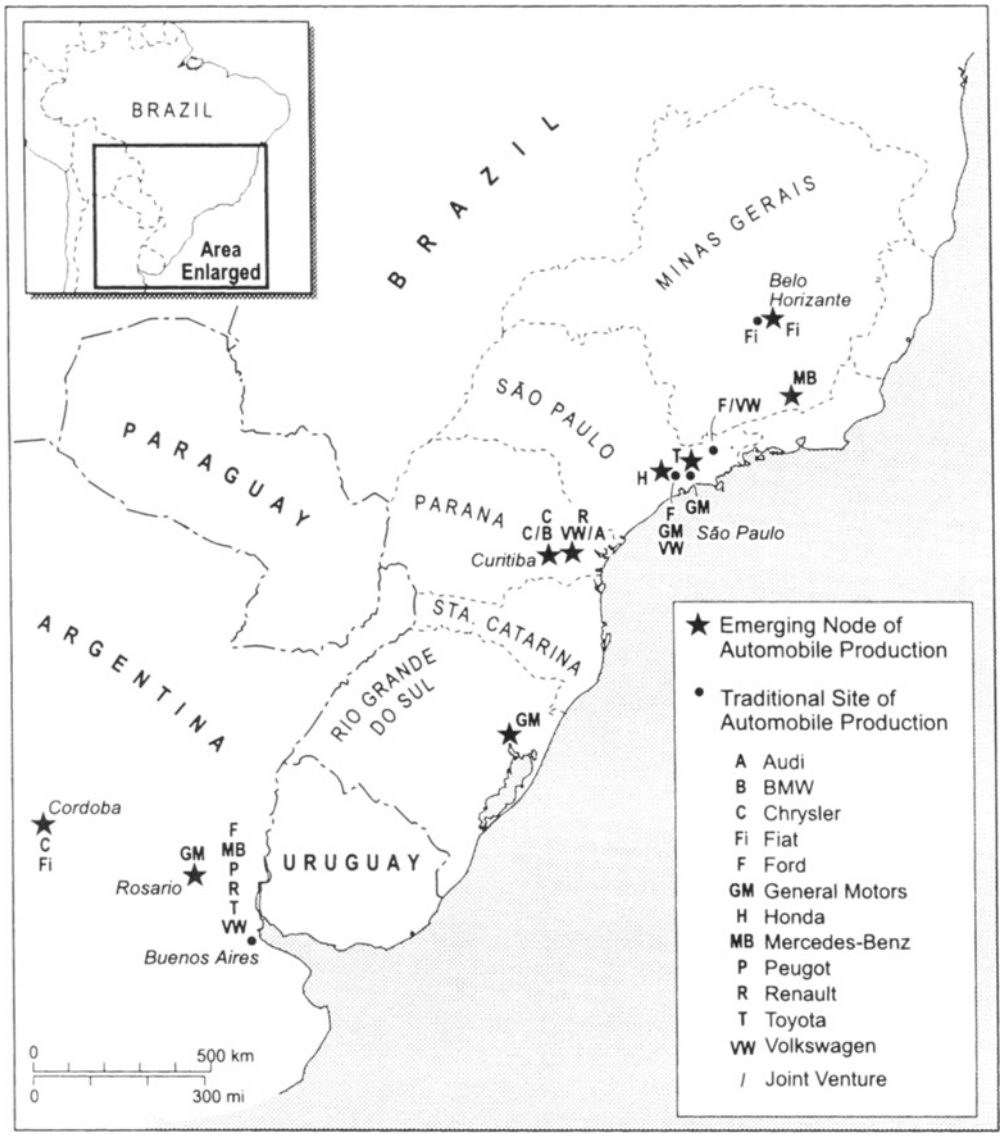

Figure 3. Emerging and traditional nodes of automobile production in Brazil in 1997. *Sources:* Associacão Nacional dos Fabricantes de Veículos Automotores (1996); Carvalho (1997); General Motors (1997).

Belo Horizonte metropolitan area in the state of Minas Gerais (Associacão Nacional dos Fabricantes de Veículos Automotores 1996). Like the São Paulo–based assembly firms, Fiat recently invested $2.5 billion to expand its existing operations in Minas Gerais, constructing new automated assembly and engine plants in Belo Horizonte (Carvalho 1997). In 1995, Minas Gerais accounted for 7 percent of the component parts made in Brazil. The remaining 6 percent of parts were manufactured in the southern states of Parana, Santa Catarina, and Rio Grande do Sul (Aby-Azar 1996b; Sindicato Nacional da Indústria de Componentes para Veículos Automotores 1996).

The vehicle assemblers' flexible production strategies also favored locating new plants in low labor cost regions. Automobile production in Brazil has deconcentrated from the heavily unionized São Paulo region to the southern states of Parana and Rio Grande do Sul and nonmetropolitan regions of Minas Gerais. While monthly salaries for automobile workers in metropolitan São Paulo and Belo Horizonte were $1,266 in 1997, their counterparts in greenfield factories averaged $658 (Silva 1997). Chrysler and Renault, and joint ventures of Chrysler and BMW and of Volkswagen and Audi, built four new assembly plants in Parana (Carvalho 1997). General Motors expanded south with a new Popular Car assembly facility in Rio Grande do Sul (General Motors 1997). Mercedes Benz built a greenfield facility in Juiz do Fora, Minas Gerais. Assembly expansion also occurred in Cordoba and Rosario, Argentina, as Chrysler, Fiat, and General Motors constructed new factories to serve both the domestic and Brazilian markets (Carvalho 1997). With an estimated annual production capacity of 1.54 million cars by 2000, these new plants will contest São Paulo's position as South America's dominant automobile-producing region (Associacão Nacional dos Fabricantes de Veículos Automotores 1996; Carvalho 1997).

