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Insertion of Costa Rica in Global Value Chains

A Case Study

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This paper is part of the Inter-American Development Bank research project "International Fragmentation of Production and Insertion of Latin America and the Caribbean in Global Production Networks" consisting on a series of case studies that were conducted during the 2011-2012 period in order to analyze the barriers that countries in the region face to insert in global value chains and the potential role for the public sector to help mitigate these barriers. The project was coordinated by Juan Blyde of the Integration and Trade Sector and Ricardo Carciofi of the Institute for the Integration of Latin American and the Caribbean (INTAL) with the technical supervision of Timothy Sturgeon from MIT and the general direction of the Trade and Integration Sector Manager, Antoni Estevadeordal

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Abstract

This study sheds light on how Costa Rica's insertion in global value chains occurs by examining governance patterns, the type of activities involved, and the level of underlying innovation in the selected value chain. The paper describes in detail two case studies of electronic-related companies in the aeronautic GVC that operate in Costa Rica as suppliers of global players in this industry. The final objective of the research is to contribute to the understanding of how public policies can be employed to improve Costa Rica's exporting and innovating performance

JEL: F14, F23
Key Words: Global Supply Chains, International Fragmentation of Production, Suppliers.

Introduction

During the last thirty years, the growth of global trade and foreign direct investment (FDI) inflows has outscored that of world output. Lately, the global exchange of intermediate inputs (both components and services) has accounted for most of the growth in international trade (Yeats 2001; Hummels, Ishii, and Yi 2001; UNCTAD 2004), taking place not only within the firms via FDI (insourcing abroad) but also outside the firms via contractual agreements among them (outsourcing abroad). This phenomenon has reconfigured the geographical allocation of world output and has modified the content, magnitudes, and direction of international trade flows.

Production processes have increasingly fragmented worldwide, thus becoming a multi-country sequential chain of mutually exclusive production stages in which different activities are carried out by specialized facilities located in several countries around the globe. Countries which specialize in different stages of the production process are thus linked in a vertical chain through trade in intermediate inputs. This phenomenon is often called vertical specialization, global production sharing networks, or global value chains (GVC), and has given rise to the concept of "Made in the World," in light of which the World Trade Organization (WTO) has recently launched an initiative with the aim to support the exchange of projects, experiences, and practical approaches in measuring and analyzing trade in value added.

This increase in international production fragmentation has opened up new opportunities for developing countries to participate in a finer and larger international division of labor.

Costa Rica is a small country in the middle of the Americas that is already inserted into global production sharing schemes. Foreign direct investment (FDI), mostly oriented toward efficiency-seeking greenfield operations rather than any other mode of foreign entry market (e.g., non-equity modes, or NEM; UNCTAD 2011), has played a critical role in that shift, as the country has adopted, since the mid-1980s, a development strategy based on export promotion and attraction of FDI.

Intel's decision to establish production facilities in Costa Rica in 1998 can be thought of as the turning point of the country's insertion into global production sharing schemes, as well as the beginning of the development of a solid export-oriented sector producing high-technology and sophisticated manufactures and services. Ever since the beginning of Intel's operations in Costa Rica, FDI has contributed to consolidate, expand, and diversify the scope of exports that are part of global production sharing schemes. Electronics was the first sector to develop this kind of external links, and others, such as medical devices, have emerged more recently.[1]

This research intends to (1) shed light on how Costa Rica's insertion in the GVC occurs; and (2) understand their governance patterns, the type of activities involved, and the level of underlying innovation in the selected value chain. The answers to these research questions (described in more detail in the following section) will allow the government, particularly the Ministry of Foreign Trade, to promote public policies aimed at improving Costa Rica's exporting and innovating performance.

The paper describes in detail two case studies of electronic-related companies in the aeronautic GVC that operate in Costa Rica as suppliers of global players (original equipment manufacturers, or OEM) of the aeronautic industry. The first case (Camtronics) is about a local electronic manufacturing supplier (EMS), and the second one (Avionyx) reviews a multinational company that offers outsourcing of embedded software to control aircraft electronic systems.

The rest of this document is organized in five sections. The first section presents a brief theoretical background that helps contextualize our research and raises the questions that the research seeks to answer. Section 2 provides a fairly detailed assessment of the global aeronautic industry and its recent evolution. Section 3 presents a description of the country industry; that is, of the firms operating in Costa Rica that are integrated in the aeronautic global value chains. Section 4 discusses the main findings of the case studies conducted on Camtronics and Avionyx, while Section 5 offers a summary of the policy implications stemming from the case studies.

[1] Costa Rica was an earlier supporter and signatory of the Information Technology Agreement (ITA),[1] a multilateral agreement adopted by several (but not all) WTO member countries and by which import tariffs on goods directly related to information technologies are removed among the signatories. In particular, when China joined the WTO and adopted the ITA as part of its accession protocol in 2001, Costa Rica's chances to develop stronger external links to the electronics GVC grew considerably (see Monge-Ariño 2011).

1. Theoretical Background

A vast set of literature attributes the rise of global value chains to globalization-related forces such as declining costs of transportation, improvements in communications technology, and institutional and policy reforms in developing countries. It seems these explanations might not capture the entire story, however. Industry specialists and business scholars have pointed out that the strategy decision by global brand-name manufacturers to modularize electronics products may also have been a critical driver of the industry transformation (Gangnes and Van Assche 2011).

Value chains in the electronics industry have steadily disintegrated across corporate and national boundaries since the early 1990s. Outsourcing has become a strategic necessity, especially in fiercely competitive and rapidly changing sectors such as electronics. According to Baldwin and Clark (2006), the electronics industry has evolved to a modular structure in which firms keep a smaller set of activities in-house (a smaller footprint) by outsourcing the functions that do not constrain overall business performance. In the past, large electronics firms designed and developed their own products, often using their internal supply chains (Linden, Kraemer, and Dedrick 2007). Did the same happen to the OEMs that Avionyx and Camtronics serve? How important are the activities that these OEMs outsourced to the two companies studied in our analysis?

Today lead firms (brand-name manufacturers) focus on core competencies, especially product innovation, marketing, and other activities related to brand development, while using specialized suppliers for non-core functions such as manufacturing (Sturgeon 2002; Yeung 2006). By outsourcing, lead firms can get more products faster and reap value from innovations before imitators enter the market all without making huge capital investments or idling in-house capital assets to meet rapid technological change and volatile market demand (Sturgeon 2002). Is there no innovation carried out by Avionyx and Camtronics from Costa Rica? If not, what should the country offer for these companies' activities to change from efficiency-driven to innovation-driven?

In accordance with Gereffi, Humphrey, and Sturgeon (2005), the U.S. electronics industry changed its governance pattern from hierarchy to modular value chain. One of the most important implications of value chain modularity is that it makes it easier to perform tasks across great distances and in geographically dispersed locations (Baldwin and Clark 2008). This has created opportunities for developing countries, both as production locations for multinational firms and for local firms seeking to participate in the industry as suppliers and contract manufacturers. The electronics industry is more extensive and dynamic than any other goods-producing sector. One reason is that electronic parts and most final products have a high value-to-weight ratio that makes long-distance shipping relatively inexpensive (Sturgeon and Kawakami 2010).

Costa Rica participates in consumer electronics, industrial electronics, and aircraft electronics chains (as defined in Table 4 in Sturgeon and Kawakami 2010, 12), among others, by providing intermediate goods and services to the United States, its main market. It is very likely that the variables that define the governance pattern of these chains in Costa Rica, such as the complexity and ability to codify transactions and the capabilities of the suppliers (Gereffi, Humphrey, and Sturgeon 2005), correspond to modular value chains, just like the governance pattern of these chains in the United States. Validating this statement is the first step in this research. If the chain in which Avionyx and Camtronics participate is not modular, what type of governance pattern does it have?

In addition, we would like to understand how relative proximity, measured as nearshoring, cultural affinity, and similar time zones between Costa Rica and the United States, affects the type of relationships that control these chains' governance. Do these differences really matter? Also, we would like to find out why Costa Rica has been less successful in non-equity foreign entry market modes, which are relatively common in these global value chains. The various forms of NEM can also be compared to FDI in terms of their motivation (e.g., market-seeking, resource-seeking, and efficiency-seeking). Besides, some types of NEM are similar to FDI in that they entail a "package" of assets, resources, technology, and know-how to be put in the care of host-country firms, as in the case of contract manufacturing, outsourcing, franchising, and concessions (UNCTAD 2011). What must the country do to improve its appeal for NEM?

