

LATIN AMERICA: HIGH-TECH MANUFACTURING ON THE RISE, BUT OUTPACED BY EAST ASIA

by Derek Hill

The global market for high-technology goods—aircraft, pharmaceuticals, communications equipment, and computer and office machinery¹—has been growing rapidly and is a key sector driving worldwide economic growth.² Over the last two decades, high-tech manufacturing has grown in importance in the United States, Western Europe, Japan, and—more recently—the newly industrialized economies (NIEs) of East Asia.³ Since these industries have become an important source of growth, a key question is whether other developing and emerging countries can harness them to foster their growth. This InfoBrief examines high-tech production and trade trends in seven Latin American countries. These countries accounted for 85 and 90 percent, respectively, of economic output and research and development expenditures in Latin America in 1996.⁴

¹The Organization for Economic Co-operation and Development has identified these industries as high technology based on the high ratios of research and development expenditures associated with their production. Communications equipment consists of conventional and cellular telephones, radio, TV, and other types of communications equipment.

²National Science Board, *Science and Engineering Indicators—2002*, NSB-02-1 (Arlington, VA: National Science Foundation), p. 6-6.

³The NIEs consist of Hong Kong, Singapore, South Korea, and Taiwan.

⁴Source: Share of economic output is from the World Bank, *World Bank Development Indicators 1998*. Share of research and development expenditures is from National Science Foundation, *Latin America: R&D Spending Jumps in Brazil, Mexico, and Costa Rica*, NSF 00-316 (Arlington, VA: National Science Foundation).

Manufacturing

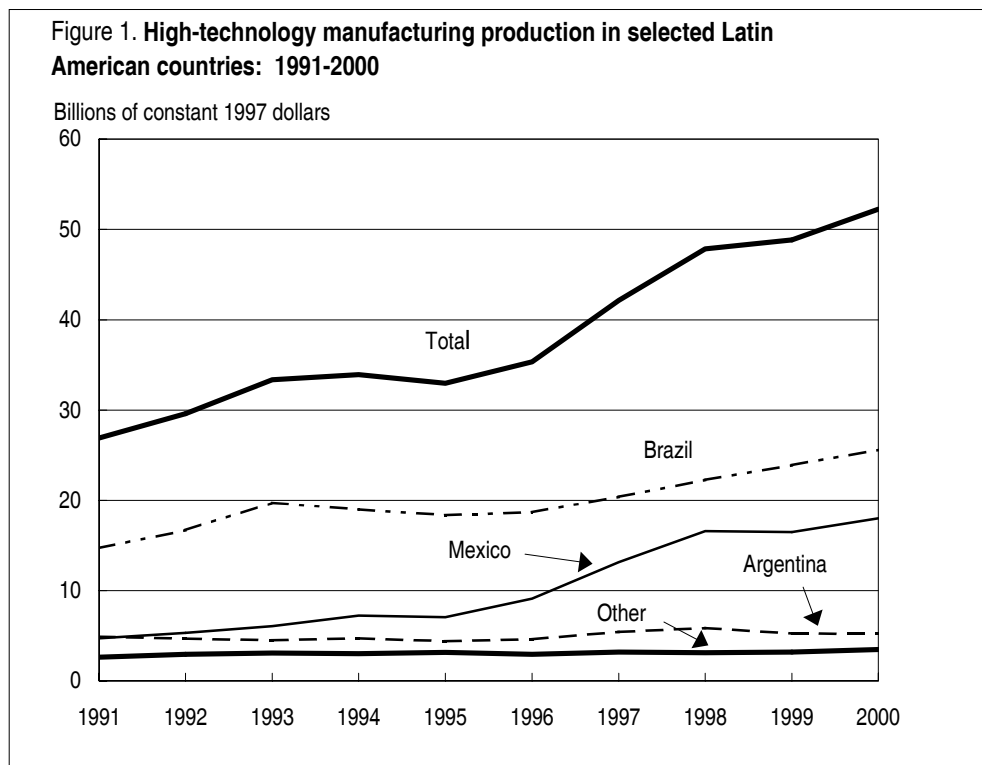
High-tech manufacturing grew substantially over the last decade in Latin America. The combined production of seven Latin American countries—Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico, Venezuela—increased 93 percent between 1991 and 2000, rising from \$27 billion to \$52 billion (figure 1).⁵ This increase was lower, however, than growth in worldwide production, which rose by 107 percent over the same period. Nevertheless, high-tech manufacturing in Latin America has become an increasingly important source of economic growth. By 2000, high-tech manufacturing accounted for 6 percent of total manufacturing production in the seven countries, nearly 50 percent greater than in 1991.