Tier One Suppliers: Organizational and Territorial Strategies

Expansion of automobile production in Brazil compelled parts makers to devise organizational and locational structures to serve new assembly centers and their traditional São Paulo–based customers. Focusing on three major component subsystems—chasses, engines, and bodies—we investigate the emergence of vertically integrated tier one supply groups. Those three subsystems account for 70 percent of a vehicle's production cost (see Fig. 4) (Posthuma 1993). Focusing on the dominant company illustrates organizational restructuring within each subsystem segment. Dana Corporation, Bradesco Bank, and British Tyre and Rubber Company are foremost in manufacturing chasses, engine components, and bodies, respectively, in Brazil.

Chasses

A chassis is the complete operable vehicle—engine, transmission, steering, drive train, frame, brakes, wheels, and suspen-

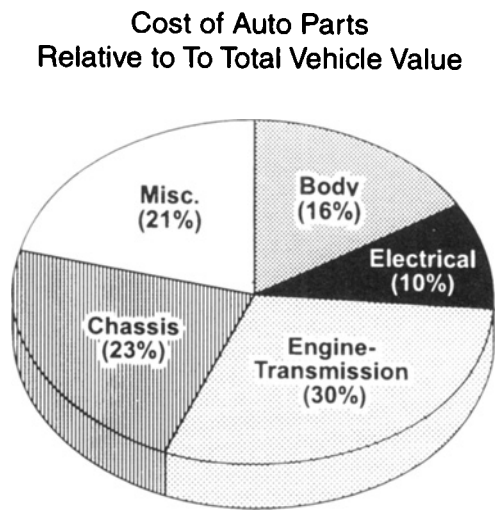

Figure 4. Major vehicle subsystem's percentage share of the cost of automobile production. *Source:* Posthuma (1993).

sion—excluding exterior and interior body work. Rolling chassis refers to the system before the addition of the engine and transmission. In the past, parts suppliers produced and shipped most individual components directly to assemblers. In contrast, modern tier one suppliers design, engineer, manufacture, assemble, and deliver entire rolling chasses. Each rolling chassis is technologically complex and requires the design and manufacture of many elaborate parts. Drive trains contain a diverse array of systems, including axles, transaxles, transfer cases, steering systems, and drive shafts, which must operate as integrated units. Precisely engineered wheels support a vehicle's weight, transfer driving and braking torque to the tires, and tolerate varied road conditions. Brakes are complex subsystems consisting of seals, cylinders, bearings, pads, linings, and lubricating fluids. The suspension supports the frame and absorbs road shock during driving. Suspension mechanisms have become increasingly sophisticated, containing a myriad of different fixed and moveable parts. Finally, the frame, a series of heavy steel cross-members to which the body is attached, serves as a vehicle's "skeleton."

The U.S.-headquartered Dana Corporation has become Brazil's largest tier one supplier of rolling chasses (Alessi Filho 1997). Dana is among the world's largest manufacturers of automobile parts, with more than $7.7 billion sales in 1996 (Dana 1997a). Dana's South American operations began in 1957, when it established an equity joint venture with Albarus, Brazil's largest manufacturer of automobile components. Albarus had facilities in Rio Grande do Sul, and with Dana's backing opened new production facilities in São Paulo. From its initial minority stake, Dana took control of 77 percent of Albarus and supplies chassis and engine components to most Brazil-based assembly firms, including General Motors, Ford, and Volkswagen (Alessi Filho 1997). Although Dana manufactures a diverse range of products, including engine and transmission components, its most notable growth has occurred in chassis production. Dana is the only tier one supplier in South America that can assemble a complete rolling chassis—the frame, drive shaft, axle, brakes, wheels, steering and suspension systems (Dana 1996c, 1996d, 1997b). Coordinating the design, testing, and manufacture of multiple chassis components requires considerable proprietary expertise, large production capacity, and strict quality control. Dana used vertical integration of parts making and rolling chassis assembly to dominate chassis production.

Seeking direct control over the production of individual chassis components—axles, drive shafts, frames, brakes, suspensions—Dana made strategic acquisitions and constructed greenfield facilities throughout Brazil and Argentina (see Fig. 5). To meet the growing demand for axles, it bought Rockwell do Brasil's light axle division, Braseixos. Dana also purchased Simesc-Parish to manufacture frames; Thompson Ramco to make assorted chassis components; Nakata to produce shock absorbers, tie rods, and ball joints; Stevaux to manufacture gaskets and oil seals; and Centrust to produce braking systems, stamped frames, and frame components (Dana 1997a, 1998). To manufacture precisely crafted drive train components, Dana opened a greenfield forging facility in Rio Grande do Sul, sidestepping Brazil's small, inefficient metal-fabricating companies (Banco Votorantim 1995; Banco Nacional de Desenvolvimento 1996b). And in an equity joint venture with locally owned Freios Varga—later named Sistemas Modulares—Dana began manufacturing rear axles, suspensions, and braking systems as integrated units. By meshing its new and existing facilities Dana realized scale economies throughout its operations (Alessi Filho 1997).