Finally, and following on the previous paragraph, Costa Rica does not have a large domestic market, but it has preferred access to the most important markets of the world, like the United States, China, and the European Union, as a result of the robust foreign trade platform it has developed over the last two decades. In addition, Costa Rica was an early promoter and is a member of the Information Technology Agreements (ITA) of the WTO, which removes all import tariffs on information technology–related goods (it includes most electronics products that are manufactured in and exported from Costa Rica). Is this part of Costa Rica's appeal? Are these international trade agreements considered in the assessments carried out by companies when choosing a country in which to establish operations?

2. Global Industry

The global aeronautic and defense industry has experienced strong growth in recent years, although it should be noted that it slowed to marginal growth in 2009 as the effects of recession were felt. The market is expected to recover and grow steadily toward 2014, although a decline is expected in 2012. The global aeronautic and defense market had total revenues of USD 920.6 billion in 2009, representing a compound annual growth rate (CAGR) of 8.7% for the period spanning 2005–2009 (Datamonitor 2010). In comparison, the European and Asia-Pacific markets grew with CAGRs of 6.5% and 11.3% respectively, over the same period, to reach respective values of USD 202.2 billion and USD 174.5 billion in 2009.

Defense sales were the most lucrative in the global aeronautic and defense market in 2009, with total sales of USD 660.8 billion, equivalent to 71.8% of the market's overall value (see Table 1; the defense market comprises defense aeronautic and arms industries). In comparison, sales of civil aeronautics had a volume of USD 259.8 billion in 2009, equating to 28.2% of the market total.

Table 1
Defense Aeronautic
(in million dollars)

Company	Country	Division	2010	2009
Lockheed Martin	USA	Includes aircrafts & electronics	27,598	25,733
Boeing	USA	Includes 85% of Boeing defense, space & security	27,152	28,612
Northrop Grumman	USA	Excludes shipbuilding and 40% of aerospace (space estimate)	23,674	23,374
BAE Systems	UK	Excludes land and armament systems	23,651	21,348
Raytheon	USA	Excludes intelligence and info systems revenues ($1,000m)	21,426	20,677
Finmeccanica	Italy	Excludes 34% aircrafts; 15% helicopters, space	17,616	17,540
EADS	Netherlands	Excludes Airbus Commercial, space and 50% Eurocopter	16,218	15,305

Thales	France	Defense and security	9,955	10,418
United Technologies	USA	80% Flight Systems (Sikorsky, Hamilton Sundstrand)	9,834	9,478
L-3 Communications	USA	Includes 71% sales to DoD	8,350	8,315
Honeywell	USA	U.S. government sales	4,354	4,288
Textron	USA	Bell Military and Textron Systems	3,979	3,546
Israel Aerospace Industries	Israel		3,148	2,881
Dassault Aviation	France	Defense division	1,270	1,364
TOTAL			**198,225**	**192,879**

Source: PricewaterhouseCoopers 2011.

The arms industry has become increasingly concentrated, nationally as well as internationally. Despite the continuing global economic recession in 2009, the total arms sales of the SIPRI Top 100 of the world's largest arms-producing companies increased by USD 14.8 billion from 2008 to reach USD 401 billion, a real increase of 8%, according to new data on international arms production released earlier in 2011 by Stockholm International Peace Research Institute (SIPRI).

America accounted for 59.1% of the global aeronautic and defense sector value. Europe accounted for a further 22% and Asia-Pacific 19% (Datamonitor 2010). The top one hundred aeronautic companies compose more than two-thirds of global revenue in 2010 (see Exhibit 1). The performance of the market is forecast to decelerate, with an anticipated CAGR of 5.3% for the five-year period 2009–2014, which is expected to drive the market to a value of nearly USD 1.2 billion by the end of 2014. Comparatively, the European and Asia-Pacific markets will grow with CAGRs of 7.3% and 11.6% respectively, over the same period, to reach respective values of USD 267.3 billion and USD 301.7 billion in 2014 (Datamonitor 2010).

Snapshot of U.S. Aeronautic Industry Output

It is estimated that the value of total U.S. aeronautic industry shipments in 2010 was USD 171 billion, a decrease of 4.5% from the 2009 figure of USD 179 billion (U.S. Census Bureau 2011). Measured by value, shipments of civil aircraft and aircraft parts in 2010, at USD 85 billion, constituted one-half of the total 2010 aeronautic industry output. The value of civil aircraft and aircraft parts shipped in 2010 decreased almost 13% from the 2009 figure (USD 97 billion). While shipments of civil aircraft and aircraft parts were down in 2010, orders for these products rose sharply, increasing by 66% in 2010 from the 2009 order value of USD 55 billion (U.S. Department of Commerce 2011).

Table 2
Civil Aircraft (LCA and General Aviation)
(in million dollars)

Company	**Country**	**2010**	**2009**
Airbus (excl. ATR)	France	36,659	36,668
Boeing	USA	31,834	34,051
Bombardier	Canada	8,614	9,357
Gulfstream	USA	5,299	5,171
Dassault Aviation	France	4,276	3,393
Embraer	Brazil	2,889	3,382
Hawker Beechcraft	USA	2,805	3,199
Cessna	USA	2,563	3,320
ATR	France	1,350	1,400
TOTAL		**96,289**	**99,941**

Source: PricewaterhouseCoopers 2011.

Large civil aircraft (LCA), that is, aircraft generally considered to have more than one hundred seats or an equivalent cargo capacity, are produced by the U.S. manufacturer Boeing and the European manufacturer Airbus. Together, they hold a near-duopoly (see Table 2).

Major developments in 2010 included clear signs of the emergence of new LCA competitors overseas. In November 2010, the Commercial Aircraft Corporation of China announced the first orders for its C919 model jetliner (a 150-seat narrow-body aircraft that would compete with aircrafts currently sold by Boeing and Airbus). Earlier in the year, Montreal-based Bombardier received its first order from a U.S. customer for its CSeries aircraft, the first LCA to be manufactured in Canada.

General aviation (GA) sales fell again in 2010. Large business jet deliveries continue to be unaffected by the downturn while smaller jet sales are more volatile. Global general aviation manufacturers shipped 2,015 units in 2010, down almost 53% from 2007, which was the best year since the early 1980s. The decline reflects the continuation of the economic downturn that began at the end of 2008. U.S. manufacturers' market share continued to fall, mostly due to significant production cutbacks at Cessna. GA manufacturers in the United States continued to shed jobs. The Brazilian Embraer is emerging as a strong competitor in the small jet area and is opening a facility to assemble these planes in Florida in 2011. Due to supply chain constraints and the significant number of layoffs at OEMs, it is unclear how the industry will respond to new orders as the economy continues to improve.

The large civil aircraft jet engine market is dominated by U.S. manufacturers GE Aviation and Pratt & Whitney, and U.K. manufacturer Rolls-Royce (see Table 3). These three companies also participate in a number of joint ventures amongst themselves or along with a smaller company or group of companies. These ventures are formed to capitalize on emerging market demand for engines, while at the same time allowing partners to share development and production costs along with risk.

Aside from the continued and increasingly common use of joint ventures for cost- and risk-sharing purposes, major developments in 2010 relate to development of new engine technologies that reduce engine fuel consumption, noise, and emissions. Representatives of this trend are Pratt & Whitney's geared turbofan (GTF) engine and the LEAP-X engine by CFM (CFM is a joint venture between GE Aviation, a division of General Electric of the United States, and Snecma, a division of Safran of France).

Table 3
Engines (Civil & Military)
(in million dollars)

Company	**Country**	**Division**	**2010**	**2009**
General Electric	USA	Aircraft engines (excl. Smiths)	15,680	15,615
United Technologies	USA	Engines (Pratt & Whitney)	12,935	12,392
Rolls-Royce	UK	Civil Aerospace & Defense	10,875	10,124
Safran	France	Propulsion (Air & Space)	7,424	7,888
Honeywell	USA	Aerospace (estimates)	5,287	5,065
MTU Aero Engines	Germany		3,586	3,630
Ishikawajima-Harima	Japan	Aero-Engines & Space Operations	3,064	2,957
Avio	Italy	Aeroengines & Avioservices	1,943	1,963
Volvo	Sweden	Aero	1,069	1,020
ITP	Spain		640	666
TOTAL			**62,503**	**61,320**

Source: PricewaterhouseCoopers 2011.

Aircraft parts include aircraft parts and auxiliary equipment, such as crop-dusting apparatuses and external fuel tanks. Measured by value, U.S. production of civil and military aircraft parts reached a trough in 2002 and 2003 (with shipments each of those two years at USD 21.1 billion). Production increased each year afterward, peaking in 2008 at USD 33.1 billion. In

2009, the most recent year for which data is available, U.S. production of aircraft parts contracted by about 5% from the year before, to USD 31.4 billion (U.S. Department of Commerce 2011).