High-tech manufacturing grew substantially over the last decade in Latin America.

The rapid growth in high-tech manufacturing occurred as many Latin American countries opened their economies to trade and foreign investment and privatized their state-owned enterprises to spur economic growth. This

⁵Production is defined as shipments by companies where their primary activity is manufacture of high-tech goods. Exports are company-level shipments of high-tech goods bound for export. Imports consist of company-level imports of goods and components. All monetary values cited in this InfoBrief are in 1997 constant dollars unless otherwise noted. Source: DRI-WEFA World Industry Monitor, World Industry Service database, October 2001. Data for 1991–98 are actual; 1999–2000 data were estimated by DRI-WEFA using actual macroeconomic and aggregate manufacturing data.





NOTES: Production data are company level shipments of goods by firms whose primary activity is the manufacture of aircraft, pharmaceuticals, communications equipment, or computer and office machinery. "Other" consists of Chile, Colombia, Costa Rica, and Venezuela. Data for 1991-1998 are actual figures; 1999-2000 are estimated.

SOURCE: DRI-WEFA World Industry Monitor, World Industry Service database, October 2001

approach was a departure from largely unsuccessful government initiatives in the 1970s and 1980s that developed indigenous high-tech industries protected from foreign competition.⁶

The liberalization of trade and investment resulted in a swift rise in foreign direct investment (FDI) to the entire region, which increased from \$11 billion in 1991 to \$67 billion in 2000. Brazil and Mexico have been the largest recipients of FDI in the region and accounted for an estimated 60 percent of total FDI to the region in 2000. After opening up their manufacturing sectors in the early 1990s, these countries shifted to liberalizing

⁶Argentina, Brazil, Mexico, and Venezuela developed industries in nuclear energy, telecommunications, petrochemicals, computers, microelectronics, and biotechnology. See United Nations University (INTECH), *Innovation Systems and Technological Specialization in Latin America and the Caribbean*, December 1995 (United Nations University/Institute for New Technologies).

and privatizing their service industries, including banking, utilities, and retail. Accordingly, FDI has shifted into services and away from manufacturing. In Brazil, the manufacturing sector received 24 percent of the estimated \$30 billion in FDI in 2000 compared to 55 percent of total FDI in 1995. In Mexico, manufacturing received 46 percent of the estimated \$11 billion in FDI in 2000 compared to 61 percent during the 1995-99 period.⁷

Argentina, Brazil, and Mexico dominate high-tech manufacturing in Latin America, accounting for over 90 percent of total high-tech production in 2000 for the seven Latin American countries examined. Brazil had the highest share (49 percent), followed by Mexico (34 percent) and Argentina (10 percent) (figure 1). As a

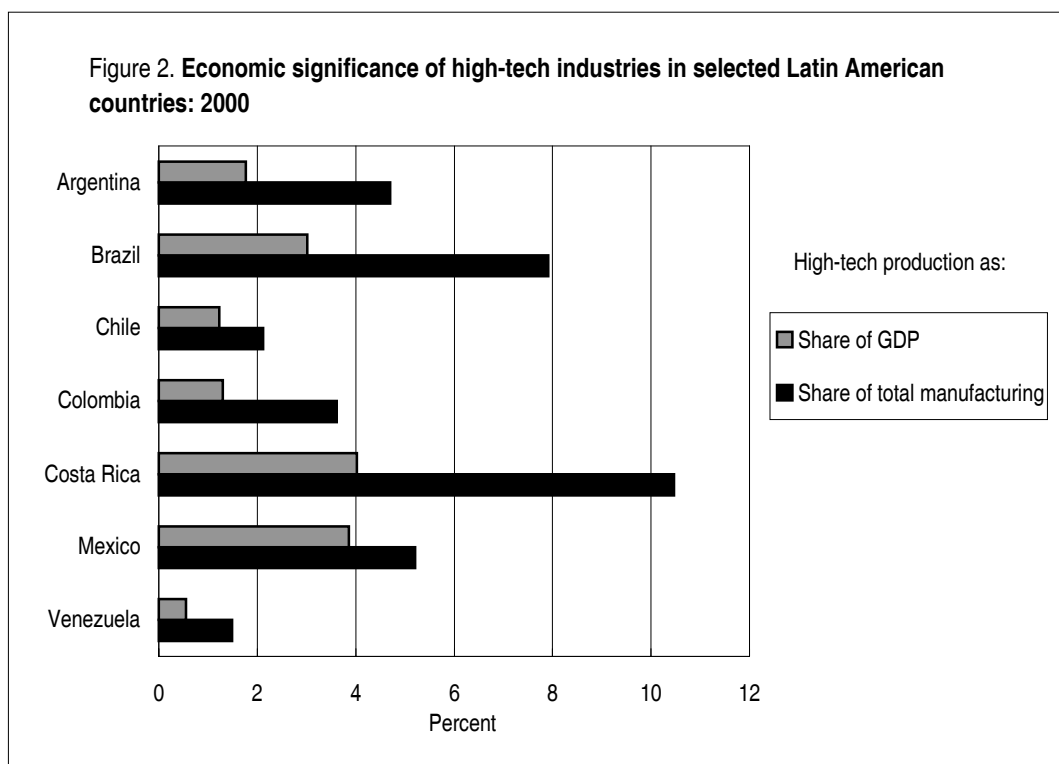
⁷United Economic Commission for Latin American and the Caribbean (ECLAC), *Foreign Investment in Latin America and the Caribbean, 2000*, LC/G.2125/P (United Nations: Santiago, 2001).

