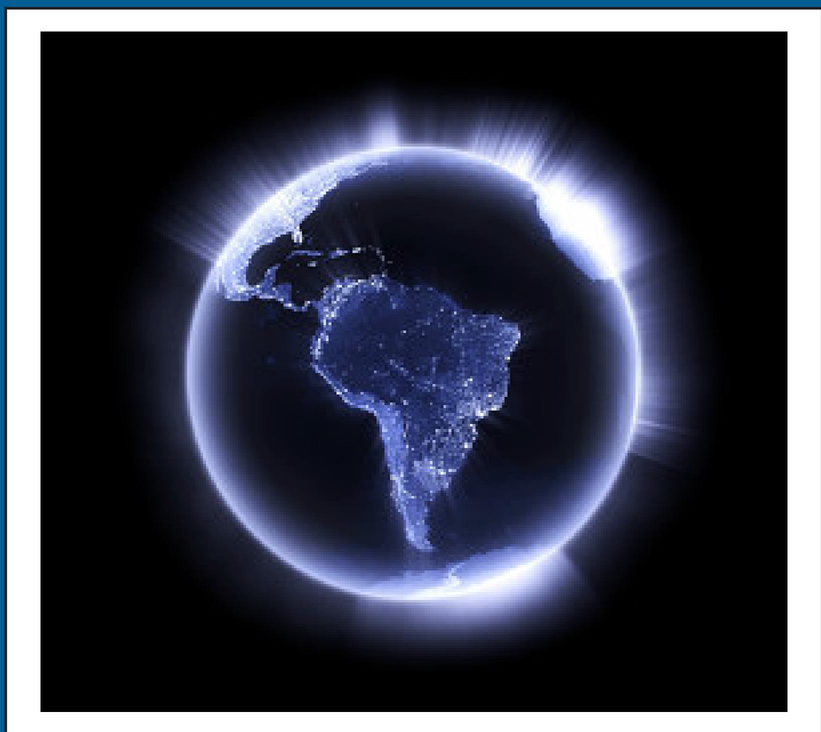
BRAZILIAN MANUFACTURING IN INTERNATIONAL PERSPECTIVE:

A Global Value Chain Analysis of Brazil's Aerospace, Medical Devices, and Electronics Industries

September, 2013

Prepared for Brazil's Confederação Nacional da Indústria (CNI)



Timothy Sturgeon, Industrial Performance Center (IPC), MIT
Gary Gereffi, Center for Globalization, Governance & Competitiveness (CGGC), Duke University
Andrew Guinn, CGGC and City and Regional Planning Dept, University of North Carolina Chapel Hill
Ezequiel Zylberberg, Said Business School, University of Oxford

Table of Contents

1. PROJECT OVERVIEW 1
PURPOSE 1
RESEARCH ACTIVITIES AND METHODS 2
MAIN FINDINGS AND POLICY CHALLENGES 3

2. THE RISE OF GLOBAL VALUE CHAINS 7

3. WHERE DOES BRAZIL STAND IN GVCS? 10
OVERVIEW OF GVC CASE STUDIES 15

4. BRAZIL'S ROLE IN THE AEROSPACE GVC 16
INTRODUCTION AND GENERAL INDUSTRY BACKGROUND 16
MAPPING OF THE AEROSPACE GLOBAL VALUE CHAIN 17
KEY ACTORS IN THE COMMERCIAL AIRCRAFT GVC 21
COMMERCIAL AIRCRAFT STANDARDS 21
THE GLOBAL COMMERCIAL AIRCRAFT MARKET 22
AN OVERVIEW OF THE COMMERCIAL AIRCRAFT INDUSTRY IN BRAZIL 22
BRAZIL'S POSITION IN THE COMMERCIAL AIRCRAFT GVC 24
KEY POLICIES AND INSTITUTIONS IN BRAZIL'S AEROSPACE INDUSTRY 29
FINDINGS AND RECOMMENDATIONS FOR BRAZIL'S COMMERCIAL AIRCRAFT INDUSTRY 30

5. BRAZIL'S ROLE IN THE MEDICAL DEVICES GVC 32
INTRODUCTION AND GENERAL INDUSTRY BACKGROUND 32
THE MEDICAL DEVICES GVC 32
MAPPING THE MEDICAL DEVICES GVC 34
KEY ACTORS IN THE MEDICAL DEVICES GVC 35
STANDARDS AND CERTIFICATIONS IN THE MEDICAL DEVICE INDUSTRY 36
THE GLOBAL MARKET FOR MEDICAL DEVICES 37
BRAZIL'S POSITION IN THE MEDICAL DEVICES GVC 38
Main sources of demand for Brazilian firms 39
KEY POLICIES AND INSTITUTIONS IN BRAZIL'S MEDICAL DEVICE INDUSTRY 43
FINDINGS AND RECOMMENDATIONS FOR BRAZIL'S MEDICAL DEVICE INDUSTRY 45

6. BRAZIL'S ROLE IN THE ELECTRONICS GVC 47
INTRODUCTION AND GENERAL INDUSTRY BACKGROUND 47
KEY ACTORS IN THE ELECTRONICS GVC 48
Lead Firms 48
Contract Manufacturers 49
Component Manufacturers 50
BRAZIL'S POSITION IN THE ELECTRONICS GVC 52
Electronics Trade and Production Statistics 52
KEY POLICIES AND INSTITUTIONS IN BRAZIL'S ELECTRONICS INDUSTRY 54
THE ELECTRONICS GVC IN BRAZIL: EXAMPLES 56
Communications Equipment 56
Mobile Handsets 57
Notebook Computers 58
Component Manufacturers 59
FINDINGS AND POLICY RECOMMENDATIONS FOR BRAZIL'S ELECTRONICS INDUSTRY 62

7. BRAZIL IN GVCS: SUMMARY ANALYSIS AND RECOMMENDATIONS 65
Brazil's industrial development in comparative perspective 65
The current industrial policy regime in Brazil 65
Opportunities and challenges: themes from the interviews 68
Industrial policy and overall investment climate 68
Workforce Development 68
Supply Chain and Logistics 68
R&D Expenditures 69
Six dimensions of GVC upgrading 69
Brazil's GVC "sweet spots" 71
What do GVC-oriented industrial policies look like? 73
8. CONCLUDING REMARKS 76
9. REFERENCES 77
10. ABBREVIATIONS 87
11. APPENDICES 88
Appendix A: Aerospace 89
Appendix B: Medical devices 91
Appendix C: Electronics 94

TABLES

Table 1. Emerging Economies in Comparative Perspective, 2011 12
Table 2. Export profile percentages of emerging economies, 2011 12
Table 3. Brazil's Top Ten 3-Digit Export Products and Share of Total Export Profile, 2011 13
Table 4. National Aerospace Standards 23
Table 5. Top five exporters of aircraft by value, 2004-2011 23
Table 6. Aircraft: Disaggregated export trends 24
Table 7. Aerospace Multinationals in Brazil 26
Table 8. Policies and institutions relevant for Brazil's aerospace industry 29
Table 9. Largest International Markets for Medical Devices and Regulatory Agencies 36
Table 10. Top Exporters of Medical Devices 37
Table 11. MNC production in Brazil by year of arrival and market segment 40
Table 12: Policies and institutions relevant for Brazil's medical devices industry 43
Table 13. Top Global EMS and ODM Contract Manufacturers in 2011 50
Table 14. Top 12 Semiconductor Manufacturers 2012 52
Table 15. Growth Rates 2007-2010: Brazilian Electronics Exports, Imports and Production 53
Table 16: Policies and institutions relevant for Brazil's electronics industry 54
Table 17. Electronics GVC Findings and Policy Recommendations 63
Table 18. Industry Focus of Brazil's Policy-making Institutions 67
Table 19. Interviews Conducted for Project 88
Table 20. Lead Firms in the Aerospace GVC 89
Table 21. Aerospace HS Code Definition 90
Table 22. Top 10 Global Medical Devices Firms by Revenue 91
Table 23. Disaggregated Medical Devices Export Trends 91
Table 24. Disaggregated Medical Devices Import Trends 92
Table 25. Medical Device HS Code Definition 92

Table 26. Top Global Electronics Firms by Revenue, 2011 94
Table 27. Top Semiconductor Equipment Suppliers by Sales, 2011 94
Table 28. Top Fabless IC Suppliers by Revenue, 2011 95
Table 29. Value of Brazilian Electronics Exports, Imports and Production 2010 96
Table 30. Electronics HS Code Definition 96

FIGURES

Figure 1. The Aerospace Global Value Chain Map 18
Figure 2. The Aerospace Production Pyramid 20
Figure 3. Value of sub-systems as % of total aircraft value 20
Figure 4. The Medical Devices Global Value Chain Map 33
Figure 5. Multinationals, National Firms and Medical Devices Market Segments in Brazil 39
Figure 6. Brazils Medical Device Exports by Product Category, 1997-2011 41
Figure 7. Brazil's Medical Device Imports by Product Category, 1997-2011 42
Figure 8. The Electronics Global Value Chain Map 48
Figure 9. The Semiconductor Global Value Chain Map 51
Figure 10: SMART Modular Technologies' Global Footprint 61
Figure 11. Brazil's Industrial Policies, a Timeline 66

BOXES

Box 1 HTA and Grauna S.A.'s expansion beyond Embraer's supply chain 27
Box 2. GE Celma: Upgrading from MRO services to propulsion system assembly 28
Box 3. Contract Manufacturers in the Brazilian Medical Devices Industry 40
Box 4. GE Healthcare and PPB Approval 44
Box 5. Magneti Marelli's Software Fuel Sensor (SFS) 54
Box 6: Foxconn in Brazil 58
Box 7: Hewlett Packard and Flextronics 59
Box 8: HT Micron and Teikon 61
Box 9: CEITEC and SIX Semicondutores 62
Box 10. The Six Dimensions of GVC Upgrading 69

1. Project Overview

Purpose

This report was commissioned by Brazil's umbrella industry association, the Confederação Nacional da Indústria (CNI). Its purpose is to investigate the incorporation of Brazil into global value chains (GVCs), in general and through three industry case studies. Our aim is to take some initial steps toward assessing the degree, character, and prospects of Brazil's GVC integration and the role of current policy instruments in supporting sustained economic development, industrial upgrading, and technological learning in the country.

The research focuses on Brazil's current role and future prospects in three industries that are high priority for Brazil's policy-makers: 1) aerospace, 2) electronics and 3) medical devices.[1] We explore how multinational firms in these industries engage with Brazil, and how local companies are connected to GVCs, either directly through imports and exports, or indirectly through the purchasing patterns and supply chains of multinational firms and global buyers.[2] We also consider the role of public policies aimed at strengthening Brazil's role in these global industries.

In the past 20 years, many industries have changed from nationally contained entities to geographically distributed networks consisting of "lead firms" (brand carrying multinationals and global buyers) and global suppliers with activities spread across multiple countries and regions, with variable levels and modes of participation by local firms. Within such networks, places can specialize in particular activities and business functions (e.g., research and development (R&D), call centers, routine product assembly, etc.) and value added can be distributed across multiple locations. These new structures are commonly referred to as global value chains. GVCs create challenges in many arenas, including corporate strategy, government policy, the collection of economic statistics, and so on. GVCs also challenge how we think about economic development. With GVCs a product or industry's value chain — consisting of specific value adding steps and activities — can be spread across a variety of countries and companies, rather than being conducted in one location by one company (vertical integration).

Several critical questions arise. Is it wise for a country to specialize in specific parts and sub-processes within GVCs, or do companies and countries that are fully vertically integrated do better? If specialization is acceptable, does it matter what the specializations are? To what degree can local firms and policy-makers in developing countries foster specific GVC roles, and to what degree must they react to the sourcing strategies of lead firms? What are the effects of GVCs on wealth creation, employment, and innovation? What strategies and policies can help national industries engage with GVCs in ways that are productive and sustainable? What does an effective GVC industrial policy look like?

[1] These three industries were selected for study by the CNI.
[2] In this context, the term "global buyers" refers to companies outside of Brazil that source in the country without making direct investments.

These are big questions, but the project underlying this report is more narrowly focused. Our goal is to examine how one country, Brazil, is being incorporated in the GVCs of three specific industries: 1) aerospace (mainly commercial aircraft); 2) electronics; and 3) medical devices. We examine not only the activities of firms, but how government policies are shaping these activities.

Research activities and methods

Between April 2012 and January 2013, the research team embarked on a desk research and telephone interview effort to construct an up-to-date picture of the character and impact of the three manufacturing GVCs in Brazil, as well as the government policies and programs impacting foreign investors and local firms. Field research was conducted on March 8-11, 2013 in São Paulo and Belo Horizonte.

The shape, character, and extent of GVCs can vary significantly across industries and countries (see Sturgeon and Memedovic, 2010). For example, because the principal lead firm in Brazil's aerospace sector is a domestic company, Embraer, this firm and its suppliers have been a main focus of our research. In the other two industry GVCs, lead firms mainly come from industrialized countries in North America and Europe, while their main suppliers are based in both industrialized and newly industrialized economies in East Asia, such as South Korea and Taiwan. While domestic Chinese companies play almost no role in these industries, Mainland China contains the world's most important final assembly and component manufacturing ecosystem for consumer electronics products, a fact that firms must consider when deciding whether and how to invest in Brazil. Because industry GVCs differ greatly in their architecture, underlying technologies, business dynamics, market structures, and regulatory requirements, we have been careful to "follow the GVC" in terms of adequately mapping current market linkages while conducting our study.

The research was led by Dr. Timothy Sturgeon of the Massachusetts Institute of Technology's (MIT) Industrial Performance Center and Professor Gary Gereffi of Duke University's Center on Globalization, Governance & Competitiveness. Research assistance was provided by Andrew Guinn, a Ph.D. student in the Department of City and Regional Planning at the University of North Carolina at Chapel Hill, and Ezequiel Zylberberg, a PhD student at the Said Business School at Oxford University.

The research team conducted 44 interviews of 1-1.5 hours in duration with senior management at foreign and local companies, industry associations, and government agencies (see Table 19). The material from interviews was combined with desk research and analysis of publicly available reports and statistics to generate the results summarized in this report.

Main Findings and Policy Challenges

While wages in Brazil are high by developing country standards, the large size of the internal market provides a strong incentive for foreign companies to invest there. Thus, government agencies in the country have considerable leverage to use tax and investment rules to encourage global companies to substitute imports with local production. Brazil's industrial policy is most active and detailed in the electronics sector, but there are also incentives for medical device companies to set up local production and partnerships to serve Brazil's public health system, which is among the largest in the world. In commercial passenger jets, Brazil has an important national lead firm, Embraer, one of only four global players in this industry segment (albeit the smallest). Because of these industry differences, and many others that will be detailed in this report, Brazil's industrial policies affect the three industry GVCs in different ways. We will discuss these issues in depth and in the industry case studies and policy sections that follow.

We highlight some of the overarching GVC-related economic development challenges for Brazil here:

- The complexity and instability of Brazil's industrial policy regime means that companies have trouble projecting into the future. This tends to impact SMEs more than larger firms that have the clout and human resource capacity to directly lobby the government to have regulations altered.

- SMEs in Brazil face difficulties in accessing GVCs. There are government programs to help SMEs (e.g., Apex-Brasil, Sebrae), but further efforts are needed to help SMEs build the capabilities (e.g., via collaborations, associations and technical certifications) and secure the financing needed to reach the scale and meet the quality standards and regulatory approvals required for GVC participation in general, and exports in particular.

- The added costs associated with working in Brazil (referred to by several interview subjects as the "Brazil cost") include poor trade and business infrastructure, baroque requirements and long waits for licenses and approvals, excessive layers of bureaucracy, corruption, and high interest rates. Our interviews suggest that industrial policy interventions, however sophisticated and nuanced, will be ineffective unless the broader issue of Brazil's business climate is addressed. These costs are particularly high for recent foreign investors without deep knowledge of Brazil's business and policy environment. [3] High logistics costs are a significant component of the "Brazil cost." RECOF[4] is one of a few efforts that take an integrated approach to lowering trade costs and speeding up customs procedures. Under the regime, exports and imports are checked and processed within six hours and import tariffs are suspended, among other benefits.

[3] As one respondent put it, "If you don't know the tax system in Brazil, if you can't work with government, and if you have no source of [local] financing, then it is very hard to operate in the market."

[4] RECOF refers to the Industrial Bonded Warehouse Regime under Electrical Control System (see Table 8).

The central problem is that the regime is limited to firms exporting over $10 million per year, and of the 33 companies certified, only one (Embraer) is Brazilian. Expedited and efficient customs should not be the privilege of a few foreign lead firms. Instead, the program should be expanded and efforts should be made to promote exports by smaller Brazilian firms.

- Some of Brazil's development goals may be unrealistic. There appear to be lingering efforts in Brazil's policy community to capture and promote full, vertically integrated Brazilian national manufacturing industries, rather than embracing aggressive promotion of GVC engagement and the development of Brazil's economy through export-oriented specializations within GVCs, including services. The goals related to the electronics industry, in particular, embrace a manufacturing-centric vision of developing the entire electronics value chain within Brazil, from component design and production (semiconductors and displays), to the manufacturing of sub-systems and final goods (computers and mobile phone handsets). While investment in capabilities for technology and capital-intensive products and processes can have positive long-term effects, the scale of the domestic market in Brazil is unlikely justify fully blown investments in all segments of industry value chains. Local production may sometimes make it impossible for others to operate effectively because "global sourcing" — from various well-established nodes of excellence around the world — has become a requirement for complex machines such as MRI devices and consumer electronics. Moreover, the focus on manufacturing takes attention away from some of the most dynamic and profitable segments of the GVC, such as R&D and engineering services and systems integration, areas where Brazil could develop competitive specializations in GVCs despite its distance from large markets in the USA and Europe. For this reason, viable import-substitution policies should be stable, inclusive of services, coordinated with export promotion policies, and implemented with prudence and transparency.

- Brazil's export-promotion policies are inconsistent and relatively weak. While enhancing productivity and technology-intensive activity within value chains are goals promoted by Brazil's policy community, industrial policy relies heavily on the domestic market. It does little to identify and encourage growth in specific GVC niches where the country might have a competitive advantage on the global stage. Policymakers and industrial leaders in Brazil should consider high-value GVC segments where Brazil can be competitive on a worldwide basis, fitting into and evolving along with specific global industries. Many of these niches are in the service segments of global industries – for example, in design, engineering, or software development. Yet current industrial policy is largely focused on localizing the supply of imported goods through import substitution (with the inclusion of multinationals). There is a need for better coordination between localization policies and export-promotion policies. Even with the large size of the Brazilian market, local production units may not achieve minimum economies of scale. Therefore, local production goals should be keyed to export promotion to generate opportunities for producers to increase the scale of production and ensure that products for the local market are compatible with global standards.

- Brazil's import-substitution policies should be more flexible. While many industrial policy instruments in Brazil tend to be applied broadly across a range of products, they also can be extremely detailed and specific as to the parts and subsystems targeted for local production and procurement. The problem with such highly detailed requirements is not only that they are difficult to monitor and comply with, and may be out of step with minimum scale requirements for capital intensive parts and materials; they can also quickly become irrelevant and obsolete in constantly evolving industries like aerospace, medical devices and electronics. Local content requirements should be refashioned to be more general, flexible, and focused on scale-appropriate goods and services, allowing firms in Brazil to innovate and specialize in niche products and services well suited to local capabilities and for domestic and international markets. Simply put, the goal of Brazil's industrial policies should be to help local and international companies establish specialized pockets of global excellence in Brazil that can serve both domestic and global markets. Exports to markets in other developing countries (South-South trade) should be a significant focus as well.

- An ambivalent relationship with multinational firms. Given the key role that multinational firms often play in GVCs regarding capability transfer and sourcing, a transparent and efficient business environment is needed in Brazil so that foreign and domestic firms can develop and implement long term-strategies and collaborate and compete on a level playing field. After modest waves of foreign investment in the 1970s and early 1980s, changes in policy, as well as the onset of the debt crisis, brought foreign direct investment (FDI) to a near halt. While the repeal of market reserves and the push towards privatization in the 1990s led to a resumption of FDI, including foreign purchases of state assets (such as parts of the telecom infrastructure), many in Brazil's policy community remain deeply ambivalent about broad participation of foreign multinationals in the Brazilian economy. While investment rules have been relaxed, there is tendency to view foreign multinationals mainly through the lens of investment and tax revenue, rather than sources of technology, jobs, exports, and linkages to GVCs. While there are good historical reasons for Brazil to be wary of MNC dominance of the technology-intensive sectors of the country's economy, there is a growing dissonance between this sort of thinking and the evolving structure of the global economy that could justify some careful rethinking. MNCs continue to grow in importance at all levels of the value chain. Research in the U.S. has shown that MNCs conduct most of the country's private R&D, dominate trade, pay workers more, and have better economic performance than entirely domestic firms (Bernard *et al*, 2005). Brazil's industrial policy should support the creation of more Brazilian MNCs, and seek to leverage the participation of foreign MNCs in the Brazilian economy in ways that align the global strategies of these firms with Brazil's development goals.

As the case studies presented later in this report will demonstrate, the formation of industrial policy does not necessarily begin with policy-makers "picking" winners, but rather with attempts to improve the performance of existing industries already linked to the global economy. This involves a search for mechanisms that can capture investment and technological learning to improve a country's position in highly mobile segments of GVCs that are *already* in the process of spreading to new locations, or may *already* be present in the jurisdiction that policy makers are responsible for. Brazil's policies to encourage local production of mobile smart phone handsets and tablet computers are examples of policy-makers trying to capture more local value added in markets that are *already* growing rapidly in their countries. Because such policies are responsive and adaptive, they cannot be equated with picking winners *ex-ante*.

Of course, broad economic growth can be slowed when markets for products that make the whole economy more efficient, such as smart phones and motor vehicles, are truncated by unduly high prices or outmoded products. But that does not mean that industrial policy should be abandoned. The relevant question is how to craft effective GVC-oriented industrial policies. We take this question up in some detail after presenting the case studies, especially the sub-section "What do GVC-oriented industrial policies look like? on page 73.

The case study sections of this report review the current situation in three GVCs and provide a specific set of recommendations for each industry. To provide context for these detailed findings, we first provide background on why GVCs have come to the fore at this time, and how Brazil compares to other developing countries with respect to trade patterns and GVC engagement.

2. The Rise of Global Value Chains[5]

International trade and foreign direct investment (FDI) have long been central features of the world economy, and their importance has grown steadily since the end of World War Two. Peter Dicken (2011, p. 7) has referred to this process as *internationalization*, defined as the "simple geographic spread of economic activities across national boundaries." Internationalization is largely driven by two mechanisms: 1) the spatial expansion of markets through arms-length trade; and 2) an expansion of the internal structures of multinational enterprises (MNEs), mainly through foreign direct investment and the intra-firm trade between parents and foreign affiliates.[6] Today, *global value chains* combine these traditional drivers of internationalization with global sourcing that requires high levels of explicit coordination that differentiate it from arms-length trade (Gereffi *et al.*, 2005). In essence, global sourcing arrangements imbue inter-firm trade with characteristics similar to intra-firm trade: better control from the center, higher levels of bi-lateral information, tolerance of asset specificity, and greater likelihood that foreign activities will substitute for activities performed at home.

Global value chains have become a central force driving structural change in many modern economies, with a range of positive and negative outcomes. For developing countries, the trade, investment, and knowledge flows that underpin GVCs provide mechanisms for rapid learning, innovation and industrial upgrading (Lall, 2000). GVCs can provide local firms with better access to information, open up new markets, and create opportunities for fast technological learning and skill acquisition. Because transactions and investments linked to GVCs typically come with quality control systems and global business standards that exceed those in developing countries, enterprises and workers in developing countries can be "pushed" to acquire new competencies and skills (Humphrey and Schmitz, 2002). In deeply linked developing countries, these business process improvements can be felt far beyond exporting firms and sectors.

At the same time, local firms in developing countries can achieve greater success in their own markets by combining domestic and foreign intermediate inputs and creating types of specialization that leverage cross-border complementarities. For example, GVCs can potentially bring local firms into closer contact with "open innovation" systems, where firms draw on and contribute to freely available technologies and standards (Chesbrough, 2003). Local firms can also take advantage of specialized knowledge garnered through GVC participation in global sourcing networks, by providing goods and services to MNE affiliates, and can even "move to the head" of GVCs by leveraging the knowledge and service assets in GVCs as inputs to their own goods and services (see the section "Six dimensions of GVC upgrading" on page 69).

Global value chains have spawned investments in new productive capacity and massive infrastructure improvements in developing countries, especially in key producing countries such as China, where we see huge factory complexes, sometimes employing 100,000 workers or more, churning out products that are sent to world markets through vast new ports and infrastructure

[5] This section is drawn from Sturgeon, 2013.
[6] Other common forms of global engagement common the era of internationalization include international portfolio investment, licensing, franchising (UNCTAD, 2011), and looser forms of cross-border "strategic alliances" and memorandums of understanding between firms (Simonin, 1999).

facilities. Through links to the business or technological competencies in the "host" developing countries, GVCs have boosted employment, increased specialization and larger scale production, driven more efficient geographical allocation of industrial activities, and expanded the availability of a multitude of intermediate goods available in the developing world. As a result, GVCs tend to "compress" the development experience, making non-linear catch up possible, as has been the case in China and other recent developers (Whittaker *et al.*, 2010; Breznitz and Murphree, 2011).

Still, GVCs are not a panacea for development. On the negative side, they can create a host of new policy challenges in the realms of economic and social development. With respect to social development, policy-makers in compressed developers face a series of "double burdens" from the simultaneous and often sudden appearance of developing and developed country problems, such as malnutrition and obesity, rapid industrialization and de-industrialization, requirements for basic literacy and world class tertiary education, and so on, creating "policy stretch" in states forced to cope with a wide range of issues at the same time (Whittaker *et al.,* 2010).

In the realm of economic and technological development, GVCs can create barriers to learning and drive uneven development over time, even as they trigger rapid industrial development and upgrading (Kaplinsky, 2005). There is considerable evidence that greater rents accrue to lead firms in GVCs that control branding and product conception (Linden *et al*., 2009, 2011; Ali-Yrkkö, 2010; OECD, 2011), as well as to the "platform leaders" that provide core technologies and advanced components (Gawer and Cusumano, 2002; Linden and Somaya, 2003). Firms that provide routine assembly tasks and other simple services within GVCs have lower profits, pay their workers less, and are more vulnerable to business cycles. If low value added activities tend to dominate a specific country or region, then consequences for economic performance and social welfare can be profound and persistent. Specifically, entrenchment in narrow, routine, low value added activities can lock firms and national industries into unprofitable and technologically shallow segments of the value chain. Learning might be rapid at first, but over time limits can be acutely felt (Schmitz, 2004; Kawakami and Sturgeon, 2010).

The implications of GVCs for industrial policy are far reaching. How can workers, firms, and industries be provided with the best environment for engaging with the global economy? How can we be sure that enough wealth, employment, and innovative capacity are generated at home as economic globalization proceeds? How much of the rewards of innovation and new industry creation can be captured domestically, and for how long? What are the motivations for investing in domestic innovation if the bulk of the jobs and value will likely be created in other countries? How much national specialization – and by extension, interdependence with other societies – is too much? These are open questions. Even if policy-makers seek few direct interventions in the areas of trade, industrial, or innovation policy, economic globalization can make the process of economic adjustment more difficult because it accelerates the pace of change.

With stakes this high, there is broad interest in finding mechanisms to ensure that GVCs not only thrive but also work to elevate, rather than depress, the welfare of societies in which they are embedded. There is an urgent need to develop better tools for evaluating the impact of economic globalization and the role that specific categories of firms and even entire national industries play within them. For this reason, there has been a resurgence of industrial policy, in Brazil and elsewhere, seeking to upgrade domestic capabilities and roles in specific industry GVCs. Later in this report, we review and critique Brazil's industrial policies related to the three case study industries and in general, and suggest elements that could be part of more effective GVC-oriented industrial policies. In order to put these topics in context, we offer a comparative perspective of Brazil's GVC engagement in the following section.

3. Where does Brazil stand in GVCs? [7]

Before we examine Brazil's role in our three industry GVCs, it is useful to consider Brazil's overall position as a member of a dynamic set of large emerging countries, known initially as BRICs[8] (Brazil, Russia, India and China), which are becoming significant drivers of aggregate supply and demand in the global economy, not only in their links to advanced economies, but also with each other. The Brazil-China bilateral relationship, in particular, has highlighted key features of Brazil's role in the global economy, such as the so-called "primarization of Brazilian exports" (Jenkins, 2012), whereby huge demand from China has shifted Brazil's export profile toward primary products with relatively low levels of processing. It has long been a central challenge for Brazil to increase the technological content of its exports in order to upgrade to higher value activities in both the primary product and manufacturing sectors, but now the issue has increased urgency, especially as demand from China has begun to wane (Rathbone and Leahy, 2013).

After 1989, the breakup of the Soviet Union, the opening of China to international investment and trade, and the liberalization of India brought the BRICs onto the global stage (Freeman, 2010). This influenced the globalization process, since these giant economies offered seemingly inexhaustible pools of low-wage workers, capable manufacturers, abundant raw materials, and large domestic markets. Thus, China became the "factory of the world," India the world's "back office," Brazil had a wealth of agricultural commodities, and Russia possessed enormous reserves of natural resources plus the military technologies linked to its role as a Cold War superpower. This first wave of emerging economies soon became deeply engaged with GVCs, although their specific roles varied according to their openness to trade and foreign investment; endowments of natural, human, and technological resources; and their geopolitical relationships to the world's most powerful countries and to their immediate neighbors.

Since 2001, the shift in production from North to South in the global economy has accelerated, and an expanding number of relatively large high-growth economies are playing prominent roles in a wide variety of industries, both as exporters and as new markets (Staritz *et al*., 2011). This reflects multiple factors, including the growing significance of domestic markets in large emerging economies (relative to slow growth in advanced markets) and renewed efforts to cut operating costs in the wake of the global economic crisis of 2008-09.

As GVCs have expanded in scope and complexity, emerging economies have clearly benefitted, surging ahead of the advanced industrial countries in terms of export performance. Between 1995 and 2007, the global export market shares of the United States and Japan fell by 3.8% and 3.7%, respectively, while China more than doubled its market share from 4% in 1995 to 10.1% in 2007, making it the world's export leader (ahead of Germany, the United States and Japan). South Korea, Mexico, Turkey, South Africa, and the former transition countries in central Europe

---

[7] This section is drawn from Gereffi and Sturgeon, 2013.

[8] Jim O'Neill (2011), the Goldman Sachs executive who coined the term BRICs in the early 1990s, now argues that there are a much larger number of "growth economies" (BRICs plus 11) that fall into this category, including South Korea, Mexico, Turkey, and Indonesia, among others.

also increased their export market shares during this period (Beltramello *et al*., 2012, pp. 9-10). Even more surprising, emerging economies made their most significant gains in high and medium-technology industries, which previously were the stronghold of OECD countries. This phenomenon was mainly driven by processing exports from China, whose share of high technology exports soared by 13.5% in the period 1995-2007, moving it ahead of the United States as the world's largest exporter of electronics (Beltramello *et al*., 2012, p. 10).

It is hard to overstate the importance of China in GVCs. China's total exports ($1,899 billion in 2011) are more than three times those of South Korea ($557 billion), its nearest rival among the emerging economies, and only slightly less than the combined exports of South Korea, Russia ($516 billion), Mexico ($350 billion), India ($303 billion), and Brazil ($256 billion). China has grown at over 9% per year for over 30 years, and it is now the second-largest economy in the world (trailing only the United States) and it has overtaken Germany as the world's largest exporter. This has had a major impact on Latin American economies, of which Brazil is the most significant. On the other hand, China has the second lowest gross domestic product per capita of these six emerging economies at US$5,445 (see Table 1), and the import content of its exports has been estimated to be as high as 80% in technology intensive products.[9]

In 2010, China was Brazil's largest trading partner, accounting for about 15% of Brazil's exports and imports. Between 2000 and 2010, Brazil's exports to China increased almost thirty-fold, and since 2002, imports have grown sixteen-fold (Jenkins, 2012). Although the Lula administration was keen to develop a strong economic partnership with China, concern has arisen due to both the composition of Brazil's exports to China (the primarization of Brazilian exports mentioned earlier), and their concentration in a relatively small number of products and exporting firms. As seen in Table 2, about 70% of Brazil's global exports in 2011 were primary products or resource-based manufactures. Furthermore, these two categories accounted for just over 60% of Brazilian exports to countries other than China in 2009, compared to almost 90% to China. Brazil's exports to China are concentrated in a very limited number of products, with iron ore and soybeans alone accounting for over two-thirds of the total in 2009 (Jenkins, 2012, pp. 26-27). This is reflected in Brazil's top 10 exports in 2011, where the top seven items are primary products or processed intermediates (see Table 3).

Thus, Brazil's trading relationship with China is skewed to the export of products (both primary commodities and manufactured goods) with a very low level of processing, while imports tend to be technology intensive components and machinery. The soybean value chain is a good example of the former. About 95% of Brazil's soybean exports to China in 2009 were unprocessed beans. In contrast, there were virtually no exports of soybean meal, flour or oil to China. In order to pursue its strategy of promoting the Chinese soybean processing industry, China imposed a tariff of 9% on soybean oil imports, while the tariff on unprocessed soybean imports was only 3%. More processed imported soybean products also paid a higher value-added tax rate in China than unprocessed beans. This same protectionist policy of tariff and non-tariff barriers imposed by the Chinese government to protect its domestic producers was applied to a range of other primary and

[9] Koopman *et al*, (2008) estimate that about half of the gross value of total Chinese exports is derived from imported inputs, rising to 80% for technology-intensive sectors such as electronics.

processed intermediate products from Brazil, including leather, iron and steel, and pulp and paper (Jenkins, 2012, pp. 28-29).

Notwithstanding the unprecedented momentum of China's rise in the global economy, these competitiveness problems for Brazil can be ameliorated, or even reversed. Mexico, which is Latin America's second-largest economy, appears to be in the midst of a remarkable turnaround, based on a little publicized manufacturing revolution that is allowing Mexico to become a credible competitor to China, after losing U.S. market share to China for more than a decade (Gereffi, 2009). Mexico currently exports more manufactured products than the rest of Latin America combined, and it has begun to diversify its export profile, with exports to the United States falling from 90% a decade ago to less than 80% today.