Estimates indicate that about 70% of total U.S. production of aircraft parts is composed of civil parts. During times of economic downturn, as has been the case in recent years, the demand for replacement parts in used civil aircrafts increases relative to the demand for parts produced for new aircraft because aircraft operators, such as airlines, are more inclined to extend the life of their existing fleet rather than to acquire new aircraft.

Aeronautic Industry Trade

U.S. exports of total civil and military aeronautic products in 2010 were valued at USD 77.8 billion and U.S. aeronautic imports were valued at USD 34.2 billion, producing a U.S. aeronautic trade surplus of USD 43.6 billion. The 2010 aeronautic trade surplus was a contraction from the 2009 surplus of USD 48.3 billion, resulting from both a year-to-year decrease in U.S. aeronautic exports and an increase in U.S. aeronautic imports.

The top five U.S. export markets accounted for 37% of total U.S. aeronautic exports: France, China, Japan, the United Kingdom, and Germany. The top five suppliers to the United States accounted for 75% of total U.S. aeronautic imports: France, Canada, the United Kingdom, Japan and Germany.

While the composition of the total U.S. aeronautic industry is roughly half civil and half military, civil aeronautics products dominate U.S. aeronautics exports. Over the last five years, 86% of all U.S. aeronautic exports consisted of civil products.

Market impediments overseas include tariffs on U.S. exports of civil aircraft and aircraft parts (India, Russia, China, and Brazil). The lack of sufficient airports or landing slots in some markets, such as India and Japan, is a challenge for U.S. exporters of general aviation aircraft. A requirement to provide offsets, well established in connection with military aircraft sales, appears to be increasingly applied to the export of civil aircraft. Offsets are compensation practices required as a condition of purchase by government-owned or -controlled airlines. The aircraft seller may be required to transfer technology to the market of the aircraft purchaser, invest in local aeronautic manufacturers, and/or purchase aircraft components from local suppliers (Bureau of Industry and Security 2010).

Aeronautic Industry Trends in the Last Three Decades

First, *concentration* has been a continuous process throughout the entire aircraft industry life cycle. By the late 1960s, the U.S. civil aircraft industry had reduced to just three main producers: Boeing, McDonnell Douglas, and Lockheed (The MIT Commission on Industrial Productivity 1989). The competitive pressure Boeing placed on its rivals was intense. By the mid-1990s, Lockheed had ceased production of the Tristar and McDonnell Douglas was in deep financial difficulties in its civil aircraft division. In 1997 came the path-breaking merger of Boeing and McDonnell Douglas. Following the merger, Boeing accounted for over 80% of the world's total civil aircraft in service. From the 1950s to the 1970s, there were several European companies each manufacturing large jet airliners (by the standards of the time). By the late 1960s, however, it was apparent that none of them was able to compete with Boeing. In 1970, France and Germany decided to join forces to build a family of large commercial aircraft that could challenge Boeing's dominance and preserve a wide array of high-technology supplier industries within Europe. They were later joined by Britain and Spain (Nolan, Zhang, and Liu 2008).

Outsourcing is the second major trend that characterizes the last three decades of the aeronautic industry. The deregulation and privatization of the air transportation industry in the late 1970s rendered American airline companies extremely sensitive to cost and price issues (The MIT Commission on Industrial Productivity 1989). In addition, the end of the Cold War caused important reductions in defense aeronautic programs. These changes forced the restructuring of the aircraft industry. Mergers and acquisitions were necessary, but not sufficient, to adapt the industry to these new and particularly demanding conditions. So, since the 1980s, American OEMs have undertaken the rationalization of their activity by focusing on their core business (design, development, and systems integration) while outsourcing the non-core subsystems to their suppliers. Since the 1990s, European companies have followed the same path (Niosi and Zhegu 2010).

Internationalization is the third major trend of the aircraft industry evolution since the 1980s. From a demand perspective, the aircraft industry has always been international. Civil aircraft production is mainly for export. Canada exported 82% of its aircraft production, followed by the United States and the European Union, whose export shares of the civil aircraft sector are 58% and 53% respectively (U.S. Department of Commerce 2011).

From a firm perspective, the main driving factor of internationalization in the aircraft industry has been the constant increase of development costs, which may represent up to 25% of overall aircraft costs. The design of a new aircraft requires enormous investments with significant up-front costs during the launch stage. While the cost of failure is high, so is the reward for success. A successful new plane can lock up its chosen market segment for over twenty years, producing sales of USD 25–40 billion and huge profits (Nolan, Zhang, and Liu 2008).

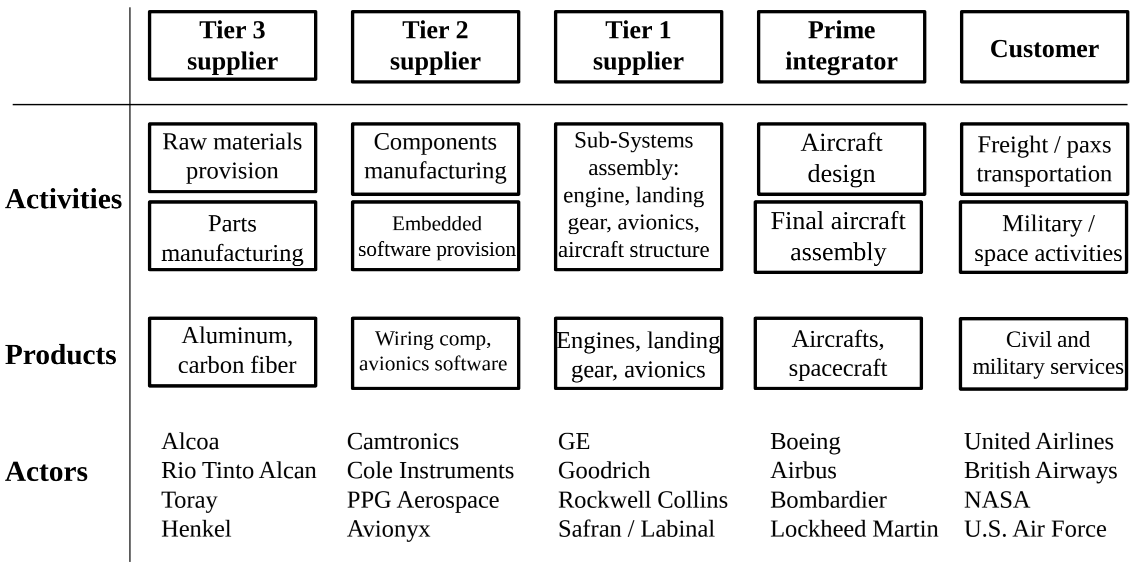
High R&D costs have increasingly pressed large OEMs to engage in strategic alliances and risk-sharing contracts with foreign partners. For example, U.S. suppliers on the Chinese project C919 include General Electric, Honeywell, Rockwell Collins, Eaton, Parker Aerospace, Crane, Kidde, Hamilton Sundstrand, and Nexcelle (GE nacelle joint venture with Safran) (U.S. Department of Commerce 2011).

Offsets agreements have been another important internationalization mechanism, which has involved several industry stakeholders including aircraft firms, national and international governments, and industry associations. In 2009, U.S. defense contractors reported entering into fifty-six new offset agreements with twenty-one countries valued at USD 6.7 billion. The value of these agreements equaled 62.7% of the USD 10.7 billion in reported contracts for sales of defense articles and services to foreign entities with associated offset agreements. The top three offset transaction categories reported by industry for 2009 were purchases, subcontracting, and technology transfer. These three categories represented 81.9% of all offset transactions reported for 2009 based on quantity, 84.0% of the transactions based on actual value, and 80.0% of the transactions based on credit value. During 1993–2009, forty-nine U.S. firms reported entering into 736 offset-related defense export sales contracts worth USD 108.2 billion with forty-six countries. The associated offset agreements were valued at USD 75.9 billion (Bureau of Industry and Security 2010).

Aeronautic GVC

The prime integrators, Airbus and Boeing, focus increasingly on coordinating and planning the supply chain, rather than on direct manufacture. As much as 60–80% of the end-product value of aeronautic products is now derived from the external supply network (Nolan, Zhang, and Liu 2008). Airbus pioneered the concept of final assembly of large subsystems. However, Boeing has taken the lead over Airbus in reorganizing its supply chain. In each aircraft program, Boeing selects risk-sharing partners who develop and design important subsystems of the aircraft (see Figures 1 and 2).