share of the entire manufacturing sector, however, high-tech manufacturing was most prominent in Costa Rica in part due to Intel's establishment of a semiconductor plant (figure 2). This contributed to Costa Rica having the highest ratio of R&D spending to gross domestic product (GDP) in Latin America.⁸

The pharmaceuticals industry accounts for the largest share of total high-tech production in Latin America; over the 1991–2000 period, production rose 40 percent to reach an estimated \$18.6 billion in the seven countries (figure 3). Argentina, Brazil, and Mexico together accounted for 86 percent of production of the seven countries in this sector, and growth in the latter two countries was very rapid over the decade. The Latin American pharmaceuticals market is dominated

by multinational companies based in Europe and North America, including Glaxo Wellcome, Pfizer, and Roche; such entities account for 9 of the top 10 companies in the region.⁹ Ache Laboratories, a company based in Brazil, is the only regional company in the top 10. Local firms may, however, have greater presence in individual country markets, partly because patent laws in many Latin American countries permit local companies to produce generic versions of drugs produced by multinationals.¹⁰

The next largest high-tech sector—communications equipment—had estimated production of \$17.3 billion in 2000, a 48 percent increase over the 1991 level. Argentina, Brazil, and Mexico are key producers in this industry; in 2000, they accounted for 96 percent of the



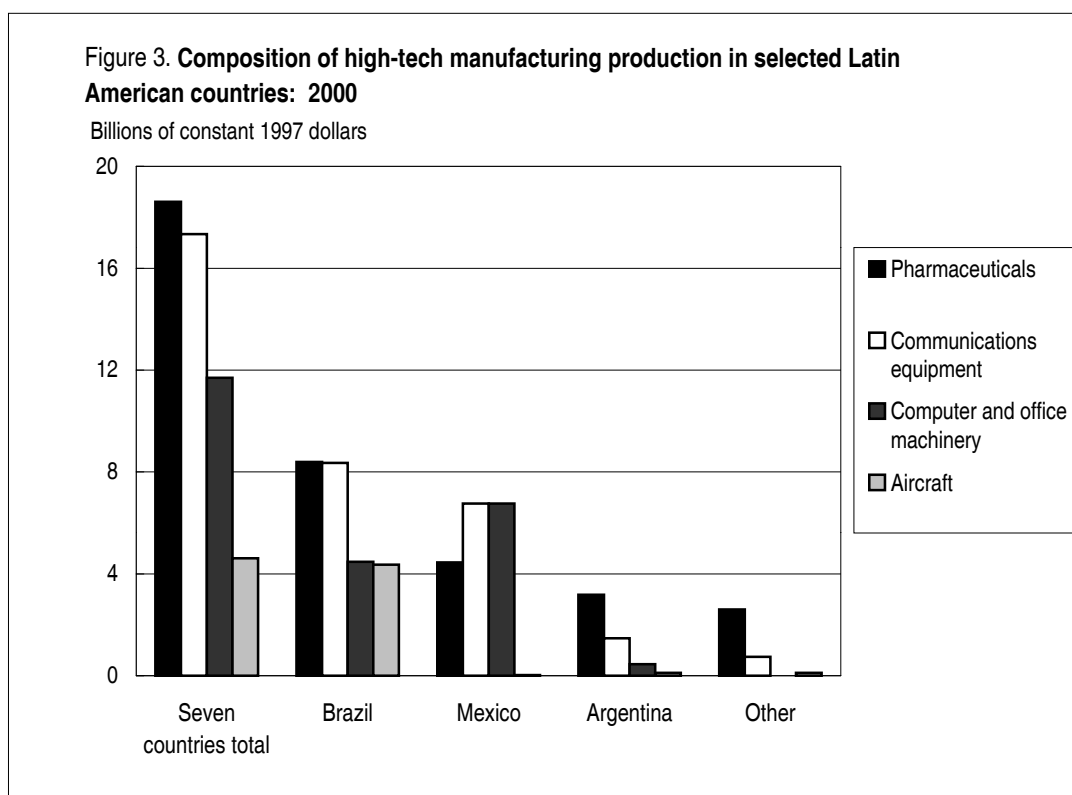
NOTE: High-tech manufacturing data are estimated; gross domestic product (GDP) and manufacturing data are actual. All data are in terms of 1997 constant dollars.