Table 1. Emerging Economies in Comparative Perspective, 2011

								Percent of GDP		
Country	Population (Millions)	2011 Exports (Billions USD)	GDP (Billions USD)	GDP/ capita (USD)	GDP/ capita (PPP in USD)	GDP growth YoY (%)		Agriculture	Industry	Services
China	1,344	$1, 899	$7,318	$5,445	$8,450	9.1		10	47	43
Brazil	197	$256	$2,476	$12,594	$11,500	2.7		5	28	67
Russia	142	$516	$1,858	$13,089	$19,940	4.3		4	37	59
India	1,241	$303	$1,848	$1,489	$3,620	6.9		17	26	56
South Korea	50	$557	$1,116	$22,424	$30,340	3.6		3	39	58
Mexico	115	$350	$1,115	$10,064	$15,060	3.9		4	34	62

Sources: World Bank: http://data.worldbank.org/; UN Comtrade, International Trade Center.

Table 2. Export profile percentages of emerging economies, 2011

		Manufacturing			
Country	Primary Products	Resource Based	Low-Tech	Medium-Tech	High-Tech
China	3	9	30	24	33
Brazil	32	37	5	19	4
Russia	45	27	2	8	1
India	11	39	21	17	8
South Korea	3	16	9	45	27
Mexico	20	8	9	38	22

Source: United Nations Comtrade, SITC Rev. 2.

Table 3. Brazil's Top Ten 3-Digit Export Products and Share of Total Export Profile, 2011

3 Digit SITC	Product	Billions $US	% of Total Exports	Product Category
281	Iron ore and concentrates	$41.8	16%	PI
333	Crude petroleum and oils obtained from bituminous minerals	$21.6	8.4%	PP
222	Seeds and oleaginous fruit, whole or broken, for 'soft' fixed oil	$16.4	6.4%	PP
061	Sugar and honey	$15.0	5.9%	PI
011	Meat and edible meat offal, fresh, chilled or frozen	$13.1	5.1%	PP
071	Coffee and coffee substitutes	$8.7	3.4%	PP
081	Feeding stuff for animals (not including unmilled cereals)	$6.0	2.3%	PP
672	Ingots and other primary forms, of iron or steel	$5.2	2.0%	MT
784	Motor vehicle parts and accessories, nes	$5.1	2.0%	MT
931	Special transactions, commodity not classified according to class	$5.1	2.0%	Other
	Total Exports	$256.0		

Notes: PP = Primary Product; PI = Processed Intermediate; LT = Low-Tech; MT = Medium-Tech; HT = High-Tech.
Source: United Nations Comtrade, SITC Rev. 2.

The main elements of Mexico's success include a very high degree of trade openness – it has free trade agreements with 44 countries, which is more than twice as many as China and four times more than Brazil. Rising wages and fuel prices have made it increasingly expensive to export from China to the U.S. market, while "Made in Mexico" has become an asset in today's cost-conscious environment, where Mexico's geographical proximity to the United States allows it to shorten supply chains, provide quicker delivery times, and also cut costs, especially on relatively bulky items. Mexico's wages, which used to be nearly four times higher than China's a decade ago, are just 29% more today. Also, Mexico not only has an abundance of cheap labor (more than half of its population of 112 million is under 29), but its workers are also becoming more skilled, with growing proportions of graduates in engineering, architecture, and other professions (Thomson, 2012). However, this turn-around is not based on the success of domestic firms. As with China, Mexico is a platform for the labor-intensive aspects of GVCs.

We believe Brazil has some distinct advantages vis-à-vis other emerging economies. Brazil is connecting to GVCs at a different historical moment, and has levers to improve its position in GVCs that neither China nor Mexico possess. In many respects, the explosion of GVCs in the 2000s passed Brazil by. But GVCs are rapidly extending into Brazil today, and the country now has the opportunity to turn this to its advantage. First, many of the low-value added-niches in GVCs, in both goods- and services-producing industries, have been filled by other countries. Lead firms are just starting to experiment with outsourcing and offshoring more technology- and knowledge-intensive business processes. This puts Brazil in an excellent position. Historically speaking, Brazil has a stronger domestic technology base than either China or Mexico. Past policies of import substitution, while unsuccessful in spurring the development of fully competitive and independent industries, has left pockets of excellence that can, with the right mix of policies, play important roles in GVCs going forward. Like Mexico, Brazil is in the same hemisphere as the United States, allowing real time collaboration on knowledge-intensive work, and Brazil's proximity to Western Europe is an advantage for the same reason.

Nonetheless, Brazil also faces significant challenges. On the import side, Brazil has also been influenced by China's structure of international trade. In 1996, low-technology products accounted for 40% of Brazil's imports from China, while high-technology products accounted for 25%. By 2009, the pattern was nearly reversed: high-technology products were 41.4% of the total, and low-technology products were 20.8%. If we look at this trend in terms of the end use of imports, consumer goods imports from China to Brazil fell from 44% to 16% between 1996 and 2009, while the imports of capital goods doubled from 12% to 25% and parts for capital goods rose from 12% to 25% (Jenkins, 2012, pp. 29-31). Thus, Brazil has been subordinated to occupy the lowest rungs of the value-added ladder in its trade with China in recent decades, which poses long-term structural imbalances for Brazil if the situation doesn't change.

From a GVC perspective, which focuses on the location of value added in global production systems, high-technology imports from Mainland China are most often driven by the products and strategies of firms based in OECD countries, along with their business partners (e.g. trading companies, contract manufacturers, and component producers) based elsewhere in the world, especially Taiwan, Hong Kong, and Singapore. Thus, the historic reliance of Brazil on the "global North" for technology-intensive products has in essence, remained, even as China's importance as a trading partner has risen. In other words, China has become a major conduit for technology from the global North.

Like China, Brazil has a large internal market, allowing it to implement industrial policies that would be impossible for a smaller country and it lies at the core of Mercosur. The question is, what sort of industrial policies make sense at this historical moment? Should Brazil pursue policies of the past, and seek to develop fully independent domestic industries, separate from GVCs? Should Brazil pursue the same low-value-added business functions that have driven growth in China and Mexico? Or should the country seek to capture more of the new, higher-value-added functions that are being hived off into GVCs today?

Overall, Brazil has come to play a much more significant role in the global economy. This can be seen not only in Brazil's booming commodity export trade, but also in the rapid growth of foreign direct investment (FDI) coming into Brazil, as well as the diversified expansion of a wide range of manufacturing and service sectors in the Brazilian economy.

Brazil's participation in the global economy can be analyzed in terms of three different "logics" or perspectives, which aren't mutually exclusive: (1) global value chains (GVCs) — referring to the extent to which Brazil is integrated into international investment, production and trade networks in different economic sectors; (2) state-led development — referring to the role played by the national state in defining, regulating and carrying out key development activities in various domestic industries (including the role of state-owned enterprises, local content rules and public sector demand in determining appropriate national economic outcomes); and (3) trade-led development — referring to the role of international trade agreements and partnerships in defining Brazil's national economic development priorities.

Each of these development logics can be promoted by different sets of policies. Our analysis of Brazil's three manufacturing GVCs focuses on GVC-oriented industrial policies, but the state-led development and trade promotion policies are inextricably intertwined with industrial policy (and in fact could be better co-ordinated). In Brazil today, these policy realms are often incongruent and work at cross-purposes with one another. We have already mentioned many of these inconsistencies earlier (in the section entitled "Main Findings and Policy Challenges"). We will discuss them in more detail as we develop our findings and recommendations for upgrading within each specific GVC, and return to them again in the final sections of the report.

The industry case studies of the electronics, aerospace and medical devices GVCs that follow are intended to explore the various ways in which Brazil is seeking to strengthen its position in these manufacturing GVCs, and to provide recommendations for the future.

Overview of GVC Case Studies

Detailed industry case studies are a standard part of good GVC research for several reasons. First, in technology- and knowledge-intensive GVCs, ownership matters. Lead firms and global buyers have a large role in selecting suppliers and production locations. Information about ownership does not generally appear in official statistics. Second, industry structure matters. In the 1990s, many lead firms and global buyers changed their sourcing practices, moving from dozens of regional suppliers to a smaller set of larger, more global suppliers. As a result, it is global suppliers rather than lead firms that make up the bulk of FDI, and hence should be the target of investment promotion efforts. Third, the details of industries in terms of products, processes, and competition matter. For example, in the electronics case below, trade statistics show a radical drop in Brazil's exports of mobile phone handsets, and an even more radical increase in imports. This shift cannot be understood without an understanding of changes in the basic architecture of mobile phone handsets, from "feature phones" to "smart phones," a change that has seen new actors (Samsung and Apple) win market share from incumbent players with a long track record of local production in Brazil (e.g., Nokia, Motorola, NEC). Such industry-specific issues of international sourcing, firm-level competition, and product evolution are important aspects of GVC research.

To uncover such industry-level patterns in GVCs, our report focuses on three specific manufacturing industries in Brazil: aerospace (mainly commercial aircraft), medical devices and electronics. For each GVC, we discuss the following nine elements:

1. Introduction and general industry background
2. Mapping of main GVC activities, actors, and institutions
3. A description of key firm-level actors
4. The role of standards and certification
5. The global market
6. Overview of the industry in Brazil
7. Brazil's position in the GVC
8. Key policies and institutions
9. Findings and recommendations

4. Brazil's role in the Aerospace GVC

Introduction and general industry background

The aerospace industry is among the largest producers of high-technology goods in the global economy, driving innovation in diverse fields such as transportation, communications and defense. The industry is often linked to national security programs, which is why the phrase "aerospace and defense" is often used to describe it. Because production for defense is highly regulated, GVCs far more constrained in this portion of the industry, and trade is dominated by final products and after-sales service. Because of this, our report will focus on the civilian aircraft industry, that is, those portions of the aerospace industry whose final products include large commercial aircraft (LCA), regional jets, business jets and general aviation aircraft.

The civilian aircraft industry accounted for $130 billion in global revenues in 2010 (GAMA 2011)[10]. Though it remains rooted in advanced economies in North America and Europe, the industry underwent dramatic changes during the 1980's and 1990's. Consolidation, through a series of mergers and acquisitions, reduced the number of lead firms in the industry. There are currently only two lead firms producing long haul commercial jets (Boeing and Airbus) and two smaller manufacturers producing regional jets (Embraer and Bombardier). As these four lead firms have outsourced peripheral capabilities, they have drastically reduced the number of direct suppliers they use (Niosi and Zhegu, 2010; Rose-Anderssen, 2008). Embraer, for example, reduced the number of suppliers from 400 in the ERJ-145 program to 40 the ERJ-170/190 program (Figueiredo *et al*., 2008).

Today, lead firms in the commercial aircraft industry are mainly responsible for the design, final assembly, and delivery of aircraft. They act as system integrators, assembling major subsystems produced by supplies into finished aircraft and installing complex control and communications systems. Crucially, for the purposes of this report, they also act as supply chain orchestrators, selecting and supporting the work of their main suppliers, and in many cases dictating the location of sub-system production to support "offset" programs: country-level deals between lead firms and governments with large state-invested airlines that offset imports of finished aircraft with local production.

This political dynamic to the structure and location of the commercial aircraft GVC is tempered by the high technical requirements for parts and sub-systems. The tier 1 suppliers that provide major subsystems often play a supporting role in the engineering work that underpins systems integration. For example, lead firms have engaged in international sourcing to gain access to specialized technologies, as exemplified by Boeing's decision to procure wing assemblies from Japan, where suppliers have strong capabilities in composite materials (Pritchard and MacPherson, 2007; McGuire, 2007). Firms with the requisite capabilities are few, and these are unevenly distributed across the globe. For example, after the 1990s, only six firms manufacture

[10] Many companies participating in civilian aerospace global value chains also serve the defense industry. The broader aerospace and defense industry accounted for $648 billion in revenues in 2010 (PwC, 2012).

regional and commercial jet engines, three American and three European. [11] Consolidation is also occurring at lower levels of the supply chain as well.

Lead firm consolidation and the shift of sub-system design responsibility to tier 1 suppliers have been partly driven by the rising costs of research and design. Lead firms are focusing more on systems integration while the design and production of most sub-systems and components as well as some design services are outsourced to *risk-sharing partners* and other large suppliers that independently manage their own supply chains (Niosi and Zhegu, 2005, 2010). Risk-sharing partnerships emerged as a means to fund the design of a new craft while spreading the enormous financial risk across a handful of important suppliers. In a risk partnership, the terms of compensation of participating tier 1 suppliers (not all tier 1 suppliers that participate in a given project serve as risk partners) is tied to the financial performance of the overall project, rather than just the contribution of the supplier. Because it builds trust and aligns incentives, this financial collaboration can help create the conditions for deep technical collaboration and other deeply "relational" linkages between business partners (Gereffi *et al.*, 2005). Such value chain linkages tend to favor co-location.

Another important trend in aerospace production is the tendency of top-tier companies (both lead firms and suppliers) to locate the production of both minor components and major subassemblies in developing countries to take advantage of lower operating costs, gain access to technology, or comply with offset agreements (Niosi and Zhegu, 2010; Goldstein, 2002). By shifting production to lower-cost locations such as China, India, Malaysia and Mexico, companies have been able to save up to 30% on labor costs (Clearwater, 2011). For example, Boeing, in a 2012 memo with the subject line "Manufacture in Mexico, Supply to the World" encouraged its American suppliers to consider offshoring activities to Mexico (Gates, 2012). While parts and component suppliers sometimes join lead firms and subsystem suppliers when they open facilities in new locations, opportunities can open for domestic suppliers as well. This process leads to a strong clustering pattern in the geography of commercial aircraft production (Niosi and Zhegu, 2005).

Mapping of the aerospace global value chain

This section outlines the various steps in the commercial aircraft GVC (see Figure 1 for a visual representation). The commercial aircraft GVC, unlike electronics or medical devices (the other case studies in the project), is organized within a strongly tiered production system, with the dominant players holding large market shares and wielding a great deal of power over lower level suppliers. Figure 2 highlights this tiered structure across four tiers of the commercial aircraft GVC.

Design: The research and development (R&D) and product design costs required to develop commercial aircraft are formidable, and the capabilities for doing so take many decades to

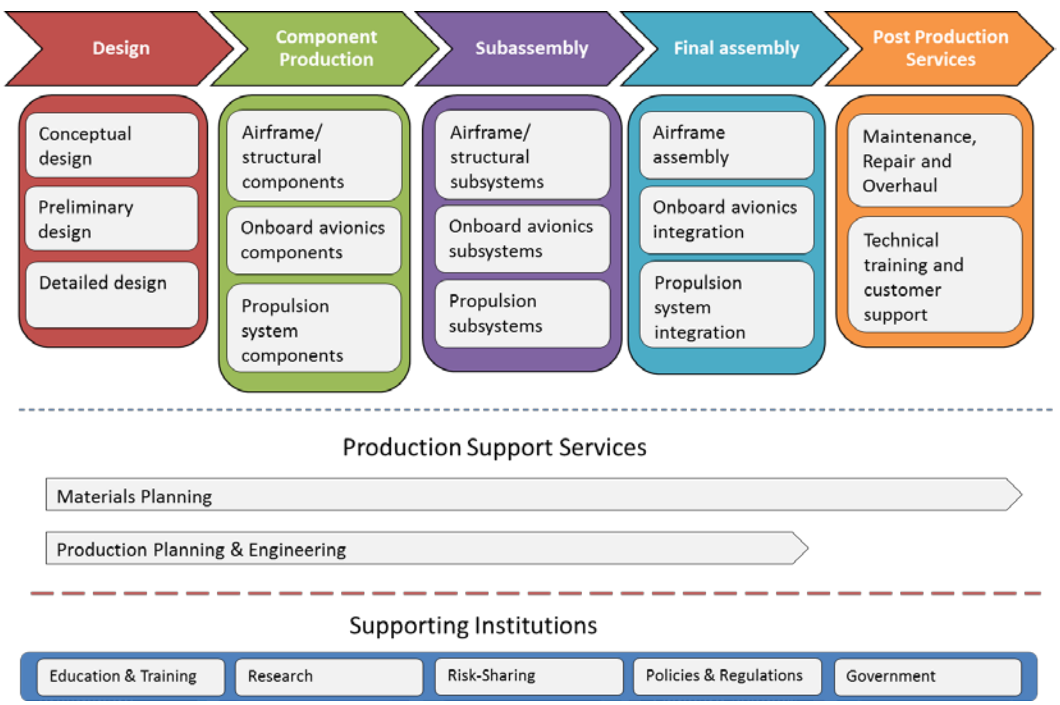
[11] The American firms are GE Aircraft Engines, United Technologies Corp. (parent of Pratt & Whitney) and the Engine Alliance (itself a joint venture between GE and Pratt & Whitney). The European firms are Rolls-Royce Group PLC, Snecma Group and International Aero Engines (a large multinational consortium) (Niosi and Zhegu, 2010).

develop and are beyond the reach of all but a few companies in the world. The development of a new airplane typically takes from five to 10 years, and it is estimated that it takes 10 to 18 years for a new aircraft line to become profitable (Niosi and Zhegu, 2010). Long development and product cycles create high barriers to entry in aerospace GVCs, but there are long-term business opportunities for firms that do participate.

The importance of the aircraft industry in national competitiveness and defense provides policy-makers with ample justification for governmental support. In 2001, governmental financial support covered 41% of R&D expenditures in the European aircraft industry. The U.S. government financed 48% of R&D investments in their national aircraft industry (GIFAS, 2004; NSF, 2006; cited in Niosi and Zhegu, 2010). Financial backing in both markets supports the development of "dual use" technologies — technologies with both military and civilian applications.

The design segment of the commercial aircraft GVC consists of three phases. During the conceptual design phase, aerospace engineers and designers prepare a digital representation that specifies fundamental aspects of the aircraft, such as the fuselage shape, engine size, and wing configuration. During the preliminary design phase, the concept design is iteratively tested and improved in fluid dynamics analytic software and other simulations to ensure that it meets design requirements. The detailed design phase involves the engineering and fabrication of individual sub-systems, components and tooling.

Figure 1. The Aerospace Global Value Chain Map



Source: Authors.

Component production: Individual components range from bare circuit boards, connectors, and electronic components, large scale wiring and control systems, to composite parts for wings, all the way down to specialized screws which are used in passenger tray tables. They may be product- or industry-specific, such as rotors or antennas, or they may be more generic, like un-machined castings or pistons. Regardless, all aircraft components must be fully specified and produced to standards that are often higher than those required for other products. Component producers manufacture inputs for other industries, such as the automotive or oil and natural gas sectors, but specialized certifications and long-term business relationships mean that higher tiered suppliers tend to be focused on aerospace and defense.

Sub-system assembly: The production and distribution of major subassemblies, such as turbojets, fuselage sections and flight control subassemblies to lead firms, is carried out by tier 1 suppliers such as Pratt & Whitney, BAE Systems and the aerospace division of Kawasaki Corporation. As lead firms have reduced the number of direct suppliers, the role of tier 1 suppliers in overseeing the distribution of components and sub-assemblies has grown.

The relative value of subassemblies is shown in
Figure 3. While assembling the airframe is still the most expensive aspect of aircraft production (37% of costs), the design, assembly and distribution of structural subassemblies (the wing, the center wing box, the front fuselage, the aft fuselage, the empennage and the nose) are very costly activities, and can be shared across multiple first- and second-tier firms and carried out in locations across the world. For example, production of structural subassemblies for the Boeing 787 program is located in Japan, Italy and the United States. Through offsets, China has attracted some subassembly manufacturing activities from Airbus, Boeing and Embraer (Pritchard and MacPherson, 2007; Osse, 2012).

Final assembly and systems integration: Final assembly and systems integration refer to the process of assembling and integrating the various systems and sub-systems that constitute the aircraft into a “complete system.” This involves far more than simple assembly. For example, controllers in the propulsion system must be programmed to monitor and respond to changes registered in the avionics system. Because aircraft manufacturers have been focusing more on the systems integration function, and leaving more component production and design to supplier firms (Jorge and Niosi, 2005, 2010; Rose-Anderssen *et al*., 2008), the most sophisticated tier 1 suppliers (e.g., propulsion and avionics systems suppliers) have assumed important R&D and design functions that necessitate a prominent role in systems integration.

Figure 2. The Aerospace Production Pyramid

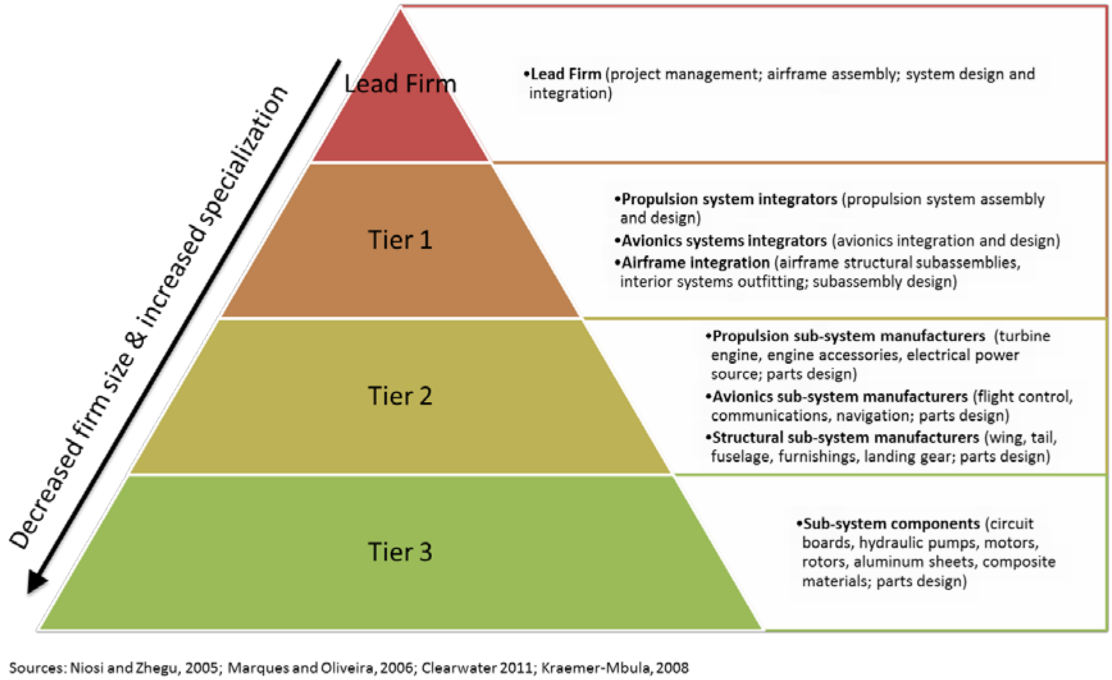
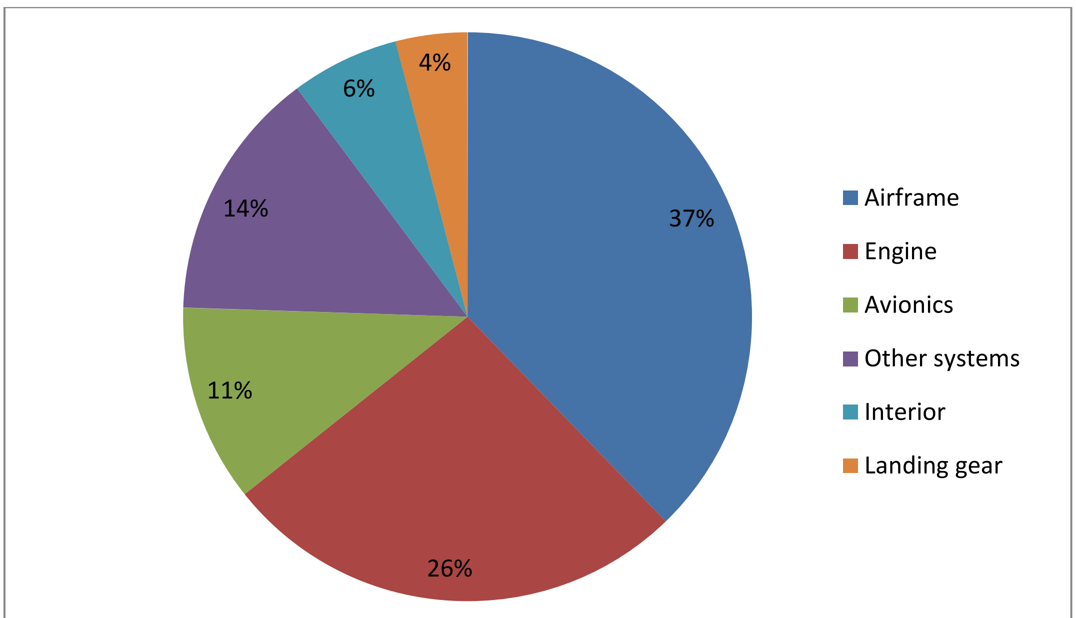


Figure 3. Value of sub-systems as % of total aircraft value



Source: Wipro 2008

Post-production services: As global aircraft fleets expand, post-production, post-sales services are becoming increasingly important revenue generators; product-specific training is required for pilots, crews and maintenance workers need to be trained to work on progressively more sophisticated aircraft systems, and the number of planes requiring routine and non-routine maintenance and repairs have increased significantly. Global spending on maintenance, repair and overhaul (MRO) services was valued at $46 billion in 2011 and is expected to grow to $65 billion by 2020 (Ali, 2011; Clearwater, 2011), with regional fleet size and projected growth providing key indicators of demand. As lead firms and large suppliers have consolidated, they have also assumed greater control over the MRO market through tactics such as limiting access to technical publications, initiating license agreements, and limiting access to replacement parts (Spafford *et al*., 2012).

Key Actors in the Commercial Aircraft GVC

There are four lead firms in the commercial long haul and regional aircraft industry: Boeing (USA), EADS (Europe), Embraer (Brazil) and Bombardier (Canada). Mitsubishi (Japan) plans to enter the regional jet market in 2013. Given the high structural and technological barriers to entry to the industry, it is remarkable that a company from a developing economy (Embraer in Brazil) appears on this very short list. These firms perform overall aircraft design, final assembly and systems integration, and are responsible for delivering the aircraft to the customer. While this concentrated industry structure provides lead firms with a great deal of power in the GVC, some of this has been delegated to tier 1 firms, which play systems integrator roles for their sub-systems and therefore exert a great deal of influence over the membership and form of their upstream supply chains (Kimura, 2006). In "Appendix A: Aerospace" there is a list of lead firms as well as top sub-system suppliers in the commercial aircraft industry, along with revenue information and the main role each firm plays. These data show that several tier 1 suppliers realized greater revenues than the assemblers of regional jets (Bombardier and Embraer) in 2010. This is because tier 1 firms supply multiple final assemblers (often including those in the defense market) and enjoy substantial control over the markets for both MRO services and components used in MRO services.

Commercial aircraft standards

Lead firms and suppliers in the commercial aircraft industry must meet international, regional, and national standards set in the end markets in which their products will be sold. Relevant standards in the commercial aircraft industry are listed in Table 4. In addition to obtaining these geographic certifications, suppliers in the aerospace industry are also expected to meet quality management standards set by their customers (such as ISO, CMMI and Six Sigma) before partnering with or selling to lead firms. Because aircraft regularly fly across national boarders, multiple certifications are the norm. This is a high requirement that adds to the long list of barriers to obtaining and maintaining a place in the commercial aircraft GVC.

The global commercial aircraft market

Seventy five percent of global demand for commercial aircraft is from airlines expanding their fleets or replacing aging aircraft (IBISWorld, 2012). Most of the remaining demand is from air cargo companies. Overall, although the industry was severely affected by the global economic crisis in 2008 and 2009, demand has recovered considerably, with large aircraft manufacturers reporting strong profits in 2011 (PwC, 2012). Boeing estimates that 20,000 aircraft will need to be replaced and 15,000 new planes will be added to the global fleet by 2030 (Boeing, 2012). The US and European markets are the most mature markets (65% share), with important growth being driven by the need to renew fleets with more fuel efficient planes (PwC, 2012), and by the rapid expansion of local airlines in developing countries with strong economic growth, including developing regions including Asia, Eastern Europe and South America.

The final assembly of aircraft is concentrated in a small number of countries, mainly the home countries of the major aircraft manufacturers: Brazil (Embraer), Canada (Bombardier), France and Germany (Airbus), and the US (Boeing). Exports in 2008 indicate that the European sales (France and Germany) accounted for approximately 45.1% of exports, while the US exports accounted for a lower market share of 39.2% (see Table 5).[12] Together with Canada and Brazil, these four exporters have maintained over 92% of global exports from 2004-2011.

An overview of the commercial aircraft industry in Brazil

The main markets for Brazilian companies in the aerospace industries are: the domestic commercial market, the domestic defense market, and the export market. The dominant source of demand in the domestic commercial market is Embraer. As risk-sharing became the prevalent model for organizing design and production and risk-sharing partners have exerted greater control over their own supply chains, however, local SMEs have faced difficulties maintaining their roles as suppliers for Embraer aircraft. Though the risk-sharing model has become popular in the defense market as well, Brazilian SMEs catering to this market benefit from the presence of offset policies, which create incentives for systems integrators to maximize domestic content.

Brazilian aerospace exports in 2010 amounted to approximately $5 billion, as indicated by Table 6. Of these exports, 80% can be attributed to exports of final aircraft, with the remaining 20% consisting of exports of parts and components. Obviously, Embraer dominates exports of final craft, accounting for $3.65 billion of the $4 billion in exports of final aircraft. The purchasers of final craft include major airlines, businesses, governments and individuals. Firm-level analysis of the aerospace value chain indicates that the figures for propulsion systems exports are somewhat misleading and likely reflect not the export of propulsion system components or newly assembled turbojets but rather services provided by MRO facilities to overseas clients. Foreign OEMs and MRO service providers comprise the sources of demand for other component exports.

[12] 30% of US aircraft sales are absorbed by the domestic market and are not exported (Yang *et al*., 2011).

Table 4. National Aerospace Standards

Standard	Country	GVC Segment	Description
NBR 15100	Brazil	Manufacturers	Applies to materials, components, equipment, project, production, evaluations, maintenance of aircrafts, subsystems, aerospace infrastructure and space vehicles. This standard was ratified by IAQG, establishing favorable conditions for the insertion of Brazilian aerospace production in the international chain.
SAE AS9100	Americas	Manufacturers	AS9100 takes the ISO 9001 requirements and supplements them with additional quality system requirements, which are established by the aerospace industry in order to satisfy DOD, NASA and FAA quality requirements. The intent of AS9100 is to establish a single quality management system for use within the aerospace industry. AS9100 is a product of an international effort to establish a single quality management system for use within the aerospace industry and is recognized by all major Aerospace OEMs. While the AS9100 standard is recognized worldwide, however, participating countries can use their own numbering conventions. For example, the standard was released as EN9100 in Europe.
JIS19100	Asia	Manufacturers	
AS 9120	Americas	Distributors	This standard addresses chain of custody, traceability, control and availability of records. AS9120 is applicable for organizations that resell, distribute, and warehouse parts found in aircraft and other aerospace components. The standard is not applicable to value-added distributors due to customer-product changes nor is it intended for organizations that rework or repair products.
AS9110	Americas	MROS	The AS9110 aerospace standard is based on AS9100 but adds specific requirements that are critical for the maintenance of commercial, private, and military aircrafts. This standard defines the quality system requirements based on AS9100 and includes additional criteria for MRO facilities serving the aircraft industry. In 2012, there were 109 certified firms listed in OASIS.
FAA 145 certified repair stations	US/International	MROS	The FAA Type 145 repair certificate authorizes facilities to perform maintenance and airframe/engine repairs on specific aircraft. The FAA uses the Type 145 certification process to determine if a repair station has the equipment, personnel, manufacturers' maintenance instructions and inspection systems to ensure aircraft repairs are completed to U.S. aviation standards.
OASIS database	International Aerospace Quality Group	All	The OASIS database is a product of the International Aerospace Quality Group (IAQG). OASIS houses supplier and audit assessment data for all companies who hold an accredited certification in any of the AQMS series of Standards (i.e. - AS9100, AS9110 and AS9120). OASIS is publicly used to identify the companies in compliance to AS9100, EN9100 and JISQ9100 standards as well as other international quality specifications.

Source: De Florio, 2006, FAA, 2012, SAE International, 2012.

Table 5. Top five exporters of aircraft by value, 2004-2011

Aircraft Exporter	Value ($US Billions)					Share (%)				
	2004	2006	2008	2010*	2011*	2004	2006	2008	2010	2011
World*	74.9	101.3	118.2	129.2	140.8					
EU-15	36.0	42.9	53.3	64.7	70.0	48.1	42.4	45.1	50.1	49.8
USA*	24.6	43.6	46.4	51.0	56.4	32.9	43.1	39.2	39.5	40.0
Canada	5.0	6.0	5.8	6.2	5.8	6.7	5.9	4.9	4.8	4.1
Brazil	3.3	3.2	5.5	4.0	3.9	4.4	3.2	4.7	3.1	2.8
Argentina	--	--	--	--	0.9	--	--	--	--	0.6
Switzerland	--	1.4	2.0	0.6	--	--	1.4	1.7	0.5	--
Russia	2.1	--	--	--	--	2.8	--	--	--	--
Top Five	71.1	97.1	112.9	126.5	137.0	94.9	95.9	95.6	97.9	97.4

Source: UNComtrade, 2012. Airplanes are represented by HS96 codes 880220, 880230, 880240;

Notes*: US data for 2010 and 2011 is from USITC and represents the share of HS 880000 of 2008 data (Airplanes represented 64.4% and helicopters 2.5%). The world value is also based on the USITC values. Reported US values for airplanes in 2010 and 2011 respectively were $883.8 and $$1,161.6; helicopters were $897.7 and $577.5 respectively.

Table 6. Aircraft: Disaggregated export trends

Product Category	Exports, 2010 ($ Billions)	% Export Growth 2007-10	% World Exports in Category, 2010	% All Brazilian exports 2010
Final craft	$4.0	-16.2%	4.7%	2.0%
Propulsion system	$0.5	97.3%	0.5%	0.2%
Other components	$0.5	26.2%	0.8%	0.2%
TOTAL	$4.9	-8.2%	2.0%	2.5%

Source: UN Comtrade (see Appendix A: Aerospace for HS codes used)
Notes: Total Brazilian exports for 2010: $197,356,436,225. Total world aerospace exports for 2010: $242,451,199,089.

Brazil's position in the commercial aircraft GVC

Companies active in the Brazilian commercial aircraft industry include Embraer, multinational tier 1 suppliers (also known as *global suppliers*), local tier 1 suppliers, and local SME suppliers serving both local and multinational tier 1 suppliers. Project interviews indicated that nearly 150 companies are involved in the Brazilian aerospace industry, 50 of which are members of the Associação das Indústrias Aeroespaciais do Brasil (AIAB). While Brazilian companies exist in each segment and sub-segment of the value chain, Brazilian capabilities are strong in only a few areas, as will be discussed later in this section. The distribution of Brazilian capabilities across each value chain segment is heavily shaped by the presence of a local lead firm (Embraer) whose activities account for roughly 90% of total industry turnover (Ecorys, 2012). Table 7 contains a list of multinational companies active in Brazil, as well as the value chain activities that they carry out in Brazil.