Figure 1
Aeronautic GVC



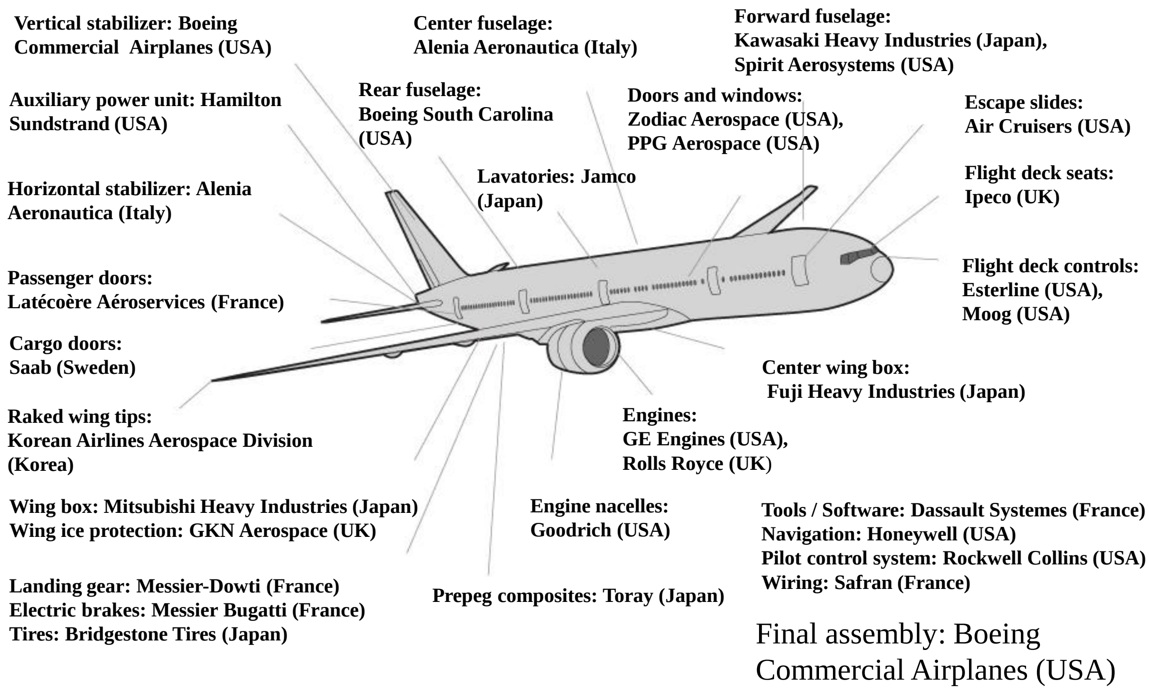
Source: Author's elaboration.

Aircraft manufacturers and Tier 1 suppliers have become large-scale integrators ("super integrators") and coordinators of aircraft production. New strategies adopted by the aeronautic industry to achieve this stage include greater dependence on Tier 1s, increased risk-sharing by suppliers, adoption of low-cost regional suppliers, increased aerostructures outsourcing, and an increased transparency in their aircraft program plans and schedules; proposal making is more a joint process between customer and supplier.

There is more focus on systems integration, less internal production capability, a desire to work with a lesser number of Tier 1 primes, and significant reduction in direct dealings with Tier 2 and Tier 3 suppliers, except when developing such suppliers in low-cost regions like Mexico and India (see Table 4).

Figure 2

Fragmentation of Production: The Boeing 787 Dreamliner



Source: Author's elaboration based on data from [http://www.newairplane.com/787/whos_building/.](http://www.newairplane.com/787/whos_building/)

Table 4
Main Aircraft Subsystems

Aircraft Subsystems	Subsystems Integrator (Tier 1)
Aircraft engines	Engines are by far the most expensive aircraft subsystem, requiring high development costs and R&D outlays. There are now only three engine makers who are able to produce large modern jet aircraft engines that meet the continuously advancing demands of Boeing and Airbus. These are GE, Rolls-Royce, and United Technology (Pratt & Whitney).
Aircraft structures	Aircraft structures are dominated by a handful of companies, including Triumph (which is the sole supplier of major structures for the B747), BAE Systems (which is the sole supplier of wings for Airbus), Finmeccanica, Mitsubishi Heavy Industries, Fuji Heavy Industries, and Kawasaki Heavy Industries.
Avionics systems (including communication and navigation systems, flight instrument systems, flight management systems, as well as traffic alert and collision avoidance technologies; also at the forefront of power distribution and pneumatic and landing systems)	Honeywell was selected to supply the core avionics systems for both the A380 and the B787. Smiths Aerospace (acquired by GE Aviation in 2007), Goodrich, and Rockwell Collins are major competitors in the supply of avionics and other control systems. All of these companies supply subsystems to both Boeing and Airbus (A380 and B787).
Landing gear, wheel and braking systems	Snecma (Safran group), Goodrich, Meggitt, Crane: between them, they have close to 80% of the global market for brakes on civil aircraft.
Aircraft lighting systems	Goodrich and Eaton, among others.
Wiring systems	The wiring systems on large civil aircraft are immensely complex. Labinal is the world leader in the supply of wiring systems. Labinal is the wiring systems subsidiary of the French aerospace group Safran. It supplies the main part of the wiring systems for both the A380 (211 miles of wiring) and the B787.

Source: Data from suppliers' websites, authors' interviews with Avionyx, and http://www.newairplane.com/.

Country Industry Description[2]

Camtronics was the first firm, currently integrated in the aeronautic GVC, to set up operations in Costa Rica in 1985. A year later, two other firms of this sector started operations in the country, but their full integration in this value chain did not take place until the late 1990s or the early 2000s, long after the world's industry internationalization began in the 1980s.

The fifteen firms currently operating in Costa Rica and integrated in the aeronautic GVC produce an interesting variety of intermediate inputs for the aircraft industry, including both goods and services (see Table 5). Their main products include design and repair of turbines for aircraft, design and testing of electronic devices for aircraft, machined parts for aircraft, printed circuit boards for aircraft, thermostats, repair of motherboards for aircraft, maintenance for helicopters, metal coatings for aircraft parts, wire harnesses for aircraft, lasers for aircraft, circuit protection gas tubes, software code for aircraft operation, and design of the first ever plasma-propelled engine for space shuttles.

Table 5

Aeronautic GVC Companies Operating in Costa Rica

Company	Description
Agilis	Aircraft engine design
Avionyx S.A.	Development of embedded software for avionics
Camtronics	Aircraft wiring harness
COOPESA	Aircraft turbine repair, aircraft parts MRO
Estrella de Precisión Tecnológica S.A.	Aluminum machined parts for aircraft
Fortech Microabrasivos S.A.	Metal coatings for aircraft parts
Helicorp S.A.	Maintenance for helicopters
Irazu Electronics	Printed circuit boards for aircraft
Marysol Technologies S.A.	Lasers for aircrafts
Olympic Fibers S.A.	Machined parts for aircrafts
Sensors Group Costa Rica S.A.	Thermostats
Techshop Internacional S.A.	Machined parts
Teradyne S.A.	Aircraft motherboard repair
Tico Electronics S.A.	Printed circuit boards for aircraft
Trimpot Electrónicas Ltd.	Circuit protection gas tubes

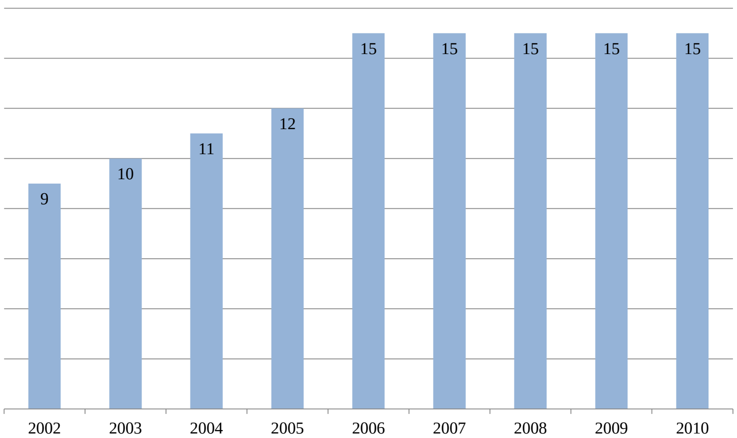
Source: Author's elaboration based on data from PROCOMER (2011).[5]

[2] This section was developed using data from PROCOMER (2011), which is available for firms operating in the EPZ regime only. Some firms have missing records for certain years of the period considered.

As Figure 3 shows, by 2002 there were already nine firms operating in Costa Rica and integrated in the aeronautics GVC. The number of firms in this sector increased linearly until 2005 and in 2006 reached fifteen, which has persisted ever since.