SOURCE: DRI-WEFA World Industry Monitor, World Industry Service database, October 2001.

⁸National Science Foundation, *Latin America: R&D Spending Jumps in Brazil, Mexico, and Costa Rica*, NSF 00-316 (Arlington, VA: 2000).

⁹IMS HEALTH, "Vigorous Growth Returns to Latin America," <http://www.ims-global.com/insight/news_story/0103/news_story_010315.htm>, 2001. Market share and firm data are based on sales in Argentina, Brazil, Chile, Colombia, Mexico, and Peru.

¹⁰IMS HEALTH (2001).



NOTES: Data are estimated. "Other" consists of Chile, Colombia, Costa Rica, and Venezuela.

SOURCE: DRI-WEFA World Industry Monitor, World Industry Service database, October 2001.

industry's combined production in the seven Latin American countries examined. Multinationals, notably Motorola, General Electric, Nippon, Sony, and Philips, have a dominant presence in this market with combined sales in the region of \$11.8 billion in 1999, of which 98 percent were in Brazil and Mexico.¹¹

Although it is not Latin America's largest high-tech industry, computer and office machinery grew more rapidly than pharmaceuticals or communications equipment during this period. Production increased from \$1.7 billion to an estimated \$11.7 billion during the 1991–2000 period—a more than sixfold rise. This growth was driven by Mexico and Brazil, which together accounted for an estimated 96 percent of this industry's total seven-country production in 2000. Mexico's gain in computers was especially remarkable, with production increasing by \$6.5 billion since 1991 to reach an estimated \$6.8 billion in 2000. Multinationals also have a significant presence in this sector, including IBM,

¹¹ECLAC (2000).

Intel, Hewlett Packard, Compaq, and Xerox, which had combined sales in 1999 of \$14.5 billion in the region. Brazil and Mexico were the biggest markets for these companies, accounting for \$10.8 billion in sales in 1999.¹²

The factors behind the rapid growth of Mexico's computer industry include preferential trade access and close geographical proximity to the United States market, an inexpensive labor force, and changes in business production. Mexico's preferential trade access to the United States has been through two key agreements, the U.S. Mexican Maquiladora¹³ (twin plant, or production sharing) Program, and, more recently, the North American Free Trade Agreement (NAFTA) signed in 1994. These agreements

¹²ECLAC (2000).

¹³This program allows Mexican or foreign subsidiary firms duty-free import of raw materials and inputs from the United States. The finished products are exported back to the United States, where duty is paid only on the Mexican/foreign value added of the product.

encouraged the United States and other multinationals to set up intermediate (maquiladora) and final production plants to take advantage of lower U.S. tariffs. Meanwhile, corporate strategies by the United States and other foreign companies evolved to meet real-time demand and resulted in computer companies outsourcing their manufacturing activities to concentrate exclusively on R&D in their home countries.¹⁴ According to the U.S. Census Bureau's Foreign Trade Division, U.S. imports of information (computer and telecommunication) products from Mexico rose from \$0.7 million to \$7.3 billion between 1990 and 1999.