Design: Much of the conceptual and preliminary design work for Embraer products is carried out by Embraer and its risk-sharing partners, most of which are global suppliers (i.e., suppliers that support lead firms with global-scale operations) headquartered in industrialized countries. As a result the design activities of risk-sharing partners typically takes place in the home countries of these companies. Nevertheless, some aspects of the design process are contracted out to Brazilian engineering services firms.[13] For example, the Brazilian company Akaer was contracted by the global supplier Sonaca (France) to engineer and design the rear fuselage for the Embraer Legacy 500/400 and to provide detailed design services to support component production. Akaer has also won contracts from suppliers to Airbus and Boeing for their A380, 400M and 747-8 programs (Akaer, 2012; Morrison, 2012).

Components: Brazil has few companies that manufacture aircraft components. Indeed, Embraer imports between 60% and 90% of the parts and components for its aircraft (see *New York Times* 2007; Figueiredo *et al.*, 2008). Most Brazilian components manufacturers are SMEs with little

[13] The Brazilian Aerospace Cluster website (http://www.aerospacecluster-brasil.com.br), maintained by Apex-Brasil and CECOMPI, indicates 27 companies with engineering and design capabilities. This program, an official Integrated Sectoral Project, has replaced the organizations' previous aerospace program, the High Technology Aeronautics SME consortium initiative.

technological competence that supply Embraer directly using raw materials, specifications and designs provided by Embraer (Cafaggi *et al*., 2012). A handful of companies, such as Bravio, produce avionics software. It is uncommon for Brazilian SMEs to supply major sub-systems integrators, as most local companies lack the certifications, managerial experience and scale necessary to work with global suppliers. There are some exceptions to this generalization, in which governmental programs have played a key role. In addition, some of these global suppliers, such as GE, Sonaca and Liebherr, have set up production facilities in Brazil (see Table 7).

Sub-systems: Given that most of the parts and components for Embraer products are imported, global suppliers without local production facilities have set up distribution facilities near Embraer's headquarters in São José dos Campos. For example, since no Brazilian companies are capable of producing turbojets, major propulsion systems integrators such as GE, Pratt & Whitney and Rolls Royce import fully completed turbojet propulsion systems for distribution to Embraer.

Final Assembly and System Integration: Embraer, the third largest commercial aircraft producer in the world, dominates Brazil's activities in the system integration segment of the value chain.[14] As risk-sharing partnerships have played an increasingly important role in design and production planning, some risk-sharing suppliers work with Embraer to integrate the propulsion system, avionics and the more complicated structural subassemblies, such as the wings, which, in the case of the ERJ-170/190, are assembled in Brazil from composite components imported from Japan.

Post-Production Services: Thanks to the presence of a local systems integrator and a rapidly growing air transportation market, Brazil is active in the MRO segment of the commercial aircraft GVC. In addition to the multinationals listed in Table 7 and discussed in Box 2, Embraer as well as major Brazilian airlines such as TAM and Gol operate MRO facilities in Brazil (Sobie, 2010).

[14] This report focuses on the subset of the aerospace industry that produces commercial airplanes. Note that Brazil also hosts Helibras, a subsidiary of EADS which acts as an integrator in the helicopter segment.

Table 7. Aerospace Multinationals in Brazil

Company	Headquarters	Year	Activities in Brazil
Boeing	USA	2012	R&D
Goodrich	USA	2009	MRO - repair services
General Dynamics	USA	2006 (MRO services began in 2010)	Distribution, MRO (airframe and components)
Thales	France	2006	Surveillance systems, long-range air traffic control radars, telecommunications satellites
Liebherr	Switzerland	2005	Component manufacturing (casings and valve blocks)
TAP Maintenance and Engineering	Portugal	2005	MRO – heavy repair and overhaul services
C&D Zodiac	USA	2005	Cabin interiors and accessories manufacturing and engineering support
Latecoere	France	2004 (factory buildings in 2006 and 2008)	Customization and assembly of center fuselages. Also controls 33% of shares of Pesola Company, which produces small, machined parts for the aerospace industry.
Kawasaki	Japan	2003 (closed 2006)	Wing assembly
Aernnova (formerly Gamesa)	Spain	2001 (FUASA), 2004 (Aernnova do Brasil)	Fuselage assembly and manufacture, stabilizer manufacture, product and systems engineering, manufacturing engineering. (Two facilities: Aeronnova do Brasil, FUASA)
Elbit	Israel	2001	Manufacture of defense avionics and unmanned aircraft
Sonaca	Belgium	2000, additional facilities 2004	Manufacture and assembly of fuselage at Sobraer facility. Partial owner of Pesola (small machined parts) and Sopeçaeros (small sheet metal parts)
Pratt & Whitney Canada	Canada	2000	MRO - propulsion
GE Aviation	USA	1991 (bought controlling stake Celma in 1996)	MRO - propulsion and components; plans to begin engine turbine manufacture and assembly
Helibras (Eurocopter)	France	1978	Civilian and military helicopter component production and assembly
Pilkington	UK	1977	Windows and transparent surfaces manufacture.
Rockwell Collins	USA	1977	MRO - avionics; some defense-related avionics assembly
Parker-Hannifin	USA	1969	Hydraulic systems manufacture, MRO services
Rolls Royce	UK	1959	MRO – propulsion

Source: Company websites

Box 1 HTA and Grauna S.A.'s expansion beyond Embraer's supply chain

Grauna Aerospace S.A., founded in 1990, is a components supplier which produced precision-machined metal parts, especially for propulsion turbines, and performs some assembly tasks for structural subassemblies. As is common among many SMEs in the Brazilian aerospace sector, Grauna was founded by former employees of Embraer who left the company during the initial years of its reorganization in the 1990's. Throughout its first decade, Grauna supplied products and services directly to Embraer (goods which, prior to industry reorganization, had been produced in-house by Embraer) on a sub-contracting basis without a written contract. Embraer supplied the raw materials and design, while Grauna produced the parts to its client's specification, implying that while Embraer chose to externalize production, it maintains design capabilities in-house. In 2003, this relationship was contractually formalized.

In 2000, Grauna participated as a founding member in the High Technology Aeronautics (HTA) program, an export consortium initiative set up by Apex-Brasil to allow SMEs joint representation in trade fairs and contract negotiations with buyers. Significantly, HTA required that member companies be ISO 9000 certified (Grauna also has NBR 15100 / AS 9100 certification). Participation in HTA allowed Grauna to enter the networks of global suppliers in aerospace GVCs. In 2005, with the assistance of BNDES, Grauna merged with two other small enterprises in the aerospace sector, SPU and Bonanza, to gain the scale and range of competencies needed to win contracts from global suppliers in the aerospace sector. The venture capital group, Stratus, provided the capital necessary to complete the merger. As a result of both its expanded network of contacts with top-tier aerospace firms, permitted through HTA, as well as enhanced scale, Grauna has managed to expand its list of clients in the global aerospace industry to include Pratt & Whitney (USA), Elbit (Israel), Liebherr (Switzerland) as well as Petrobrás, which has an equity stake in the company. This year, GE Aviation (USA) signed an MOU with Grauna, signaling its interest in purchasing components from the Brazilian company for engines to be supplied to Boeing military aircraft. Nevertheless, unforeseen reductions in orders from Embraer and Pratt & Whitney in 2012 placed the company in crisis, highlighting the importance of client diversification to the sustainability of the Brazilian supply base. (Sources: Caffagi, 2012; Boeing, 2012; Grauna)

Box 2. GE Celma: Upgrading from MRO services to propulsion system assembly

GE Celma, an engine overhaul and repair facility based in Petrópolis (RJ), began from modest roots in 1951 as a manufacturer of household fans. It moved into the MRO market in 1957 as an engine repair center for Panair do Brasil, a subsidiary of Pan American World Airways. As the facility's workload waned in the 1960's, it was acquired by the military to provide engine overhaul services in 1965. The company gained experience repairing GE, Rolls-Royce and Pratt & Whitney engines as a publicly owned entity until it was privatized in 1991 and sold to a consortium of buyers. GE bought out the other partners in 1996 and in subsequent years the facility became Latin America's largest engine overhaul shop, repairing 330 turbines in 2011 (up from 300 the previous year). GE Celma's currently serves primarily the export market: 95% of its work comes from clients outside of Brazil; 90% is from outside of Latin America. This facility is Brazil's largest exporter of services.

Local MRO work could grow in coming years, however, as signaled by the signing of a 10-year, $1 billion contract in 2010 with Azul Linhas Aéreas do Brasil to repair GE's CF34-10E engines on the airline's Embraer E-190 fleet, as well as a separate twelve-year, $345 million contract in 2009 with the airline TAM. Clients from Asia are also entering Celma's dealbook. Because many of the components that Grauna uses in its maintenance activities are imported, the company has benefited from participation in the RECOF customs regime (see the section on key policies and institutions).

In 2006, GE announced plans to begin manufacturing components and assembling turbojet engines for regional aircraft at its Celma facility, which will represent GE's first engine assembly plant outside of North America. With the help of ANAC, Celma received FAA certification for its new assembly plant, named 14 BIS, named after the experimental biplane designed by Brazilian aviation pioneer Alberto Santos-Dumont. Celma began producing the low-pressure turbine for the CF34-10E line this year, though other parts and subassemblies are still sourced from the main CF34 facility in Durham, North Carolina, USA. Workers from the Durham facility have been providing technical training to their Brazilian counterparts in Petrópolis. With this move, GE represents the first major commercial turbojet producer to assemble in Brazil, and the company is hoping that its commitment to increasing local content will help to secure a position as a propulsion provider for the E-X stretch version of Embraer's E-170/190 series of regional jets. GE Celma also recently announced plans to with Embraer, Azul Linhas Aéreas and biofuels producer Amyris to collaborate on renewable jet fuel R&D, with the support of the government's FINEP program. In order to meet growing demand, GE announced plans in 2011 to invest $90 million to expand capacity in the Celma facility.
(Sources: Magalhães 2010, Mecham 2012, Rosas 2011, GE Aviation 2009)

Key policies and institutions in Brazil's aerospace industry

Policies and institutions supporting the commercial aerospace industry are primarily oriented towards ensuring the international competitiveness of Embraer, rather than expanding the SME supply base. With respect to the first goal, the special RECOF customs regime (see Table 8) has been crucial to the success of Embraer, as it drastically reduces the tax obligations faced by the company for importing components and other inputs. This is of critical importance to Embraer, which depends on the ability to cheaply integrate foreign technology into its aircraft for international price competitiveness. However, while Embraer's suppliers benefit from the Embraer's competitiveness, the import tax cuts provided through RECOF have the negative effect of reducing incentives to localize content in Brazil.

Indeed, in contrast to the medical devices and electronics cases below, the commercial aerospace industry in Brazil does not face any formal local content programs at all, though the state's "golden share" in Embraer (seeTable 8) creates a mechanism through which the government can informally advocate for increased local content. However, as the vast majority of Embraer's inputs are still sourced abroad from established tier 1 and tier 2 suppliers, it does not appear that the state is prepared to pursue an aggressive localization strategy in the commercial aerospace industry. In fact, such a strategy would harm the international competitiveness of Embraer, the cornerstone of the national aerospace industry.

Like most other countries, however, the Brazilian government supports the national defense industry, including through a defense offset policy that creates incentives for the local sourcing of defense-related goods. A defense procurement policy oriented towards the localization of dual-use technologies, which have applications to both the defense and civilian industries, could have positive spillovers for the commercial aerospace industry.

Table 8. Policies and institutions relevant for Brazil's aerospace industry

ANAC: ANAC (National Civil Aviation Agency), formed in 2006, is the Brazilian agency responsible for the regulation of the domestic civil aviation market, including the provision of flight permissions, the oversight of compliance with operational safety and environmental regulations and the certification of products sold on the domestic market. Aerospace products to be sold in Brazil must be certified by ANAC. ANAC has agreements with regulatory agencies in other countries, such as the Federal Aviation Administration (FAA) in the United States and the European Aviation Safety Agency (EASA), in order to ensure the harmonization of certification requirements. Embraer and only a small handful of local SMEs have taken advantage of ANAC's international agreements in order to certify their products for sale in other jurisdictions; interviews suggested that the opportunity remains underutilized.

RECOF: The RECOF (Industrial Bonded Warehouse Regime under Electrical Control System) customs regime was introduced through the passage of law 2,412 in 1997 and has been a key enabler of Embraer's competitiveness. Embraer is not the only aerospace company in Brazil to take advantage of RECOF; GE Celma, the propulsion MRO and assembler discussed in Box 2, also participates in the RECOF customs regime. Under this regime, the participating importer is entitled to the suspension of federal taxes levied upon the importation of goods to be used in the production of good to be exported. Perhaps more importantly, RECOF also grants participating companies expedited customs clearance, allowing them to bypass a process that can otherwise take up to a month. This regime only applies to expressly approved products, such as aerospace products, electronic and telecommunication products, automotive products and semiconductors. To be entitled to RECOF, Brazilian aerospace companies must meet basic equity requirements and export at least $10 million per year[15] (Softway, 2013a). The RECOF process is managed by the IT firm Softway, a Brazil-based subsidiary of Thompson and Reuters, which provides software platforms for import-export processes to clients in Brazil and other Latin American countries (Softway, 2013b).
The Golden Share: Upon privatizing Embraer in 1994, Brazil's federal government retained a 1% "golden share" in the company. The golden share grants the government the same voting rights as owners of ordinary shares, but also allows the government veto power over decisions in particular areas including changes in the mission or social objectives of the company, changes in military programs, transfers of military technology and transfers in the shareholder control of the company (Embraer, 2009). The government has used the voting power afforded by the golden share to advocate for higher local content in Embraer's supply chains.
Law 12,598: Law 12,598, passed in March 2012, provides incentives for defense-related industries. The law establishes the Special Tax for the Defense Industry (Retid), which provides companies in the defense industry with differential access to funding. The law also exempts these companies from some taxes and social security contributions and permits the federal government to exercise preference for local producers in procurements. Given that many suppliers to the commercial aerospace market also serve (or have the potential to serve) the defense market, this law could create opportunities for firms in the commercial segment of the market.
Defense Offset Policy: Decree 764 of the Ministry of Defense provides the basis for Brazilian offset policy. This policy requires that companies bidding on defense-import contracts valued at more than $5 million must include the execution of offset agreements in the bid. Generally, prime contractors must offset 100% of the contract value, though indirect offsets allow these companies to fulfill the offset requirement by expanding local production of some other high-tech product. In addition, Brazilian offset policy introduces technology transfer as a consideration in procurement negotiations. Since global suppliers in the commercial aerospace market overlap substantially with those in the defense market, the offset policy creates incentives for upgrading in the domestics commercial aerospace industry. Notably, Helibrás, a subsidiary of Eurocopter that today acts as a lead firm in the civilian and military helicopter sector, was established in São José dos Campos in 1978 as a result of defense offset negotiations (Perlo-Freeman, 2004).

Findings and recommendations for Brazil's commercial aircraft industry

Thanks to the presence of Embraer and a historical commitment on the part of the state to the aerospace industry, Brazil is recognized throughout the world for its aerospace industry. However, the success of the Brazilian aerospace industry remains too heavily dependent upon Embraer, a point which is underscored by the industry's declining trade surplus. Indeed, Brazil lacks completely the tier 1 and tier 2 firms that are have come to play a greater role in industry decision-making due to the rise of the risk-sharing partnership. Furthermore, Brazilian SMEs have a highly concentrated customer base; many have become captive suppliers to Embraer, lacking the research, design and manufacturing capabilities and financial resources to diversify their markets.

In order to enhance the competitiveness of its aerospace industry, Brazilian policy-makers should adopt a new industrial policy approach focused on building scale, diversifying markets and

[15] The minimum export value to qualify for RECOF was reduced in 2012 from $20 million to $10 million for firms in the aerospace and automobile industries (Softway, 2013).

enabling Brazilian firms to secure world-class imports. As Embraer's presence is unquestionably an enormous boon to the Brazilian economy, the industrial policy regime must be effectively reformed without "killing the goose that laid the golden egg." By better facilitating links to global suppliers and supporting the capabilities of the domestic supply base, policy can promote the discovery and exploitation of niche activities in additional GVC segments.

Findings	Recommendations
Links to Global Suppliers. The best way for local SMEs in Brazil to link to GVCs in the aerospace industry is to win contracts from global suppliers, either remotely or, more likely, with their affiliates in Brazil. Global suppliers want lower tier suppliers to be able to produce to adequate scale, to have received international public and private certifications, and to have demonstrated technical and managerial competence.	• Assist SMEs in building scale and competence through the facilitation of mergers and new consortia. High Technology Aeronautics (HTA), which was cancelled in 2009, may serve as a model. • Facilitate the certification of local SMEs by taking advantage of ANAC's partnerships with foreign regulatory agencies. • Establish specific programs attract more global supplier facilities to Brazil and to retain and those already in the country. • Explore options for opening the benefits of the RECOF tariff regime to SMEs. By gaining access to world-class inputs, rather than needing to produce them in-house, Brazilian SMEs will be in a better position to upgrade into higher value-added activities.
R&D Capabilities. Few Brazilian firms have the know-how and experience to operate in the design segment of the value chain, especially with regards to avionics and propulsion systems. Lack of design capabilities limits these firms to the lower tiers of the production pyramid and makes participation in projects as a risk-sharing partner impossible.	• Encourage the formation of aerospace engineers, and their retention in the national industry. • Facilitate relationships between Brazilian SMEs and Tier 1 firms in order to foster technology transfer and build design experience.
Cross-Industry Linkages. Machined metal components are a major input in not only the aerospace industry but also in a number of other industries that represent diversification opportunities for Brazilian components manufacturers, including defense, automotive, oil and gas and shipbuilding. In the oil and gas and shipbuilding industries in particular, there is currently a drive to increase local content, which could present opportunities for aerospace manufacturers. However, owners of aerospace SMEs are frequently ex-employees of Embraer and may not be aware of opportunities in other markets.	• Conduct a set of research projects to identify cross-cutting processes, competencies and product categories across related industries. Widely publicize the results to relevant firms. • Establish cross-industry marketing boards staffed by personnel from the representative firms. • Investigate the economic development impacts of offset programs and identify opportunities to leverage technology transfer to support innovation in the commercial market. • Sometimes, divisions within large firms operate very separately and efforts to identify and build synergies across the organization and current and potential customer bases need to be undertaken

5. Brazil's Role in the Medical Devices GVC

Introduction and general industry background

The medical device industry is extremely heterogeneous, including products with radically different price points, technologies and end-markets. Following the World Health Organization (WHO, 2010), we define a medical device as "any instrument, apparatus, implement, machine, appliance, implant, in vitro reagent or calibrator, software, material or other similar or related article that does not achieve its primary intended action in or on the human body solely by pharmacological, immunological or metabolic means." This ranges from low-technology disposables such as adhesive bandages and suture materials to large, complex, and extremely expensive diagnostic equipment such as magnetic resonance imaging (MRI) systems. Making claims about the medical devices sector "in general," then, is not possible. For this reason, we examine GVC dynamics within different sub-sectors of the medical devices industry when considering policy interventions and upgrading initiatives.

In this study, we follow BNDES (Pieroni *et al*., 2009) and ABIMO (2011), dividing the medical devices industry according to the following product categories: dental equipment, disposables, implants, laboratory equipment, medical/hospital equipment and radiology/diagnostic equipment. We do this to remain consistent with relevant Brazilian industry classifications, since there is no broadly accepted approach to disaggregating the medical devices sector. "Appendix B: Medical devices" contains the product list, including HS codes and sub-sector designations, used in our analysis.

The global medical devices industry is changing rapidly as advances in technology drive innovation in new product markets. For example, there are two emerging product areas that reflect the growing importance of information technology (IT): *integrated solutions*, which combine medical device hardware with training, consulting and other post-purchase services; and *convergence products*, devices that combine technologies from the medical device, information technology and/or pharmaceutical sectors. Medical IT systems are an example of a convergence product. They include information systems used in the administration of laboratories and hospitals, as well as software interfaces used with various types of therapeutic and monitoring devices, such as drug-eluting stents and implants (McCaffery *et al*., 2004; McHugh *et al*., 2012).

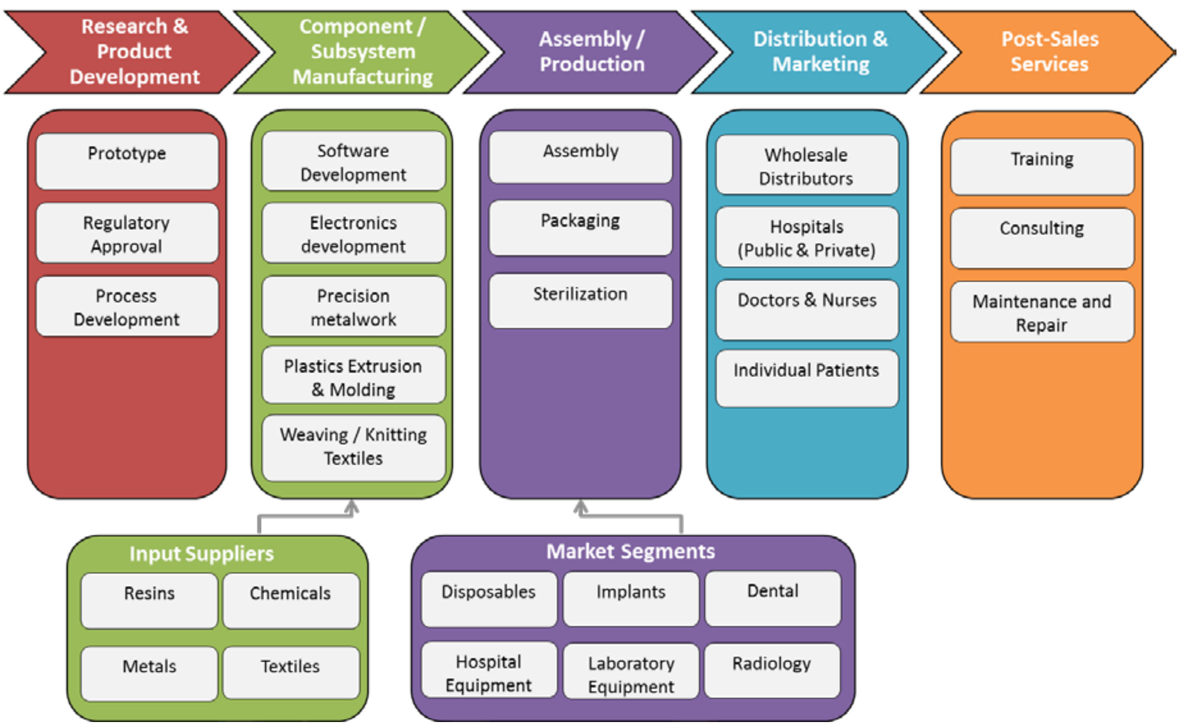
Estimates of the size of the global market for medical devices differ based on the products included in the classification of the sector. Such estimates range from US$164 billion in 2010 (Markets and Markets, 2011) to Johnson and Johnson's (J&J) estimate of $350 billion in 2010. BNDES estimated a global market size of $210 billion in 2008 (Pieroni *et al*., 2009).

The medical devices GVC

The medical devices GVC, unlike the aerospace and automotive GVCs, is not a tiered system. Medical device producers tend to be vertically integrated, a pattern driven in large part by the unique character of regulations in medical device markets. Regulatory approvals are product-specific, and are often difficult or impossible to extend to suppliers[16]. Many lead firms in the medical device sector also prefer to maintain as many operations in-house as possible in order to protect intellectual property (Forfás, 2009). As a result, the largest medical devices firms are highly vertically integrated, and perform in-house (though not necessarily within the same geographic location) nearly all of the activities in the value chain from R&D, through components manufacturing to assembly, and packaging and, finally, the distribution and maintenance of their products. Nevertheless, the industry is slowly adopting outsourcing strategies, as contract manufacturers gain the certifications required to begin to provide plastic and metal components for use in medical devices. However, because new regulations tend to place the burden of quality and supplier compliance for any part of the manufacturing process on the lead firm (McHugh *et al*., 2012), supplier selection tends to be extremely selective and occurs early in the product development process.

Figure 4 provides a graphic representation of the stages in the medical device sector, along with detailed activities, inputs, main market segments and the key state-level institutions underpinning the chain (R&D, education, sector supports, and policies and regulations).

Figure 4. The Medical Devices Global Value Chain Map



Source: Authors.

[16] In the aerospace industry, it is suppliers – not products – that are certified by national regulatory bodies.

Mapping the medical devices GVC

Research and Product Development: The highest value segment of the chain is research and product development (ProduCen, 2007). During this stage, new products are conceptualized, prototypes are produced and tested, and potential manufacturing capabilities are assessed. Following initial concept tests, the product is then registered for regulatory approval in the desired markets. The need for regulatory approval sets the medical device sector apart from many other industries. Depending on the risk-category of the device, regulatory approval alone can take up to six years, and as many as eight years can pass from product conceptualization to finally reaching the market.

Process development takes place at the same time as product prototyping in conjunction with engineers at manufacturing plants to determine the most efficient means of production. Inputs and production processes must be validated by the firm's quality assurance department in order to obtain regulatory approval. As a result, lead firms in the medical device GVC are acquiring new products and sources of supply through mergers and acquisitions (M&As) (Simoens, 2009). However, research and product development functions drive some segments of the medical devices industry (say, diagnostic devices) more than others (disposables). Nevertheless, regulatory diversity across countries and regions of the world can slow the process of new product and market development down, and require lead firms to establish a presence in multiple end markets to ensure that new products meet regulatory requirements and gain the needed regulatory approvals. Local firms may be acquired mainly because they hold the needed certifications.

Component and Subsystem Manufacturing: Given the enormous breadth of medical devices, several types of components feed into the assembly process. Knitting, weaving and cutting are required for products such as compression socks, mastectomy bras and bandages. Extrusion and molding are essential processes for making plastics components for products such as intravenous drug delivery catheters. Precision metalwork is required for stents and pumps, while electronic components and software development are required for a range of products, from small therapeutic devices such as pacemakers and neuromodulators to large equipment such as X-ray and ultrasound equipment. The importance of electronics and information technology in the industry is a growing segment of the industry, indicated by the inclusion of software and electronic components and subsystems such as key component production activities along with medical grade metals, plastics, and fabrics and fibers. Components may also require coating, electroplating or polishing prior to assembly.

Value-added in the components manufacturing segments of the value chain depends on the complexity of the manufacturing process. While component production typically remains vertically integrated within the assembling firm, there has been some steps towards outsourcing some activities to contract manufacturers, such as Tegra Medical and Suntron Corp., driven by the prevalence of contract manufacturing in the electronics sector. In fact, assembling circuit board and final products for lead firms such as Johnson & Johnson, GE Medical, and Medtronic is an important line of business for diversified electronics contract manufacturers such as

Flextronics International (see page 49). From a manufacturing point of view, home medical devices such as glucose meters and pulse/oxygen monitors have much in common with other consumer electronics products such as mobile phones, and are often assembled by contract manufacturers.

Final Assembly/Production: Final assembly of medical devices may be done either manually or by automation, again depending on the final product. Standardized products such as bandages are made on fully automated lines. Products such as infusion pumps have as many as 500 different components and require up to 200 different assembly processes. While some aspects of this work can be semi- or fully-automated, the work tends to be done by hand. Large, expensive systems such as MRI machines are produced in small lots with a great deal of precision work, accomplished by both machines and humans. Once final assembly is complete, many medical devices (aside from capital equipment) must be labeled, packaged and sterilized per applicable regulations in the end-market before distribution. Once packaged, most products undergo final sterilization using one of three technologies: E-beam (electrons are accelerated through the product), Ethylene-oxide (E-O) gas, or gamma rays. Sterilization services may be provided by a contract manufacturer. Home medical devices such as glucose meters and pulse/oxygen monitors have much in common with other consumer electronics products such as mobile phones, and are often assembled by contract manufacturers.

Distribution and Marketing: Medical device producers may distribute through wholesale distributors or directly to their end clients via internal distribution centers. End clients may be hospital or clinic administrators, those responsible for direct patient care such as doctors and nurses, or (via retail) patients themselves. In other words, the end market depends upon the characteristic of the device: hospital administrators are likely purchasers of large systems such as X-ray equipment, while individual patients are the most common purchasers of adhesive bandages. In terms of distribution channels, lower-value products tend to be distributed through wholesale distributors, while high value products are likely to be sold directly hospitals administrators.

Post-Sales Services: Post-sales services related to medical devices include training doctors, nurses and technicians to use medical equipment and devices; consulting services; and account management services for the regular supply of consumables, accessories, maintenance and repairs. The provision of post-sales services is a key characteristic of new integrated services products and is an emerging competitive differentiator among medical devices firms. Post-sales services like installation and maintenance tend to be more relevant in product markets characterized by high technology content, such as radiological and diagnostic imaging devices as well as some hospital equipment. Expensive equipment may be leased to hospitals clinics as a service, or be part of a mobile or centralized service where it is shared across multiple facilities.

Key actors in the medical devices GVC

In total, there are an estimated 27,000 firms in the global medical devices sector, 80% of which are small and medium sized firms (WHO, 2010). However, the industry remains highly concentrated in five lead firms, which account for 40% of the market (see Table A3 in the appendix). These firms are: Johnson & Johnson (USA), GE Healthcare (USA), Siemens Healthcare (Germany), Medtronic (USA) and Baxter Healthcare (USA). Each company makes products that cover a broad range of markets segments, from disposable adhesive bandages to ostomy supplies to advanced diagnostic equipment. The next 40% of the market is divided among the next 10 largest firms (Datamonitor, 2011; Seligman, 2012). Product diversity is being enabled by a spate of mergers and acquisitions as the twin dynamics of consolidation and globalization have swept the industry. Of the top 10 global medical devices firms, six have production facilities in Brazil, though all have at least one local office to oversee marketing, distribution and post-sales services.

Standards and certifications in the medical device industry

The medical devices sector is governed by a combination of public and private standards that are closely related and are designed, in principal, to ensure the safety of patients and quality of products. Regarding public standards, companies that wish to sell medical devices within a given national market must have each product approved by the relevant public agency. Table 9 shows the largest markets for medical devices, as well as the agencies that regulate the national sale of medical devices. Each market is overseen by a distinct regulatory body, and each regulatory body has distinct requirements (though different national standards frequently overlap) for certification in the domestic market. However, due to their significant market shares, the public standards of the United States, the European Union and, to a lesser extent, Japan tend to guide the development and commercialization of new products in this sector. Because approval in the United States continues to be more complex and time-consuming than in the European Union, the European market is often used as a launch pad for products that will later be sold to the US market (Puri *et al*., 2011).

Table 9. Largest International Markets for Medical Devices and Regulatory Agencies

Country	Medical Device Sales, 2009 (USD Billions)	Agencies
USA	91.3	Food and Drug Administration (FDA), Center for Devices and Radiological Health
European Union	78.4	Notifying Bodies (NB)
Japan	22.7	Pharmaceuticals and Medical Devices Agency (PMDA)
China	6.2	State Food and Drug Administration (SFDA)
Brazil	2.6	Agência Nacional de Vigilância Sanitária (ANVISA)
Mexico	1.9	Comisión Federal para la Protección contra Riesgos Sanitarios (COFEPRIS)
India	1.6	Indian Medical Devices Regulatory Authority

Source: ABIMO, Emergo Group, 2011

Private standards are also an important characteristic of the global medical devices industry, especially for SMEs that wish to become suppliers to MNCs. Medical device manufacturers, like those in many other industries, have based their quality systems on the ISO 9000:2000 family of generic business process and manufacturing quality standards (McCaffery *et al*., 2004). This general ISO standard is complemented by the industry-specific ISO 13485:2003 (Medical Devices, Quality Management Systems). The ISO 13485 standard is aligned with the United States Food and Drug Administration's regulations for good manufacturing practices in the medical device sector and has been granted to nearly 20,000 firms internationally as of 2012 (JQP, 2012).

The global market for medical devices

Demand for medical devices is highly concentrated in the United States, the European Union and Japan, which together account for more than 85% of medical devices purchases (WHO, 2010). These markets have reached maturity, with annual growth rates of 2% - 2.5% annually (Business Insights, 2010). As a result, developing countries represent an important growth opportunity for the sector, especially large emerging economies such as Brazil, China and India, where the average annual growth rates of healthcare expenditures have exceeded 10% in recent years (Business Insights, 2010). In Latin America, Brazil is the largest market for medical devices, followed by Mexico, and the region as a whole is considered to have important growth potential. In Asia, after Japan, China is the largest market for medical devices, followed by India.

Because the United States and Europe are the largest markets with the largest companies, medical devices production remains highly concentrated within these countries. Some estimates place the US production share as high as 51% (ProduCen, 2007).[17] As result of manufacturing concentration in the Global North, exports to developing countries are high (see Table 10).

Table 10. Top Exporters of Medical Devices

	Total medical devices exports (USD Billions)	Export Market Share
World	126,717	100%
EU-15	60,146	47.5%
USA	30,424	24.0%
Switzerland	7,620	6.0%
Mexico	4,274	3.4%
Japan	4,210	3.3%
China	2,634	2.1%

Source: UN Comtrade (for HS codes used see Appendix B: Medical devices)

In spite of rapidly growing demand, currently medical devices product lines do not necessarily meet the demand profile of these emerging markets. "Many medical devices designed for high-income countries do not respond to low- and lower- middle-income country needs. Devices which are complicated to use, for example, are not appropriate in settings where there is a shortage of trained staff" (WHO, 2010). Multinational medical device companies are responding by placing production and R&D facilities in developing countries with rapidly growing demand. For

[17] Measuring market share using international trade data is complicated due to significant intra-firm transfers, whereby a product may be exported by a subsidiary into the US as an unfinished product, sterilized and then re-exported as a finished product. Additionally, a significant portion of medical devices is consumed within the United States without being exported.

example, with the expectation that the Chinese market will soon account for 20% of the company's total demand for X-Ray equipment, GE Healthcare recently announced the relocation of its X-ray machine division headquarters to China (GE, 2011).

Driven by cost-cutting efforts, new regulatory environments and competitive pressures to locate facilities near fast-growing markets, medical device manufacturers are siting more and more facilities and activities in developing countries with little history of medical device production. On the regulatory side, growing tariffs and complex regulations in key emerging markets such as Brazil and China are encouraging the localization of design, production, sales and services capabilities. Regulatory changes in developed countries in some cases also help to push production to lower-cost countries. U.S. healthcare reforms, for example, place an additional 2% excise tax on all medical devices manufactured and sold in the US, which could be helping to drive production towards developing countries (Axendia, 2012; BMI, 2012b).