Figure 3

Number of Aeronautic GVC Firms Operating in Costa Rica



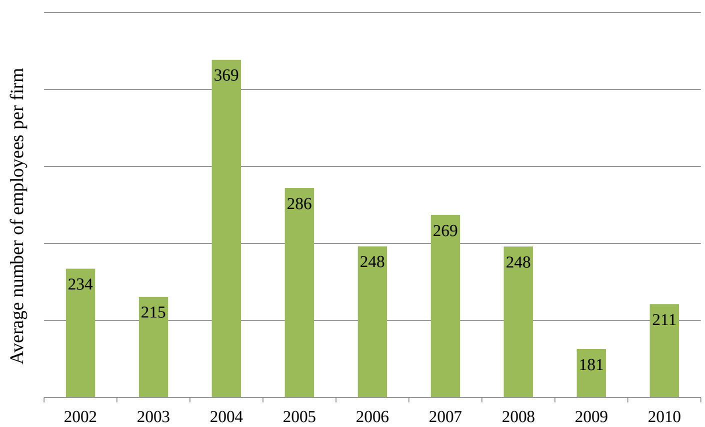
Source: Author's elaboration based on data from PROCOMER (2011).

The average size of the aeronautic GVC firms operating in Costa Rica has fluctuated over the years, averaging around 240 employees per firm, reaching a peak of 369 in 2004 and an absolute minimum of 181 in 2009 (Figure 4). The peak in 2004 seems to follow the expansion of the aeronautic GVC firms participating at the time, rather than being a result of new firms joining the group.[3] In turn, the minimum average size observed in 2009 was mainly due to the effects of the last international financial crisis.

[3] The firm that joined the aeronautic GVC group of firms operating in Costa Rica in 2004 does not participate in the EPZ regime and no statistics are available for it. Thus, its employment figures were not included in this data.

Figure 4

Average Size of the Aeronautic GVC Firms Operating in Costa Rica



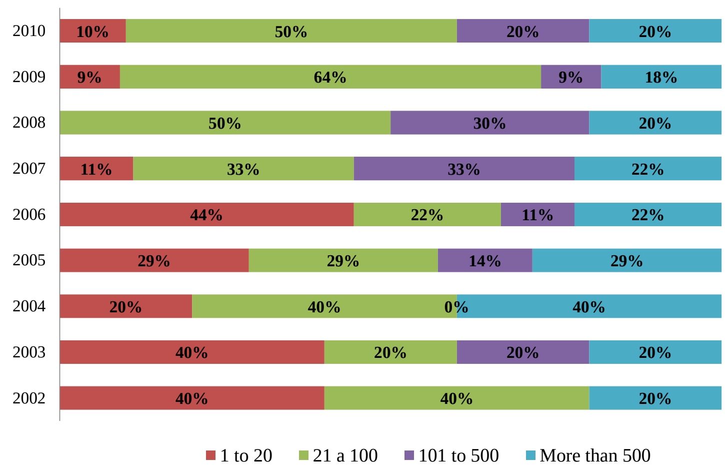
Source: Author's elaboration based on data from PROCOMER (2011).

The evolution of the size of aeronautic GVC firms operating in Costa Rica becomes even clearer when analyzing the frequency distribution of firms according to their number of employees between 2002 and 2010 (Figure 5).

In 2002, 80% of the firms corresponded to micro and small firms, while large firms accounted for the other 20%. Some of the small firms of 2002 increased their size in 2003 and became medium-sized. Such increases in number of employees continued in 2004, when some 2003 micro firms became small and the 2003 medium-sized expanded to become large companies. Therefore, the peak of the average size of the aeronautic GVC firms operating in Costa Rica in 2004 took place because 40% of them became large firms (more than five hundred employees) and only 20% were micro (twenty employees or less). After 2006, all changes in the frequency distribution of the firms' size is due to fluctuations in the employment level, as no additional firms operating in Costa Rica have integrated into the aeronautic GVC since that year.

Figure 5

Distribution of the Aeronautic GVC Firms Operating in Costa Rica by Number of Employees

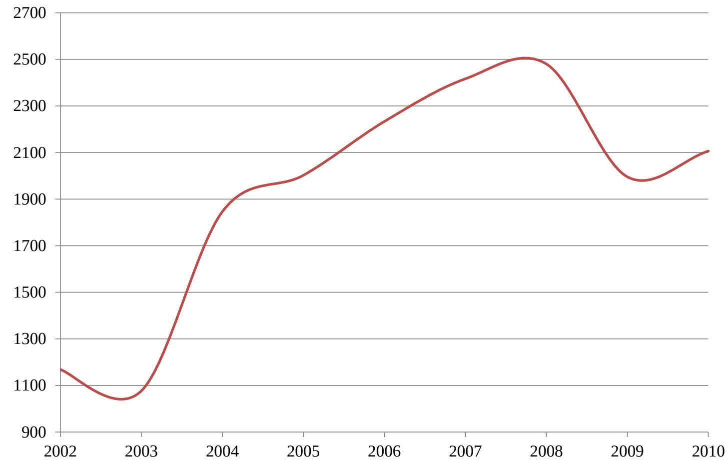


Source: Author's elaboration based on data from PROCOMER (2011).

Another interesting change in the frequency distribution of the firms' size took place in 2008, when all of the aeronautic GVC firms operating in Costa Rica had more than twenty employees, and half of them had more than one hundred employees. The effect of the international crisis is visible in 2009, when employment cuts drove some medium-sized firms into micro enterprises and 60% of all the firms integrated in the aeronautic GVC became mid-sized (between twenty-one and one hundred employees). The year 2010 depicted a very preliminary and modest step toward recovery.

Figure 6

Number of People Employed by the Aeronautic GVC Firms Operating in Costa Rica

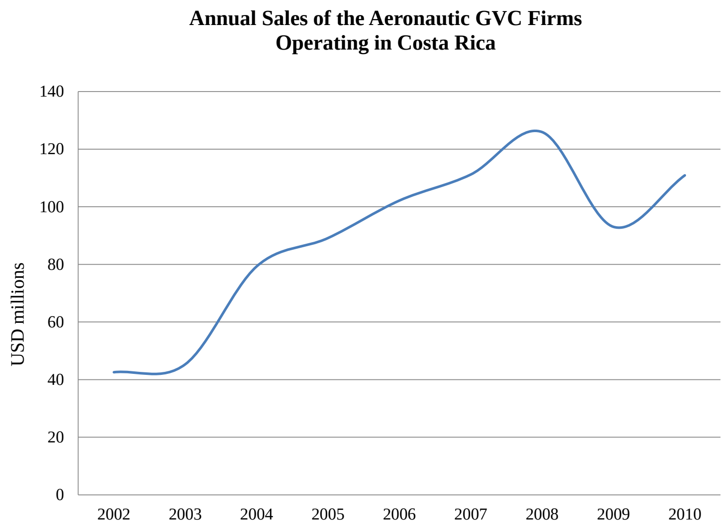


Source: Author's elaboration based on data from PROCOMER (2011).

The total number of people employed by the aeronautic GVC firms operating in Costa Rica more than doubled between 2002 and 2008, rising from 1,168 to 2,480 (Figure 6). The international crisis reduced the aggregate employment of these firms by 20% in 2009, but it went up again in 2010 (6%).

As shown in Figure 7, total sales of the aeronautic GVC firms operating in Costa Rica almost tripled between 2003 and 2005, going from USD 43 million to USD 126 million. The international crisis reduced total sales by 26% in 2009, but they increased 19% in 2010, thus showing a more rapid recovery than total employment. Figures include both merchandise and service sales.

Figure 7



Source: Author's elaboration based on data from PROCOMER (2011).

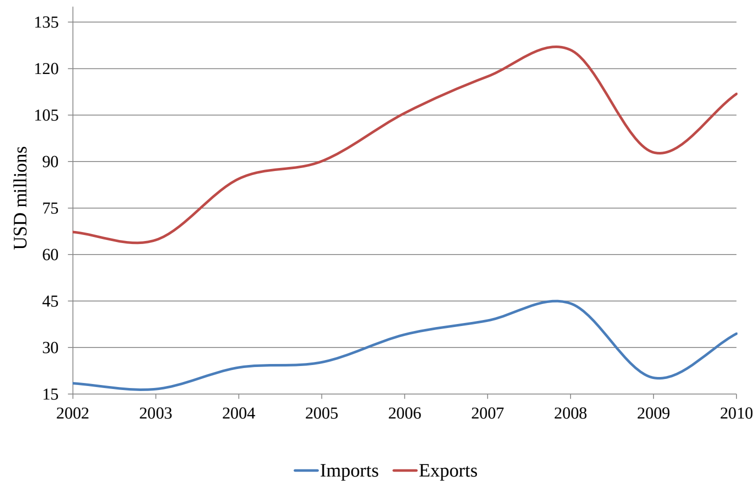
Imports and exports have followed a path similar to that of employment and sales (Figure 8). Imports of raw materials and intermediate inputs doubled between 2002 and 2007, while reaching their peak in 2008 (USD 44 million). Exports, in turn, went from USD 67 million in 2002 to USD 126 million in 2008, for an average geometric annual growth rate of 11%. Although the international crisis hit imports harder than exports (-54% vs. -26%, respectively), the recovery experienced in 2010 favored imports more than exports (+70% vs. +20%, respectively). It is not clear whether the strong reduction in imports of raw materials and intermediate inputs was addressed mostly with inventories or rather through domestic supplies.