Internalizing parts making and subsystem assembly prevented opportunistic subcontractors from pirating Dana's designs. Because its chassis designs are highly specific, Dana's chief executive officer S. J. Morcott argued, "you're certainty not going to offer a proprietary idea to someone who

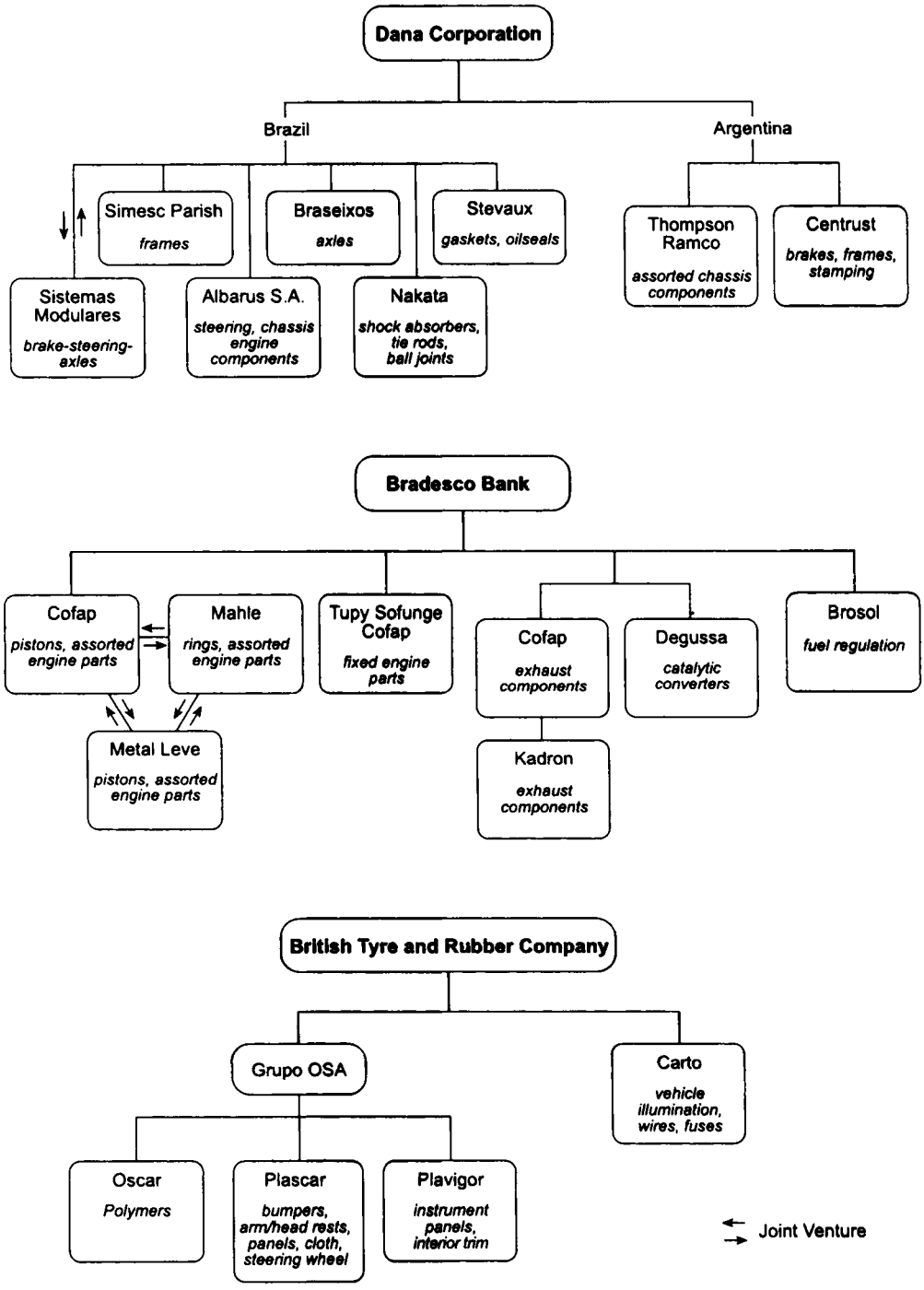

Figure 5. Brazilian automobile component manufacturers acquired by Dana Corporation, Bradesco Bank, and British Tyre and Rubber. *Sources:* Balbi (1996); Dana (1995, 1996a); Lacerda (1996); Alessi Filho (1997); Silveira (1997).

will give it to competitors" (Dana 1997b). Dana's joint venture with Freios Varga also highlights the role-bounded rationality—incapacity of individuals to assimilate or even know all feasible choices for action—played in the vertical integration drive. Before forming the Sistemas Modulares venture, the chief executive officer of Freios Vargas noted, "what happens to a company that has been a tier one supplier who suddenly moves to second-tier? You lose your edge in communications with the customer. You don't find out about future projects. We want to stay tier one but we have to have partners to do it" (Chappel 1994, 8). In short, Freios Vargas viewed second-tier status as a major obstacle to direct access to vehicle assemblers and as a barrier to growth.