Location selection for production facilities is therefore based on multiple factors (e.g., the presence of qualified workers, production costs, the established presence of key supply chain actors and distance to market), and varies by product category (Fennelly & Cormican, 2006; Kimelberg & Nicoll, 2012). For example, low-value, high-volume commodity products such as surgical gloves and bandages are already produced, in large part, in relatively low-cost countries such as Brazil, Thailand and Malaysia (Business Insights, 2010), while many medical device production facilities that use electronics components are often based in Asia in order to remain close to electronics supply chains.

Brazil's position in the medical devices GVC

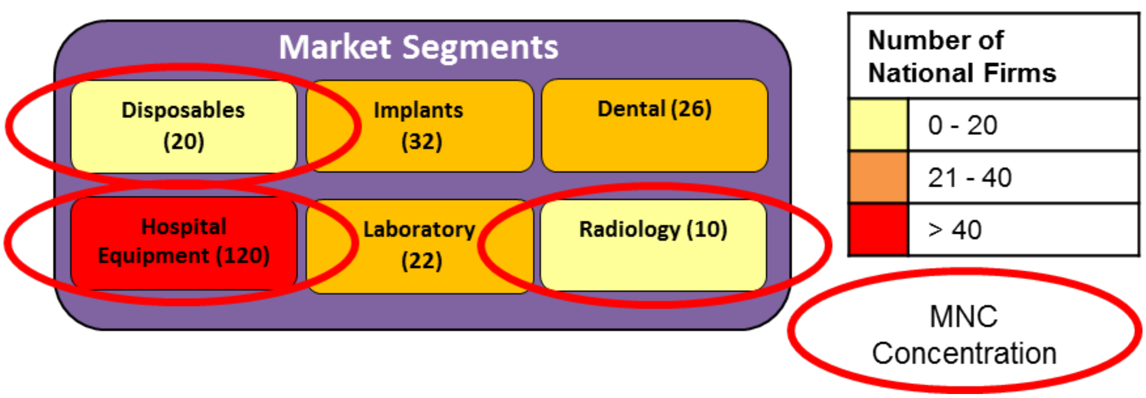
Revenues in Brazil's medical devices industry in 2011 were $9.9 billion (ABIMO 2012). Firms within Brazil occupy many segments of the medical devices GVC, though capabilities within any given sub-segment of the chain vary according to the market segment. Eighty-two percent of companies in the Brazilian medical devices sector are SMEs, and 52% of these focus on the hospital equipment segment of the industry (ABIMO 2012). Multinational companies tend to dominate the high and low value (per unit) segments of the market, particularly technology-intensive products such as radiological devices and high-volume consumables such as adhesive bandages (see Figure 5). In technology-intensive products, capabilities are high and patents create barriers to entry. In high-volume products, capital requirements for production facilities are high, and brand recognition creates barriers to entry for rivals.

Given their strong role in the global medical devices industry, the strategies of MNCs with respect to the Brazilian market are crucial (See Box 3).

Table 11 illustrates the years in which MNCs began producing medical devices in Brazil (note that all top 20 medical devices companies have at least a distribution office in Brazil). Broadly speaking, these companies can be divided into two groups: those that entered before the 1980's and those that entered after 2000. Companies that have used Brazil as a base of production for many decades primarily produce disposables, though some have expanded their product lines over time. For example, Becton-Dickinson, which had been producing primarily glass and plastic syringes, added laboratory equipment to its line of products made in Brazil. It is now the largest medical device supply producer in Brazil (Becton-Dickinson, 2013). Johnson & Johnson expanded its product portfolio as well, adding adhesive bandages to the line of disposable sanitary products that it has been manufacturing in Brazil for more than 50 years.

Newcomers (Phillips, GE, Samsung and Siemens) tend to manufacture larger, more technology-intensive radiological/diagnostic devices and medical equipment.[18] The entry of these companies correlates with both the growth of the domestic healthcare market as well as the introduction of production incentives through the informatics law and semiconductor policies. Though these last two policies are aimed at electronics companies, the growing use of electronic components like circuit boards and flat panel displays in high-tech medical devices means that some medical device manufacturers also fall under their purview. At the same time, the growth of contract manufacturers which provide assembly and other services, such as sterilization, in Brazil to medical devices lead firms has enabled the localization of more and more manufacturing activities (see Box 3). Given the complications of navigating this regulatory environment, these lead firms frequently pursue a strategy of acquiring already-certified local companies when initiating local production in Brazil.

Figure 5. Multinationals, National Firms and Medical Devices Market Segments in Brazil



Source: Authors.

Main sources of demand for Brazilian firms

The main sources of demand for Brazilian medical devices are the export market, the domestic private market and the domestic public health care system. The most dynamic areas of demand for Brazilian firms currently appear to be the domestic private and public markets. Though there has been some growth in recent years, Brazilian medical device exports remain relatively small, both as a share of the world market and as a share of total Brazilian exports.

[18] Covidien, a manufacturer of surgical sutures, is an outlier in this regard. Covidien's Polysuture subsidiary, set up in 2001, may help account for much of the growth in sutures exports over the last decade (see Appendix B: Medical devices).

Box 3. Contract Manufacturers in the Brazilian Medical Devices Industry

The outsourcing of component manufacturing, assembly and sterilization to contract manufacturers is a growing trend in the global medical devices industry, and Brazil hosts a handful of such firms. Baxter's facility in São Paulo, for example, both produces own-brand intravenous (IV) administration sets and also provides contract manufacturing services for the production of parenteral devices for local and international clients. Autocam, a US-based company that manufactures parts for automobiles and medical devices, set up a contract manufacturing facility in São João de Boa Vista in 2011 for the production of precision-machined components for medical devices (the company has been operating two automotive parts facilities in the country since the 1990's). Autocam's new facility was built specifically to serve medical devices multinational lead firms producing in Brazil. (Sources: Baxter, 2012; Autocam, 2011)

Table 11. MNC production in Brazil by year of arrival and market segment

Company	Began Production	Main Market Segments
Siemens	Expected by 2017	Radiology (Digital imaging devices)
Steris	2011	Medical Equipment (Sterilizers for hotels, clinics, etc.)
Samsung	2011 (via acquisition of Medison, which entered in 1985)	Medical Equipment, Radiology (Ultrasound devices, digital imaging)
GE	2010	Radiology, Medical Equipment (Analog x-ray, digital x-ray, CT scan, MRI, mammography)
Phillips	2008	Radiology, Medical Equipment (Digital x-ray, MRI, CT scans, mammograms, haemodynamic, arch surgery devices)
Covidien	2001	Disposables (Suture material)
Baxter	1977 (second factory: 1998)	Disposables (Dialisis, blood transfusion and ostomy accessories)
Becton-Dickinson	1954 (second factory: 1989)	Disposables, Laboratory (Syringes and parts, infusion devices, devices for analysis of blood)
Johnson & Johnson	1943 (current facility in São José dos Campos: 1954)	Disposables (sanitary products, cotton swabs, bandages, tapes)

Note: This list includes only foreign MNCs with production facilities in Brazil. It does not include companies with only distribution facilities.

Source: Company websites

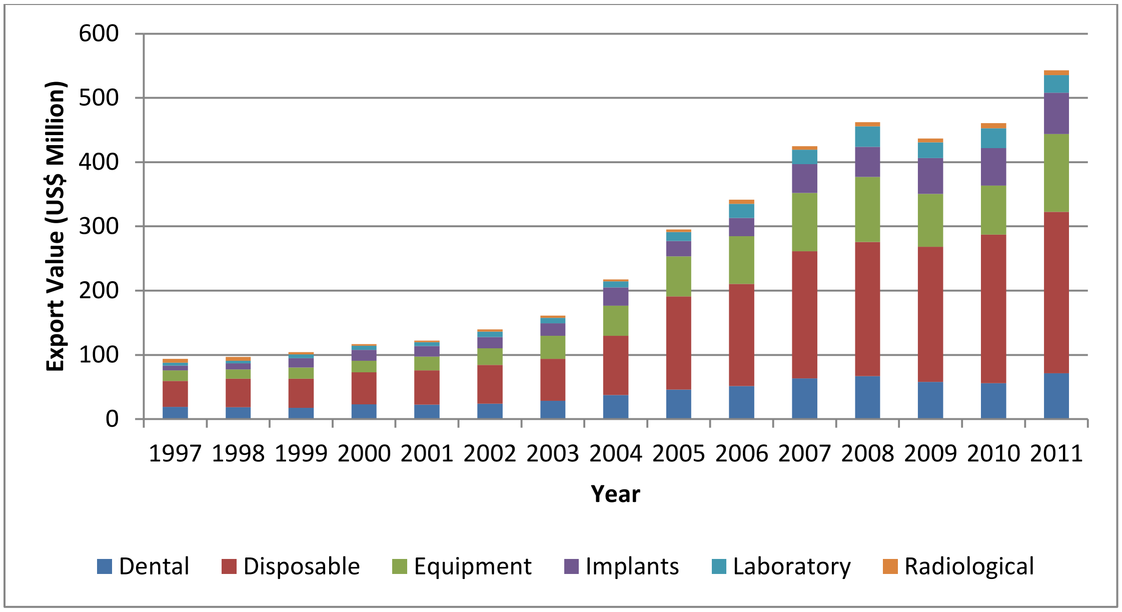
Figure 6 shows Brazil's participation in the world export market. Since 2000, Brazil's medical device exports have expanded five-fold from a small base, growing from $116 million to $542 million. In spite of this growth, exports still account for only 5.5% of production, which suggests that Brazil's medical devices industry still looks mostly inward for demand. Out of the six sub-sectors, disposables account for the greatest portion of this growth in both absolute and relative terms. The expansion of disposables exports has been driven by adhesive dressings (such as bandages), which saw very rapid growth (4913% between 2000 and 2010) and are currently the most-exported product in the sector, accounting for fully 15.8% of all medical device exports from Brazil in 2010. Surgical suture materials have also been an important driver of disposables exports, seeing 178% growth between 2000 and 2010, rising to 14.6% of the sector's exports. Exports in both product categories are largely controlled by MNCs that produce in Brazil for international distribution: Johnson & Johnson in the case of adhesive dressings and Covidien (via its manufacturing subsidiary, Polysuture) in the case of suture materials.

In terms of world export market share, disposables are also the dominant sub-sector for Brazilian medical devices, comprising 1.13% of the world market. Brazilian exports of dental equipment is relatively high, making up 0.51% of the world market, mostly consisting of dental exam chairs, which have a world export market share of 5.42%, the largest of any medical device product category. Prominent Brazilian firms exporting dental chairs include Gnatus and Olsen. Brazilian exports in high-technology medical devices remain low, however. Exports of radiological equipment, for example, amounted to only $25 million in 2010, implying a world export market share of 0.08%.

Thus, if we were to use export figures alone to identify Brazil's strengths in medical devices, we would conclude that Brazil's comparative advantage is in low-tech disposables. However, such products do not entail much industrial upgrading or technological learning. It is better to focus on the mid- to high-technology sectors in which Brazilian capabilities have been expanding in recent years, such as radiology equipment and healthcare IT systems for the domestic market. To develop some hints about this trend, it is helpful to examine the evolution of Brazil's imports of medical devices.

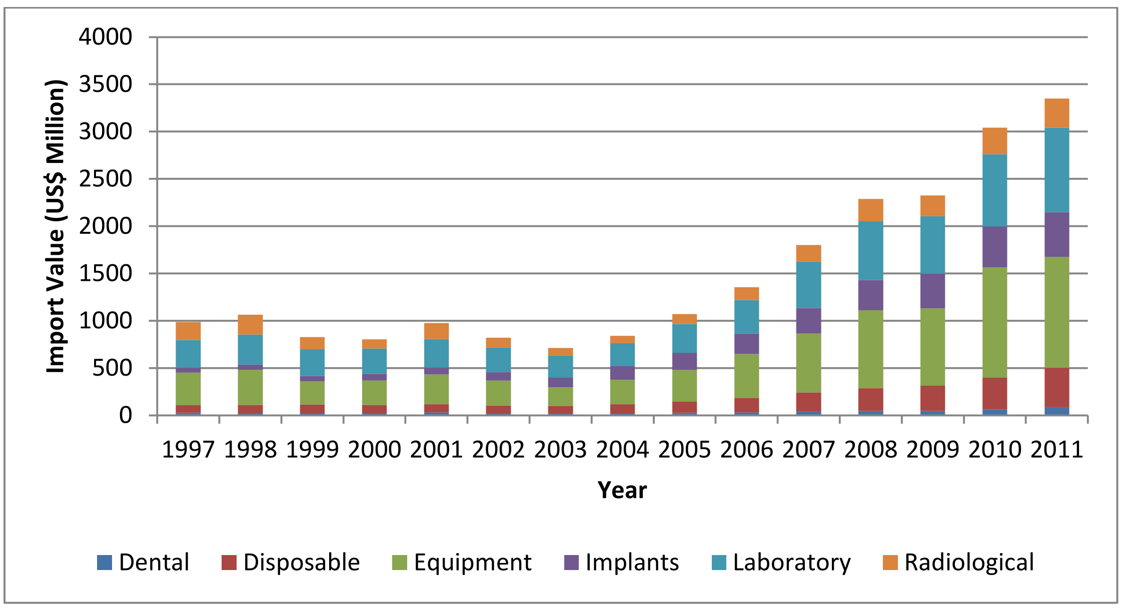
Given the significant size and growth of the Brazilian market for medical devices (currently the fifth largest in the world), import trends can shed light on recent and potential increases in domestic production (see Figure 7 and Appendix B: Medical devices). Total medical device imports for Brazil were $3.07 billion in 2010, 6.16 times greater than the value of exports. The two main categories of imports are medical equipment and laboratory equipment. In medical equipment, diagnostic imaging devices, ultrasonic scanning devices and hospital furniture have been the major import categories (see Appendix B: Medical devices). As for laboratory equipment, diagnostic reagents and associated instrumentation make up a large share of imports. Indeed, in recent years, there has been particularly high growth in imports of X-ray devices, MRI devices and computed tomography devices.

Figure 6. Brazils Medical Device Exports by Product Category, 1997-2011



Source: UN Comtrade

Figure 7. Brazil's Medical Device Imports by Product Category, 1997-2011



Source: UN Comtrade

One of the main factors explaining the growth of imports has been the expansion of the private healthcare system. As more Brazilians are entering the middle class through formal-sector employment, rates of private insurance coverage are increasing, which has accelerated demand for medical devices from private hospitals, which our interviews suggest prefer imported devices. Brazilians covered by the SUS, on the other hand — roughly half of the Brazilian healthcare market — receive care through the public hospital system, which have incentives to purchase locally made products. As of 2012, public hospitals receive 25% "preference" for local procurements through the Ministry of Health. In other words, the Ministry of Health authorizes public hospitals to spend 25% more on goods with high local content (at least 60%) than goods with low local content – a “classic” import substitution policy.

Key policies and institutions in Brazil’s medical device industry

We have already mentioned the importance of regulations and regulatory institutions in both production development and industrial location in the medical device industry. We have found that multiple agencies in Brazil are responsible for regulating the national medical devices market as well as facilitating local production. However, it is not clear that these agencies are pursuing a common and integrated vision for promoting and regulating the Brazilian medical device industry. The fact that major regulatory agencies lack coordination and sometimes even appear to work at cross-purposes increases the probability that the Brazilian policy environment may create unintended consequences. Because MNCs have a difficult time navigating the complex regulatory environment, they often acquire locally owned firms which already have ANVISA certification and Basic Production Processes (PPBs – see electronics section) approval rather than to build new facilities outright. For example, when Philips decided to move from distribution alone into the production of diagnostic devices in 2008, it purchased two local manufacturers in Brazil in order to gain entry into the market. More recently, GE acquired XPRO, a Brazilian manufacturer of invasive X-ray devices, both to take advantage of the company’s technology, which is well suited for emerging markets, and also to more quickly and easily overcome potential regulatory obstacles (see
Box 4).

Table 12: Policies and institutions relevant for Brazil's medical devices industry

ANVISA: The National Health Surveillance Agency (ANVISA) is charged with “sanitary control over production and marketing of products and services subject to sanitary surveillance. The latter embraces premises and manufacturing processes, as well as the range of inputs and technologies concerned with the same” (ANVISA 2003). ANVISA is a financially and administratively autonomous agency that operates under a management contract from Brazil’s Ministry of Health. In order to produce or sell medical devices or pharmaceutical products in Brazil, a firm must first receive a “good manufacturing” certificate from ANVISA. Medical devices take an especially long time to bring to market in Brazil. Receiving ANVISA approval takes, on average, one year, though the process is likely to become shorter due to recent reforms intended to streamline certification procedures. Some firms complain that ANVISA requirements are excessively strict – stricter, in fact, than the U.S. Food and Drug Administration. The ANVISA requirements are especially burdensome to MNCs that operate within GVCs because these firms must have all component manufacturers ANVISA-approved in order to sell products that are assembled and sold in Brazil, and many use global sourcing strategies to secure inputs.

Ministry of Health: The Ministry of Health oversees the Sistema Único de Saúde (SUS), Brazil's network of public hospitals, at which all Brazilians are entitled to receive care regardless of insurance status. By receipts, the SUS is among the largest healthcare systems in the world (CNS, 2008) and represents a promising market for manufacturers of medical devices and pharmaceuticals. Thus, the procurement decisions made by Brazil's Ministry of Health have major implications for the Brazilian healthcare sector, including the medical devices industry. Two relatively recent legislative changes have increased the discretion of the Ministry of Health in the procurement of goods destined for the SUS. Passed in 2010 under President Lula, law 12,349 sets a 25% preference for local producers during government procurement processes. Decree 7767 applies this preference margin to health-related goods, including medical devices. In order for a product to be considered "local," Brazilian content must be 60% or greater. The intent of these measures is to encourage the economic development of Brazilian industry and generate employment. However, given the global nature of multinational company structures in this industry, it is unclear if the 60% local content target can be met in practical terms.	
Apex-Brasil: Apex-Brazil has recently undertaken a project in partnership with ABIMO, the Brazilian medical devices industry association. Apex-Brazil has provided funding for ABIMO to hire international marketing representatives in key markets, including North America, Europe and Japan. This program seeks to create new distribution channels for small- to medium-sized Brazilian firms by allowing sales to foreign hospitals and wholesalers via ABIMO rather than through a foreign-owned distributor. Apex-Brasil's promotion activities in life sciences span both pharmaceuticals and medical devices. The dynamics of these two sectors, however, are very different. Competitiveness and innovation in pharmaceuticals is driven by patents. When a patient's life-span ends, importing the technology and manufacturing locally is a fairly straightforward process. In medical devices, on the other hand, technological improvements occur incrementally and are driven by interactions with users.	
Informatics Law: The Informatics Law's regulations surrounding PPBs are relevant for the newer, electronics-based medical devices that are currently high priorities for Brazil.	

Box 4. GE Healthcare and PPB Approval

GE Healthcare's new facility, built in 2010, has expanded the company's role in Brazil from simple distribution into upstream activities such as assembly and, for some items, component manufacturing. The company decided to expand its product line from three to 17 products, hoping to showcase these products in May, 2012, at Hospitalar, an important trade fair for medical devices in Brazil. GE knew that it had to acquire PPBs for these devices in order to produce and sell them in Brazil and, anticipating the standard six-month registration process, submitted PPB applications to MCT in October, 2011. With little explanation, however, MCT delayed its approval process, threatening GE's ability to unveil its new, Brazilian made medical devices at the trade show. Approval finally came, but only after an appeal on the part of GE. By nearly preventing GE's deployment of its (substantial) marketing capabilities at Hospitalar, this regulatory delay came close to negatively impacting demand for these Made in Brazil products. While GE was able to successfully deploy its influence and organizational resources in order to secure approval, it is unlikely that SMEs could pull off a similar feat, indicating that small firms could face a substantial institutional barrier to serving the local market.

Findings and recommendations for Brazil's medical device industry

Economic expansion has driven rapidly growing demand for healthcare services, creating a large and growing market in Brazil for medical devices. However, in recent years this market has been increasingly serviced through imported, especially as complicated digital components have become more important inputs to the sorts of high-value medical devices that Brazilian hospitals – both public and private – seek, including tomography devices, MRIs and x-ray equipment. However, given the inherently complex dynamics of the healthcare industry, multiple regulatory agencies influence the decision to produce (or not) in Brazil, and these agencies lack a coordinated strategy. As a result, industry executives complained about the uncertainty surrounding the timing and onerousness of various regulatory processes. In addition, they noted that current incentives to localize production seem out-of-step with an industry that (unlike pharmaceuticals, an industry which has seen a more successful overhaul of industrial policy) relies heavily on global production networks to bring products to market.

In light of these findings, we believe that policies should in most cases be reoriented away from traditional import substitution measures and towards the globalized realities of the contemporary medical devices industry. Adopting a more GVC-oriented set of industrial policies is in fact likely to contribute to closing the trade deficit in medical devices by redirecting the policy focus towards niches where Brazilian firms can be export leaders. Our research indicates that such opportunities exist in several high-value niche markets, including the development of medical software and R&D for products marketed towards other developing countries. However, achieving these goals will require greater coordination both among government agencies as well as between the government and industry actors.

Findings	Recommendations
<u>Promoting local production</u>. Brazil's exports are currently dominated by low-technology, high-volume consumables made by MNCs, while high-technology products are being imported. Avenues for FDI and technology transfer are hampered by a cumbersome regulatory environment. The slow approval process and strict local content regulations for medical devices creates a trade-off between the availability of new products in the market and an emphasis on local content. This could negatively impact patient care and the development of the industry in Brazil.	• In light of the preference for local content in procurement for public hospitals, the approval process should be streamlined. This will help to promote local production without slowing the diffusion of new technologies into Brazil. • Introduce incentives for R&D in order to facilitate longer-term innovation, rather than the simple import of foreign technologies, among local firms and MNCs. • Differentiate regulations and supporting initiatives affecting medical device companies from those governing pharmaceutical production. Production in these industries entails distinct technology drivers and risk factors.
<u>Access to inputs</u>. High-tech medical devices are complex products that incorporate complicated and highly specific inputs that are often unique to particular MNC production networks. In spite of local content regulations and procurement preferences, many of these inputs may never be produced in Brazil, at least not within a realistic policy horizon (for example, magnets for MRI devices), Not only do existing policies potentially inflate the local price of medical devices, they may also harm the international competitiveness of domestic firms who might wish to export to other countries.	• Identify product segments where import policies have a plausibly negative effect on the export performance of Brazilian medical device manufacturers. • Reduce barriers to imports of intermediate goods for high-priority product segments of the medical devices industry.

Inter-agency collaboration. Brazil lacks an integrated policy for the medical device sector. Relevant government agencies – ANVISA, the Ministry of Health, MCT, MDIC and Apex-Brasil – do not seem to have a shared vision. As is the case in many countries, policies aimed at assuring public safety are not well coordinated with policies aimed at fostering economic development, technological learning and innovation, and employment, Consequently, there is no common strategic plan to help the medical device industry move up the value chain.	• Develop an integrated vision for Brazilian medical devices across agencies. Develop complementary policy instruments and a clear focus for each agency. • Facilitate roundtable discussions between industry representatives and government agencies in order to identify potential niches where Brazilian firms might be globally competitive. Interviews suggested that medical devices with a big IT component could be a competitive area for Brazil.

6. Brazil's Role in the Electronics GVC

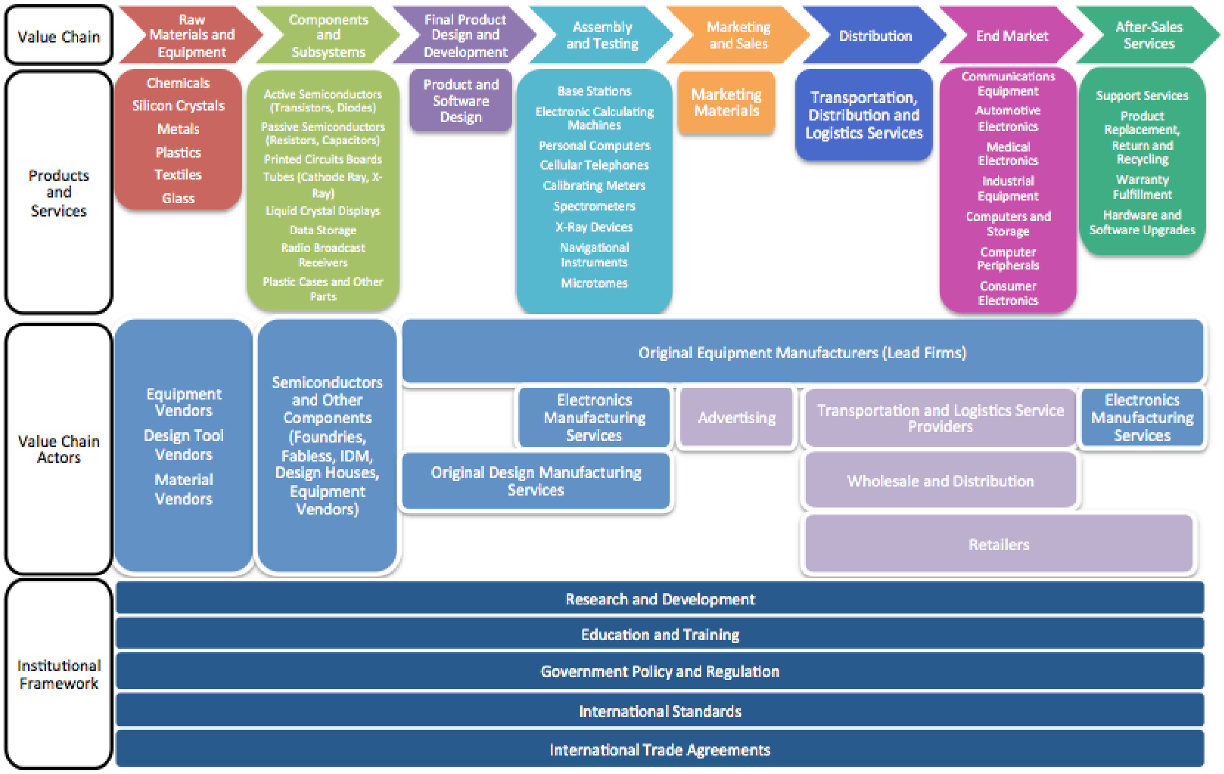
The electronics industry, broadly defined, makes products that rely on semiconductor devices to control the flow of electrons on electrical circuits. In turn, these circuits define and often allow users to manipulate product features and functionality. The electronics industry is distinct from the electrical industry, which is primarily involved in the generation, transmission, storage and conversion of high-voltage electrical energy. [19] Because the design and manufacturing requirements of electronic components and systems can be captured by computerized design and manufacturing software with relative ease, firms can exchange complex information at a distance more easily than in some other industries (Gereffi *et al.*, 2005). As a result, the industry is well suited to outsourcing and offshoring, and its GVCs tend to be spatially extensive. This "modular" character of electronics GVCs creates both opportunities and risks for countries like Brazil. On one hand, there are ample opportunities for attracting specific, narrow value chain segments; on the other hand, these are risks of becoming specialized in low value added segments. The GVC map in Figure 8 provides a stylized overview of the structure of the electronics value chain, highlighting the flow of products and services from one actor to another and the policy environment in which these relationships exist.

Introduction and general industry background

The electronics industry plays an extremely important role in international trade; electronics is the largest and fastest growing component of global trade in manufactured goods. The dispersed character of the electronics GVC means that trade in intermediate goods has increased even faster than trade in final goods; it has grown from 11.5% ($231 billion) of total intermediate manufactured goods in the electronics, automotive, and textile/apparel industries in 1988 to 20.3% ($1.9 trillion) in 2006 (Sturgeon and Memedovic, 2010b). In fact, electronics is one of the few industries for which growth in the trade of manufactured intermediate goods has outpaced trade in final goods, reflecting the pervasive trends of outsourcing and offshoring. The modular nature of the electronics GVC has allowed lead firms to delegate an increasing number of lower value added functions to contract manufacturers, including Electronics Manufacturing Services (EMS) firms, which provide manufacturing and ancillary services, and Original Design Manufacturers (ODMs), which provide manufacturing plus non-strategic (iterative) product design services. What follows below is a brief discussion of the key GVC actors, the roles they fulfill and the institutional framework that governs them.

[19] This industry primarily develops electro-mechanical products, which rely on higher-voltage electricity to actuate mechanical systems. In today's context, electronics are key elements of "smart" electrical grids and complex electro-mechanical systems such as automobiles and robots, which are in fact controlled – in whole or in part – by electronic control modules.

Figure 8. The Electronics Global Value Chain Map



Source: Authors.

Key actors in the electronics GVC

Lead Firms

Lead firms coordinate electronics GVCs and tend to earn the lion's share of profits through the sale of branded products and systems to end-users. They are often diversified in terms of the market segments they serve, and are highly recognizable due to their global branding efforts. Because of their technological leadership and large investments in brand development, they are able to exert power over all but a few of their suppliers (Sturgeon and Kawakami, 2011).[20] Most are headquartered in industrialized countries like the United States, Japan and Western Europe; however, some are based in other East Asian countries, such as South Korea (e.g., Samsung and LG) and China (e.g. Huawei and ZTE).

Lead firm strategies vary widely. Some lead firms like Samsung (South Korea) and NEC (Japan) design and produce many of their own components and subsystems, as well as final products. They also market and sell an array of products and systems to end-users. Other firms, such as Apple, outsource a majority of value chain functions to specialized component producers, contract manufacturers, and other services providers. For example, Dell (U.S.) outsources much

[20] Exceptions include suppliers of core technology platforms, such as Intel in PCs and Qualcomm in mobile communications.

of the design and manufacturing of its notebook PCs to ODM contract manufacturers based in Taiwan (with manufacturing in Mainland China). In Brazil, Dell even outsources R&D activities to a global contract manufacturer, in order to meet government requirements for R&D spending in the country. Nevertheless, Dell retains a great deal of power in the value chain due to its ability to select suppliers, its branding efforts, and its significant market share in PCs and computer servers (see Appendix C: Electronics, Table C1 for more details).

Contract Manufacturers

As lead firms like Dell and Hewlett Packard continue to outsource production, contract manufacturers have become increasingly important players in the assembly, testing and after-sale service nodes of electronics GVCs. Some are small. For example, Escatec, a Swiss contract manufacturer that operates in Switzerland, Malaysia and the U.S. earns a relatively modest $200 million in annual revenues. It specializes in the provision of design and manufacturing services for highly advanced products, such as digital lighting systems, industrial controls, and medical electronics. While these market niches are highly profitable, they generally involve lower volume production. It is not uncommon for firms like Escatec to fill orders numbering in the hundreds of units (Ojo, 2012). Conversely, a large EMS contractor like Flextronics will generally not open up a surface mount technology (SMT) line for a commitment below several hundred thousand units.

In some cases, contract manufacturers specialize in final product design plus high volume manufacturing. This is what, in large part, differentiates traditional EMS from ODM contract manufacturers. By performing product design as well as manufacturing services, ODM contractors capture more segments of the value chain; yet due to the specificity of product design capabilities (relative to manufacturing, which is more or less generic), ODMs tend to focus on a narrow range of products, especially products where product designs are iterative, and based on core technology platforms (i.e., PCs and mobile phone handsets). As the markets for the products they specialize in have grown, ODMs have become very large. For example, Quanta Computer of Taiwan is the largest manufacturer of notebook computers in the world. In general, because of intense competition and relatively easy substitutability, high volume contract manufacturers tend to have low profit margins. Table 13 shows the largest EMS and ODM contract manufacturers in the world.

Seven of the 12 largest contract manufacturers are based in Taiwan. One of Taiwan's most successful contract manufacturers, Foxconn Technology Group (Hon Hai Precision Industry), has eclipsed its competitors, bringing in almost three times the revenue of the second-place contractor, Quanta Computer. However, Foxconn, like other EMS contract manufacturers, suffers from low profit margins (just 2.4% in 2011) and must compete on a global level to maintain market share (Mishkin and Palmer, 2012). Foxconn's close relationship with Apple has been its main driver of revenue growth in recent years. EMS and ODM contract manufacturers fill an increasingly complex role in the electronics GVC; they must not only work closely with lead firms to develop products and meet tight production schedules, but also with component manufacturers to ensure that they can meet demand and keep their lines operating at, or near, full capacity.

Table 13. Top Global EMS and ODM Contract Manufacturers in 2011

Rank	Company	Primary Business Model	Ownership	2011 Revenues ($ Million)	Manufacturing Facilities in Brazil
1	Foxconn Technology Group	EMS	Taiwan	$93,100	Yes (4*)
2	Quanta Computer	ODM	Taiwan	$35,721	No
3	Compal Electronics	ODM	Taiwan	$28,171	Yes (1)
4	Flextronics	EMS	U.S & Singapore	$27,450	Yes (3)
5	Winstron	ODM	Taiwan	$19,538	No
6	Jabil Circuit	EMS	U.S.	$16,760	Yes (2)
7	Inventec Corp	ODM	Taiwan	$12,696	No
8	Pegatron Corp.	ODM	Taiwan	$12,418	No
9	Celestica	EMS	Canada	$7,210	No
10	Sanmina SCI	EMS	U.S.	$6,040	Yes (1)
11	Cal-Comp Electronics	ODM	Thailand	$4,469	No
12	Lite-On IT Corp	ODM	Taiwan	$4,125	No

*Foxconn agreed to open 5th plant in Sao Paulo in 2014, will reach full capacity and employ 10,000 in 2016
Source: The Circuits Assembly, Top 50 EMS Companies 2011; Company Annual Reports; Bloomberg Businessweek

Component Manufacturers

While products like iPads, digital thermostats and mass spectrometers serve a diverse set of purposes and end markets, they all depend on the same underlying technology: semiconductors. Semiconductors are produced in a handful of very expensive and highly sophisticated fabrication plants, otherwise known as 'fabs'. The semiconductor fabrication market is highly concentrated, due in large part to high barriers to entry. The estimated cost associated with building a fabrication facility capable of manufacturing semiconductors at the current high volume frontier ranges between $1 and $10 billion, depending on the size and specific technology adopted (Mokhoff, 2012). Moreover, these facilities can require upwards of $1 billion in annual R&D expenditures to remain competitive. Most of these costs are paid to a handful of highly sophisticated semiconductor equipment firms, such as AMSL (Netherlands), Applied Materials (U.S.) and Tokyo Electron (Japan). See Appendix C: Electronics, Table C2 for a list of the top global semiconductor equipment suppliers.