The aircraft sector had the smallest share of total high-tech production in Latin America (9 percent) but experienced explosive growth in production, rising from \$0.2 billion in 1991 to an estimated \$4.6 billion in 2000. A Brazilian company, Embraer, accounted for virtually all production in Latin America and has had worldwide success with its short-haul commercial airplane and military aircraft.¹⁵ Embraer originated as a heavily subsidized public venture that successfully transitioned to a world class company.¹⁶ Three key factors appear

to underlie its success—close ties to and reliance on research and trained graduates from public institutions, focus on export markets, and adept use of government finance.¹⁷

Trade

Over the 1991–2000 period, two-way high-tech trade in the seven Latin American countries expanded by more than \$70 billion, rising from \$15.4 billion to \$85.6 billion (table 1).¹⁸ High-tech manufacturing has become more reliant on trade than other manufacturing industries, as measured by trade intensity (the combined value of exports and imports as a share of production). In 2000, trade intensity in high-tech manufacturing was more than 150 percent compared to 62 percent in the entire manufacturing sector. However, Mexico skews these results; trade intensity is considerably less excluding Mexico, although the pattern of greater intensity in high-tech relative to overall manufacturing (87 percent versus 51 percent) holds for the other six countries.

Several distinct patterns of high-tech trade emerged in Latin America during the 1991–2000 decade (table 1).

Table 1. Latin American trade by high-technology industries: 1991, 1995, and 2000

Country	1991			1995			2000		
	Exports	Imports	Trade balance	Exports	Imports	Trade balance	Exports	Imports	Trade balance
Billions of constant 1997 dollars									
Total.....	0.90	14.53	-13.62	11.97	24.12	-12.15	40.13	45.43	-5.29
Argentina.....	0.22	1.17	-0.95	0.36	2.58	-2.22	0.38	4.76	-4.39
Brazil.....	0.25	4.29	-4.04	1.06	6.96	-5.90	5.22	9.84	-4.62
Chile.....	0.02	0.93	-0.92	0.36	1.56	-1.20	0.12	2.58	-2.47
Colombia.....	0.03	0.59	-0.56	0.28	1.73	-1.45	0.29	2.16	-1.88
Costa Rica.....	0.03	0.18	-0.16	0.05	0.27	-0.22	1.24	1.00	0.25
Mexico.....	0.37	6.57	-6.20	9.85	10.18	-0.33	32.83	23.16	9.67
Venezuela.....	0.00	0.80	-0.80	0.02	0.85	-0.83	0.07	1.93	-1.86

NOTES: 2000 data are estimated. High-technology industry trade consists of trade by firms whose primary activity is aircraft, pharmaceuticals, communications equipment, or computer and office machinery. These data are collected on an industry basis and are not comparable with trade data collected on a product basis.

SOURCE: DRI-WEFA World Industry Monitor, World Industry Service.

¹⁴ECLAC (2001).

¹⁵The Industry Standard, "Embraer-Empresa Brasileira de Aeronautica S.A.," <<http://www.thestandard.com/companies/dossier/0,1922,265282,00.html>>

¹⁶The Brazilian government holds a 40 percent stake in the company.

¹⁷The World Bank, *National Systems Supporting Technical Advances in Industry: The Brazilian Experience*, June 1990, Industry and Energy Department Working Paper No. 32.

¹⁸These data, which are collected on a company-level basis, are not comparable to trade data collected on a product basis.

- Argentina, Chile, Colombia, and Venezuela are primarily importers of high-tech goods, and they increased their reliance on imports during this period.
- Brazil was also a net importer during this period, but its trade intensity is much lower relative to other Latin American countries. Brazil's large domestic market and its indigenous capability in some areas, such as aircraft, would be consistent with its more limited reliance on trade.
- Mexico and Costa Rica shifted from net importers to net exporters of high-tech goods during this period:
 - The factors driving Mexico's success in computers were also important for its success in other areas of high-tech trade. The country's high-tech exports increased from less than \$400 million in 1991 to nearly \$33 billion in 2000—by which time, they accounted for more than 80 percent of total high-tech exports from these seven Latin American countries. However, Mexico's export success may have limited impact on the domestic economy since the maquiladoras and final assembly plants at the U.S. border are weakly linked and geographically isolated from the domestic economy.¹⁹
 - In the case of Costa Rica, several key factors were crucial for the decisions of Intel and others to invest: the government's liberalization of trade and investment, political stability, geographical proximity to the United States, and a highly educated workforce and good education system relative to other Latin American countries.²⁰

¹⁹United Nations University (INTECH), *Innovation Systems and Technological Specialization in Latin America and the Caribbean*, December 1995 (United Nations University/Institute for New Technologies), pp. 9-10.