Vertical integration of parts making and chassis assembly solidified Dana's existing manufacturing network in Rio Grande do Sul and São Paulo and propelled its expansion into Parana and northern Argentina (see Fig. 5). Its Simesc-Parish subsidiary has production facilities in São Paulo, Parana, and Santa Catarina. Braseixos, renamed Dana Indústria Limitada, has two axle plants in São Paulo and another in Rio Grande do Sul. Stevaux, Nakata, and Sistemas Modulares operate manufacturing facilities in the São Paulo metropolitan region. Dana strategically located its greenfield forging plant in Rio Grande do Sul to service its subsystem integration facilities in southern Brazil, São Paulo, and Argentina. In Argentina, its Thompson Ramco and Centrust subsidiaries own parts plants in Cordoba and Buenos Aires. Beyond its recent acquisitions, the Albarus subsidiary manufactures integrated steering subsystem and assorted engine and chassis components—pumps, valves, and clutches—in Rio Grande do Sul.

Ability to coordinate the production of complex rolling chassis subsystems in multiple locations enabled Dana to win major subsystem contracts with assemblers (Dana 1996b, 1996c) (see Fig. 6). For example, Dana supplies complete rolling chasses to Chrysler's assembly plants in Parana and Cordoba, Argentina. To assemble the diverse assortment of components made in its São Paulo and Rio Grande do Sul parts plants, Dana built a new subsystem assembly plant near the Parana final assembly facility. The company won a similar rolling chassis contract from Ford's pickup truck factory in Buenos Aires, Argentina (Dana 1996b). It serves that assembly plant with parts drawn from its facilities in southern Brazil and Argentina. Its subsidiary Sistemas Modulares ships integrated axle, suspension, and braking systems to Volkswagen's assembly plant in São Paulo (Dana 1996c). In short, Dana successfully consolidated its traditional manufacturing base in São Paulo while penetrating the emerging automobile industrial complexes of southern Brazil and Argentina.

Engines

Engines convert chemical energy into mechanical power. Beyond providing the force that propels a vehicle, engines power climate, alternator, and steering systems. Automobile engines consist of a network of fixed and moveable parts, and their efficiency depends on interrelated fuel management, exhaust, and ignition systems. Engines are often a vehicle's key selling point. Although many assembly firms make engines, some have begun subcontracting the design and assembly of engine subsystems to tier one suppliers (Banco Nacional de Desenvolvimento 1994). Again, we found that internalization of parts production and subsystem assembly enabled tier one suppliers to bypass inefficient and opportunistic subcontractors, guarantee delivery of high-quality products, and exploit scale economies (Banco Votorantim 1995; Vassallo 1996; Raposo 1997).

In the early 1990s, Bradesco Bank emerged as Brazil's dominant financier of automobile engine production, arranging mergers, acquisitions, and joint ventures among engine component makers. Bradesco's internal allocation of capital to its associated companies alleviates malfunctioning capital markets that prevail