The prohibitive cost associated with building and operating a fab has driven the development of the fabless/foundry model, whereby design and manufacturing are split. 'Fabless' semiconductor design firms outsource the production of their integrated circuits to cutting-edge semiconductor 'foundries' that work for multiple design houses. Fabless semiconductor companies focus on design, sales and R&D, while outsourcing the manufacturing to either pure-play foundries that specialize in manufacturing other firms' designs, or to integrated device manufacturers (IDMs) with excess capacity. Semiconductor firms have experimented with different models. For many years, IBM set significant capacity aside for its foundry business, while other firms, such as AMD and MPS (U.S.), have experimented with 'fab-light' models whereby they have smaller fabs for key products and use pure play foundries for less important products. Producers of key technology platforms have chosen both the IDM model (Intel) and the fabless model

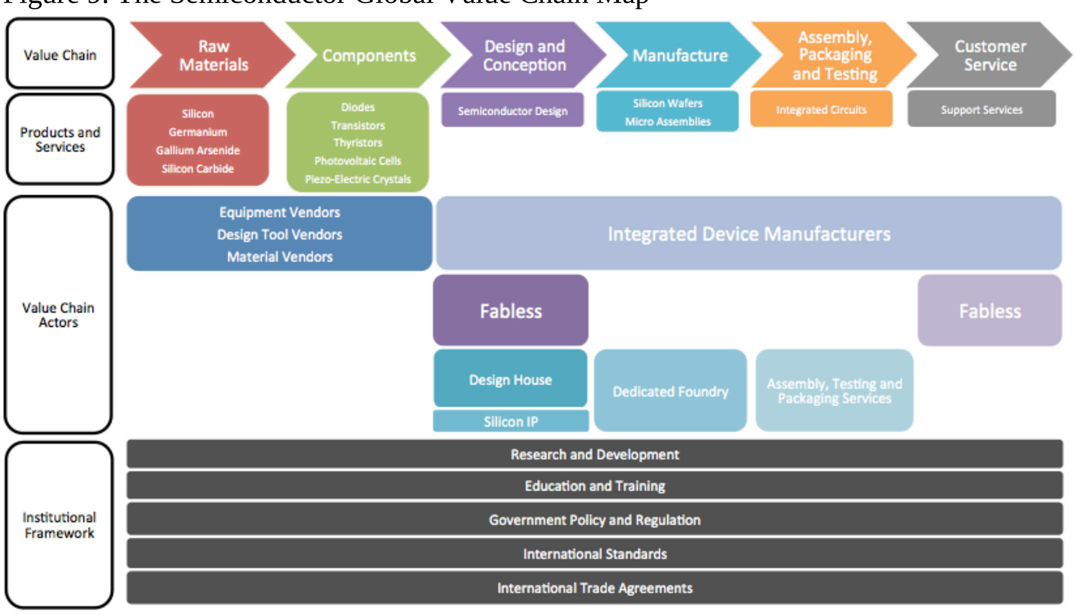
(Qualcomm). The largest 25 fabless semiconductor firms are listed in Appendix C: Electronics, Table C3.

The GVC map in Figure 9 outlines the array of functions, products, services, actors and nodes found in the semiconductor value chain. The map includes several nodes and niches important in the developing country context. Fabless design houses are often located in developing counties because they require little in the way of capital investment. Semiconductor assembly, packaging and testing – where raw semiconductors are packed into usable electronic components – has long been performed in developing countries, especially Malaysia, the Philippines and Costa Rica. Finally, there is a growing cadre of silicon intellectual property (IP) firms like ARM Holdings (UK) and MIPS Technologies (U.S.), which license their technology for inclusion in more elaborate semiconductor designs.

Because of the success of the fabless/foundry model, a greater volume of semiconductors — greater than the sales of any single design firm — can be made by a single pure-play foundry.

Table 14 shows the dominance of Taiwan Semiconductor Manufacturing Corporation (TSMC), the company that pioneered the foundry model in 1987, and produces chips on behalf of design houses all over the world. While foundries are impractical propositions for most developing countries, their presence has allowed for the proliferation of fabless design companies, creating valuable points of entry into the GVC for emerging economies like Brazil.

Figure 9. The Semiconductor Global Value Chain Map



Source: Authors.

Table 14. Top 12 Semiconductor Manufacturers 2012

Rank	Company	Foundry Type	Ownership	Projected Sales ($ Million)
1	TSMC	Pure-Play	Taiwan	$16,720
2	GlobalFoundries	Pure-Play	U.S.	$4,285
3	UMC	Pure-Play	Taiwan	$3,775
4	Samsung	IDM	South Korea	$3,375
5	SMIC	Pure-Play	China	$1,625
6	TowerJazz	Pure-Play	Israel	$655
7	Grace/HHNEC	Pure-Play	China	$605
8	Vanguard	Pure-Play	Taiwan	$590
9	Dongbu	Pure-Play	South Korea	$540
10	IBM	IDM	U.S.	$435
11	WIN	Pure-Play	Taiwan	$425
12	MagnaChip	IDM	South Korea	$375

Source: IC Insights; Company Annual Reports

The key actors in the electronics GVC operate within an institutional framework governed by international certifications and standards, trade agreements and national policies, which in turn drive education and R&D priorities. Perhaps most important are the *de facto* standards set by foundries (design rules that fabless design houses must follow for the foundry to produce the semiconductor), by semiconductor manufacturing equipment companies, etc. Firms that sell these products set many of the standards that their customers need to follow. The institutional framework that governs the electronics GVC in Brazil is the product of a unique historical legacy, marked by periods of import substitution industrialization and periods of liberalization.

Brazil's position in the electronics GVC

Brazil's role in the electronics GVC has evolved over time, and has received increased attention from policy makers. A growing middle class has begun to demand consumer electronics on an unprecedented scale. According to the World Bank, Brazil's poverty rate declined from 41.9% in 1990 to 21.4% in 2009 (World Bank, 2012). Brazil's middle class is demanding improved communications infrastructure to cope with increased smart phone penetration and Internet usage. This current demand will be heightened by the projected influx of visitors during the World Cup and Olympic games. In addition, Brazil's dynamic energy and natural resource sectors will continue to drive demand for increasingly sophisticated industrial equipment. These trends present Brazil with a range of upgrading opportunities in the electronics GVC.

Electronics Trade and Production Statistics

An analysis of Brazil's trade and production statistics in recent years provides some clues about where the country stands within the electronics GVC. For the purposes of this project, the research team developed a sector definition based on the 2007 HS classification system. The sector definition was translated through CONCLA conversion tables to obtain CNAE codes required to access IBGE production data. The HS codes were then aggregated into sub-sectors based on classifications developed by both the Brazilian Electrical and Electronics Industry Association (ABINEE) and existing academic literature (Sturgeon and Kawakami, 2011). A full list of these codes can be found in Appendix C: Electronics, Table C5.

According to our data, the Brazilian electronics sector is highly dependent on imports (see Table 15). For instance, consumer electronics imports grew by 142.7% between 2007 and 2010, while exports dipped by 24.8%. In terms of domestic production, the strongest performing sectors include medical electronics, industrial equipment and automotive electronics. These sectors are competitive globally, exhibiting positive export growth as well as increased production between 2007 and 2010.

Overall, Brazil's trade deficit in the electronics sector is dramatic. The country exported $2.5 billion worth of electronic goods in 2010 and imported over $17 billion. Between 2007 and 2010, exports declined by 32.3% and imports increased by 36.0%. (For trade and production statistics, see Appendix C: Electronics, Table C4). A significant portion of the deteriorating trade deficit can be explained by changes in the communications equipment sector. First, investment in Brazilian network infrastructure by European network operators has declined in the face of the European financial crisis. Second, the shift of the mobile handset market from feature to smart phones has cut dramatically into Brazil's mobile phone exports, and reversed the balance of trade toward imports. This trend will be discussed in greater detail below.

Table 15. Growth Rates 2007-2010: Brazilian Electronics Exports, Imports and Production

Sector	% Export Growth	% Import Growth	% Production Growth
Medical Electronics	25.4%	62.9%	107.6%
Computers and Storage Devices	-61.9%	31.9%	58.9%
Consumer Electronics	-24.8%	142.7%	39.6%
Industrial Equipment	7.9%	36.8%	35.1%
Computer Peripherals and Office Equipment	-12.5%	63.6%	35.0%
Automotive Electronics	12.6%	51.8%	33.1%
Communications Equipment	-46.8%	-26.0%	-28.8%
Electronic Components	-26.5%	96.6%	-48.5%
Total Electronics*	-32.3%	36.0%	13.5%

*Total refers to the HS/CNAE Electronics sector definition; please see Appendix Table C5 for details

Source: Production Data: Conversions from CONCLA Correspondence Tables; Data from IBGE; Trade Data: UN Comtrade

Automotive electronics is one of the more competitive sub-sectors within the Brazilian electronics GVC. Brazil was the world's seventh largest producer of automobiles in 2011, with 3,406,150 units produced (OICA, 2012). However, all major automakers and suppliers are foreign multinationals, mostly from the U.S., Europe, and Japan. As Brazil's growing middle class stokes demand for new automobiles, and industrial policies continue to favor local production, global suppliers like Delphi, Visteon, Yazaki and Kromberg & Schubert are likely to increase production in the country. There are also industry-specific requirements that encourage certain technologies to continue to be developed in the country as well (see Box 5).

Box 5. Magneti Marelli's Software Fuel Sensor (SFS)

Global automotive supplier Magneti Marelli (Italy) began to develop an on-board, software-based solution for flexfuel cars in its Brazilian R&D center in the late 1990s. Variable amounts of gasoline and ethanol in Brazilian gasoline favored an on-the-fly mechanism capable of adjusting engine performance to the composition of the fuel. The product, composed of 100,000 lines of code, was developed in Brazil by a team of 30 researchers. The technology is now being exported to similar markets around the world. Magneti Marelli had 47% of the global flex fuel technology market in 2009 (Nascimento, *et al*., 2009).

Key policies and institutions in Brazil's electronics industry

While support for Brazil's electronics industry has been fairly strong for some time, efforts increased after 1991 when the Brazilian government began to target it explicitly and energetically. The key laws and programs shaping the Brazilian electronics industry today are listed below:

Table 16: Policies and institutions relevant for Brazil's electronics industry

Informatics Law: The Informatics Law of 1991 initially recognized the importance of the electronics sector and sought to incentivize local production and R&D through the use of Basic Production Processes (PPBs) and R&D investment quotas (Gutierrez, 2010).
Local content incentives: Firms are encouraged to manufacture in Brazil through product-specific PPBs – "the minimum group of operations, within the industrial plan, which characterizes real industrialization of a certain product" (Egypto, 2012). PPBs reduce industrial product taxes (IPI) on final products, raw materials, intermediate products and packaging goods associated with the incentivized product from 15% to near zero. In addition to federal incentives, PPBs call for a reduction in ICMS (state VAT) in many states (Sales, 2012). They can be claimed for production carried out in any area of the country (aside from the Manaus Free Trade Zone, which is governed by a different set of laws). PPBs are product, not company specific; only those products meeting the PPB's criteria receive benefits. They are defined and monitored by the Ministry of Science, Technology and Innovation (MCTI) and Ministry of Development, Industry and Foreign Trade (MDIC). Although the details of the PPB have evolved through several revisions to the Informatics Law, the goal of this policy has remained the same: to increase local content. PPBs set 'nationalization indices' that define how much of the incentivized product must be local content in order to retain the incentives offered. For example, the PPB for computer tablets in 2012 set the nationalization index at 30%; the stated objective is to raise the nationalization index to 80% by 2014.[21] The PPB goes below the aggregate product to develop a nationalization index. What does it mean for a tablet to be 80% Brazilian by 2014? According to the tablet PPB, this means that by 2014, 95% of the motherboard, 80% of the wireless communications interface, 30% of the mobile network access card, 80% of the AC/DC converter, 50% of the memory card and 50% of the display must be produced in Brazil (Positivo, 2012). Reaching ambitious nationalization indices for electronics products will depend largely on the development of a local component industry, something that the Brazilian government has sought to address through targeted policy measures during the last decade.

[21] According to Virgilio Almeida, Secretary for Information Technology for the MCTI, the increasing nationalization index should create jobs in Brazil, improve the profitability of component manufacturers and strengthen the entire tablet value chain (Vlasic, 2012).

R&D spending requirements: In exchange for the benefits associated with PPBs, firms must invest 5% of gross revenue from incentivized products in local R&D.[22] What constitutes R&D is quite flexible, allowing firms to pursue strategic objectives largely unhindered by government requirements. The key stipulation is that R&D must involve the discovery of a new technology or the development of new workforce capabilities, and not simply extend an existing, mature technology. To this end, R&D can be directed towards theoretical work; product, material, device and/or system development; and human capital development at the undergraduate and postgraduate levels in Brazil and abroad (Egypto, 2012).
Incentives for the semiconductor industry: The Brazilian Microelectronics Program, launched by the MCTI in 2002, sought to incentivize segments of IC manufacturing by offsetting exorbitant capital requirements involved in building a foundry with the latest technological capabilities. This focus on microelectronics continued through the 'Política industrial, Tecnológica e de Comércio Exterior' (PITCE) enacted by President Lula in March of 2004. PITCE focused on developing outward-oriented software and integrated circuit industries, among various others deemed to be of strategic importance to the country. In 2007, the government enacted PADIS, a subset of the broader industrial policy 'Plano Brasil Maior.' The program was designed to develop local semiconductor and display industries by targeting companies investing in R&D and manufacturing capabilities in Brazil.[23] While the focus has been on semiconductors, the program also creates incentives for display manufacturing in the country.[24] PADIS simplifies the process of acquiring equipment, raw materials and design tools. It also facilitates semiconductor device and display commercialization by eliminating social security contributions as well as IPI and corporate taxes.[25] In exchange, the firm must have fiscal regularity in Brazil and invest 5% of gross revenues from the incentivized product on local R&D. These incentives are valid until January 22, 2022 (Sales, 2012).
Plano Tecnologia da Informação (TI) Maior: Software is the fastest growing IT market segment in Brazil with a 16% compound annual growth rate (CAGR) between 2011-2015 (BMI, 2012a); the market itself is worth \$5.5 billion according to the MCTI. With the value of software increasing relative to hardware, the government is creating policies to foster growth in this node of the electronics GVC. Brazil has long had a viable cluster of software SMEs. Plano TI Maior is the most recent attempt to scale these firms up, the majority of which remain small and unable to compete outside Brazil.[26] Plano TI Maior seeks to leverage Brazil's existing base of firms and capabilities working in Brazil — the world's 7th largest IT market — to foster local industry growth (France-Presse, 2012). The most important component of Plano TI Maior is CTENIC, an equivalent of the PPB for software. This certification is currently under development and will define what constitutes 'Brazilian software.' When developed, CTENIC will create opportunities for preferential procurement if firms develop software locally. Explicit efforts to bolster software development in Brazil are important, as software developers cost considerably more in Brazil than they do in China and India.

[22] Of that 5%, just over 2% must be invested through partnerships with Brazilian research centers, institutes or educational institutions accredited by the government or deposited in a National Fund for Technological and Scientific Development. Up to two thirds of the other 2.7% may be invested into the National Fund for Technological and Scientific Development alone. The rest may be invested internally (Egypto, 2012).

[23] Those involved in semiconductor design and development, diffusion (front-end) and encapsulation and testing (back-end) receive incentives.

[24] Specifically in conception, development and design, the manufacture of photosensitive elements, photo and electroluminescent and light emitters and final assembly, electrical and optical tests of panel modules.

[25] A company submits an application to the MDIC or MCTI; outlining what products will be manufactured or designed in Brazil. If the products are linked to the legislation (fitting the HS codes supported by PADIS), then they are eligible for further analysis and ultimately fiscal incentives.

[26] Brazil's software industry began developing in the 1980s, mostly with banks like Itau developing financial automation software. The privatization push of the early 1990s provided incentives for an indigenous software industry, as programs like the Sub-committee of Software Quality and Productivity were installed in 1993 to encourage local R&D. The Secretariat of Information Technology (SEPIN) in the MCTI came to be responsible for designing and implementing software policy and developing training programs, government procurement guidelines and investment vehicles through which to capitalize innovative firms (Gouvea, 2007: p. 150). Additionally, various universities including Unicamp, Universidade do Estado da Sao Paulo (USP) and Universidade Federal do Rio Grande do Sul began to support the budding industry through specialized software development programs. An ecosystem of thousands of SMEs, a regulatory framework that supports export-oriented firms, and a network of public institutions providing funding and R&D bode well for Brazil's future as a software hub.

The electronics GVC in Brazil: examples

Trade and production data are a useful starting point to analyze interesting sub-sectors within the electronics GVC. Alone, however, they do not explain the complex relationships, growth potential and value of services in each sub-sector. Therefore, properly understanding where Brazil currently stands in the electronics GVC requires a more detailed analysis of specific sub-sectors and their constituent niche products and services.

The type and scope of work conducted by key GVC actors in Brazil is dictated, in large part, by a broad institutional framework. Lead firms, contract manufacturers and component suppliers are affected by industrial policies in different ways. What follows is an analysis of key GVC actors and how their activities in Brazil are subject to domestic policies and trends in the electronics GVC. The analysis will form the basis on which to build policy recommendations presented at the end of this section and at the end of this report.

Communications Equipment

Brazil's telecommunications sector has evolved in significant ways in the past 30 years, moving from a disorganized network of over 800 operators to a state-owned monopoly model before it was finally broken up after 26 years in 1998.[27] These shifts have had important implications for equipment manufacturers in the country. Several multinational equipment firms that ceased operations in the early 1990s and 2000s have returned in the last few years. However, many have chosen to source through contract manufacturers – as is the case with Nokia Siemens Networks – in order to stay asset-light and remain adaptive to rapidly changing market conditions and Brazilian regulations. According to a telecommunications industry executive, ANATEL, the telecommunications regulator, initially required a 50% nationalization index for infrastructure contracts awarded as part of its auction of 4th generation licenses. This requirement will increase to 60% in 2016.

[27] The creation of Telebras in 1972 signaled an important shift that led to the consolidation of the Brazilian telecommunications network under a state monopoly. As the sole institutional customer for telecommunications equipment, Telebras was able to leverage its purchasing power to ensure that technology and production remained local. Brazil was able to develop a complex ecosystem capable of innovation through a network of companies, public agencies, research institutes and universities (de Souza Szapiro, 2000; Mattos and Coutinho, 2005). In this 'triple helix system,' universities provided high level human resources and basic research while CPqD provided high-level research and developed prototypes. Firms worked with CPqD and other research centers to develop prototypes, and then scale them up for mass production. Telebras and its network of operators worked closely with CPqD to define technical specifications, test equipment and communicate network maintenance and expansion needs. In July 1998, the 26-year-old virtual state monopoly of Brazilian telecommunications was privatized in an effort to increase investment and competition, thus improving quality and access for a rapidly growing consumer base. This consumer base has continued to grow, leading some communications equipment MNCs to bring manufacturing operations back to Brazil. According to one industry executive, Brazil has one-quarter the number of base stations as Spain, a country with a much smaller number of mobile phone users.

Since privatization, the mobile operator market has become concentrated in four large firms.[28] The urgent need for investments in infrastructure became very public on July 23 last year, when ANATEL imposed heavy sanctions on TIM, Claro and Oi in response to complaints from consumers fed up with poor service quality and coverage. According to ANATEL, Brazil will need 240 billion Reais ($120 billion) invested in the next decade to avoid a collapse of the network under the weight of a rapidly growing contingent of subscribers (Economist, 2012). Thirty percent of this investment is earmarked for 4G technology, composed primarily of cutting-edge small cell base stations that will improve coverage in densely populated areas likely to become overloaded during the Olympics and the World Cup.

According to a telecommunications industry executive, just 10 years ago 80% of the value of an electronics product was in the hardware, 10% was in the software and 10% was in services. This has shifted dramatically in recent years, as the value is now spread evenly across each. Hardware is becoming less valuable relative to the software and services necessary to operate and maintain the IT systems. This caused a shift in lead firm strategy: companies now place a great deal of their focus on software and services aimed at upgrading existing infrastructure, or customizing products and services through systems integration. Existing hardware is capable of running different generations of standards, making upgrading a matter of better software as opposed to installing new hardware. This trend is readily apparent in NEC's activities in Brazil. It shifted its equipment manufacturing operations to Celestica (a Canadian contract manufacturer) in 2003, and now has 800 employees in the country, 300 of which work in the managed services division. In the future, companies developing IT software and services in Brazil will stand to gain from preferential public procurement through CTENIC.

Mobile Handsets

Mobile handset penetration in Brazil has grown very rapidly in recent years, from 32 million units in 2004 to 58 million in 2011 (ABINEE, 2012). Increasing demand for handsets has become largely a function of demand for smart phones, which causes a larger strain on an already limited network because of greater demand for data transmission. In 2007, Brazil exported over two billion dollars' worth of cellular phones. This figure dropped by over 50% by 2010 to just over one billion dollars. In 2004 – before smartphones came to dominate the market – Brazil exported 10 million units per year and imported just 1.3 million. By 2011, demand for smartphones had increased dramatically. In this year, Brazil exported 7.4 million units and imported 15.7 million (ABINEE, 2012).

Brazil's policy makers have tried to respond quickly to this shift in part by negotiating directly with Foxconn, the manufacture of the Apple iPhone and the world's largest electronics contract manufacturer. This move signals an understanding on the part of Brazil's policy makers that it is contract manufacturers (e.g., Foxconn and Flextronics) rather than lead firms (Apple and Motorola) that are currently making the bulk of manufacturing investments in the electronics

[28] Vivo (Spain's Telefonica), TIM (Telecom Italia), Claro (Mexico's America Movil) and Oi (Portugal Telecom). As of July 2012, these four companies have 99.7% market had in Brazil. Vivo is the largest, with 29.7% of the market (Geromel, 2012).

industry. The government hopes to directly target firms like Foxconn, and indirectly target lead firms like Apple, through policy instruments like PADIS (See
Box 6).

Box 6: Foxconn in Brazil

Foxconn has begun to assemble iPhones, iPads and most recently iPad minis in Brazil. While the company has promised to eventually manufacture components in the country as well, Foxconn currently imports 90-95% of its components. Recent negotiations for a fifth Foxconn factory in Brazil have included language to suggest that once production is at 100% in 2016, Foxconn will be manufacturing components in Brazil, including cables, cameras, touch-sensor glass, LED products, printed-circuit boards (PCBs) (Luk, 2012). Foxconn's presence in Brazil creates a number of immediate advantages, including employment opportunities and assembly capabilities to satisfy local content requirements. Foxconn currently employs 6,000 in Brazil and could add 10,000 more jobs by 2016 (Luk, 2012).

Because policy instruments remain dependent on Harmonized System (HS) codes to classify products eligible for fiscal incentives, smartphones do not have individual PPBs yet. The smartphone PPB is currently under development in consultation with HT Micron and ABINEE among other stakeholders. Local smartphone production will increase in earnest once projected Foxconn investments are complete. Moreover, the local company Positivo Informática will begin producing smartphones locally in the coming years.[29]

Notebook Computers

The country's leading sub-sector in terms of domestic production ($8 billion in 2010), computers and storage devices offers Brazil an opportunity to build off recent success and upgrade into higher value products like multi-user servers. Brazil is the world's third largest market for PCs, and the market is expected to grow by 8% to 17 million units sold by the end of 2012 (IDC, 2011). Active players in the country include global lead firms like Dell, Hewlett Packard, Lenovo and Positivo, among others. Until 2005, 70% of the total Brazilian computer market consisted of unbranded "white box" PCs. The 'Lei do Bem' (nº 11.196, 2005) reduced taxes on PCs valued at less than 4,000 Reais ($1,700 in 2005), dramatically increasing the size of the market. A Hewlett Packard executive claims that before the Lei do Bem, his firm had to compete fiercely for a small share of a small market. Since 2005, Hewlett Packard has increased its manufacturing and R&D in the country significantly to meet growing demand. HP has been aided in large part by contract manufacturers, which have also taken on a key role in R&D (See Box 7).

[29] Founded in 1972, Positivo Informática is one of Brazil's oldest and most successful electronics lead firms and has almost 16% of the PC market share in the country. It recently announced its intention to begin production of three different smartphone models on the Android operating system in Brazil directly in response to the PPB for smartphones under development (Prescott, 2012).

Box 7: Hewlett Packard and Flextronics

> Hewlett Packard (HP) has five manufacturing plants in Brazil, four of which are in partnership with contract manufacturers. The firm manufactures computers, desktops, portables, workstations, servers, single function printers and multi-function printers in the country; local production accounts for 95% of all local sales. HP only imports products without the scale to manufacture locally, including large format printers, high-end servers and some high-end portables. HP also manufactures ink jet printer cartridges according to PPB. The RFID chips in the printer cartridges are developed by CEITEC, a local foundry. HP Brazil has 400 engineers and researchers in its lab in the south of Brazil and has another 1,000 collaborators from universities and research centers in the country. It also has four software centers working on local, customer-specific applications. HP conducts a great deal of its Brazilian research through two R&D centers run in collaboration with the Flextronics Institute of Technology: the RFID Center of Excellence, which has worked on over 100 RFID-related projects with HP, and the newer Sinctronics IT Innovation Center, which focuses on environmental compliance and product recycling (Flextronics, 2012).

Multinational firms operating and selling in the Brazilian market must conduct local R&D in return for fiscal incentives. This has led to an expanded role for contract manufacturers once charged solely with production. In one case, the Flextronics Institute of Technology (FIT) was created in 2003 to offer clients services beyond outsourced manufacturing. In addition to the work it does for HP, FIT runs research institutes to develop software solutions on behalf of a number of global customers. It also conducts R&D on behalf of competing contract manufacturers, which do not have the R&D facilities to spend their quota internally. Hence, Flextronics has been able to develop economies of scale in R&D, much like it does through its manufacturing and assembly services. By increasing its role in the design and development GVC node, Flextronics has moved to fill a more sophisticated and profitable role than simple manufacturing and assembly, which is notorious for its wafer-thin profit margins (Lüthje, 2002). In general, the government has been flexible in terms of what it defines as R&D, allowing firms to pursue research that furthers their strategic objectives and offers the country benefits in terms of increased capabilities.

Component Manufacturers

The fragmentation of the semiconductor GVC following the development of the foundry model has enabled local IC design, semiconductor encapsulation and even small-scale semiconductor fabrication to emerge in Brazil. Still, government officials and investment promotion agents express serious concerns about the trade deficit in electronic components. Brazil’s electronic components imports roughly doubled between 2007 and 2010, from $1.2 billion to $2.4 billion while exports declined from $72 million to $53 million. Production of electronic components declined precipitously as well, a drop of 48.5% between 2007 and 2010. This growing trade deficit and shrinking production output have motivated the Brazilian government to address semiconductor manufacturing, specifically, through a number of collaborative projects, a few of which are listed below:

- Brazil’s IC Program was launched in 2005 to create local design houses and attract foreign ones as well. So far, these design houses work with Brazilian technical institutes and multinational firms to design chips for local niche markets. The first design houses included: The Renato Archer Research Center (CenPRA), currently CTI, in the city of Campinas; The Center of Excellence in Advanced Electronic Technology (CEITEC), in the city of Porto Alegre; Integratable Systems Laboratory of the Polytechnic School of the University of São Paulo (LSITec), in the city of São Paulo; and Brazil's IP Network (Rede Brazil IP), to which eight universities were connected.[30] Since the launch of Brazil's IC Program, the number of design houses has only expanded from seven to 25 and employ about 600 engineers (Gutierrez & Leal, 2004; Gutierrez & Mendez, 2008). The problem, as articulated by investment promotion agents and government officials, is an inadequate market. The design houses active in Brazil are limited to working with local SMEs, which do not provide enough demand for customized chips. Industry executives confirm that local design houses simply cannot compete and are not commercially viable in their current state. Nevertheless, some partnerships have developed successfully – namely between Toshiba, Semp Toshiba (a local Toshiba affiliate), and the Wernher von Braun Center for Advanced Research (VBC); and between Jasper Design Automation Inc. and the Universidade Federal de Minas Gerais (UFMG) in Belo Horizonte.

The MCTI sees semiconductor memory packaging and encapsulation[31] as a route into commercial scale semiconductor fabrication. Most domestic semiconductor packaging and encapsulation is done by HT Micron (Brazil/South Korea) and SMART Modular Technologies (USA). HT Micron was created through a joint venture between Hana Micron, a Korean chip assembly firm, and Parit Participações, a Brazilian holding company that also owns Teikon, a domestic contract manufacturer (See

- Box 8). HT Micron was initially developed with an eye toward integrated upstream into semiconductor fabrication. Company executives now admit that they doubt this will happen. SMART Modular Technologies is a Silicon Valley-based multinational firm specializing in the design, development and deployment of memory products including DRAM, SRAM and Flash. SMART currently does IC packaging, assembly and testing in Brazil, while keeping higher value-added activities like memory engineering in the US and in East Asia. Figure 10 maps SMART's global footprint, describing the activities undertaken in each of its global facilities.

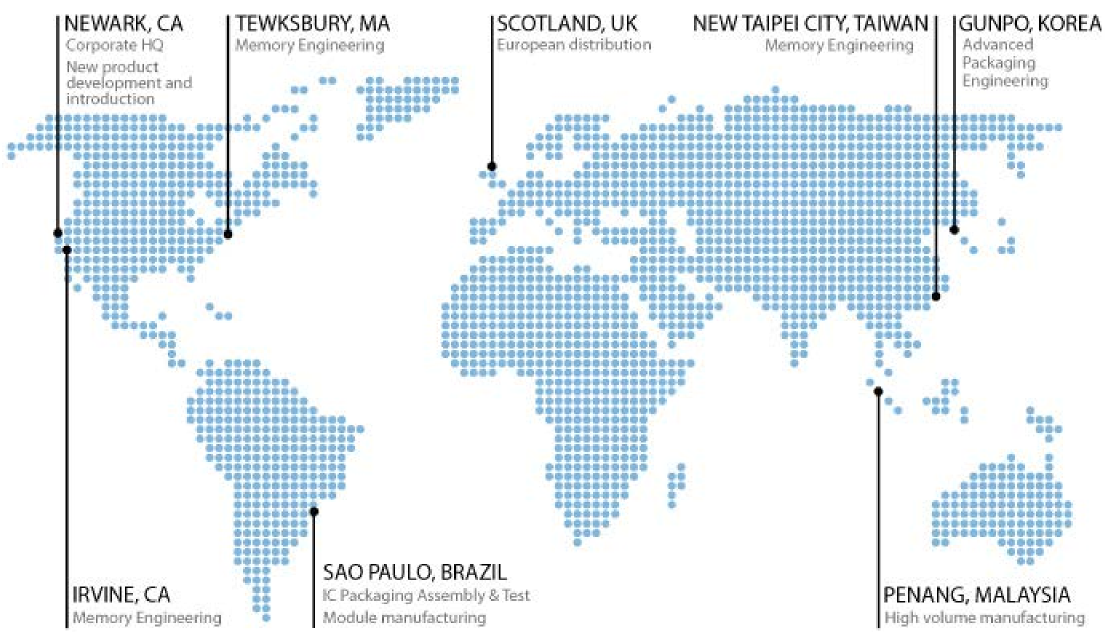
[30] CEITEC and CTI were the initial anchors of the domestic IC design sector, as they had the facilities, training capabilities and equipment to be successful from the onset. The government charged Brazil's IP Network and FINEP with initial workforce development efforts (Gutierrez & Mendes, 2008). FINEP supported the development of two IC design training centers, one located in Campinas and the other in proto Alegre. These programs train 150-160 designers a year and are expected to have trained over 1000 people by the end of 2012.

[31] Packaging and encapsulation (sometimes called chip assembly) are the stages of semiconductor manufacturing where the fabricated silicon chip is placed in its outer shell (the package), the circuitry is connected (bonded) to leads on the outer package, and then sealed (encapsulated) with special epoxy resin.

Box 8: HT Micron and Teikon

Parit Participações S.A originally owned contract manufacturer Teikon and industrial automation manufacturer Altus before taking a 50% stake in HT Micron. When HT Micron's plant is constructed and fully operational in June 2013 (encapsulating 50 million smartphone, digital TV and memory chips per month), Teikon will cease to operate as a contract manufacturer, becoming a 'captive module assembler' for HT Micron. While the semiconductor wafer manufacturing and dicing will continue to be done in Korea for the foreseeable future, company executives confirm that the company is in discussions with both CEITEC and SIX Semicondutores to begin sourcing some wafers locally. Additionally, the municipality is developing the infrastructure required for semiconductor dicing. A beneficiary of PADIS, HT Micron conducts a great deal of R&D in the country, although sources state that the core R&D is conducted in Korea. The partnership depends on HT Hana transferring technology to HT Micron, which can navigate the complex Brazilian tax code and incentive structure to facilitate access to fiscal incentives.

Figure 10: SMART Modular Technologies' Global Footprint



- HT Micron will collaborate closely with CEITEC, and will look to work with SIX Semicondutores (Formerly CBS, Companhia Brasileira de Semicondutores), once they are operational in 2013. CEITEC and SIX Semicondutores are projected to be the only two commercially viable foundries in the country in 2014, and their stories provide an interesting example of how state involvement in strategic industries can produce very different outcomes (See Box 9). According to our interviews, the relationship between CEITEC, SIX Semicondutores, SMART Modular Technologies and HT Micron is quite collaborative. The firms work together in Brazil to ensure government policy supports local content requirements for semiconductor-based products. In this sense, local firms have an implicit advantage over foreign ones. While there are informal avenues for interaction between government entities and private firms, they are based on personal relationships and informal working groups.

Box 9: CEITEC and SIX Semicondutores

CEITEC expanded its capacity significantly in 2008 as it received $250 million from the government to begin manufacturing ICs. Operating 20-year-old machinery donated by Motorola, CEITEC has been limited to producing RFID products on largely outdated 6-inch wafers in 1,500 square meters of cleanroom space. In contrast, TSMC (Taiwan), accounts for nearly 50% of the semiconductor market and produces 12-inch wafers in its 'gigafabs,' the latest of which includes 104,000 square meters of clean room space. CEITEC's products include: 'Chip do Boi' to track cattle, transportation chips to store automobile information and blood bag chips to track blood products during transit. The government agency most involved with CEITEC has been the MCTI, which has used it primarily as a tool for workforce development. Numerous executives familiar with the microelectronics industry in Brazil have pointed to several flaws in CEITEC's business model, namely that it lacks the vertical integration necessary to grow its portfolio, and that while it serves a useful purpose as a training facility, it is not commercially viable.