The growing gap between exports and imports observed in Figure 8, along with the slightly declining trend of the average within-firm value added (Figure 9), may be taken as an indication of some increasing importance of domestic providers of goods and services for the aeronautic GVC firms operating in Costa Rica. If this is the case, the domestic component (within-firm value added plus purchases of inputs produced domestically) of the exports by the aeronautic GVC firms operating in Costa Rica in 2009 may well exceed the 43% of value added within these firms.[4]

[4] Monge-Ariño (2011) found that the average domestic component of the exports by the aeronautic GVC firms operating in Costa Rica was 72% in 2009.

Figure 8

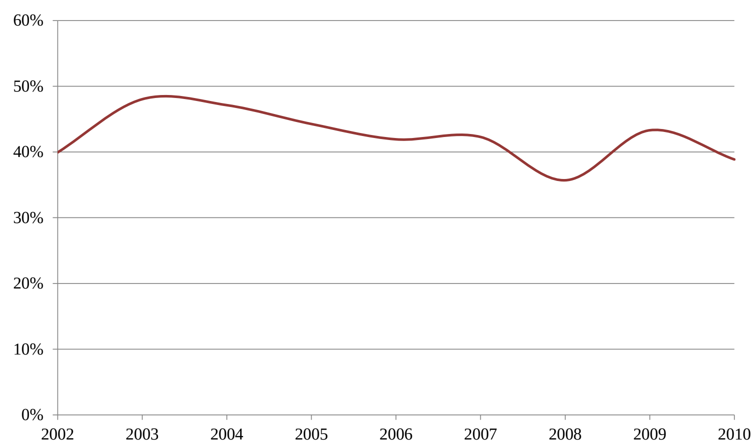
Imports and Exports of the Aeronautic GVC Firms Operating in Costa Rica



Source: Author's elaboration based on data from PROCOMER (2011).

Figure 9

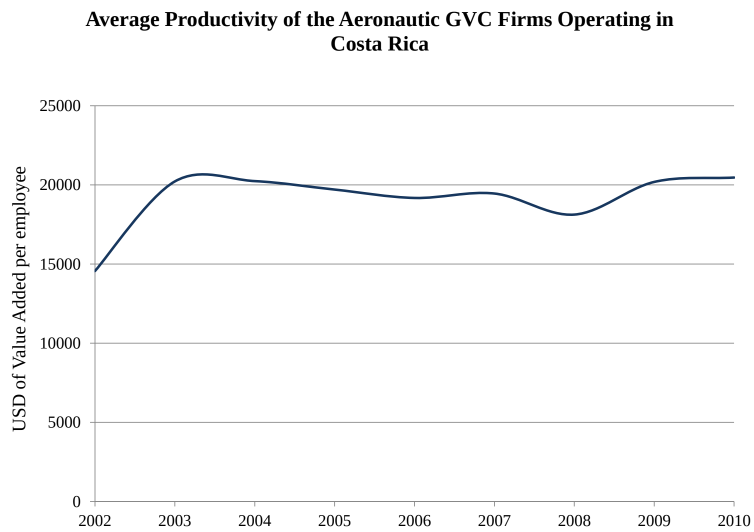
Average Value Added by the Aeronautic GVC Firms Operating in Costa Rica



Source: Author's elaboration based on data from PROCOMER (2011).

For the purposes of this study, productivity was measured as USD of value added per employee. As can be seen in Figure 10, this measure of productivity leap-frogged between 2002 and 2003, shifting from USD 14,500 to over USD 20,000 per employee. Ever since, average productivity has been close to USD 20,000 per employee, with the exception of 2008, probably as a result of the peak in employment.

Figure 10



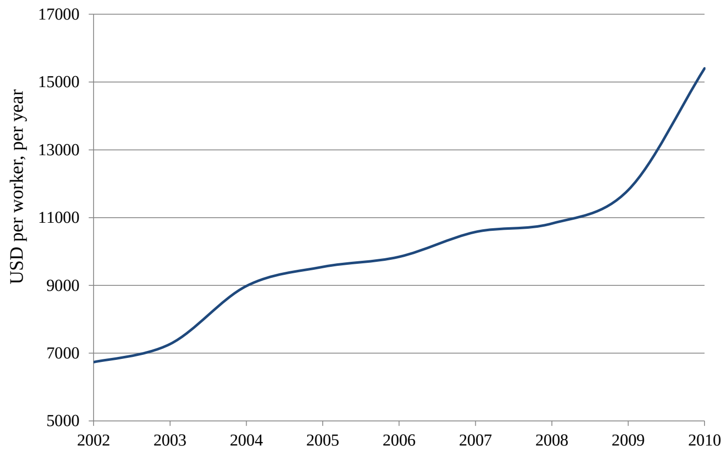
Source: Author's elaboration based on data from PROCOMER (2011).

Finally, the average annual wage per worker has followed a somewhat linear trend of growth between 2002 and 2009, rising from USD 6,700 to USD 11,800, for an average geometric growth rate of 8% per year. Such a pattern contrasts with the sharp increase observed in 2010, when the average wage per year reached USD 15,400, which implies an increase of 31% (Figure 11).

The activity of the firms operating in Costa Rica and integrated in the aeronautic GVC has grown notably over the last eight years as a result of an increase in both the number of firms participating and in the operations of the participating firms. Such a growing level of activity has not been reflected in a significant increase in the average value added within the firms. Nevertheless, this sector has delivered positive results for the Costa Rican economy in terms of growing levels of employment and growing wages, the latter being particularly meaningful in the path to recovery after the last international crisis.

Figure 11

Average Annual Wage Paid by the Aeronautic GVC Firms Operating in Costa Rica



Source: Author's elaboration based on data from PROCOMER (2011).

The expected growth of this industry in the next few years will most likely continue to depend on the efforts made by Costa Rica's investment promotion agency (CINDE) to attract FDI (new and expanding investments of those firms already operating in the country) and on the isolated efforts in NEM. Costa Rica does not have a local airline nor armed forces; therefore, the government does not have budget allocations for defense (it only spends on police forces for domestic security). There is very little chance in the country to carry out offset agreements to divert part of the production of parts and pieces to local suppliers. This type of agreement is becoming a global trend and seems critically important for driving production to some countries to make their participation in the aeronautic global value chain more relevant.

3. Firm and Linkages: Case Studies

a. Avionyx

President and CEO Larry Allgood founded Avionyx Inc. in 1989 to provide on-site embedded software engineering consulting services to a customer's specifications, with a focus on DO-178B[5] software verification. In 1998, Avionyx opened its first engineering facility in Melbourne,

[5] DO-178B, Software Considerations in Airborne Systems and Equipment Certification. The Federal Aviation Administration (FAA) uses document DO-178B for guidance in determining if the software will perform reliably in an aircraft environment.

Florida, to expand its service offering to include project outsourcing. In 2004, Avionyx S.A. opened its engineering facility in San Jose, Costa Rica, and over the next three years all engineering operations were moved to the Costa Rica facility, where all outsourcing is currently done. In 2005, Avionyx S.A. began providing software engineering services compliant with DO-178B standard (Table 6). The primary business function is to provide avionics[6] software engineering development and verification/testing to the aircraft subsystems integrators (Tier 1). Avionics software is embedded software with legally mandated safety and reliability concerns used in avionics.

Embedded software is computer software that integrates systems from third-party electronics components. The main difference between avionic software and conventional embedded software is that the development process is required by law and is optimized for safety. This software can become very sophisticated in applications like aircrafts, missiles, process control systems, and so on. For example, Boeing's new 787 Dreamliner required about 6.5 million lines of software code (MLOC) to operate its avionics and onboard support systems.

Since 1989, Avionyx has completed over one hundred DO-178B projects for virtually every aircraft subsystem, including navigation, weather/traffic/terrain surveillance, communication, flight control, cockpit displays, engine and system monitoring, autopilots, instrument/microwave landing systems, audio panels, boot loaders, data concentrators, and verification of math and graphics libraries.

Table 6
In Which Countries Has Your Organization Sourced Activities?

Business Function	**USA**	**USA**	**Costa Rica**
	1998–2004	**2005 to present**	
Primary business function	**X**		**X**
Research & development	**X**		**X**
Marketing & sales	**X**	**X**	
Customer and after-sales service	**X**	**X**	
Management, administration, and back office	**X**		**X**
Information technology systems	**X**		**X**
Facilities maintenance	**X**		**X**

Source: Avionyx Inc.