²⁰World Bank, "Education: The People's Asset" <http://wbln0018.worldbank.org/Networks/ESSD/icdb.nsf/D4856F112E805DF4852566C9007C27A6/7EBFB3F9299C29D9852567FD0062CD97>, July 14, 1998, prepared for an International conference on poverty and growth. Intel's decision to establish its semiconductor plant was based in part on these factors. See "Big Trading, little countries," http://www.gbwnet/content/Articles/World_Trade_Magazine/12-97/big_trading_lit.

The United States was the primary recipient and beneficiary of the expansion in Latin America high-technology trade. According to data from the OECD, the share of U.S. high-tech manufacturing imports from Argentina, Brazil, and Mexico nearly doubled, rising from 5.3 percent in 1991 to 10 percent, amounting to \$19.3 billion in 1998 (table 2).²¹ Similarly U.S. exports of these goods to these Latin American countries rose rapidly from \$6.9 billion in 1991 to \$20.6 billion, accounting for nearly 11 percent of U.S. high-tech exports in 1998. Costa Rica also has become a significant trader with the United States, with exports of high-tech goods to the United States amounting to \$3.2 billion in 1999.²² In addition to its major trade ties, the United States is also a key investor in the region. In 2000, U.S. FDI in the Latin American manufacturing sector was \$2.9 billion, 7 percent of a total worldwide \$41.9 billion for this sector.²³

In contrast to the United States, high-tech exports from Argentina, Brazil, and Mexico made little headway in Western Europe or Japan. Their exports remained below 0.5 percent of the share of combined high-tech imports of six major Western European economies—the United Kingdom, Germany, France, Italy, Spain, and the Netherlands. Spain was the only country where the import share of the three Latin American countries increased, rising from 0.4 percent to 1.2 percent between 1991 and 1998. However, the dollar value of exports was small, amounting to less than \$200 million in 1998.

Comparison with Emerging Economies

Despite the dynamism of high-tech manufacturing industries in Latin America, they were outperformed during the 1990s by East Asian economies. In Asia's combined NIEs production rose by an average of 15 percent per year between 1991 and 2000. In other emerging Asian economies—China, Indonesia, Malaysia,

²¹OECD International Trade by Commodity Statistics, April 2000. Data are in nominal dollars.

²²Source: U.S. Bureau of the Census, Foreign Trade Division, Washington, DC. Trade data are on a product basis and are not comparable to WEFA or OECD trade data, which are on an industry basis.

²³Source: U.S. Bureau of Economic Analysis, U.S. Direct Investment Abroad, June 2001. Data are in terms of 1997 constant dollars estimated from nominal figures.

Table 2. High-tech manufacturing imports by United States, Western Europe, and Japan from three Latin American and seven East Asian countries: 1991 and 1998

Importing country/region	Exporting region			
	Latin America		East Asia	
	1991	1998	1991	1998
United States				
Billions of dollars.....	4.6	19.3	29.0	86.2
Import share (percentage)....	5.3	10.0	33.5	44.6
Western Europe				
Billions of dollars.....	0.5	1.0	17.1	46.5
Import share (percentage)....	0.3	0.4	10.4	16.9
Japan				
Billions of dollars.....	0.2	0.2	4.8	20.3
Import share (percentage)....	0.8	0.4	23.5	42.2

NOTES: Latin America consists of Argentina, Brazil, and Mexico. Asia consists of China, Hong Kong, Indonesia, Malaysia, Philippines, South Korea, Singapore, Taiwan, and Thailand. Western Europe consists of United Kingdom, France, Germany, Italy, Spain, and Netherlands. High-tech trade data are derived from product trade data classified into industry classifications.

SOURCE: OECD International Trade by Commodity Statistics, April 2000.

Philippines, and Thailand—production rose at the same average rate as the NIEs. Comparable annual growth in Latin America was just 7 percent. Moreover, high-tech industries play a significantly larger role in Asian economies, accounting for 31 and 11 percent, respectively, of overall manufacturing in the NIEs and the other emerging Asian economies. Another difference is that communications equipment and office and computer machinery are far more prominent in the Asian countries than in Latin America as a share of high-tech and overall manufacturing.²⁴ In trade, the NIEs, China, Indonesia, Malaysia, Philippines, and Thailand, were far more successful in increasing their market share with substantial gains in their share of exports to the United States, Western Europe, and Japan. The collective market share of these nine Asian countries rose from 10 percent in 1991 to 17 percent of Western European imports, or \$46.5 billion in 1998

²⁴In the emerging Asian economies, computer and office machinery and communications equipment comprise 87 and 10 percent, respectively of high-tech and overall manufacturing in 2000. High-tech manufacturing has higher shares in the NIEs. In contrast, the share in Latin America is 57 and 3 percent, respectively.