SIX Semicondutores, unlike CEITEC, was always conceived of as an IDM with an outward orientation. It is the product of a public-private partnership between government entities BNDES and the development bank of Minas Gerais (BDMG) and private actors like the EBX Group and IBM. The foundry will begin production in 2014 and will focus on what IBM calls 'mixed-signal chips', or 'hybrid devices.' These are useful in industrial automation, the automotive sector and medical devices; markets that can command premium profit margins and don't require very large scale manufacturing capabilities. The core of the SIX Semicondutores' strategy is around customized, low-volume devices that suit local needs, yet have the scope for global expansion into similar markets abroad.

CEITEC was developed with a public orientation, whereas SIX Semicondutores has always focused on being commercially viable. The MCTI and BNDES approached these projects in very different ways, showing that within government there are different priorities and goals to reconcile. If Brazil is to create the critical mass required to succeed in semiconductor manufacturing these issues will need to be reconciled and a clear strategy will need to be pursued.

Findings and policy recommendations for Brazil's electronics industry

Our review of the trade statistics, secondary literature, and a number of interviews with industry leaders, contract manufacturers, semiconductor manufacturers and government officials all highlight that Brazil's role in the electronics GVC is changing. During the project interviews, one industry executive implied that neither SIX Semicondutores nor CEITEC will compete with leading global foundries in the foreseeable future. The presence of the RECOF tariff regime (See page 29 for more details) enables cost-effective production of finished electronics products in Brazil, yet hampers the development of local high-volume component manufacturing capacity.[32] Therefore, if Brazil is successful at developing a semiconductor industry at all, it will likely be in semiconductor design and low-volume packaging and fabrication of niche semiconductor

[32] Contract manufacturers like Flextronics, Solectron, Sanmina-SCI, Foxconn and Celestica import components duty-free and benefit from an expedited customs process

products based on older technology that can serve the local market and similar ones abroad. At this stage in history, it will be impossible to compete with high volume-foundries in Taiwan, the USA, and Singapore without massive subsidies, subsidies that will do little in the way of job creation (semiconductor foundries are highly automated) or even technological learning (much of the core technology in foundries is embedded in production equipment).

Therefore, Brazil should focus on its competitive advantage in higher end, customized finished electronics products, software, and services and perhaps continue to seek "sweet spots" in the semiconductor GVC for products like RFID chips and hybrid devices. Most industry executives and government officials we spoke to believe that a domestic components industry is a desirable goal, given the spillover effects for a broad range of sub-sectors within electronics and other industries, but they are quick to point out that there are a variety of other policy prescriptions that could more efficiently and effectively foster private sector growth and encourage greater collaboration between MNCs and local companies. The project's findings and policy recommendations for Brazil's electronics industry are summarized in Table 17.

Table 17. Electronics GVC Findings and Policy Recommendations

Findings	Recommendations
<u>PPBs</u>: PPBs are too complex, detailed, and rigid for the rapidly evolving electronics industry. In their current state, they dictate local content requirements for each key component within any given product. Many PPBs require at least 10% of each component to be sourced locally. The convergence and development of electronics devices has outpaced the government's ability to regulate local content effectively.	• PPBs should be granted on a product level, giving firms the power to allocate component contracts according to what is available locally. Sourcing locally where Brazilian competencies are strongest would allow certain products to achieve scale and possibly become competitive internationally. • A more flexible PPB rubric and a comprehensive nationalization index would encourage local SMEs to specialize and develop linkages to global lead firm affiliates manufacturing in the country.
<u>Software and Services</u>: The value of electronics has shifted significantly from hardware to software and services; in some industry segments, the three now make up equal parts of the final product value. Plano TI Maior recognizes this and seeks to bolster local software and service capabilities. Plano TI Maior has the potential to be a valuable asset as Brazil seeks to upgrade within the electronics GVC into more sophisticated nodes of activity.	• Specific instruments like the CTENIC local content requirements for software need be developed in close coordination with industry leaders to ensure their utility as a means of GVC upgrading. • Efforts to train software developers should be expanded through scholarships and workforce development initiatives from CNPq, CAPES, MCTI and FINEP in order to meet increasing demand for human capital. The 'Science Without Borders' program should be extended beyond 2014.
<u>Industry-Government Dialogue</u>: The nature of industry-government dialogue is often limited to informal settings. Industry executives claim that regulations and incentive packages do not always suit the rapidly evolving electronics industry. This is especially true for the semiconductor industry, which is largely managed by different government agencies, universities and public research institutes. There is an informal government working group on semiconductors with participation from the MCTI, ABDI, Apex-Brasil, MDIC, BNDES, FINEP, and the MC.	• This working group should be formalized and meet regularly. It should also create a more prominent, permanent role for semiconductor industry leaders, potentially working through ABINEE. • Semiconductor stakeholders in Brazil are too isolated. International events focused on the semiconductor industry, like the Brazil-South Korea Forum on Science, Technology, and Innovation organized by the University of Vale do Rio dos Sinos (UNISINOS), should be expanded to include stakeholders from other countries as well. This would both bolster innovation in Brazil and allow potential foreign investors to build relationships with local universities, research centers and government officials responsible for developing semiconductor policies.

Semiconductor Industry: The electronic components industry is very underdeveloped in Brazil, suffering from a large trade deficit in electronics components. Growth in this sub-sector will largely emanate from lower value-added activities like encapsulation, assembly and testing for the foreseeable future. Prospects for semiconductor fabrication remain limited to CEITEC and SIX Semicondutores, which produce similar niche products according to two very different business models.	• Brazil should continue to develop niche semiconductor products such as RFID chips and hybrid devices that suit CEITEC and SIX Semicondutores' low technical and investment capacity. • The MCTI should work to change the CEITEC business model, employing SIX Semicondutores as a model. It must seek greater involvement by BNDES as well as foreign partners in order to become a commercially viable foundry.
R&D Spending: R&D spending linked to fiscal incentives is highly regimented in terms of where it is spent. The law is fairly specific in terms of how much should be invested through partnerships with Brazilian research centers, institutes or educational institutions accredited by the government, how much should be deposited in a National Fund for Technological and Scientific Development, and how much can be spent internally or through other private parties. What R&D can be spent on is fairly flexible and can be determined largely by an individual firm's strategic objectives.	• Contract manufacturer-operated R&D centers like FIT's RFID Center of Excellence should be explicitly included among potential outlets for R&D quotas in policy guidelines. • Government agencies should support the development of public-private partnerships in electronics R&D by leveraging access to low-interest finance (BNDES) and human capital (MCTI and CNPq) to attract more advanced technologies from abroad. SENAI's planned innovation centers could and should play a major role.

7. Brazil in GVCs: Summary Analysis and Recommendations

Brazil's industrial development in comparative perspective

Emerging economies are playing significant and diversified roles in GVCs. During the 2000s, they have become major exporters of both manufactured goods (China, South Korea, and Mexico) and primary products (Brazil, Russia and South Africa). However, market growth in emerging economies has also been shifting end markets in GVCs, as more trade has been flowing South to South, especially since the 2008-2009 economic recession (Staritz *et al*., 2011). China has been the focal point for both patterns. Since it is the world's leading exporter with an emphasis on manufactured goods, it has also stoked the primary product export boom as the world's largest importer of a wide range of primary products. Companies from China and India have emerged as major investors in Africa and elsewhere in the developing world.

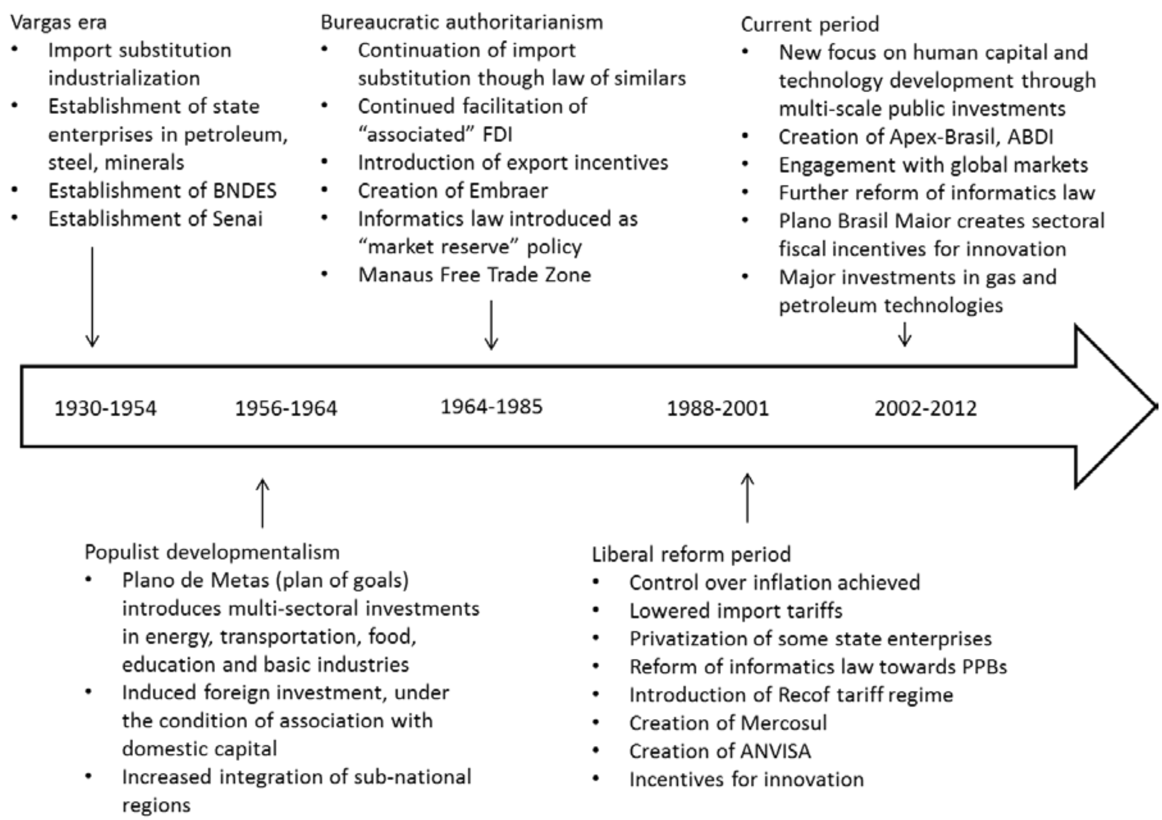
The primary product exporting profiles of Brazil, Russia, and India (BRI) suggest that these countries are contributing to China's role as a materials processing and final assembly hub. Finished goods are then exported from China back to these BRI countries and the rest of the world. Still, trade statistics cannot reveal where ownership, intellectual property (IP), and GVC coordination — and much of the profits in GVCs — lie. But from case studies (e.g., Linden *et al*, 2007) and the new research on trade in value added (e.g., WTO and IDE-JETRO, 2011), we know that many of China's exports consist of foreign-branded products, contain core IP from industrialized countries (USA, Europe, Japan), and include sophisticated intermediate products imported from the most industrialized and advanced emerging economies, such as South Korea and Taiwan, as well as other developing countries in East Asia (Malaysia, Thailand, etc.). Thus, rising South-South trade may in fact signal the emergence of a GVC structure that continues to reinforce China's role as "the world's workshop." Continued demand from China may hamper efforts by the BRI countries to diversify away from primary commodities by adding more value to exported commodities. If China's growth slows, which may be happening (Rathbone and Leahy, 2013), there is no guarantee that upgrading will occur. Either way, there is a clear focus in Brazil's industrial policy to try to move the country's industrial base toward technology-intensive segments in global manufacturing industries such as automobiles, medical devices, aerospace, and electronics.

The current industrial policy regime in Brazil

Industrial policy is once again occupying a prominent place in Brazil. In this section, we highlight how elements of Brazilian industrial policy shape the country's current insertion into GVCs and opportunities for continued upgrading. But first, it is helpful to understand the legacy of past industrial policy regimes. Indeed, today's industrial policies carry traces of past policy configurations, and they are implemented within a context largely created by the successes and failures of prior development strategies.

Figure 11 provides a chronological illustration of the broad development strategies and associated policy instruments for five "eras" of Brazilian industrial policy. We can see that today's diverse set of industrial policies incorporates many aspects of the activist industrial policies of the past, even as they maintain the emphasis on competitiveness and global integration that was the hallmark of the liberal reform period of the 1990's. For example, the IT law – which was highly influential in each of the sectors studied in this report – has been altered and adjusted several times since its creation in the 1980's. Whereas the original formulation of the law focused on a protectionist (and ultimately unsuccessful) "market reserve" policy, the current formulation is oriented more towards facilitating FDI in targeted product markets, increasing local content, and enhancing domestic technological capabilities.

Figure 11. Brazil's Industrial Policies, a Timeline



Sources: Suzigan and Furtado, 2006; Bonelli et al 1997; Baer 2001; authors

In addition, today's industrial policies must confront the economic realities generated by the policies of the past. The Brazilian aerospace industry is a case in point. Using heavy investments in physical and human capital as well as the creation of Embraer, the Brazilian state acted as the "handmaiden" of the Brazilian aerospace industry. Through import substitution policies, Embraer quickly upgraded from assembling military planes on license from imported components, to assembling planes from mostly local components to eventually internalizing design capabilities for the production of commercial regional jets. In spite of its early successes, however, Embraer lost competitiveness during the late 1980's as rapid consolidation and globalization steadily drove down prices in end markets. As Embraer thrives under private ownership, Brazilian industrial policy has made tentative attempts at enhancing the capabilities of the domestic aerospace supply base, though these efforts require much more attention and a greater attention towards the GVC dynamics that now characterize the industry.

By situating the current industrial policy regime within a historical context, we can better understand how Brazil is relatively open to FDI today even as the state maintains a strong role in shaping economic upgrading trajectories through an abundant menu of institutional supports and policy instruments. Table 18 contains a partial list of relevant institutions and organizations as well as important policy instruments that are currently in place. From a GVC perspective, such an approach to industrial policy offers many promising opportunities, provided that these policies and institutions can be deployed in a coherent and stable way.

Table 18. Industry Focus of Brazil's Policy-making Institutions

Supporting institutions/organizations	**Impacted industries**
Ministry of Science, Technology and Innovation (MCTI)	All
Ministry of Development, Industry and Foreign Trade (MDIC)	All
Ministry of Health	Medical devices
Ministry of Defence (MD)	Aerospace
National Health Surveilance Agency (ANVISA)	Medical devices
Brazilian Agency for Industrial Development (ABDI)	All
The Brazilian Development Bank (BNDES)	Aerospace, electronics
The Brazilian Agency of Telecommunications (ANATEL)	Electronics
Council for Scientific and Technological Development (CNPq; within MCTI)	Electronics
Brazilian Innovation Agency (FINEP)	Aerospace, electronics
Secretariat of Information Technology (SPEIN)	Electronics
Brazilian Electrical and Electronics Industry Association (ABINEE)	Electronics
Aerospace Industries Association of Brazil (AIAB)	Aerospace
Brazilian Medical Device Manufacturers Association (ABIMO)	Medical devices
Brazilian Medical Devices Importing Companies Association (ABIMED)	Medical devices
National Civil Aviation Agency (ANAC)	Aerospace
Apex-Brasil	All
Brazilian Assistance Service to Micro and Small Enterprises (SEBRAE)	All
Center for Competitiveness and Innovation of the Eastern Region of Sao Paulo (Cecompi)	Aerospace, electronics
Aerospace Technology and Science Department (DCTA; within MD)	Aerospace
Policies, programs and initiatives	**Impacted industries**
Recof	Aerospace, electronics
Plano Brasil Maior	Electronics
Program for the Development of the Semiconductor and Display Industry (PADIS)	Electronics, medical devices
Basic Production Process (PPB, part of the Informatics Law)	All
Plano TI Maior	Electronics
Defense Offset Policy (MD Decree 764)	Aerospace
Retid	Aerospace
Procurement preferences (Law 12,349)	Medical devices, electronics
Proex	Aerospace, electronics
Minas Gerais Aerotropolis	All

Opportunities and challenges: themes from the interviews

Industrial policy and overall investment climate

Brazil faces a distinct set of challenges and opportunities as it continues to develop capabilities in high-value activities within a targeted set of GVCs. Chief among these challenges is the complexity and instability of the country's industrial policy regime, which makes it difficult for companies to plan for the future. Policy uncertainty impacts SMEs more significantly than larger firms that have the clout and human resource capacity to go to Brasilia and work with the government to have regulations altered.

Policy uncertainty is one of the many elements of what has come to be known as "Brazil cost." The added costs associated with working in Brazil include poor infrastructure, excessive layers of bureaucracy, corruption and high interest rates, among others. Interviews with industry executives reflect the fact that while industrial policy interventions are needed, they will be for naught unless the broader issue of "Brazil cost" is addressed.

Even if the instruments are in place, Brazil's industrial policy sometimes lacks coherent or realistic goals. While one of Plano Brasil Maior's main priorities is enhancing productivity and technology-intensive activity within GVCs, it does little to encourage growth in specific niche segments where Brazil has or could have a competitive advantage globally. Policymakers and industry stakeholders need to identify specific high-value GVC niches where Brazil can be competitive and focus on these. Many of these niches may be in the service segments of target industries, for example, product design, engineering services, and software development.

Local content requirements are too onerous in product markets where global sourcing is the unimpeachable norm, such as MRI devices. Industrial policy instruments like the PPB cannot keep up with constantly evolving industries like aerospace, medical devices and electronics. Local content requirements must be rethought to be both broader and more flexible, allowing firms in Brazil to make rational sourcing decisions based on Brazil's strengths, and encouraging local firms to specialize in niche products well suited for the domestic market and exports.

Workforce Development

The trend towards higher value activities like systems integration, software development, design and engineering require a significant effort to improve workforce capabilities, especially in occupations in the high value-added segments of value chains. There is need for a greater supply of engineers, designers, and project managers. Retention is a particularly pressing issue, given the tight labor market. Current efforts to train semiconductor designers need to be bolstered and expanded across additional industries and occupations, such as product and project management and engineering.

Supply Chain and Logistics

Logistics remains a bottleneck in all of the GVCs we studied. Operating in fragmented GVCs requires well-run customs agencies and good trade infrastructure to ensure that tight production schedules are met. There have been isolated efforts to improve logistics in Brazil; however, this remains a key component of the "Brazil cost" mentioned earlier. RECOF is one of a few efforts aimed at improving customs procedures. Under the regime, exports and imports are checked and processed within six hours and import tariffs are suspended, among other benefits (see Table 8). The central problem is that the regime is limited to firms exporting over $10 million per year, and of the 33 companies certified, only one (Embraer) is Brazilian. Expedited and efficient customs should not be the privilege of a few foreign lead firms. Instead, expanding the program and making clear efforts to draw in smaller Brazilian firms could facilitate greater GVC integration.

R&D Expenditures

Many of Brazil's industrial policy instruments include the stipulation that foreign invested firms engage in local R&D to access government incentives, and such programs can be quite flexible, making it easier for companies to comply. The growing availability of contract R&D services provides multinational firms with a flexible platform to increase R&D expenditures locally without have to invest extensively in their own facilities Nonetheless, R&D expenditures in Brazil remain low. Government agencies should support the development of public-private partnerships in electronics R&D by leveraging access to low-interest finance (BNDES) and human capital (MCTI and CNPq) to attract more advanced technologies from abroad. SENAI's planned innovation centers could and should play a major role in coordinating Brazil's R&D efforts.

Six dimensions of GVC upgrading

If the goal is to grow the Brazil's participation relatively high-level activities in the GVCs, it is useful to conceptualize these upgrading paths according to the six dimensions of GVG upgrading presented in Box 10.

Box 10. The Six Dimensions of GVC Upgrading

1. Business process upgrading: improving existing process technologies, work organization and business systems
2. Product upgrading: moving from simpler, lower value products to more complex, higher value products
3. Scale upgrading: more activities in the same GVC role (e.g., wire harness cluster) with a focus on process improvements, trade infrastructure, workforce development, shared services and suppliers.
4. Vertical upgrading: focus on creating linkages to upstream and downstream products and processes, especially (but not exclusively) between global and local firms.
5. Horizontal (inter-industry) upgrading: seek out investments with similar processes (e.g., sewing for apparel and automotive seat covers).
6. Cluster upgrading: maximize product and process variety (initially) so inter-firm linkages

1. Business process upgrading: improving existing process technologies, work organization and business systems
    a. Business process upgrading is a crucial pre-requisite for scale and vertical upgrading. Business processes need to be responsive to outsourcing strategies of lead firms and first- and second-tier global suppliers
    b. Brazilian firms and SMEs in particular will need assistance to gain business process certifications, such as ISO, CMMI, Six Sigma, etc. If nothing else, low interest loan should be made available to pay for the services of certification consultants.
    c. Consult with MNCs to better understand the requirements for participating in GVCs as suppliers. MNCs must manage tremendously complicated supply chains and are quite risk-averse in their selection of suppliers. Supplier requirements remain fairly idiosyncratic. However, MNCs tend to look for certifications, well run facilities, tacit capabilities, and up-to-date equipment and IT systems when evaluating suppliers.
    d. Apex-Brasil is in a good position to disseminate information to SMEs and industry associations about process upgrading requirements relevant for their GVC niche.
2. Product upgrading: moving from simpler, lower value products to more complex, higher value products
    a. In the medical device sector, this could involve the integration of information technology in capital equipment, such as dental chairs and radiographic devices, or in implants, as has been done the case of drug-eluting stents.
    b. Brazil has lost its competitive edge in mobile phones. But with increasing demand, there is a clear opportunity to develop policy instruments to encourage local manufacturing (a smartphone PPB is currently under development). Positivo has already announced its intention to move beyond computers and develop a presence in the smartphone market. Still, because the electronics GVC is fully global, local production will very likely depend on imported inputs for the foreseeable future.
3. Scale upgrading: more activities in the same GVC role with a focus on process improvements, trade infrastructure, workforce development, and shared services and suppliers.
    a. Achieving scale is especially important for firms hoping to gain access to GVCs through vertical upgrading.
    b. SMEs have problems achieving the certifications and financing necessary for scale upgrading. SME consortia, such as the now-defunct HTA, are one tactic for building economies of scope and scale.
    c. Contract manufacturers are vital to scale upgrading efforts in Brazil. With the passage of the Lei do Bem, the “white box” market for personal computers has declined from 70% to 25-30%. Lead firms in the computer market stand to gain significantly from this and are scaling up production to meet increased need. Contract manufacturers are vital for scale upgrading efforts in the modern electronics GVC. Four of HP’s five manufacturing facilities in the country are run in collaboration with Foxconn, Jabil and Flextronics.

4. Vertical upgrading: focus on creating linkages to upstream and downstream products and processes, especially (but not exclusively) between global and local firms.
    a. There are many possibilities for vertical upgrading in aerospace. Grauna is an example of a company that developed linkages, not only with Embraer, but eventually to global suppliers including Pratt & Whitney. GE Celma has moved upstream from MRO activities to turbojet assembly. The next step will be to consolidate a competitive local supply base that can serve both GE as well as other propulsion systems integrators.
    b. HT Micron will import precut semiconductor wafers from Korea and plans to encapsulate 50 million chips per month, creating "flash" memory modules for use smartphones, thumb drives, and digital TVs. The next, incremental step is to develop the infrastructure required to allow HT Micron to cut wafers in Brazil.
5. Horizontal (inter-industry) upgrading: seek out investments with similar processes (e.g., sewing for apparel and automotive seat covers).
    a. Contract manufacturers sometimes serve multiple industries. In aerospace and medical devices, there is room to piggy-back off of the success of the Brazilian automotive industry. Autocam, for example, provides contract manufacturing services in Brazil for both automotive and medical device lead firms. In medical devices, contract service providers can also fill process gaps, in sterilization for example, to serve firms in multiple industries.
6. Cluster upgrading: maximize product and process variety (initially) so inter-firm linkages (horizontal and vertical) can eventually form.
    a. Brazil has strong clusters in aerospace (around São José dos Campos) and medical devices (Riberão Preto). The aerotropolis in Belo Horizonte, Minas Gerais is an example of a cluster strategy that targets each of the three industries that we have studied. There are a few strong semiconductor clusters as well (especially around Porto Alegre) and strong electronics clusters around the country, although primarily in the South and the Manaus Free Trade Zone.

Brazil's GVC "sweet spots"

Relatively few final products in any of the three industries examined in this report are produced in single countries by vertically integrated national industries. One of the insights of GVC-oriented industrial policy is that countries should instead specialize in specialized GVC niches (see p. 68-71). In this section, we consider niches the aerospace, medical devices and electronics industries that were indicated as possible "sweet spots" that Brazilian GVC-oriented industrial policies can target. Broadly speaking, Brazilian capabilities are strong in software development and systems integration. Opportunities exist across all three industries to leverage these capabilities, as well as other industry-specific strengths, to promote national development goals.

Aerospace

- Embraer has a strong presence in the U.S. market. Embedding greater domestic content in Embraer's exports is one approach for improving the aerospace components trade balance.
- MRO services are a strong niche for Brazil. Distance from the US and other markets is not necessarily a drawback in the MRO services because planes can be moved to MRO

facilities for scheduled service. GE Celma, for example, serves primarily clients from outside of Latin America.

- Developing indigenous tier 1 suppliers is probably not feasible in the short term and will require extensive development of R&D and systems integration capabilities. There are multiple opportunities to gain access to existing foreign tier 1 and tier 2 suppliers. The presence of tier 1 global supplier distribution offices in Brazil to support Embraer could be used as a point of contact for local SMEs to gain familiarity with global firms and potentially gain access to approved supplier lists.
- Brazilian software capabilities could be better leveraged within the avionics segment of the industry.

Medical devices

- The rapidly growing Brazilian market and the existence of procurement preferences should be used to aggressively upgrade the scale and business processes of domestic firms. These firms should be encouraged to specialize and seek global niche markets in the US and Europe.
- Interviews suggest that Brazil is well positioned to export in mid-tech segments of the medical device industry, such as X-ray and tomography devices.
- There is room for Brazilian software firms to participate in emerging product niches such as integrated solutions, convergence products and medical IT systems. Market opportunities in these product segments should be explored and information disseminated to domestic firms.
- It will be critical to improve programs to help local companies understand and meet global standards and seek approvals in target markets. This is a collective challenge well suited for government assistance.

Electronics

- Software development in GVC segments like industrial equipment, telecommunications and automotive electronics are a good opportunities for Brazil.
- Magneti Marelli's software-based Flexfuel engine management system is an example of a niche solution to a market-specific problem that can be sold in export markets as well.
- Niche semiconductor market segments like RFID and mixed signal/hybrid devices could offer Brazil a path into commercially viable semiconductor fabrication. For example, hybrid devices are useful in industrial automation, automotive and medical devices (all large and growing sectors in Brazil), do not require cutting edge semiconductor fabrication technology, and can command premium profit margins. They don't require large-scale manufacturing capacity and can benefit from the local design houses.
- High-end consumer electronics like smartphones, tablets, servers and notebook computers offer Brazil the opportunity to leverage a growing domestic market, and expand the presence of global contract manufacturers like Foxconn and Flextronics that in turn can be useful for new targeted policy instruments and as a basis for providing local firms with leading edge, global manufacturing capabilities. However, as stated earlier, the fully global character of the electronics GVC means that local assembly will very likely depend on imported inputs for the foreseeable future. This is a normal feature of operating in the electronics GVC.
- Telecommunications infrastructure will need to expand significantly in the next two years. Interviews with telecommunications executives and consultants indicate that small cell tower manufacturing and associated services may be a valuable niche moving forward in light of local content requirements, growing demand for data and the Olympics and World Cup. These technologies may be a niche well suited for export to other developing countries with infrastructure issues similar to Brazil's.

What do GVC-oriented industrial policies look like? [33]

A key aspect of many industrial policies is that they are industry-specific. While this puts them in line for criticism when policy-makers are seen to be "picking winners," the industry-focus is essential. Research at the level of global industries clearly shows that the structure and upgrading trajectories of GVCs vary significantly, and as a result, cross-industry comparisons are essential. For example, trade in customized intermediate goods is extremely high, growing, and global in scope in electronics, while trade in automotive parts tends to be organized in regional production systems (i.e., North America, Europe, Asia), and trade in intermediate inputs to apparel products (fiber and fabric) is actually *falling* as the major apparel producing countries (e.g., China and Bangladesh) gain huge capabilities in textile production (Sturgeon and Memedovic, 2010). The reasons for these differences are complex. On one hand, the detailed characteristics of product designs, intermediate components, final goods, and logistics requirements greatly influence the geography of industry GVCs (Gereffi *et al*., 2005). On the other hand, certain products (e.g., autos) come with high levels of political sensitivity that drive production toward end markets (Sturgeon and Van Biesebroeck, 2010).

As the case studies presented in this report will demonstrate, the formation of industrial policy does not always begin with policy-makers "picking" industries, but rather with attempts to improve the performance of existing industries already linked to the global economy. This involves a search for mechanisms that can capture investment and technological learning to improve a country's position in highly mobile segments of GVCs that are *already* in the process of spreading to new locations, or may *already* be present in the jurisdiction that policy makers are responsible for. The example of the Brazil's policies to encourage local production of mobile smart phone handsets and tablet computers are examples of policy-makers trying to capture more local value added in markets that are *already* growing rapidly in their countries. Because such policies are responsive and adaptive they cannot be equated with picking winners.

Of course, policy-makers must also be concerned with slowing market growth by raising prices to levels that block consumers' access to leading-edge products. Broad economic growth can be slowed when markets for products that make the whole economy more efficient, such as smart phones and motor vehicles, are truncated by higher prices or outmoded products. But it is possible for policies that pressure lead firms to add more value locally to be modest and targeted enough that they do not raise prices to the point where market growth is impeded and leading edge products fail to make it into the hands of the businesses and consumers that want them.

As was discussed in the Project Overview, the effectiveness of industrial policies lies in their details: how they fit in with the realities of global industries and how they balance the drive for local capability development with the need to leveraging assets and capabilities elsewhere in GVCs. Once the proposition that a balanced approach is possible is accepted by policy-makers, the question then becomes how to craft effective GVC-oriented industrial policies. One way to examine this question is to ask how current industrial policies differ from traditional industrial

[33] This section is drawn from Gereffi and Sturgeon, 2013.

policies. A superficial analysis of the Brazil's current industrial policies cases might suggest that the motivations and policy tools being employed by large emerging economies have many of the features of traditional ISI industrial policy: driving import substitution with local content requirements, instituting requirements for investment in local R&D, stimulating demand in key product areas, etc. However, we see three major differences:

1. Global suppliers. Instead of merely demanding that lead firms make major investments, the GVC-oriented industrial policies described in this report reveal an increasingly sophisticated understanding of the global-scale patterns of industrial organization that have come to the fore in GVCs since the 1990s. Lead firms in many industries are relying on global suppliers and intermediaries for an array of processes, specialized inputs, and services, and demanding that their most important suppliers have a global presence. Hence it is suppliers, not lead firms that are making many of the new investments that developing countries are seeking to capture. Furthermore, the largest suppliers serve multiple customers, so the success of investments is not necessarily tied to the success of any single lead firm. It is no accident that Brazil's policy makers sought investments from Foxconn, rather than Apple, in their drive to have iPhones and iPads produced in the country. Finally, by serving multiple customers global suppliers can generate enough business to justify capital intensive investments that have high minimum scale requirements, such as electronics displays and complex automotive parts. However, implementation of policies to target investments from global suppliers are less likely to be effective in industries where outsourcing has not been pervasive, such as medical devices. They have more potential in industries such as aerospace, automotive, and electronics.

2. Moving to the head of GVCs. Encouraging global suppliers to establish facilities within a country can have long-term advantages. Local lead firms can rely on global suppliers in their midst, and on broader industry GVCs for a wide range of inputs and services, from design to production to logistics to marketing and distribution. This can lower risk and barriers to entry for local firms, provide access to capabilities and scale that far outstrip what is available domestically, and ensure that products and services are up to date, precisely because they participate in GVCs from the beginning. Up-to-date, world-class products and services also open up export markets.

3. Global sourcing and value chain specialization. Policies that promote linkages to GVCs have very different aims from traditional industrial policies that intend to build fully-blown, vertically integrated domestic industries. Policies can target specialized niches in GVCs. These should be higher-value niches well suited to existing capabilities. They can also be generic capabilities that can be pooled across foreign investors. Either of these can serve both domestic or export markets. This sort of value chain specialization assumes an ongoing dependence on imported inputs and services. Reliance on global sourcing means that the entire value chain may never be captured, but it also assures ongoing involvement in leading-edge technologies, standards, and industry "best-practices." Clearly, industries in developing countries can no longer make outmoded

> products. As the Brazilian mobile phone case shows, consumers with rising incomes will no longer accept them. Even in in integrated industries like medical devices, lead firms are establishing country-specific centers of excellence in narrow GVC functions to support the company on a global basis. This might include aspects of R&D or less technology-intensive business activities such as call centers or centralized back office functions.

The use of industrial policies by emerging economy policy-makers should not come as a big surprise. Both developed and developing countries have used these policies in the past, and often with considerable sophistication, as in the case of East Asian economies, such as Japan, South Korea, Singapore, Taiwan, and now China. However, there are two GVC-related features of emerging economies that are distinctive today. First, there is the centrality of China. A number of natural resource-based emerging economies, such as Brazil, South Africa and Russia, see China's procurement policies as limiting their ability to add value to their raw material exports, whereas manufacturing powers such as South Korea, Mexico, and to a lesser degree India, see China as their most formidable competitor in both export and domestic markets. Second, the flourishing of GVCs has led intermediate goods exports to exceed the total of final and capital goods exports for the first time. This raises a new competitiveness challenge over who wins the "trade in value added" battle. Countries now seek to capture the highest value segments of GVCs, not only to increase total exports, but to provide local firms with access to world class inputs. GVCs and GVC-compatible industrial policy appear to be elements of the current industrial landscape that are here to stay.

8. Concluding remarks

GVCs initially developed in a period of falling trade barriers, the rise of the World Trade Organization (WTO), and the policy prescriptions associated with the "Washington Consensus" – i.e., governments had only to provide a strong set of "horizontal" policies (such as education, infrastructure, and macro-economic stability) and be open to trade to succeed. Of course, many observers noted that the fastest-growing emerging economies (e.g., South Korea, Taiwan, Singapore) did much more than this through a set of industrial policies that targeted key domestic industries for growth, either behind protectionist walls, through import-substituting industrialization (ISI), and/or increased market access through export promotion, known as export-oriented industrialization (EOI). The goal of these "domestic industrial policies" was to nurture a set of fully blown national industries in key sectors that could eventually compete head to head with the industrialized nations (Baldwin, 2011).