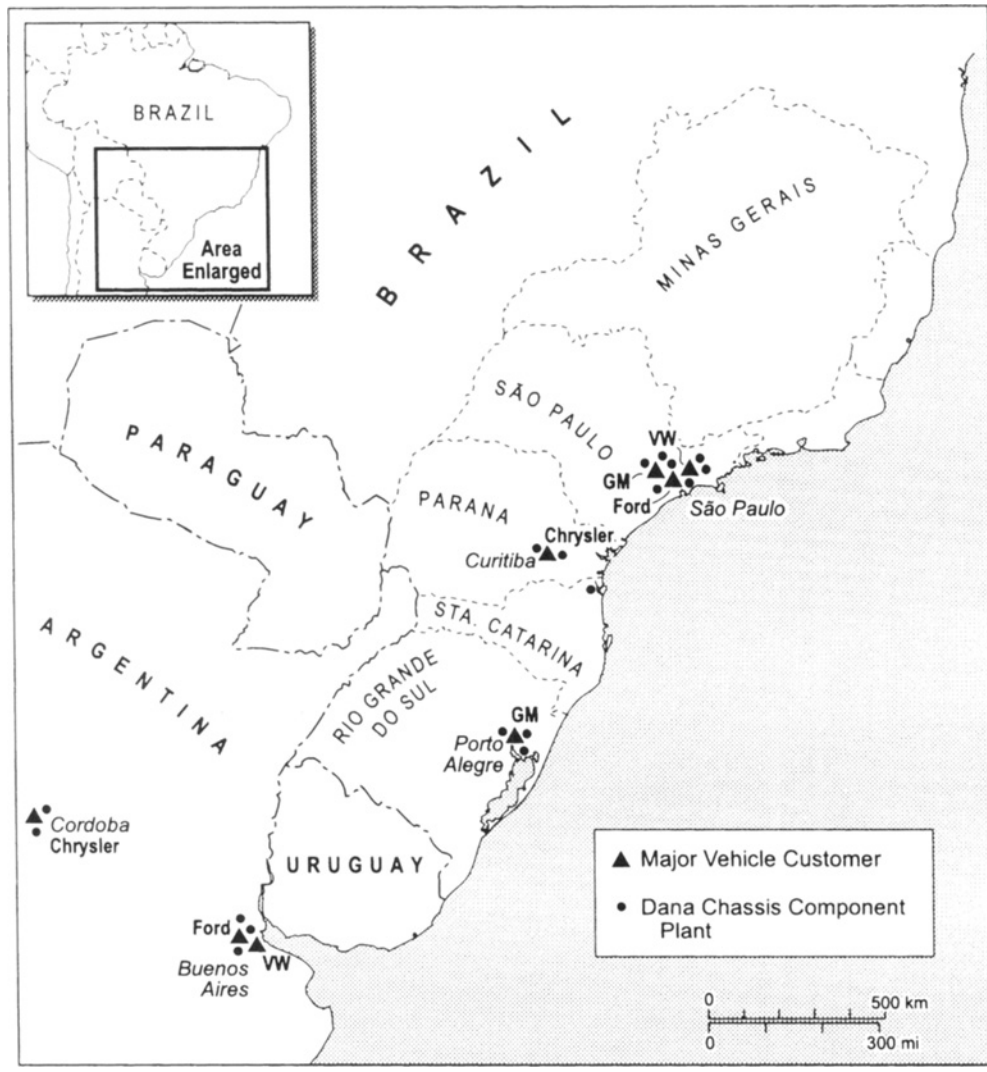

Figure 6. Location of Dana Corporation's parts plants and major vehicle assembly customers. *Sources:* Alessi Filho (1997); Dana (1995, 1996a, 1998).

during Brazil's periods of high inflation. In 1994, Bradesco purchased Tupy, the world's third largest independent metal forger, making fixed engine parts including blocks, cylinder heads, and oil pans (see Fig. 5). Tupy, in turn, bought Mercedes Benz's forging subsidiary, Sofunge, which had supplied Mercedes Benz and Ford (Banco Nacional de Desenvolvimento 1994; Carvalho 1996). Bradesco also bought a 40 percent share of Cofap, South America's largest maker of fixed and moveable engine parts. Cofap supplied many vehicle assemblers with engine blocks and cylinder heads, especially General Motors. Those three acquisitions gave Bradesco control of 80 percent of the output of fixed engine parts produced in Brazil (Banco Nacional de Desenvolvimento 1994).

Bradesco also acquired moveable engine parts production capacity. It bought 15 percent of Metal Leve, Brazil's largest maker of pistons. Bradesco's subsidiary Cofap also produced moveable engine components, especially piston rings. Throughout the 1990s, Bradesco had urged the formation of a joint venture between Metal Leve and Cofap, to make completed engine cylinders (Balbi 1996). Interfirm management conflicts impeded the establishment of that venture. Furthermore, although Metal Leve produced a high-quality product, it failed to exploit economies of scale fully and frequently suffered financial losses (Vassallo 1996). Bradesco eventually financed a complex joint venture with the German pistonmaker Mahle and Cofap to control Metal Leve. The venture enabled Bradesco to eliminate Metal Leve's inefficient management and production practices. With an estimated annual output of $1.5 billion and direct control of 81 percent of all moveable engine parts produced in Brazil, the Metal Leve, Cofap, Mahle venture became, in 1996, one of the world's largest producers of pistons and rings (Vassallo 1996).

Bradesco also bought several engine-related subsystem manufacturers, especially exhaust makers. Catalytic converters are essential to vehicle exhaust systems and are mandatory on all cars produced in Brazil. Without a reliable supply of catalytic converters, Bradesco affiliates could not supply complete exhaust subsystems. Fearing opportunistic behavior by independent producers, Bradesco obtained direct control of exhaust production by purchasing Degussa S.A., a catalytic converter manufacturer (Raposo 1997). It used that acquisition and Cofap's earlier purchase of the exhaust manufacturer Kadron to supply Fiat, General Motors, Ford, and Volkswagen with integrated exhaust system modules. By 1997, the combined outputs of Degussa S.A., Cofap, and Kadron enabled Bradesco to control 50 percent of the Brazilian exhaust system market (Raposo 1997). Finally, Bradesco expanded into fuel control subsystems by purchasing São Paulo–based Brosol—Brazil's only producer of carburetors. The purchase gave Bradesco control of all carburetors made in Brazil.

The mergers, acquisitions, and joint ventures forged by Bradesco linked a geographically extensive group of parts makers throughout São Paulo, Minas Gerais, southern Brazil, and Cordoba, Argentina (see Fig. 7). Cofap and Mahle controlled five piston-ring facilities in São Paulo and one in Minas Gerais. Cofap manufactured exhaust subsystems in São Paulo, Minas Gerais, and in a new plant in Cordoba, Argentina. They produced catalytic converters at Degussa's plants in São Paulo, Parana, and Rio de Janeiro. Tupy and Cofap's foundries made fixed engine parts in Santa Catarina and São Paulo. The campaign of acquisitions, joint ventures, and new plant openings enabled the Bradesco group to supply engines and related systems to assembly plants throughout Brazil and Argentina.