Table 7

[6] Avionics is a term derived from "*AVI*ation" and "electr*ONICS"* and is defined as the electromechanical and solid-state components and systems installed in the cockpit and the electronics compartments, which aid pilots in the safe and efficient operation of an aircraft.

Location by Business Function as % of Costs of Services Sold

Business Function	by headquarters	by a foreign affiliate
	DOMESTICALLY	INTERNATIONALLY
Primary business function		100%
Research & development		100%
Marketing & sales	100%	
Customer and after-sales service	100%	
Management, administration, and back office		100%
Information technology systems		100%
Facilities maintenance		100%

Source: Avionyx Inc.

Table 8
Offshoring by Type of Location (as % of Costs of Services Offshored)

Type of location	%
Industrialized countries where costs **ARE ABOUT THE SAME OR HIGHER** than in the United States	0%
Emerging countries where costs **ARE MODERATELY LOWER** than in the United States	100%
Developing countries where costs **ARE MUCH LOWER** than in the United States	0%
TOTAL	**100%**

Source: Avionyx Inc.

Avionyx S.A.

Avionyx S.A. was formed as an independent Costa Rican corporation to support Avionyx Inc.'s customers in the avionics industry that needed low-cost software engineering outsourcing services (Table 7). The main drivers to open operations in Costa Rica were relative low cost (Table 8), geographical proximity to the United States, economic and political stability, attractive tax incentive package (EPZ), fast shipping, good educational system, English-speaking engineering candidate pool, and cultural similarities with the United States (as compared to India). Argentina and Chile were the countries competing with Costa Rica at the time the decision was made. At the time, EPZ incentives were granted in six months. Now, that procedure does not take more than two months.

Larry Allgood (pers. comm.) explained:

Our competition is primarily in India (HCL Tech, Infosys), but also in other countries (Core Tek Systems in China, and others in Israel and Mexico), most of which are very far from the United States, so our inherent advantages are distance and time-zone differences. Employee turnover is better in Costa Rica, and cultural differences and communication problems are less of an issue in Costa Rica than in India. Shipping time is also less in Costa Rica than in India.

The reasons why customers prefer Avionyx over suppliers in India and other countries are diverse. We could list the following:

Similar or even lower costs than in other countries. Although hourly wages are usually lower in other countries, the volume is much higher (low efficiency).

Quality. Avionyx deliverables are high quality; little or no correction/improvement is required (quality control carried out by Avionyx and the customer).

Less need for supervision. India suppliers require constant supervision and control. Avionyx, in contrast, is very independent and develops its own working method (technological development).

Logistics. The time zone in Costa Rica is UTC-6 (U.S. Central Time), which is very convenient for communication purposes. At the same time, geographic proximity facilitates traveling and shipping of equipment to the place where the embedded software that was developed is tested.

Cultural proximity. The cultural barrier between Costa Rica and the United States is much lower than in other countries; this helps to improve and manage the customers' expectations.

Table 9
 # Employees and Wages by Business Function (Affiliate)

Business Function	**# employees**	**% less than USD 40,000**	**% USD 40,000 to less than USD 60,000**	**Total**
Primary business function	31	94%	6%	**100%**
Research & development	2	100%		**100%**
Management, administration, and back office	3	33%	67%	**100%**
Information technology systems	1	100%		**100%**

Facilities maintenance	1	100%		**100%**
TOTAL	**38**			

Source: Avionyx S.A. (Costa Rica).

Costa Rica's appeal for Avionyx operation is the availability of relatively low-cost engineers who speak the required language (Table 9 shows the number of employees and wages by business function). Entry-level monthly wages for computing and/or electronic engineers are USD 2,000 to USD 2,500 in Costa Rica, 40% less than in the United States. This difference in wages makes labor arbitrage possible. Besides, U.S. clients prefer Costa Rican assistance because they have less trouble understanding a moderate Spanish accent than they do the most polished English spoken in India. However, wage pressure for highly qualified bilingual staff started to develop in Costa Rica as an increasing number of companies followed Procter & Gamble, Sykes, Hewlett Packard, Intel, Oracle, Fiserv, and Western Union, and established centers to provide information, advice, technical support, and testing, or to develop software in the country.

Avionyx S.A. has not grown much since 2005 (from sixteen employees then to thirty-eight today). It is still a small company. The company's top executive argued that the labor costs in Costa Rica have risen considerably over the past seven years, and competition for engineering talent has limited their ability to grow—thus the need to find a partner in Mexico, where they have already established a relationship with a similar company to support overflow needs. Close to 90% of Avionyx S.A.'s headcount are electronic and computing engineers (Table 10).

Table 10
Employee Profiles (Affiliate)

Employee Profile	**# employees**	**% employees**	**Profile Description**
Electronic Engineer	10	26%	Works on a project through all its stages: from the initial brief for a concept to the design and development stage; to the testing of one or more prototypes; to the final manufacture and implementation of a new product or system.
Computing Engineer	24	63%	Develops and maintains computer embedded software programs.
Subtotal Engineers	**34**	**89%**	
Site manager	1	3%	Manages Costa Rican site.

IT engineer	1	3%	Maintains technology platform.
Accountant/admin/ HR	2	5%	Compiles, analyzes, and prepares financial records. Performs administrative tasks.
TOTAL	**38**	**100%**	

Note: All of the electronic and computing engineers are graduates of only two of fifty-nine universities in Costa Rica.

Source: Avionyx S.A. (Costa Rica).

Revenues and Market

Avionyx Inc. has offered outsourcing services in the U.S. market to customers in the avionics industry for the last twenty years. If customers needed "on-site" embedded software engineering services, Avionyx Inc. offered its services from Melbourne, Florida. Since 2005, it has offered, to almost the same customer base, a low-cost outsourced, offshored embedded software engineering service performed by Avionyx S.A. in Costa Rica. The ICT revolution lowered the cost of coordinating complex activities at a distance, and this made the geographical dispersion of supply chains feasible and profitable (Baldwin 2011). Technology and cost pressure helped Avionyx Inc. to change from where it delivers the service, not what it delivers. At the same time, greater competition improves how the service is delivered.

Larry Allgood, who has direct contact with customers in the United States, negotiates and signs contracts for given projects. Every contract specifies detailed conditions, milestones, deadlines, and price. Usually, no advance payment is required. Customers pay an installment of the agreed price when a milestone has been reached. Intellectual Property Rights (IPR) belong to the subsystem integrator (Tier 1), the customer. Avionyx agrees, as part of the signed contract, to develop and deliver the embedded software, the testing results, and the source code to the customer. However, new programing or testing techniques developed by Avionyx for a given project might be used in other projects; "knowledge spillover" takes place, which helps to improve quality and efficiency.

Since most avionics manufacturers see software as a way to add value without adding weight, the importance of embedded software in avionic systems is increasing. Ever since Avionyx started operations in Costa Rica, their revenues have multiplied sixfold. This represents a compound annual growth rate (CAGR) of 37.8% for the period spanning 2005–2010. The global embedded market size was estimated at USD 40 billion in 2009, growing to nearly USD 46 billion in 2010 (15% in one year).The software engineering labor expenditure represents more than 90% of both years. Automotive, consumer electronics, and mobile phones segments are growing faster. The estimated number of embedded engineers was 820,000 in 2009, which grew to 880,000 in 2010 (annual growth of 7%) (Balacco 2011).

Avionyx S.A. participates in both the aircraft industry and the software sectors. The aeronautic sector in Costa Rica is still an emerging activity. We identified fifteen companies (see Table 6) that operate in Costa Rica and are integrated in the GVC. They exported USD 22 million value merchandise in 2009 (USD 14.5 million in 2010), 34% of which was sold to the United States. The most important products were machined parts, printed circuit boards, thermostats, metal coatings for aircraft parts, aircraft wiring harness, lasers for aircrafts, and circuit protection gas tubes.

Exports by companies providing services to the aeronautic industry from Costa Rica increased from USD 71 million in 2009 to USD 97.5 million in 2010 (37% increase). The most notable services exported from Costa Rica are related to aircraft engine design, development of embedded software for avionics, aircraft motherboards repair, and maintenance for helicopters and aircraft engines. The latter service is provided to the two main Central American airlines, TACA and COPA, among others, by a company located near the San Jose International Airport.

The software sector in Costa Rica is a little bit more developed. There are 255 software companies operating in the country; they exported USD 217 million in 2010. Most of those companies are local (Monge-González and Hewitt 2010). However, foreign software companies in EPZ are the biggest exporters. They represented 66% of total software exports.[7] The lack of evolution of local companies toward exporting might be explained by what Lopez, Kundu, and Ciravegna (2009) found: Most Costa Rican software companies internationalized gradually, and did not export immediately upon start-up.