Today, despite a growing list of signatories to the WTO, industrial policy is on the upswing. WTO accession often comes with allowances for selective industrial policies (e.g., trade promotion, local content rules, taxes, tariffs, and more indirect programs that drive local production) to remain in force for specified periods. Bilateral trade agreements can supersede what has been agreed to under WTO rules, and a handful of relatively large and advanced emerging economies (such as those in the G-20) have more clout in the institutions of global governance and are using it to create greater leeway to engage in activist industrial policies.[34]

Still, the fragmentation of global industries in GVCs complicates industrial policy debates. We argue that there can be no return to the ISI and EOI policies of old. Domestic industries in both industrialized and developing countries no longer stand alone and compete mainly through arms-length trade; instead, they have become deeply intertwined through complex, overlapping global-scale business networks created through the recurrent waves of FDI and global sourcing that comprise GVCs. Because of this, today's industrial policies have a different character, and generate different outcomes than before. Like it or not, governments must now engage in GVC-oriented industrialization when targeting key sectors for growth. As the research presented in this report shows, much remains to be learned about how to do this effectively.

Brazil is in a good position for GVC upgrading due to its large domestic market and access to a wide array of industrial policy tools. But there is a lack coordination that creates tension and drives policies and agencies to sometimes work at odds with one another. GVCs can allow for extremely rapid economic development in niche sectors, but leveraging these opportunities requires good communication between policy makers and industry representatives (including representatives from multinational firms) and coordination within the policy community. The CNI is in a good position to convene stakeholders and act as a liaison to the government on behalf of its members. It can propose policy recommendations to the Brazilian government aimed at increasing the clarity of the industrial policy regime, initiate discussions about which GVC segments to target for upgrading, develop proposals for how to coordinate policy more effectively to achieve these goals, and help develop ideas for reducing the overall cost of doing business in Brazil. It is our hope that this report will help stimulate these conversations.

[34] For example, the new Brazilian director general to the WTO has appointed a Chinese deputy director.

9. References

ABIMO. 2012. Dados Econômicos. Electronics access: http://www.abimo.org.br/modules/content/content.php?page=dados-economicos

AIAB. 2012. Assocação da Indústria Aeronaútica do Brasil, main webpage. http://www.aiab.org.br/

Ali, Khwaja. 2011. "Trends in Aviation & Impacts on MROs" presented at the IATA 7th Maintenance Cost Conference, October 19, Singapore. http://www.iata.org/workgroups/Documents/MCC-2011-SIN/Day_02/1400-1430_Boeing_Trends_in_Aviation_and_MRO_Opportunities.pdf.

Ali-Yrkkö, J. 2010. "The Value Creation of Mobile Phones: The Case of Nokia N95" in Ali-Yrkkö (ed.) *Nokia and Finland in a Sea of Change*. Helsinki: Taloustieto.

ANFAVEA. 2012. Anuário da Indústria Automobiliística Brasileira. São Paulo: Anfavea.

ANVISA. 2003. "Overview", from http://www.anvisa.gov.br/eng/index.htm

Autocam. 2011. "Autocam Medical Certified as Contract Manufacturer in Brazil", from http://www.autocam-medical.com/studies_news/2011/06/autocam-medical-certified-as-contract-manufacturer-in-brazil/

Axendia. 2012. Walking the Global Tightrope: Balancing the Risks and Rewards of Med-Tech Globalization: Camstar Systems Inc, iGATE and PwC.

Baldwin, Richard. 2011. "Trade and industrialisation after globalisation's 2nd unbundling: How building and joining a supply chain are different and why it matters." Cambridge, MA: National Bureau of Economic Research, Working Paper 17716, December. Electronic access: http://www.nber.org/papers/w17716

Baer, Werner and Gustavo Borges. 2001. "Foreign Investment in the Age of Globalization: The Case of Brazil." *Latin American Business Review* 2 (1-2): 83-99.

Baxter. 2012. "Baxter in Latin America and Canada", from http://www.careers.baxter.com/about_us/latin_america_canada.html

Beckton-Dickinson. Milestones. Electronic access: http://www.bd.com/aboutbd/history/

Beltramello, Andrea, Koen De Backer, and Laurent Moussiegt. 2012. "The export performance of countries within global value chains (GVCs). *OECD Science, Technology and Industry Working Papers*, 2012/02. OECD Publishing. http://dx.di.org/10.1787/5k9bh3gv6647-en.

Bernard, Andrew; Jensen J. Bradford and Schott, Peter. 2005. "Importers, exporters and multinationals: a portrait of firms in the U.S. that trade goods", *NBER Working Paper*, 11404.

BMI. 2012a. "Brazil Information Technology Report Q4 2012." *Market Research.* November 7.

BMI. 2012b. BRIC Medical Device Markets to Expand Rapidly: Business Monitor International.

Boeing. 2012. "Current Market Outlook". Presentation, from http://www.boeing.com/commercial/cmo/pdf/CMO_2012_Presentation.pdf.

Bonelli, Regis, P da M Viega and A F Brito. 1997. As políticas industrial e de comércio exterior no Brasil. Rio de Janeiro: IPEA/DIPES, nov. 1997 (Texto para Discussão, 527).

Breznitz, Dan and Michael Murphee. 2011. *Run of the Red Queen*. New Haven: Yale University Press.

Business Insights. 2010. The Medical Device Outlook in Emerging Markets.

Cafaggi, Fabrizio, Ronaldo Porto Macedo Junior, Luana F. Joppert Swensson, Tiago Andreotti e Silva, Clarissa Piterman Gross, Lucila Gabriel de Almeida, and Thiago Alves Ribeiro. 2012. "Accessing the GVC in a Changing Institutional Environment: Comparing Aeronautics and Coffee". Inter-American Development Bank.

Chesbrough, Henri. 2003. *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Cambridge: Harvard Business School Press.

Clearwater. 2011. "Aerospace Global Report 2011". IMAP. http://www.imap.com/imap/media/resources/Aerospace_8_1FED752787A1E.pdf.

CNS. 2008. "O SUS". Conselho Nacional da Saude. http://conselho.saude.gov.br/web_sus20anos/sus.html

Dassbach, Carl. 1989. *Global Enterprises and the World Economy: Ford, General Motors, and IBM, the Emergence of the Transnational Enterprise*. New York: Garland Publishing.

Datamonitor. 2011. Global Health Care Equipment. Retrieved May, 2012,

Daviron, Benoît; and Ponte, Stefano. 2005. *The coffee paradox: global markets, commodity trade and the elusive promise of development*. London: Zed Books.

de Souza Szapiro, M. H., and D. Aalborg. 2000. "Technological Capability in the Telecommunications Industry in Brazil: Development and Impacts of the Structural Reform in the 90s." In *4th International Conference on Technology Policy and Innovation, Held in Curitiba, Brazil, Available at Http://in3. Dem. Ist. Utl. pt/downloads/cur2000/papers/S27P02. Pdf*. http://in3.dem.ist.utl.pt/downloads/cur2000/papers/S27P02.PDF.

Dicken, Peter. 2011. *Global Shift: Mapping the Contours of the World Economy*. Sixth edition. London: Sage Publishing.

DiMaggio, Paul; and Powell, Walter. 1983. "The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields." *American Sociological Review*, 48:2, 147-160.

Dossani, Rafiq, and Kenney, Martin. 2003. "Lift and Shift; Moving the back office to India" Work in Progress (Sept.). *Information Technologies and International Development*, 1:2, pp. 21–37.

Dossani, Rafiq, and Kenney, Martin. 2005. "Moving Services Offshore: A Case Study of an U.S. High-Technology Firm." Report was prepared for the European Union - U.S. Department of Labor seminar *Offshoring of Services in ICT and Related Services*.

Egypto, Flavia. 2012. "Information on PPB". Apex-Brasil.

Embraer. 2009. "Golden share". Corporate governance webpage, from http://ri.embraer.com.br/show.aspx?idCanal=UCZ2tsp0QeM07fvoT8OubA==

Emergo Group. 2012. Regulatory Process Chart for Medical Devices, from: www.emergogroup.com

Engardio, Peter; Bernstein, Aaron; and Kripalani, Manjeet. 2003. "Is Your Job Next?" *Business Week*, February 3, pp. 50-60.

Feenstra, Robert C. 1998. "Integration of trade and disintegration of production in the global economy." *Journal of Economic Perspectives* 12, 4: 31-50.

Fennelly, Dermot and Kathryn Cormican. 2006. "Value chain migration from production to product centred operations: an analysis of the Irish medical device industry." Technovation, 26(1): 86-94.

Fernandez-Stark, Karina; Bamber, Penny; and Gereffi, Gary. 2011. "The offshore services value chain: upgrading trajectories in developing countries." International Journal of Technological Learning, Innovation and Development, 4:1/2/3, 206-234

Flextronics. 2012. "FIT: Flextronics Institute of Technology Capabilities" October 21.

Forfás. 2009. Health LifeSciences in Ireland: An Enterprise Outlook. Dublin: Forfás.

France-Presse, Agence. 2012. "Brazil's High-Tech Industry Urged to Go Global." Industry Week, October 4. http://www.industryweek.com/information-technology/brazils-high-tech-industry-urged-go-global

Freeman, Richard. 2006. "The Great Doubling: America in the New Global Economy." Usery Lecture, April 8, Georgia State University. emlab.berkeley.edu/users/webfac/eichengreen/e183.../great_doub.pdf

Freeman, Richard. 2010. "What Really Ails Europe (and America): The Doubling of the Global Workforce." *The Globalist*, June 3. http://www.theglobalist.com/StoryId.aspx?StoryId=4542 .

Fröbel, Folker; Jörgen, Heinrichs and Kreye, Otto. 1980. *The New International Division of Labor*, Cambridge: Cambridge University Press.

Frost & Sullivan. 2010. An Overview of the Medical Device Supply Chain and Trends in Europe.

GAMA. 2011. "General Aviation Statistical Handbook & Industry Outlook". General Aviation Manufacturers Association. http://www.gama.aero/files/GAMA_DATABOOK_2011_web_0.pdf.

Gates, Dominic. 2012. "Boeing invites suppliers to conference on outsourcing in Mexico." *The Seattle Times*, October 25, 2012. From http://seattletimes.com/html/businesstechnology/2019526318_boeingoutsource26.html.

GE Aviation. 2009. "Embraer, General Electric, Azul and Amyris announce renewable jet fuel evaluation project". Press Release, from http://www.geaviation.com/press/other/other_20091118.html

GE. 2011. "GE Healthcare Global X-ray Business Announced Leadership Move to China." Retrieved August, 2012, from http://www.genewscenter.com/content/Detail.aspx?ReleaseID=12879&NewsAreaID=2.

GE. 2012. "GE Healthcare to Acquire XPRO, a Brazilian Medical Device Company." Retrieved July, 2012, from http://newsroom.gehealthcare.com/articles/ge-healthcare-to-acquire-xpro-a-brazilian-medical-device-company/

Gereffi, Gary. 1994. "The Organization of Buyer-Driven Global Commodity Chains: How U.S. Retailers Shape Overseas Production Networks." Pp. 95-122 in Gereffi and Korzeniewicz (eds.): *Commodity Chains and Global Capitalism*, Westport, CT: Praeger.

Gereffi, Gary. 1999. "International Trade and Industrial Upgrading in the Apparel Commodity Chain." *Journal of International Economics* 48, 1 (June): 37-70.

Gereffi, Gary. 2009. "Development models and industrial upgrading in China and Mexico." *European Sociological Review* 25, 1: 37-51

Gereffi, Gary, John Humphrey, and Timothy Sturgeon. 2005. "The Governance of Global Value Chains." *Review of International Political Economy* 12 (1): 78–104.

Gereffi, Gary and Timothy Sturgeon. 2013. "Global Value Chain-Oriented Industrial Policy: The Role of Emerging Economies." In Deborah K. Elms and Patrick Low (eds.): *Global Value Chains in a Changing World*, Geneva: World Trade Organization, Fung Global Institute and Temasek Foundation Centre for Trade & Negotiations.

Geromel, Ricardo. 2012. "What Is Brazil's Most Promising Sector?" *Forbes*, March 29. http://www.forbes.com/sites/ricardogeromel/2012/03/29/what-is-brazils-most-promising-sector/.

Gewar, Annabelle and Michael Cusumano. 2002. *Platform Leadership: How Intel, Microsof, and Cisco Drive Industry Innovation*. Cambridge: Harvard Business Review Press.

GIFAS. 2004. "French Aerospace Industry Key Figures 2003-2004". Groupement des Industries Françaises Aéronautiques et Spatiales. http://www.gifas.asso.fr.

GKN. 2012. "Maket Segments." http://www.gkn.com/aerospace/market-segmants/markets/Pages/default.aspx.

Goldstein, Andrea. 2002. "The Political Economy of High-tech Industries in Developing Countries: Aerospace in Brazil, Indonesia and South Africa." Cambridge Journal of Economics 26: 521–538.

Gouvea, R. 2007. "The Transnationalization of Brazil's Software Industry." *Transnational Corporations* 16 (1): 145.

Graham, John M., with Steven Davis, Douglass Lippoldt, Catherine Mann, and Jack Triplett, 2007. "The Measure of a Nation: Quantifying Innovative Strength through Improved Service Sector Metrics." National Bureau of Asian Research, Special Report No. 11, February

Grauna. Corporate webpage. http://www.graunaaerospace.com.br/

Gutierrez, Regina Maria Vinhais, and C. F. C. Leal. 2004. "Estratégias Para Uma Indústria De Circuitos Integrados No Brasil." *BNDES Setorial* 19: 3–22.

Gutierrez, Regina Maria Vinhais, and Lilian Ribeiro Mendes. 2008. "The Electronics Sector: Microelectronics Design in Brazil." *BNDES Setorial*.

Gutierrez, Regina Maria Vinhais. 2010. "Complexo Eletrônico: Lei De Informática e Competitividade." *BNDES Setorial* (31). http://www.inovacao.unicamp.br/report/inte-eletroeletronicos100712.pdf.

Guzmán, G. C., and D. L. López. 2000. "Contract Manufacturing in Brazil: Challenges and Opportunities of a New Model of Production." *Anais Do XX Encontro Nacional De Engenharia De Produccão, São Paulo, SP*. http://www.abepro.org.br/biblioteca/ENEGEP2000_I0265.PDF.

Haltiwanger, John; Jarmin, Ron, Krizanb, C.J. 2010, "Mom-and-Pop meet Big-Box: Complements or substitutes?" *Journal of Urban Economics*, 67:1, January, 116–134.

Humphrey, John. 2003. "Globalization and supply chain networks: The auto industry in Brazil and India," *Global Networks*, 3(2): 121-141.

Humphrey, John and Hubert Schmitz. 2002. “How does insertion in global value chains affect upgrading in industrial clusters?” *Regional Studies*: 36(9): 1017-1027.

International Data Corporation (IDC). 2011. "Brazil Quarterly PC Tracker."

International Organization of Motor Vehicle Manufacturers (OICA). 2012. "Production Statistics." http://oica.net/category/production-statistics/

ISO. 2012. ISO 13485: 2003 Medical Devices Quality Management Systems. Retrieved May, 2012, from http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=36786

Jenkins, Rhys. 2012. “China and Brazil: Economic impacts of a growing relationship.” *Journal of Current Chinese Affairs*, 1: 21-47.

JQP. 2012. "ISO Survey Reveals Increase in QMS Certifications." Journal for Quality & Participation, 34(4): 37-38.

Kaplinsky, Raphael. 2005. *Globalization, Poverty and Inequality: Between a Rock and a Hard Place*. Cambridge: Polity.

Kawakami, Momoko and Timothy Sturgeon. 2010. “Global Value Chains in the Electronics Industry” in Cattaneo, O., Gereffi, G. and Staritz, C (eds), *Global Value Chains in a Postcrisis World*. Washington, DC: World Bank.

Kimelberg, Shelley McDonough and Lauren A. Nicoll. 2012. "Business Location Decisions in the Medical Device Industry: Evidence From Massachusetts." [Article]. Economic Development Quarterly, 26(1): 34-49.

Kimura, Seishi. 2006. “Learning for Upgrading: The ‘Controlled’ Growth of the Japanese Aircraft Firms.” In Princeton University. http://www.princeton.edu/~ina/gkg/confs/kimura.pdf.

Knight, Gary and Cavusgil, Tamar. 2004. “Innovation, organizational capabilities, and the born-global firm.” *Journal of International Business Studies*, 35, March, 124-141.

Koopman, Robert; Wang, Zhi; and Wei, Shang-Jin (2008), How Much of Chinese Exports is Really Made in China? Assessing Domestic Value-Added When Processing Trade Is Pervasive, *NBER Working Paper Series*, No. 14109, Cambridge, MA.

Kraemer-Mbula, Erika. 2008. “Sectoral Analysis of the Aerospace Industry in South Africa”. Institute for Economic Research on Innovation. http://www.uif.gov.za/ContentPages/2469094508.pdf.

Lall, Sanjaya. 2000. “The technological structure and performance of developing country manufactured exports, 1985-98”, *Oxford Development Studies*, 28(3), 337-369.

Linden, Greg; Kraemer, Kenneth; and Dedrick, Jason. 2011. “Innovation and Job Creation in a Global Economy: The Case of Apple’s iPod” US Trade Commission. *Proceedings of the Joint Symposium of U.S.-China Advanced Technology Trade and Industrial Development.* Journal of International Commerce and Economics. May, pp. 223-240. http://www.usitc.gov/journals/jice.htm

Linden, Greg and Deepak Somaya. 2003. “System-on-a-Chip Integration in the Semiconductor Industry: Industry Structure and Firm Strategies. *Industrial and Corporate Change*, 12: 545-575.

Linden, Greg, Kenneth Kramer and Jason Dedrick. 2009. “Who Captures Value in a Global Innovation System? The Case of Apple’s iPod.” *Communication of the ACM*. 52(3):140-144.

Luk, Lorraine. 2012. “Foxconn to Build Fifth Brazil Plant.” *The Wall Street Journal*, September 19. http://online.wsj.com/article/SB10000872396390444165804578005722309270246.html.

Lüthje, B. 2002. “Electronics Contract Manufacturing: Global Production and the International Division of Labor in the Age of the Internet.” *Industry and Innovation* 9 (3): 227–247.

Marques, Rosane Argou and L. Guilherme de Oliveira. 2009. “Sectoral System of Innovation in Brazil: Reflections About the Accumulation of Technological Capabilities in the Aeronautic Sector (1990-2002).” In Sectoral Systems of Innovation and Produciton in Developing Countries: Actors, Structure and Evolution. Northamption, MA: Edward Elgar Publishing.

Mattos, Cesar, and Paulo Coutinho. 2005. “The Brazilian Model of Telecommunications Reform (BMTR).” *Telecommunications Policy* 29 (5-6). Telecommunications in Latin America (July): 449–466.

McCaffery, Fergal, Peter Donnelly, Alec Dorling, and F.G. Wilkie. 2004. A Software Process Development, Assessment and Improvement Framework for the Medical Device Industry. Conference: Fourth International SPICE Conference, Lisbon, Portugal. 28-29 April

McGuire, Steven. 2007. “The United States, Japan and the Aerospace Industry: From Captrue to Competitor?” The Pacific Review 20 (3) (September): 329–350.

McHugh, Martin, Fergal McCaffery and Valentine Casey. 2012. "Changes to the International Regulatory Environment." Journal of Medical Devices, 6(2): 021004.

Ministerio de Ciencia, Tecnología e Innovación (MCTI) 2012. “TI Maior: Programa Estratégico De Software e Serviços De Tecnologia Da Informação 2012 – 2015”

Mishkin, Sarah, and Maija Palmer. 2012. "Foxconn Survives on Thin Slices of Apple." *Financial Times, Tech Hub*. September 24. http://www.ft.com/intl/cms/s/0/170a225c-0356-11e2-a284-00144feabdc0.html

Moen, Øystein and Servais, Per. 2002. “Born Global or Gradual Global? Examining the Export Behavior of Small and Medium-Sized Enterprises.” *Journal of International Marketing*, 10: 3, 49-72.

Mokhoff, Nicolas. 2012. “Chip Fab Costs Hampering Industry Growth.” *EE Times*. October 3.

Morrison, Murdo. 2012. “Brazil looks to create a supply chain and industry base of SMEs”. *Flight International*. 22 May 2012.

Nascimento, Paulo Tromboni de Souza, Abraham Sin Oih Yu, Francisco Nigro, Robson Quinello, Rosária de Fátima S. Macri Russo, and Nilton Cesar Lima. August 2-6. “The Case of Magneti Marelli Brasil: Endogenous and Exogenous Factors in Local Dominant Technology Development.” In *PICMET 2009*. Portland, Oregon.

Nelson, Richard and Winter, Sidney. 1982. *An Evolutionary Theory of Economic Change*. Cambridge: Harvard University Press.

Niosi, Jorge and Majlinda Zhegu. 2005. “Aerospace Clusters: Local or Global Knowledge Spillovers?” Industry and Innovation 12 (1) (March): 5.

———. 2010. “Multinational Corporations, Value Chains and Knowledge Spillovers in the Global Aircraft Industry.” International Journal of Institutions and Economics 2 (2) (October): 109–141.

NSF. 2006. “Science and Engineering Indicators”. National Science Foundation. Electronic access: http://www.nsf.gov.

O’Neill, Jim. 2011. *The Growth Map: Economic Opportunity in the BRICs and Beyond*. New York: Penguin.

OECD. 2011a. "Global value chains: Preliminary evidence and policy issues." Paris: Organisation for Economic Co-operation and Development, DSTI/IND(2011)3. Electronic access: http://www.oecd.org/dataoecd/18/43/47945400.pdf

OECD. 2011b. “Achieving strong and sustainable growth,” in OECD Economic Surveys: Brazil 2011. Paris: OECD Publishing. Electronic access: http://dx.doi.org/10.1787/eco_surveys-bra-2011-7-en

Ojo, Bolaji. 2012. “Think Electronics Manufacturing Is on Life Support? Think Again.” *EE Times*, September 18. http://www.eetimes.com/electronics-news/4396537/Think-electronics-manufacturing-is-on-life-support--Think-again.

Osse, Jose Sergio. “China Plant Gives Embraer Asia Jet-Sales Boost: Corporate Brazil.” Bloomberg. Electronic access: http://www.bloomberg.com/news/2012-06-25/china-plant-gives-embraer-asia-jet-sales-boost-corporate-brazil.html.

Perlo-Freeman, S. 2004. “Offsets and the Development of the Brazilian Arms Industry,” chapter 13 in J Brauer and J P Dunne (eds) *Arms Trade and Economic Development: Theory Policy and Cases in Arms trade Offsets*. London: Routledge.

Pieroni, João Paulo, Carla Reis, and José Oswaldo Barros de Sousa. 2010. “A indústria de equipamentos e materiais médicos, hospitalares e odontológicos: uma proposta de atuação do BNDES.” In *Complexo Industrial da Saúde*. *BNDES Setorial* 31, p. 185-226.

Pine, J.P. and S. Davis 1999. *Mass Customization: The New Frontier in Business Competition*, Cambridge, MA: Harvard Business School Press.

Positivo Informatica. 2012. "Taxation in Brazil's PC Industry." November 8. http://www.mzweb.com.br/positivo/web/conteudo_en.asp?idioma=1&conta=44&tipo=21962

Prahalad, C. and Hamel, G. 1990. “The Core Competence of the Corporation.” *Harvard Business Review*. May-June (3): 79-91.

Prescott, Roberta. 2012. “Brazil Market Shakeup: Lenovo to Acquire CCE; Positivo to Produce Cellphones.” *RCR Wireless News Americas*, September 5. http://www.rcrwireless.com/americas/20120905/devices/brazils-market-shaken-levono-acquire-cce-positivo-produce-cellphones/.

Pritchard, David, and Alan MacPherson. 2004. “Outsourcing US Commercial Aircraft Technology and Innovation: Implications for the Industry’s Long Term Design and Build Capability”. Canada-United States Trade Center.

———. 2007. “Strategic Destruction of the North American and European Commercial Aircraft Industry: Implicatoins of the System Integration Business Model”. Canada-United States Trade Center.

ProduCen. 2007. Actualización del programa para el desarrollo del Cluster de Productos Médicos de las Californias. Tijuana, B.C.: ProduCen. October.

PROMINP. 2012. Conteúdo Local, Electronic access: http://www.prominp.com.br/data/pages/8A95488830FCBB0C013123EAF5943361.htm

Puri, Ankur, Ipek Demirsoy, Lucinda Woods, and Mi Zhou. 2011. The Minnesota Medical Devices Cluster. Harvard Business School.

PwC. 2012. "Aerospace & Defense: 2011 Year in Review and 2012 Forecast." Pricewaterhousecooper, LLC. http://www.pwc.com/en_US/us/industrial-products/assets/pwc-aerospace-defense-review-and-forecast.pdf.

Rathbone, John Paul and Joe Leahy. 2013. "Brazil faces brave new world of making hard decisions." *Financial Times*, August 11.

Reardon, Thomas; Timmer, Peter; Barrett Christopher; and Berdegue Julio. 2003. "The rise of supermarkets in Africa, Asia, and Latin America." *American Journal of Agricultural Economics*, 85; 5, 1140-1146.

Rose-Anderssen, Christen, James S. Baldwin, Keith Ridgway, Peter Allen, and Liz Varga. 2008. "Aerospace Supply Chains as Evolutionary Networks of Activities: Innovation via Risk-Sharing Partnerships." Creativity and Innovation Management 17 (4): 304–318.

Sales, Jose Ricardo Ramos. 2012. "The Brazilian Semiconductor Landscape." Powerpoint presentation at the CeBIT, March 8, Hannover, Germany.

Schmitz, Hubert. 2004. *Local Enterprises in the Global Economy: Issues of Governance and Upgrading*. London: Edward Elgar Publishing.

Seligman, Phillip. 2012. Healthcare: Products and Supplies. http://www.netadvantage.standardandpoors.com.proxy.lib.duke.edu/docs/indsur///hps_0212/hps_0212.htm.

Simoens, Steven. 2009. "Which Barriers Prevent the Efficient Use of Resources in Medical Device Sectors?". *Applied Health Economics and Health Policy*, 7(4): 209-217.

Simonin, Bernard. 1999. "Ambiguity and the Process of Knowledge Transfer in Strategic Alliances." *Strategic Management Journal*, 20(7): 595-623.

Sinaval. 2011. Brazilian Shipbuilding and Offshore Industry: An Overview. Presentation at "Mare Forum South America", 13 September 2011. Electronic access: http://www.mareforum.com/BRAZIL_PRESENTATIONS/Sergio_Leal.pdf

Slaughter, Matthew. 2009. "Globalization and Productivity: Current Research Findings and Policy Implications." Paper prepared for the Federal Reserve Board Academic Consultants Meeting, Microeconomic Perspectives on Productivity, October 16.

Softway. 2013a. "Sobre o RECOF." Electronic access: http://www.recof.com.br/regime_recof.htm

Softway. 2013b. "Company Description." Electronic access: http://www.softwaysa.com/site_ingles/empresa_descricao.shtml

Spafford, Chris, Tim Hoyland, and Roger Lehman. 2012. "MRO Industry Landscape 2012". Electronic access: Oliver Wyman. http://www.oliverwyman.com/media/373424_NYC-AGE98201-001_P1_-_Press_Proof.pdf.

Staritz, Cornelia, Gary Gereffi, and Olivier Cattaneo (eds.). 2011. *Int. J. Technological Learning, Innovation and Development* 4, 1-3. Special issue on "Shifting end markets and upgrading prospects in global value chains."

Sturgeon, Timothy. 2002. "Modular Production Networks. A New American Model of Industrial Organization," *Industrial and Corporate Change*. 11(3):451-496.

Sturgeon, Timothy, 2007. "How Globalization Drives Institutional Diversity: The Japanese Electronics Industry's Response to Value Chain Modularity." *Journal of East Asian Studies*, 7:(1):1–34.

Sturgeon, Timothy. 2013. Global Value Chains and Economic Globalization: Towards a New Measurement Framework. Report in support of Eurostat's initiative in the area of global value chains and economic globalization. Web access at: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Global_value_chains

Sturgeon, Timothy J., and Gary Gereffi. 2009. "Measuring success in the global economy: International trade, industrial upgrading, and business function outsourcing in global value chains." *Transnational Corporations* 18, 2: 1-36.

Sturgeon, Timothy, Gary Gereffi, Andrew Guinn and Ezequiel Zylberberg. 2013. "O Brasil nas cadeias globais de valor: implicações para a política industrial e de comércio." *Revista Brasileira de Comércio Exterior* 115 (Abril-Juhno): 26-41. http://www.funcex.org.br/downloadexterno/exclusivoautores/115_TSGGAGEZ.pdf.pdf

Sturgeon, Timothy and Ji-Ren Lee. 2005. "Industry Co-Evolution: Electronics Contract Manufacturing in North American and Taiwan" Chapter two in Suzanne Berger and Richard Lester (eds.): *Global Taiwan: Building Competitive Strengths in a New International Economy*, Armonk, NY: M.E. Sharpe.

Sturgeon, Timothy and Lester, Richard. 2004. "The New Global Supply-base: New Challenges for Local Suppliers in East Asia." Chapter 2 in: Shahid Yusuf, Anjum Altaf and Kaoru Nabeshima, eds., *Global Production Networking and Technological Change in East Asia*. Oxford: Oxford University Press.

Sturgeon, T. J., and M. Kawakami. 2011. "Global Value Chains in the Electronics Industry: Characteristics, Crisis, and Upgrading Opportunities for Firms from Developing Countries." *International Journal of Technological Learning, Innovation and Development* 4 (1): 120–147.

Sturgeon, Timothy, and Olga Memedovic. 2010. "Mapping Global Value Chains: Intermediate Goods Trade and Structural Change in the World Economy". UNIDO. Web access at http://www.unido.org/fileadmin/user_media/Publications/Research_and_statistics/Branch_publications/Research_and_Policy/Files/Working_Papers/2010/WP%2005%20Mapping%20Glocal%20Value%20Chains.pdf

Sturgeon, Timothy J., with Frank Levy, Clair Brown, J. Bradford Jensen, and David Weil, 2006. "Why We Can't Measure the Economic Effects of Services Offshoring: The Data Gaps and How to Fill Them." Final Report from the MIT Industrial Performance Center's Services Offshoring Working Group, September. MIT Industrial Performance Center working paper 06-006.

Suzigan, Wilson and João Furtado. 2006. "Poliítica Industrial e Desenvolvimento." *Revista de*

Economia Política 26 (2): 163-185.

The Brazilian Electrical and Electronics Industry Association (ABINEE). 2012. “Economic Overview and Performance of the Sector.” Powerpoint Presentation.

The Economist. 2012. “Telecommunications in Brazil: The Next Big Blackout?” *The Economist*, August 11. http://www.economist.com/node/21560271.

The New York Times. 2007. Executive jets to sustain Embraer expansion. (2007, May 25). The New York Times. Electronic access: http://www.nytimes.com/2007/05/25/news/25iht-25.oxan.5864420.html?_r=0

Thomson, Adam. 2012. “Mexico: China’s unlikely challenger.” *Financial Times,* September 19.

UNCTAD. 2011. *Non-Equity Modes of International Production and Development.* World Investment Report 2011. Geneva, Switzerland

United Nations Commodity Trade Statistics Database (UN Comtrade). 2012. "Data." http://comtrade.un.org/db/

Vlasic, Bill, Hiroko Tabuchi, and Charles Duhigg. 2012. “The iEconomy - Nissan’s Move to U.S. Offers Lessons for Tech Industry.” *The New York Times*, August 4. http://www.nytimes.com/2012/08/05/business/the-ieconomy-nissans-move-to-us-offers-lessons-for-tech-industry.html?pagewanted=all&_r=0.

Whittaker, D. Hugh Tianbiao Zhu, Timothy Sturgeon, Mon-han Tsai, and Toshie Okita. 2011. “Compressed Development.” *Studies in Comparative International Development*, 45 (4).

Williams, Karel 2000. “From Shareholder Value to Present-day Capitalism.” *Economy and Society*. 29:1 February: 1–12

Wipro. 2009. “Aerospace Manufacturing Transfer Systems”. Wipro Council for Industry Research. Electronic access: http://www.wipro.com/documents/insights/aerospace-manufacturing-transfer-systems.pdf.

World Bank. 2012. “Data.” http://data.worldbank.org/

WTO and IDE-JETRO. 2011. "Trade patterns and global value chains in east asia: From trade in goods to trade in tasks." World Trade Organization and Institute of Developing Economies, Geneva and Tokyo. Electronic access: http://www.ide.go.jp/English/Press/pdf/20110606_news.pdf.