Bodies

Automotive bodies consist of assorted metal, fiberglass, and plastic panels, which with windows, doors, seats, trim, and upholstery enclose a vehicle's passenger, engine, and luggage compartments. The transition to lean production altered the industrial organization of automotive body manufacturing. Similar to the organization of production of most other major subsystems, body parts makers traditionally supplied assemblers with individual components, such as door panels, to mount on the chassis. Vehicle assemblers now require tier one suppliers to develop and deliver integrated body units. Consequently, tier one body suppliers must assemble a variety of individual parts, including bumpers, exterior panels, plastic moldings, interior trim, and lighting (Beck 1989; Banco Nacional de Desenvolvimento 1996a). Although many of those parts are simple, their design and manufacture require substantial technical ability and specialized machinery. Moreover, subsystem assembly

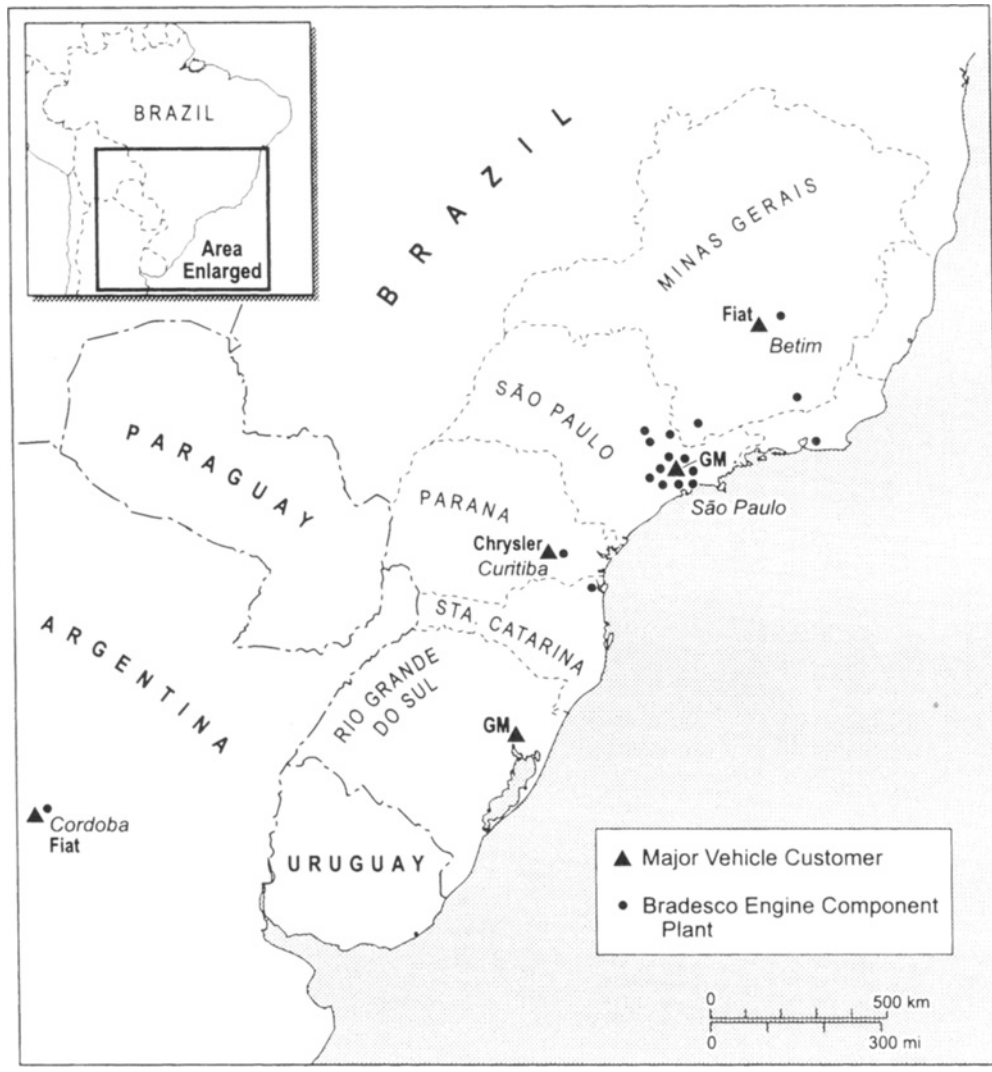

Figure 7. Location of Bradesco Bank's parts plants and major vehicle assembly customers. *Source:* Balbi (1996).

requires close coordination of design and manufacturing as small revisions in the chemical composition of parts can significantly alter the weight and fuel efficiency of vehicles.

First-tier body suppliers faced a daunting transactional environment once Brazil entered the MERCOSUR free trade agreement and launched its Popular Car program. High import tariffs had allowed body part makers to sell low-quality products at prices well above those prevailing outside Brazil. As restructuring commenced and multiple vehicle assemblers rapidly brought many new models to market, each demanded just-in-time delivery of high-quality, low-cost, complex body subsystems. In response, internalization of parts making by tier one suppliers, and not continued reliance on small independent