(table 2). High-tech exports from East Asian countries greatly increased their presence in Japan, with their share of Japanese high-tech imports rising from 23 percent in 1991 to 42 percent in 1998.

Latin America's performance was more comparable to three emerging countries outside of East Asia—India, Poland, and South Africa. Their high-tech manufacturing accounts for 4-6 percent of their total manufacturing production, a level of intensity roughly similar to most Latin America countries. The pharmaceutical industry in these countries is the dominant industry in high-tech production as it is in Latin America. High-tech production in India and Poland grew rapidly during 1991-2000, increasing at an average annual rate of 11 percent, higher than Latin America but lower than the growth rate in East Asia. In trade with industrialized countries, India and Poland increased their share of imports in Western Europe but did not gain market share in Japan or the United States.

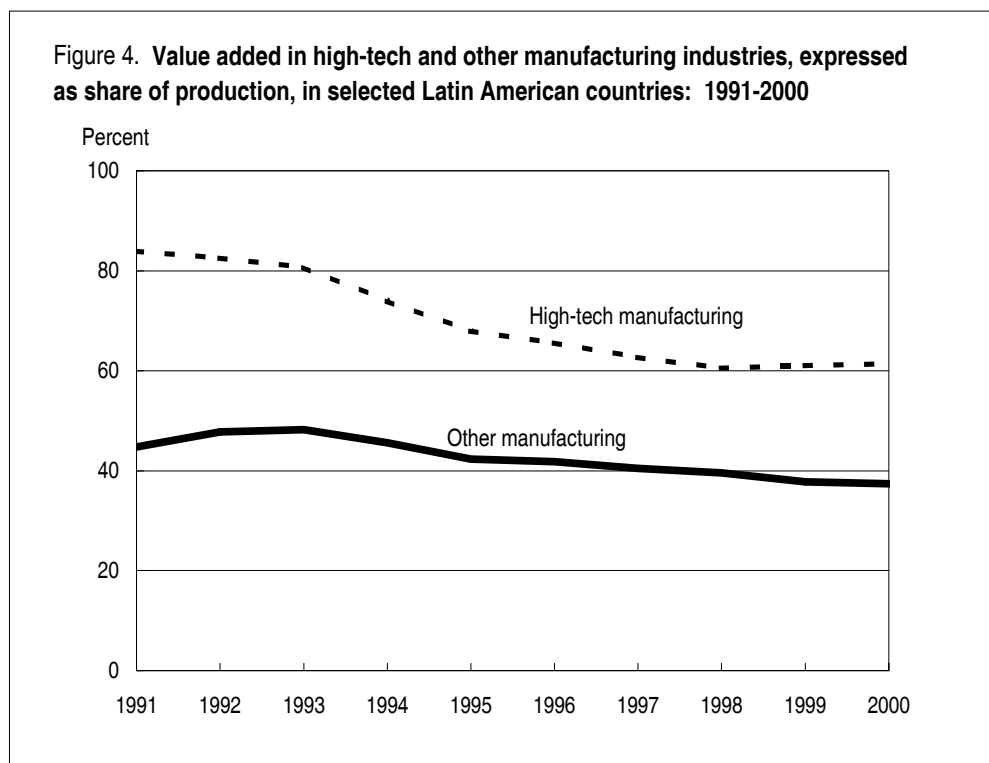
Future Prospects

Latin American countries, particularly Brazil, Costa Rica, and Mexico have made important strides in production and trade in high-technology manufacturing. These industries have become an important source of economic growth. High-tech manufacturing is associated with benefits such as innovation, higher value added production,²⁵ success in foreign markets, and spillover effects for other sectors of the economy. For example, these industries have a higher value added (as share of production) compared to the other manufacturing industries in most countries though the share fell in the 1990s (figure 4). Moreover, these industries may help support higher compensation to the workers they employ, and foreign-owned industries may be an important source of technology transfer that could bolster indigenous capability.²⁶

The crucial issue is whether these countries can continue to consolidate their progress and compete successively in the world market. Economic liberalization appears to have been a major factor in stimulating foreign investment into high-tech manufacturing, which has been the prime

²⁵Value added is the value of final production less the value of purchased inputs used in the production process.