10.Abbreviations

ABDI – Brazilian Agency for Industrial Development
ABIMO – Brazilian Medical Device Industry Association
ABINEE – Brazilian Electrical and Electronics Industry Association
AIAB – Brazilian Aerospace Industry Association
ANAC – National Civil Aviation Agency
ANATEL – The Brazilian Agency of Telecommunications
ANVISA – National Agency for Health Surveillance
BNDES – The Brazilian Development Bank
CEITEC – Center of Excellence in Advanced Electronic Technology
CNAE – National Classification of Economic Activity
CNPq – Council for Scientific and Technological Development
CTENIC – National Certification of Information and Communication Technologies
EMS – Electronic Manufacturing Service
EOI – Export-Oriented Industrialization
FINEP – Brazilian Innovation Agency
FIT – Flextronics Institute of Technology
GVC – Global Value Chain
HS – Harmonized System
HTA – High Technology Aeronautics
IBGE – Brazilian Institute of Geography and Statistics
IC – Integrated Circuit
ICMS – Tax on Circulation of Goods and Services
IPI – Industrial products Tax
ISI – Import Substitution Industrialization
ISO – International Standards Organization
MC – Ministry of Communications
MCTI – Ministry of Science, Technology and Innovation
MDIC – Ministry of Development, Industry and Foreign Trade
MNC – Multinational Corporation
MRO – Maintenance, Repair and Overhaul
ODM – Original Design Manufacturer
PADIS – Program for the Development of the Semiconductor and Display Industry
PCB – Printed Circuit Board
PPB – Basic Production Process
R&D – Research and Development
SEPIN – Secretariat of Information Technology
SME – Small/Medium Enterprise
SMT – Surface Mount Technology
TSMC – Taiwan Semiconductor Manufacturing Corporation
WTO – World Trade Organization

11.Appendices

Table 19. Interviews Conducted for Project

	Organization name	Sector
1	GE Celma do Brasil	Aeronautics
2	Embraer	Aeronautics
3	Composites Atlantic	Aeronautics
4	Embraer	Aeronautics
5	Embraer	Aeronautics
6	GOL (MRO)	Aeronautics
7	MDIC	Aeronautics/Federal Government
8	Ministry of Science, Technology and Innovation	Electronic/Federal Government
9	Ecil Informatica	Electronics
10	NEC Latin America S/A	Electronics
11	Nokia Siemens Networks	Electronics
12	WEG S/A	Electronics
13	Hewlett Packard	Electronics
14	HT Micron	Electronics
15	Flextronics	Electronics
16	Flextronics Institute of Technology	Electronics
17	IBM	Electronics
18	Ecil Informatica	Electronics
19	NEC Latin America S/A	Electronics
20	Nokia Siemens Networks	Electronics
21	Apex-Brasil	Electronics
22	WEG S/A	Electronics
23	Hewlett Packard	Electronics
24	HT Micron	Electronics
25	Flextronics	Electronics
26	Flextronics Institute of Technology	Electronics
27	IBM	Electronics
28	Apex-Brasil	Electronics/Federal Government
29	Ministry of Science, Technology and Innovation	Electronics/Federal Government
30	Ministry of Development, Industry and Foreign Trade	Electronics/Federal Government
31	Ministry of Science, Technology and Innovation	Electronics/Federal Government
32	Ministry of Science, Technology and Innovation	Electronics/Federal Government
33	Ministry of Development, Industry and Foreign Trade	Electronics/Federal Government
34	Hermes Pardini	Medical
35	GE Healthcare	Medical Devices
36	Apex-Brasil	Medical Devices/Federal Government
37	ABIMO	Medical Devices/Industry Association
38	Medical City	Medical/Industry Cluster Association
39	Biomm	Medical/Life Sciences
40	Precon Park Management (Fashion City)	Clothing Wholesale
41	Reserva Real	Residential Development
42	Fundação Dom Cabral	Executive Education
43	Sistema FIEMG	Industry Association
44	Sistema FIEMG	Industry Association
43	State Secretariat for Economic Development, Minas Gerais	State Government
44	State Secretariat for Economic Development, Minas Gerais	State Government

Appendix A: Aerospace

Table 20. Lead Firms in the Aerospace GVC

Company	Headquarters	2010 Revenues (USD M)	Role in Aerospace GVCs
Boeing	USA	64,306	Final craft (commercial jets)
Airbus (EADS)	France	60,599	Final craft (commercial jets)
Bombardier	Canada	9,357	Final craft (regional jets)
Embraer	Brazil	5,364	Final craft (regional jets)
BAE Systems PLC	UK	34,428	Avionics and other commercial operations
Pratt & Whitney	USA	25,227*	Aircraft engines
Hamilton Sunstrand	USA	25,227*	Engine, flight and environmental controls
Finmeccania SPA	Italy	24,762	Avionics and fuselage components
GE Aircraft Engines	USA	17,619	Aircraft engines
Thales	France	17,364	Avionics, computer software and hardware
Rolls-Royce Group PLC	UK	16,794	Aircraft engines
Snecma Group	France	13,847	Aircraft engines and aircraft equipment
Honeywell International	USA	10,683	Turbofan and turboprop engines, flight safety systems
Goodrich Corporation	USA	6,967	Airframe, engine systems, electronic systems, landing systems
Harris Corporation	USA	5,206	Communications equipment, small aircraft
Rockwell Collins, Inc.	USA	4,631	Aviation communications
MTU Aero Engines	Germany	3,585	Components and engine parts
Parker Hannifin Corp.	USA	1,744	Support systems
Eaton Corporation	USA	1,536	Hydraulic systems
Vought Industries	USA	1,295	Airframe structures
Volvo Aero	Germany	1,069	Aircraft engines and components
Smiths Group PLC	UK	887	Avionics, mechanical and electrical equipment
International Aero Engines	Switzerland	N/A**	Aircraft and aircraft engines
The Engine Alliance	USA	N/A**	Aircraft engines

* Hamilton Sunstrand and Pratt & Whitney are both wholly owned by United Technologies, Co.
**International Aero Engines and The Engine Alliance are both joint ventures
Source: Niosi and Zhegu (2010); 2010 revenues from PwC, 2012

Table 21. Aerospace HS Code Definition

Type	HS	Description	Final Good	Intermediate Good
Component	401130	New pneumatic tyres, of rubber, of a kind used on aircraft		x
Component	401213	Retreaded pneumatic tyres of rubber, of a kind used on aircraft		x
Component	700711	Toughened (tempered) safety glass, of size & shape suit. for incorporation ...		x
Component	700721	Laminated safety glass, of size & shape suit. for incorporation in vehicles ...		x
Component	880310	Propellers & rotors & parts thereof , of gds. of 88.01/88.02		x
Component	880320	Under-carriages & parts thereof , of gds. of 88.01/88.02		x
Component	880330	Parts of aeroplanes/helicopters, other than propellers, rotors, under-carri ...		x
Component	880390	Parts of gds. of 88.01/88.02, n.e.s. in 88.03		x
Component	880400	Parachutes (incl. dirigible parachutes & paragliders) & rotochutes; parts t ...		x
Component	880510	Aircraft launching gear & parts thereof ; deck-arrestor/sim. gear & parts t ...		x
Component	880521	Air combat simulators & parts thereof		x
Component	880529	Ground flying trainers other than air combat simulators, & parts thereof		x
Component	901420	Instruments & appls. for aeronautical/space navigation (excl. compasses)		x
Component	910400	Instrument panel clocks & clocks of a sim. type for vehicles/aircraft/space ...		x
Component	940110	Seats of a kind used for aircraft		x
Propulsion	840710	Spark-ignition recip./rotary int. comb. piston engines for aircraft		x
Propulsion	840910	Parts suit. for use solely/princ. with the aircraft engines of 84.07		x
Propulsion	841111	Turbo-jets, of a thrust not >25kN		x
Propulsion	841112	Turbo-jets, of a thrust >25 kN		x
Propulsion	841121	Turbo-propellers, of a power not >1,100kW		x
Propulsion	841122	Turbo-propellers, of a power >1,100kW		x
Propulsion	841181	Gas turbines other than turbo-jets/turbo-propellers, of a power not >5000kW ...		x
Propulsion	841182	Gas turbines other than turbo-jets/turbo-propellers, of a power >5000kW		x
Propulsion	841191	Parts of the turbo-jets/turbo-propellers of 8411.11-8411.22		x
Propulsion	841199	Parts of the oth. gas turbines of 8411.81 & 8411.82		x
Propulsion	854430	Ignition wiring sets & oth. wiring sets of a kind used in vehicles/aircraft ...		x
Final Craft	880211	Helicopters of an unladen wt. not >2000kg	x	
Final Craft	880212	Helicopters of an unladen wt. >2000kg	x	
Final Craft	880220	Aeroplanes & oth. aircraft, of an unladen wt. not >2000kg	x	
Final Craft	880230	Aeroplanes & oth. aircraft, of an unladen wt. >2000 kg but not >15000kg	x	
Final Craft	880240	Aeroplanes & oth. aircraft, of an unladen wt. >15000kg	x	
Final Craft	880260	Spacecraft (incl. satellites) & suborbital & spacecraft launch vehicles	x	

Appendix B: Medical devices

Table 22. Top 10 Global Medical Devices Firms by Revenue

Company	Currently Producing in Brazil?	Head-quarters	2011 Revenue (USD Billions)	Main Industry Segment(s)
Johnson & Johnson	X	USA	25.8	Hospital Equipment, Disposables, Laboratory Equipment
GE Healthcare	X	USA	18.1	Radiology, Hospital Equipment
Siemens Medical		Germany	16.1	Radiology, Hospital Equipment, Laboratory Equipment
Medtronic		USA	15.9	Disposables, Implants, Laboratory Equipment
Baxter	X	USA	13.9	Disposables, Implants
Phillips Healthcare	X	Netherlands	11.5	Radiology, Hospital Equipment, Laboratory
Covidien	X	Ireland	11.6	Disposables, Laboratory Equipment, Implants
Boston Scientific		USA	7.6	Implants, Disposables, Laboratory Equipment
Stryker		USA	8.3	Implants, Hospital Equipment
Becton Dickinson	X	USA	7.6	Consumables, Laboratory Equipment

Source: Company websites, Hoovers

Table 23. Disaggregated Medical Devices Export Trends

Sub-sector	Exports, 2010 (USD Billions)	% Export Growth 2007-10	% World Exports in sub-sector 2010*	% All Brazilian exports 2010**
Dental	$0.073	-11.5%	0.51%	0.037%
Disposables	$0.213	18.0%	1.13%	0.108%
Equipment	$0.064	-16.9%	0.10%	0.032%
Implant	$0.098	20.9%	0.19%	0.050%
Laboratory	$0.025	32.1%	0.06%	0.013%
Radiology	$0.025	18.2%	0.08%	0.013%
All Medical Devices	$0.498	8.0%	0.22%	0.252%

*Total world exports of medical devices for 2010: $223,393,480,167
**Total Brazilian exports for 2010: $197,356,436,225
Source: UN Comtrade

Table 24. Disaggregated Medical Devices Import Trends

Sub-sector	Imports, 2010 (USD Billions)	% Import Growth 2007-10	% World Imports in sub-sector 2010*	% All Brazilian Imports 2010**
Dental	$0.063	67.9%	0.68%	0.035%
Disposables	$0.119	59.2%	0.80%	0.066%
Hospital Equipment	$0.804	98.3%	1.25%	0.446%
Implant	$0.682	58.3%	1.33%	0.378%
Laboratory	$0.707	59.0%	1.62%	0.392%
Radiology	$0.643	69.5%	2.06%	0.356%
All Medical Devices	$3.018	70.3%	1.41%	1.673%

Total world medical imports for 2010: $214,286,766,866
Total Brazilian imports for 2010: $180,458,788,518
Source: UN Comtrade

Table 25. Medical Device HS Code Definition

Sub-sector	HS Code	Description	Intermediate Good	Final Good
Dental	300640	Dental cements & oth. dental fillings; bone reconstruction cements		x
Dental	340700	Modelling pastes, incl. those put up for children's amusement; preps. known as dental wax/dental impression comps.		x
Dental	901841	Dental drill engines, whether or not combined on a single base	x	
Dental	901849	Instruments & appls. used in dental sciences (excl. drills)		x
Dental	902121	Artificial teeth		x
Dental	902129	Dental fittings (excl. art. teeth)		x
Dental	902213	Apparatus based on the use of X-rays (excl. of 9022.12), for dental uses		x
Dental	940210	Dentists' chairs; barbers'/sim. chairs having rotating as well as both reclining & elevating movements, & parts thereof		x
Diagnostic	300630	Opacifying preps. for X-ray examinations; diagnostic reagents designed to be administered to the patient		x
Diagnostic	900630	Cameras specially designed for underwater use/aerial survey/medical/surgical examination of internal organs; comparison cameras for forensic/criminological purps.		x
Diagnostic	901813	Magnetic resonance imaging app.		x
Diagnostic	901814	Scintigraphic app.		x
Diagnostic	901819	Electro-diagnostic app. used in medical/surgical/dental/veterinary sciences (incl.app.for functional exploratory examination/for checking physiological parameters), n.e.s. in 90.18		x
Diagnostic	901820	Ultra-violet/infra-red ray app. used in medical/surgical/dental/veterinary sciences		x
Diagnostic	902212	Computed tomography app.		x
Diagnostic	902214	Apparatus based on the use of X-rays (excl. of 9022.12), for medical/surgical/veterinary uses		x
Diagnostic	902221	Apparatus based on the use of alpha/beta/gamma radiations, for medical/surgical/dental/veterinary uses, incl. radiography/radiotherapy app.		x
Diagnostic	902230	X-ray tubes	x	

Diagnostic	902290	X-ray generators (excl. tubes), high tension generators, control panels & desks, screens, examination/treatment tables, chairs and the like	x	
Disposable	300510	Adhesive dressings & oth. arts. having an adhesive layer		x
Disposable	300590	Wadding, gauze, bandages & sim. arts.		x
Disposable	300610	Sterile surgical catgut, sim. sterile suture mats. & sterile tissue adhesiv ...		x
Disposable	300650	First-aid boxes & kits		x
Disposable	300670	Gel preps. designed to be used in human/veterinary medicine as a lubricant for parts of the body for surgical operations/physical examinations		x
Disposable	901831	Syringes, with/without needles		x
Disposable	901832	Tubular metal needles & needles for sutures		x
Equipment	401511	Surgical gloves of vulcanised rubber		x
Equipment	901811	Electro-cardiographs		x
Equipment	901812	Ultrasonic scanning app.		x
Equipment	901850	Ophthalmic instr. & appls. n.e.s. in 90.18		x
Equipment	901890	Instruments & appls. used in medical/surgical/veterinary sciences, incl. oth. electro-medical app. & sight-testing instr., n.e.s. in 90.18		x
Equipment	901910	Mechano-therapy appls.; massage app.; psychological aptitude-testing app.		x
Equipment	901920	Ozone therapy/oxygen therapy/aerosol therapy/art. respiration/oth. therapeu ...		x
Equipment	902000	Breathing appls. (excl. of 90.19) & gas masks (excl. protective masks having neither mech. parts/replaceable filters)		x
Equipment	902110	Orthopaedic/fracture appls.		x
Equipment	940290	Medical/surgical/veterinary furniture (e.g., op. tables, examination tables, hospital beds with mech. fittings; parts of the foregoing arts.)		x
Implant	901839	Catheters, cannulae and the like		x
Implant	902131	Artificial joints		x
Implant	902139	Artificial parts of the body other than teeth, dental fittings & joints		x
Implant	902140	Hearing aids (excl. parts & accessories)		x
Implant	902150	Pacemakers for stimulating heart muscles (excl. parts & accessories)		x
Implant	902190	Appliances which are worn/carried/implanted in the body, to compensate for ...		x
Laboratory	300620	Blood-grouping reagents		x
Laboratory	382200	Diagnostic/laboratory reagents on a backing, prepd. diagnostic/laboratory r ...		x
Laboratory	841920	Medical/surgical/laboratory sterilisers, whether or not electrically heated ...		x
Laboratory	842119	Centrifuges, incl. centrifugal dryers, other than cream separators & clothe ...		x
Laboratory	842191	Parts of centrifuges, incl. centrifugal dryers	x	
Laboratory	901110	Stereoscopic microscopes		x
Laboratory	901120	Compound optical microscopes (excl. stereoscopic), for photomicrography/cinephoto-micrography/microprojection		x
Laborato	901180	Compound optical microscopes (excl. of 9011.10 & 9011.20)		x

ry				
Laboratory	901190	Parts & accessories of the compound optical microscopes of 90.11	x	
Laboratory	902720	Chromatographs & electrophoresis instr.		x
Laboratory	902730	Spectrometers, spectrophotometers & spectrographs using optical radiations (UV, visible, IR)		x
Laboratory	902750	Spectrometers, spectrophotometers & spectrographs using optical radiations (UV, visible, IR)		x
Laboratory	902790	Microtomes; parts & accessories of instr. & app. of 90.27	x	

Appendix C: Electronics

Table 26. Top Global Electronics Firms by Revenue, 2011

Rank	Company	Headquarters	Revenue (USD Millions)	Industry Segment
1	General Electric	U.S.	$151,628	Industrial Equipment, Medical Electronics
2	Samsung Electronics	South Korea	$133,781	Consumer Electronics
3	Hewlett-Packard	U.S.	$126,033	Computers and Storage, Computer Peripherals and Office Equipment
4	Hitachi	Japan	$108,766	Consumer Electronics
5	Siemens	Germany	$102,657	Industrial Equipment, Medical Electronics
6	Panasonic	Japan	$101,491	Consumer Electronics
7	IBM	U.S.	$99,870	Computers and Storage
8	Sony	Japan	$83,845	Consumer Electronics, Computers and Storage
9	Toshiba	Japan	$74,706	Consumer Electronics, Computers and Storage
10	Apple	U.S.	$65,225	Consumer Electronics
11	Robert Bosch	Germany	$62,593	Industrial Equipment
12	Dell	U.S.	$61,494	Computers and Storage
13	ThyssenKrupp	Germany	$57,586	Industrial Equipment
14	Nokia	Finland	$56,218	Consumer Electronics, Communications Equipment
15	Fujitsu	Japan	$52,871	Consumer Electronics, Computer Peripherals and Office Equipment
16	LG Electronics	South Korea	$48,236	Consumer Electronics
17	Cisco Systems	U.S.	$40,040	Communications Equipment
18	Denso	Japan	$36,561	Automotive Electronics
19	NEC	Japan	$36,374	Communications Equipment
20	Johnson Controls	U.S.	$34,305	Automotive Electronics

Source: CNN Money's Global 500; Author's analysis

Table 27. Top Semiconductor Equipment Suppliers by Sales, 2011

Rank	Company	Ownership	Semiconductor Equipment & Service Sales (USD Millions)
1	ASML	Netherlands	$7,877
2	Applied Materials*	U.S.	$7,438
3	Tokyo Electron	Japan	$6,203

4	KLA-Tencor	U.S.	$3,106
5	Lam Research	U.S.	$2,804
6	Dainippon Screen Mfg. Co.	Japan	$2,105
7	Nikon Corporation	Japan	$1,646
8	Advantest**	Japan	$1,447
9	ASM International	Netherlands	$1,443
10	Novellus Systems***	U.S.	$1,319
11	Hitachi High-Technologies	Japan	$1,139
12	Teradyne	U.S.	$1,106
13	Varian Semiconductor Equipment****	U.S.	$1,096
14	Hitachi Kokusai Electric	Japan	$838
15	Kulicke & Soffa	U.S.	$781

*Includes Varian's revenues for Nov 1 - Dec 31, 2011
**Includes Verigy's revenues for July 1 - Dec 31, 2011
***Acquired by Lam Research in June 2012
****Includes revenues as an independent company for Jan 1 - Oct 31, 2011
Source: VLSIresearch

Table 28. Top Fabless IC Suppliers by Revenue, 2011

Rank	Company	Ownership	Revenue (USD Millions)	% Change 10-11
1	Qualcomm	U.S.	$9,910	38%
2	Broadcom	U.S.	$7,160	9%
3	AMD	U.S.	$6,568	1%
4	Nvidia	U.S.	$3,939	10%
5	Marvell	U.S.	$3,445	-4%
6	MediaTek	Taiwan	$2,969	-17%
7	Xilinx	U.S.	$2,269	-2%
8	Altera	U.S.	$2,064	6%
9	LSI Corp.	U.S.	$2,042	26%
10	Avago	Singapore	$1,341	13%
11	Mstar	Taiwan	$1,220	15%
12	Novatek	Taiwan	$1,198	4%
13	CSR	Europe	$845	5%
14	ST-Ericsson*	Europe	$825	-28%
15	Realtek	Taiwan	$742	5%
16	HiSilicon	China	$710	9%
17	Spreadtrum	China	$674	95%
18	PMC-Sierra	U.S.	$654	3%
19	Himax	Taiwan	$633	-2%
20	Lantiq	Europe	$540	-2%
21	Dialog	Europe	$527	77%
22	Silicon Labs	U.S.	$492	0%
23	MegaChips	Japan	$456	35%
24	Semtech	U.S.	$438	9%
25	SMSC	U.S.	$415	5%

*Represents the 50% share not accounted for by ST.

Source: Company reports, IC Insights' Strategic Reviews Database

Table 29. Value of Brazilian Electronics Exports, Imports and Production 2010

Sub-sector	Export Value	Import Value	Production value*
Computers and Storage Devices	$72,027,514	$1,920,486,941	$7,714,355,077
Communications Equipment	$1,279,723,343	$3,396,326,908	$6,070,304,935
Automotive Electronics	$478,715,733	$686,816,901	$4,998,127,880
Consumer Electronics	$32,726,316	$3,557,051,857	$3,292,611,952
Industrial Equipment	$339,015,226	$2,006,387,085	$1,223,776,168
Medical Electronics	$119,041,438	$1,296,309,616	$729,449,621
Computer Peripherals and Office Equipment	$109,693,473	$1,920,486,941	$568,922,413
Electronic Components	$52,829,418	$2,426,047,617	$474,776,984
Total Electronics**	$2,483,772,461	$17,012,695,836	$25,072,325,030

*Production Value converted fro BRL using Average Daily Exchange Rate for 2010 = .599 BRL/USD
**Total refers to the HS/CNAE Electronics Sector definition, Please see Appendix C5 for details
Source: Production Data: Conversions from CONCLA Correspondance Tables; Data from IBGE; Trade Data: UN Comtrade

Table 30. Electronics HS Code Definition

Sub-Sector	HS Code	HS Description	Intermediate Good	Final Good
Automotive Electronics	851120	Ignition Magnetos; Magneto-dynamos; Magnetic Flywheels	x	
Automotive Electronics	851180	Electrical Ignition, Starting Equipment and Cut-outs for Internal Combustion Engine	x	
Automotive Electronics	852729	Other Radio-broadcast Receivers, for Motor Vehicles	x	
Automotive Electronics	851130	Distributors; Ignition Coils	x	
Automotive Electronics	851140	Starter Motors and Dual Purpose Starter-generators	x	
Automotive Electronics	851110	Sparking Plugs	x	
Automotive Electronics	851150	Other Generators for Internal Combustion Engines	x	
Automotive Electronics	852721	Radio-broadcast Receivers Combined With Sound Recording or Reproducing Apparatus (For Vehicles)	x	
Automotive Electronics	851190	Parts of Ignition , Starting Equipment, for Internal Combustion Engine	x	
Automotive Electronics	851220	Other Electrical Lighting or Visual Signalling Equipment	x	
Automotive Electronics	854430	Ignition Wiring Sets & Other Wiring Sets, for Vehicles, Aircraft or Ship	x	
Computer Peripherals and Office Equipment	847029	Other Electronic Calculating Machines		x
Computer Peripherals and Office Equipment	847030	Other Calculating Machines		x
Computer Peripherals and Office Equipment	844312	Offset Printing Machinery, Sheet Fed, Office Type		x
Computer Peripherals and Office Equipment	847021	Electronic Calculating Machines, Incorporating a Printing Device		x

Computer Peripherals and Office Equipment	847010	Electronic Calculators, Operation Without an External Source of Power		x
Computer Peripherals and Office Equipment	847090	Other Machines, Incorporating a Calculating Device		x
Computer Peripherals and Office Equipment	847340	Parts, Accessories, of Duplicating Machines, or Other Office Machines	x	
Computer Peripherals and Office Equipment	847050	Cash Registers		x
Computer Peripherals and Office Equipment	847330	Parts and Accessories of the Automatic Data Processing Machines	x	
Computer Peripherals and Office Equipment	847290	Other Office Machines		x
Computer Peripherals and Office Equipment	847210	Duplicating Machines		x
Computer Peripherals and Office Equipment	847230	Machines for Sorting or Folding Mail or for Inserting Mail in Envelope		x
Computer Peripherals and Office Equipment	847310	Parts and Accessories of Typewriters and Word-processing Machines	x	
Computers and Storage Devices	847141	Dig auto data proc w/cpu		x
Computers and Storage Devices	847149	Dig auto data proc units		x
Computers and Storage Devices	847160	I/O units w/n storage u		x
Computers and Storage Devices	847130	Portable digital data pr		x
Computers and Storage Devices	847180	Units of auto data proce		x
Computers and Storage Devices	847190	Automatic data processin		x
Computers and Storage Devices	847170	Storage units		x
Computers and Storage Devices	847150	Digital process units wh		x
Computers and Storage Devices	847110	Analogue or Hybrid Automatic Data Processing Machines		x
Consumer Electronics	900610	Cameras for preparing printing plates or cylinders		x
Consumer Electronics	910310	Clocks with watch movements, battery (except vehicle)		x
Consumer Electronics	900659	Photographic, other than cinematographic cameras nes		x
Consumer Electronics	910591	Clocks, nes, battery or mains powered		x
Consumer Electronics	910390	Clocks with watch movements, nes (except vehicle)		x
Consumer Electronics	852791	Other reception apparatus for radio-broadcasting, combined with sound recording/reproducing apparatus		x
Consumer Electronics	852719	Other Radio-broadcast Receivers, Operating Without an External Source		x
Consumer Electronics	910119	Wrist-watch, precious metal, battery, other		x
Consumer Electronics	920790	Musical instruments nes, electric/requiring amplifier		x
Consumer Electronics	920710	Keyboard instruments electrical/requiring amplifier		x
Consumer Electronics	900630	Cameras for special use, underwater,aerial, etc		x
Consumer Electronics	910521	Wall clocks, battery or mains powered		x
Consumer Electronics	910511	Alarm clocks, battery or mains powered		x
Consumer Electronics	852110	Video recording/reproducing apparatus, magnetic tape		x
Consumer Electronics	910291	Pocket-watch, base-metal case, battery		x
Consumer Electronics	910111	Wrist-watch, precious metal, battery, with hands		x

Consumer Electronics	851822	Multiple loudspeakers, mounted in single enclosure		x
Consumer Electronics	851821	Single loudspeakers, mounted in enclosure		x
Consumer Electronics	910219	Wrist-watch, base-metal case, battery, other		x
Consumer Electronics	851810	Microphones and stands thereof		x
Consumer Electronics	910211	Wrist-watch, base-metal case, battery, with hands		x
Consumer Electronics	851840	Audio-frequency electric amplifiers		x
Consumer Electronics	852290	Parts and accessories of recorders except cartridges	x	
Consumer Electronics	910212	Wrist-watch, base-metal case, battery, opto/electric		x
Consumer Electronics	852799	Other reception apparatus for radio-broadcasting, excl. 8527.91 & 8527.92		x
Consumer Electronics	851890	Parts of non-recording electronic equipment	x	
Consumer Electronics	852190	Video record/reproduction apparatus not magnetic tape		x
Consumer Electronics	851830	Headphones, earphones, combinations		x
Consumer Electronics	852990	Parts for radio/tv transmit/receive equipment, nes	x	
Consumer Electronics	851920	Apparatus operated by coins, banknotes, bank cards, tokens/by other means of payment		x
Consumer Electronics	852210	Pick-up cartridges	x	
Consumer Electronics	852712	Radio-broadcasting Receivers Capable of Operating Without an External Source of Power		x
Consumer Electronics	852792	Other reception apparatus for radio-broadcasting, not combined with sound recording/reproducing apparatus but combined with a clock.		x
Consumer Electronics	900640	Instant print cameras		x
Consumer Electronics	900651	Cameras, single lens reflex, for roll film <= 35 mm		x
Consumer Electronics	900652	Cameras for roll film of a width <35 mm		x
Consumer Electronics	900653	Cameras for 35 mm roll film except single lens reflex		x
Consumer Electronics	910191	Pocket-watch, precious-metal case, battery		x
Consumer Electronics	920810	Musical boxes		x
Electronic Components	854099	Parts of electronic valve & tubes, except cathode ray	x	
Electronic Components	854071	Magnetron tubes	x	
Electronic Components	854081	Receiver or amplifier valves and tubes	x	
Electronic Components	854040	Data/graphic display tub	x	
Electronic Components	854060	Cathode-ray tubes, nes	x	
Electronic Components	853310	Electrical resistors, fixed carbon	x	
Electronic Components	854011	Colour cathode-ray television picture tubes, monitors	x	
Electronic Components	853290	Parts of electrical capacitors	x	
Electronic Components	854020	Television camera tubes and other photo-cathode tubes	x	
Electronic Components	853390	Parts of electrical resistors, rheostats, etc	x	
Electronic Components	853339	Wirewound variable resistors, rheostats, etc > 20 wat	x	
Electronic Components	854089	Electronic valves/tubes, except receiver/amplifier	x	

Electronic Components	854190	Parts of semiconductor devices and similar devices	x	
Electronic Components	854091	Parts of cathode-ray tubes	x	
Electronic Components	853329	Electrical resistors, fixed, except heating, > 20 wat	x	
Electronic Components	853331	Wirewound variable resistors, rheostats, etc, <20 wat	x	
Electronic Components	854121	Transistors, except photosensitive, < 1 watt	x	
Electronic Components	854290	Parts of electronic integrated circuits etc	x	
Electronic Components	854129	Transistors, except photosensitive, > 1 watt	x	
Electronic Components	854160	Mounted piezo-electric crystals	x	
Electronic Components	853321	Electrical resistors fixed, power capacity < 20 watt	x	
Electronic Components	854140	Photosensitive/photovoltaic/LED semiconductor devices	x	
Electronic Components	854150	Semiconductor devices, not light sensitive or emittin	x	
Electronic Components	853340	Variable resistors, rheostats and potentiometers, nes	x	
Electronic Components	854130	Thyristors/diacs/triacs, except photosensitive device	x	
Electronic Components	854110	Diodes, except photosensitive and light emitting	x	
Electronic Components	853400	Electronic printed circuits	x	
Electronic Components	854239	Other Electronic integrated circuits, other than Amplifiers/Memories/Processors & controllers	x	
Electronic Components	854012	Monochrome cathode-ray picture tubes, monitors	x	
Electronic Components	854079	Microwave tubes, nes	x	
Industrial Equipment	903032	Multimeters with a recording device		x
Industrial Equipment	902720	Chromatographs, electrophoresis instruments		x
Industrial Equipment	902490	2011 Parts and accessories of material testing equipment	x	
Industrial Equipment	903020	Cathode-ray oscilloscopes, oscillographs		x
Industrial Equipment	901410	Direction finding compasses		x
Industrial Equipment	901600	Balances of a sensitivity of 50 milligram or better		x
Industrial Equipment	903031	Electrical multimeters		x
Industrial Equipment	903010	Instruments to measure or detect ionising radiations		x
Industrial Equipment	903084	Other instruments & apparatusspecially designed for telecommunications, with a recording device		x
Industrial Equipment	901490	Parts and accessories for navigational instruments	x	
Industrial Equipment	903281	Hydraulic and pneumatic automatic controls		x
Industrial Equipment	902480	Machines for testing mechanical properties nes		x
Industrial Equipment	852610	Radar apparatus		x
Industrial Equipment	903089	Electrical measurement instruments nes		x
Industrial Equipment	903090	Parts & accessories, electrical measuring instruments	x	
Industrial Equipment	902910	Revolution counters/taximeters/mileometers/pedometers		x

Industrial Equipment	903033	Other instruments & apparatus, for measuring/checking voltage, current, resistance/power, without a recording device, other than 9030.31 & 9030.32		x
Industrial Equipment	903039	Ammeters, voltmeters, ohm meters, etc, non-recording		x
Industrial Equipment	901480	Navigational instruments and appliances nes		x
Industrial Equipment	902750	Instruments nes using optical radiations		x
Industrial Equipment	903040	Gain, /distortion and crosstalk meters, etc		x
Industrial Equipment	852692	Radio remote control apparatus		x
Industrial Equipment	902410	Machines for testing mechanical properties of metals		x
Industrial Equipment	902730	Spectrometers, spectrophotometers, etc using light		x
Industrial Equipment	902790	Microtomes, parts of scientific analysis equipment		x
Industrial Equipment	903220	Manostats		x
Industrial Equipment	903300	Parts/accessories nes for optical/electric instrument	x	
Industrial Equipment	902810	Gas supply/production/calibration meters		x
Industrial Equipment	902780	Equipment for physical or chemical analysis, nes		x
Industrial Equipment	902990	Parts and accessories of revolution counters, etc	x	
Industrial Equipment	903290	Parts and accessories for automatic controls	x	
Industrial Equipment	902710	Gas/smoke analysis apparatus		x
Industrial Equipment	902890	Parts, accessories for gas, liquid, electricity meter	x	
Industrial Equipment	852691	Radio navigational aid apparatus		x
Industrial Equipment	901420	Instruments nes for aeronautical/space navigation		x
Industrial Equipment	903210	Thermostats		x
Industrial Equipment	902830	Electricity supply, production and calibrating meters		x
Industrial Equipment	902820	Liquid supply, production and calibrating meters		x
Industrial Equipment	902920	Speed indicators, tachometers, stroboscopes		x
Industrial Equipment	903289	Automatic regulating/controlling equipment nes		x
Industrial Equipment	901210	Microscopes except optical, diffraction apparatus		x
Industrial Equipment	901290	Parts and accessories for non-optical microscopes, et	x	
Industrial Equipment	903082	Instr f/msrng semiconductor		x
Medical Electronics	901814	Scintigraphic apparatus		x
Medical Electronics	902140	Hearing aids, except parts and accessories		x
Medical Electronics	901811	Electro-cardiographs		x
Medical Electronics	902212	Computed tomography appa		x
Medical Electronics	902150	Pacemakers for stimulating heart muscles		x
Medical Electronics	901820	Ultra-violet or infra-red ray apparatus		x
Medical Electronics	901812	Ultrasonic scanning appr		x
Medical Electronics	902290	Parts and accessories for radiation apparatus	x	
Medical Electronics	902230	X-ray tubes	x	
Medical Electronics	901813	Magnetic resonance imagi		x
Medical Electronics	902213	X-rays apparatus, dental		x
Medical Electronics	901819	Electro-diagnostic apparatus, nes		x
Medical Electronics	902214	X-rays apparatus, medica		x

Medical Electronics	902190	Orthopaedic appliances, nes		x
Medical Electronics	902110	Orthopaedic/fracture appls		x
Medical Electronics	902131	Artificial joints		x
Medical Electronics	902139	Artificial parts of the body other than teeth, dental fittings & joints		x
Medical Electronics	902221	Medical apparatus using alpha, beta or gamma radiation		x
Communications Equipment	851711	Line telephone sets,cord		x
Communications Equipment	852560	Transmission apparatus for radio-broadcasting/televison incorporating reception apparatus		x
Communications Equipment	851769	Machines for the reception, conversion & transmission/regeneration of voice, images/other data, incl. switching & routing apparatus		x
Communications Equipment	852550	Transmission apparatus for radio-broadcasting/television		x
Communications Equipment	851718	Other telephone sets, incl. telephones for cellular networks/for other wireless networks, other than 8517.11 & 8517.12		x
Communications Equipment	851762	Other apparatus for transmission/reception of voice, images/other data, incl. apparatus for communication in a wired/wireless network (such as a local/wide area network) , other than 8517.61 & 8517.62		x
Communications Equipment	851761	Parts of telephone sets, incl. telephones for cellular networks/for other wireless networks; other apparatus for the transmission/reception of voice, images/other data, incl. apparatus for communication in a wired/wireless network (such as a local/wide area…	x	
Communications Equipment	851770	Base stations for transmission/reception of voice, images/other data, incl. apparatus for communication in a wired/wireless network (such as a local/wide area network)		x
Communications Equipment	851712	Telephones for cellular networks/for other wireless networks, other than Line telephone sets with cordless handsets		x