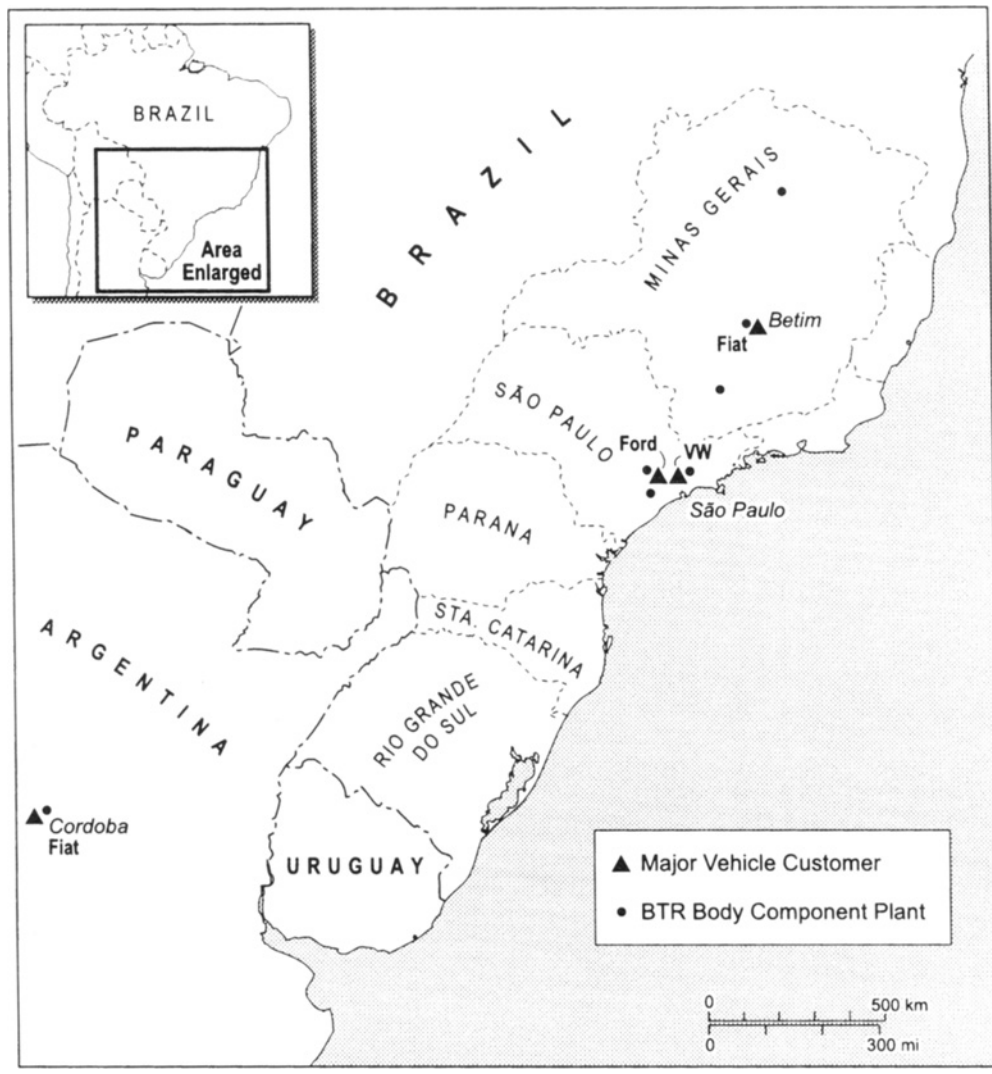

Figure 8. Location of British Tyre and Rubber's parts plants and major vehicle assembly customers. *Sources:* Lacerda (1996); Silveira (1997).

manufacturers, became the favored mode of organization in body production. Through internalization, tier one suppliers coordinate the production of multiple parts, exploit scale economies, and muster sufficient capital to retool production lines and purchase new equipment (Banco Nacional de Desenvolvimento 1996a; Silveira 1997).

The activities of British Tyre and Rubber Corporation (BTR), which emerged as Brazil's dominant body supplier, is instructive in the drive toward increasing vertical integration at the tier one level. BTR's automotive component parts group is among the world's fastest-growing tier one suppliers, with more than $1 billion in annual revenue and 50 facilities worldwide (British Tyre and Rubber 1997). With core skills in the development of engineered polymers, BTR produces the rubber and

plastic components of automotive bodies. To maintain global tier one status, BTR sought to service its customers—especially Volkswagen and Ford—as they expanded in Brazil. By acquiring and modernizing local body parts firms and building greenfield facilities, BTR took direct control of the design, manufacture, and assembly of body subsystems. Although BTR's acquisitions were large firms, each required substantial organizational restructuring and capital inputs to exploit scale economies, improve quality, and lower production costs. BTR doubted those independent subcontractors would make needed investments. Vertical integration gave BTR direct supervision of factory renovations and equipment purchases and the ability to service assemblers in São Paulo, Minas Gerais, and Cordoba (British Tyre and Rubber 1997).

In 1996, BTR acquired the OSA group, Brazil's largest producer of body parts. OSA controlled three subsidiaries: Plascar, Oscar NE, and Plavigor. Plascar manufactured exterior body panels, bumpers, arm and head rests, instrument panels, automotive cloth, and steering wheels (Fig. 5). Oscar NE supplied Plascar with polymers for making body panels, headlights, and electrical wiring (Banco Votorantim 1995; Banco Nacional de Desenvolvimento 1996a). Plavigor, which was bought by Plascar in 1994, produced instrument panels and interior cloth trim. The acquisition gave BTR control over OSA's existing production contracts and manufacturing facilities in São Paulo and Minas Gerais. OSA owned two factories in São Paulo, which manufactured steering wheels, bumpers, and body panels for Ford and Volkswagen. OSA also owned three facilities in Minas Gerais, all near Fiat: a polymer processor, a dashboard and body panel factory, and an interior trim plant. A second strategic acquisition in 1996 gave BTR control of Carto in São Paulo, Brazil's largest manufacturer of vehicle illumination systems—headlights, tail lights, wires, and fuses (Banco Nacional de Desenvolvimento 1996a; British Tyre and Rubber 1996; Silveira 1997).