²⁶National Science Board, *Science and Engineering Indicators—2000*, NSB-00-1 (Arlington, VA: National Science Foundation), p. 7-5.



NOTES: Value added is the value of final production less the value of purchased inputs used in the production process. Value added and production are aggregated across six countries, Argentina, Brazil, Chile, Colombia, Costa Rica, and Mexico. Value added and production data for high-tech and other manufacturing are estimates provided in the source data. High-technology consists of firms whose primary activity is manufacture of aircraft, pharmaceuticals, communications equipment, or computer and office machinery.

SOURCE: DRI-WEFA World Industry Monitor, World Industry Service database, October 2001.

driver of production. However, future success may hinge on factors such as political stability, access to capital, and infrastructure and institutions that can support technological and economic development. A set of four leading indicators designed to project future export potential in high-technology manufacturing provides a means of assessing the prospects of Latin American countries compared with other economies such as those of Asia.²⁷ According to these indicators, Argentina, Mexico, and Venezuela generally scored

²⁷Alan L. Porter, J. David Roessner, Nils Newman, and Xiao-Yin Jin, *Indicators of Technology-Based Competitiveness of Nations, Summary Report*, prepared for the National Science Foundation under Purchase Order No. BO4841X-00-0 (Atlanta: Georgia Institute of Technology, 2000). The four leading indicators are national orientation, socioeconomic infrastructure, technological infrastructure, and productive capacity. For more information on the composition of these indicators, see National Science Board, *Science and Engineering Indicators—2002*, NSB-02-1 (Arlington, VA: National Science Foundation), Appendix table 6-8.

lower than East Asian and other emerging economies, primarily in terms of government policy and entrepreneurship (components of “national orientation”) and the quality of skilled labor and local suppliers (components of “productive capacity”).²⁸ Brazil, with higher scores on these indicators, ended up with a rating comparable to that of other emerging economies. Mexico’s relatively low ratings, both within the Latin American countries and compared to other emerging economies, suggest that it could face challenges in sustaining its progress.

²⁸The electronics industry is far more prominent in Asia than in Latin America, which may skew the comparisons because electronics production is a key component of “productive capacity.”

Table 3. Indicators of technological competitiveness: 1999 (index)

Region/country	National orientation	Socioeconomic infrastructure	Technological infrastructure	Productive capacity
Latin America				
Argentina.....	41.3	53.3	27.5	31.0
Brazil.....	61.5	49.1	40.4	39.6
Mexico.....	41.8	40.4	21.8	24.8
Venezuela.....	39.8	49.4	21.3	24.3
East Asia				
China.....	65.3	52.4	46.4	41.9
Indonesia.....	53.9	43.8	19.2	23.7
Malaysia.....	69.5	58.9	31.9	44.1
Philippines.....	60.9	63.7	24.4	42.6
South Korea.....	74.9	73.5	44.6	48.8
Thailand.....	50.7	46.5	20.5	30.6
India.....	67.7	48.4	46.8	51.3
Poland.....	69.6	58.4	38.2	44.3
South Africa.....	50.2	53.6	40.5	28.7

NOTES: National orientation provides evidence that a nation is taking direct action to achieve technological competitiveness. Socioeconomic infrastructure assesses the social and economic institutions that support a modern technology-based industrial nation. Technological infrastructure assesses the institutions and resources that contribute to high-technological development. Productive capacity assesses the level and efficiency of physical and human resources devoted to manufacturing. For more information on the composition of the indicators, see National Science Board, *Science and Engineering Indicators --2002*, NSB-02-1 (Arlington, VA: National Science Foundation), Appendix table 6-8.

SOURCE: Alan L. Porter, J. David Roessner, Nils Newman, and Xiao-Yin Jin, Indicators of Technology-Based Competitiveness of Nations, Summary Report, report to the National Science Foundation under purchase order no. BO4841X-00-0 (Atlanta: Georgia Institute of Technology, 2000).

RETURN THIS COVER SHEET TO ROOM P35 IF YOU DO NOT WISH TO RECEIVE THIS MATERIAL , OR IF CHANGE OF ADDRESS IS NEEDED , INDICATE CHANGE INCLUDING ZIP CODE ON THE LABEL. (DO NOT REMOVE LABEL).

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE \$300

NATIONAL SCIENCE FOUNDATION
ARLINGTON, VA 22230

NSF 02-331

**PRESORTED STANDARD
POSTAGE & FEES PAID
National Science Foundation
Permit No. G-69**