With that substantial manufacturing base, BTR won several large subsystem supply contracts. In 1996, BTR built a new facility in Minas Gerais to supply Fiat's Popular Cars with instrument panels, door panels, and bumpers. BTR built a similar facility in Cordoba, Argentina. BTR also produces integrated body units for Ford, inside that firm's São Paulo assembly plant ("Fiat Lançar o Palio mille em 30 dias" 1996; Pereira 1997; Lacerda 1996; Silveira 1997). The integration of body part making and subsystem assembly enabled BTR to penetrate the Brazilian automotive body component market and to serve multiple assembly plants both in São Paulo and in the fast-growing automobile regions of Brazil and Argentina. By 1996, BTR's combined holdings controlled 60 percent of the total Brazilian output of exterior panels, 60 percent of bumpers, 40 percent each of steering wheels and interior trim, and 80 percent of vehicle illumination (Banco Nacional de Desenvolvimento 1996a).

Conclusions

Brazil's automobile industry provides an opportunity to investigate the related effects of adoption of neoliberal trade policies and flexible industrial systems on the location and organization of manufacturing. The government revitalized this ailing industry by reducing sales taxes on cars and cutting import tariffs on component parts, vehicles, and manufacturing equipment. Those collective actions—the Popular Car program and the MERCOSUR trade agreement—significantly reduced the price of new cars and stimulated demand. To make their operations more flexible, vehicle assemblers restructured existing facilities in São Paulo and built new plants in emerging automobile complexes in southern Brazil and northern Argentina. Production of inexpensive cars required significant reductions in manufacturing costs. Building greenfield plants, modernizing existing facilities, adopting lean meth-

ods of production, and shifting production to low-wage locations were pivotal in successfully reviving vehicle assembly.

As reforms took hold, most vehicle assemblers subcontracted parts production to selected tier one suppliers. The latter assumed an active role in the design, manufacture, assembly, and delivery of complex component subsystems and in the management of subordinate tiers of parts makers. Traditionally, Brazilian component firms produced low-quality and expensive products. Tier one suppliers risked delivering shoddy subsystems to assemblers and significant cost overruns if they continued to rely on local component firms. Internalization of parts production and subsystem assembly enabled first-tier suppliers to guarantee quality, safeguard proprietary designs and manufacturing technologies and to exploit scale economies. By buying existing parts companies and building new production facilities, tier one suppliers supplanted a large network of small suppliers who thrived in a previously protected market.

The rise of large tier one parts suppliers in Brazil contests the notion that subcontracting by vehicle assembly firms is the only form of vertical reorganization occurring in automobile production chains. Furthermore, the mass manufacturing of large batches of parts and subsystems shows that economies of scale remain a dominant force in the automobile industry. And consolidation of parts companies reveals that the control of multinational firms strengthened, not eroded. As restructuring commenced in Brazil, first-tier suppliers located facilities near new vehicle assembly plants in Minas Gerais, southern Brazil, and northern Argentina. They also invested in São Paulo, the traditional heart of Brazil's industry, to serve expanding assembly facilities. Tier one suppliers in Brazil are integrated in global networks of parts production, assembly, and delivery. Dana Corporation and British Tyre and Rubber design, manufacture, assemble, and deliver vehicle subsystems to assembly plants in North America, Europe, Asia, and Latin America. Bradesco's case shows that domestic firms in emerging markets can penetrate the first tier through acquisitions of local companies and joint ventures with international suppliers.

The transaction cost theory of the firm provided a useful conceptual framework for interpreting the recent restructuring we observed. Domestic component firms developed behind high trade barriers, allowing small inefficient manufacturers to flourish. We showed that, in the manufacturing of chasses, engines, and bodies, many small parts companies were bought by large subsystem assemblers. Motivations driving the first-tier companies to internalize component making included a resolve to deter subcontractors from divulging highly specific subsystem designs to rivals, a lack of confidence in the restructuring ability of small inefficient local parts companies, and a need to exploit mass manufacturing for scale economies. Some Brazilian parts firms used partial integration or joint ventures with large tier one companies to protect their direct access to assemblers. They avoided sinking to second-tier status, with the consequent risk of restricted access to information on technological and market directions in vehicle assembly.

The early 1990s was a period of substantial restructuring in the Brazilian automotive industry. Here we emphasized the effects on organization and location of a loosening of governmental control, although Brazil still implements industrial policies that encourage regional development. Recent legislation seeks to create new automotive assembly and component parts complexes in the less-developed northern states. Whether those policies encourage the development of both assembly and parts facilities or *maquiladora*-style assembly plants without local component production is uncertain. Subsidies favor vehicle assembly and provide few inducements to component makers ("Brasil deverá renovar cotas para carros" 1997). Future comparison of the heavily subsidized northern region with the less-regu-

lated southern complex will further our understanding of the role governments play in the ongoing vertical integration, disintegration, and reintegration of industrial systems.

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