Exhibit 2 shows that Avionyx, Ridge Run, and Via Information Tools are the only embedded software companies working in Costa Rica. Apparently, software testing services are offered by Avionyx and Prosoft Nearshore. Recently, HP Networking (two hundred employees), Intel's Engineering Center (one hundred employees), and Teradyne (twenty employees) are offering embedded software services from their own captive site in Costa Rica, but they do not offer such software service to third parties. These well-known companies compete with Avionyx for the same limited pool of English-speaking engineers.

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[7] Costa Rica Central Bank reported that software exports were USD 217 million in 2010. USD 145 million came from EPZ software companies.

Future

Avionyx expects to continue its operations in Costa Rica providing engineering services that can compete in the global marketplace. The CEO said they are not planning to open more operations in other countries. About the future, Larry Allgood (pers. comm.) says:

> The activities we currently perform are already very sophisticated. However, there are a number of opportunities for us to automate activities to help us improve our efficiency and overcome the labor cost inflation we are dealing with. We have been investing each year in research and development in identifying these automation opportunities and developing tools to implement them, but it is very time consuming and expensive. There are also some commercial off-the-shelf tools that we could purchase in some cases, but they are also very expensive and, without assistance from the government, we will not be able to buy them in the near future.

The limited pool of English-speaking engineers and high level of competition is Avionyx's major roadblock.

Avionyx's competitive advantage was summarized by Larry Allgood (pers. comm.):

> We invest heavily in automation, training, and process improvement, all of which help to improve quality and efficiency, which, of course, reduces our overall operating costs and makes us more competitive. Our low employee turnover (less than 5% per year) also helps us to leverage our experience from previous projects, which is important to do in a knowledge-based industry such as ours to minimize training overhead costs.

Industry analysts forecast that global avionics manufacturers have to rely on newer technologies for growth opportunities until aircraft production starts to recover in the general aviation market. They will also be heartened by the overall rise in the age of fleets across the world. Older aircraft could need significant hardware changes to comply with the 2020 U.S. implementation date of the Automatic Dependent Surveillance-Broadcast (ADS-B) and the related Required Navigation Performance programs. As the air transport market is likely to experience less contraction and a quicker recovery, manufacturers in that market space will be well positioned for growth after five years. Manufacturers that develop newer technology systems are likely to find novel applications that traditional suppliers cannot. This is clearly an opportunity for Avionyx and Costa Rica.

b. Camtronics

Camtronics is an electronic manufacturing supplier (EMS) that makes products to the customer's specifications using its own technology and procedures, which spreads to a wide customer base. It is a fully Costa Rican company founded in 1985 by an American entrepreneur who later sold the company to its present owner, Enrique Ortiz, in 1993. Mr. Ortiz began to work in Camtronics as general manager in 1990, three years before acquiring the company. Camtronics is in itself the headquarters, and it does not have branches in other countries. The main drivers to start operations in Costa Rica were relative low cost, geographical proximity to the United States (the market where 95% of total sales originate), economic and political stability, attractive tax incentive package (EPZ), easy shipping and logistics, and cultural similarities with the United States. The granting of EPZ took about six months. Interestingly, it took Avionyx a similar amount of time to get it several years later.

At first, the company began working in the production of electronic parts of commercial products (that is to say, of massive public consumption). For example, parts or components for Polaroid cameras, remote controls for television, electronic cards, etc. When he joined the company in 1990, Mr. Ortiz decided to explore new products and sectors, this time thinking about industrial products (components for industrial products) and phasing out commercial product components. Thus, the opportunities in the field of cables or harnesses appeared, specifically for products of the telecommunications sector and medical products. In the former case, the customers were companies that make products for the U.S. telecommunications industry, while in the latter, Camtronics first client was a medical company operating under the Export Processing Zone in Costa Rica (in the same industrial park where Camtronics is located). Since the year 2000, Camtronics no longer produces components for commercial products and specializes in the production of components (electronic manufacturing) for industrial products.

The main reasons to shift the production line from commercial to industrial products were profitability and stability. While commercial products are characterized by high volume, fast delivery, low profit margin, and fast death of the product, industrial products, like medical devices, are characterized by low volume, high quality, and relatively larger profit margins.

According to data from 2001 to 2010, the most important products made by Camtronics are: assembled electronic cards, assembled mechanisms for medical use,[8] connectors, assembled wire or wired harnesses,[9] electrodes, and mini-transformers.[10] These products go to U.S. companies in aircraft, medical, telecommunications, and other industrial sectors. Camtronics' strategy is to focus on U.S. companies that seek high quality at a relatively lower cost. This allows Camtronics to operate with a high mixture of products, reducing idle capacity and combining mechanized and semi-mechanized operations with manual assembly processes. In some cases, Camtronics even makes recommendations to clients on improving process engineering. Camtronics does not design products and, therefore, does not have patents. In essence, the company competes internationally in market niches where efficiency is the key to succeed within the first tier of some value chains.

Getting new customers is likely Camtronics' major roadblock. Enrique Ortiz is based in Costa Rica but travels to the United States constantly to negotiate future contracts. CINDE has asked him on several occasions to show his plant to foreign investors to demonstrate Costa Rica's capacities for contract manufacturing services (non-equity mode to enter a new market). This is how Hologic (formerly Cytyc) started operations in the country. Hologic assembled NovaSure (medical devices for women's health) in Camtronics' clean room for a few years before opening its own plant in Costa Rica. Unfortunately for Camtronics, this situation is not common, so it would be better to have more presence in the target market. More initiative from the company itself, clear plans for expansion, and the government's support are required for non-equity mode (NEM) to allow an increase in Costa Rica's participation in the GVC.

In 2003 Camtronics served its first client from the aeronautic GVC. CINDE took Smiths Aerospace (later acquired by GE Aviation) to see Camtronics' plant in Cartago, and the first

[8] Camtronics currently makes a machine for a company in the United States that then sells this machine to hospitals for monitoring oxygen in patients' blood. Camtronics produces all the components and assembles the machine, but the machine design is given by the client.
[9] For Tier 1 suppliers of aeronautic industry in the U.S. market.
[10] Based on Camtronics annual reports presented to PROCOMER (2011).

commercial agreement, which still prevails, was made right there. Lowering direct costs and diversifying their supplier base were Smiths Aerospace's main reasons for hiring Camtronics.

Camtronics' customer base increases only through word of mouth, via references from satisfied customers. There is no exploration of target markets, which might explain why their sales growth has remained low for the last ten years.

Camtronics currently has eighty-nine workers: three industrial engineers, one electrical engineer, one technician in electronics, and eighty-four plant workers. Of these eighty-four workers, fourteen are involved in administrative activities, and the other seventy in semi-mechanized and manual tasks. In short, Camtronics is an unskilled labor–intensive business.

Most employees work in the primary business function (Table 11), followed by those working in the administration and back office. Only one person works mainly in R&D activities, suggesting improvements in process engineering for clients. Finally, only two people work in marketing and sales, one of them being the owner/manager of the company.

Table 11
Employment by Business Function

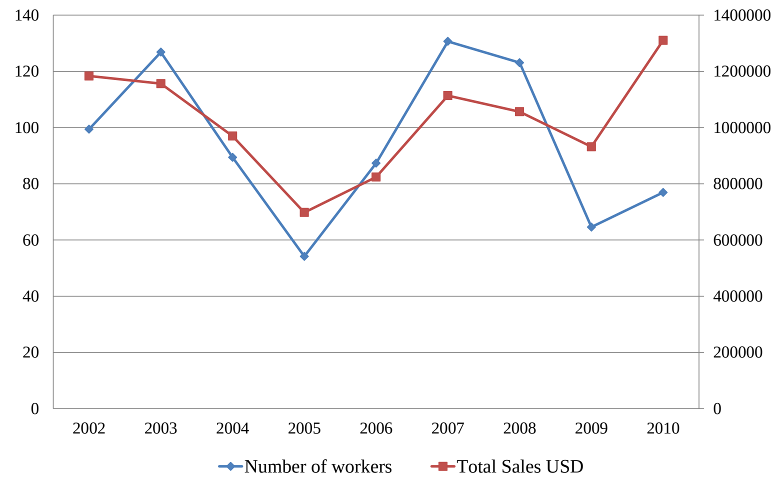
Business functions	**# employees**	**% employees**
Primary business function	71	80%
Research & development	1	1%
Marketing & sales	2	2%
Transportation, logistics, and distribution	2	2%
Customer and after sales service	1	1%
Management, administration, and back office	8	9%
Facilities maintenance	4	5%
TOTAL	**89**	**100%**

Source: Camtronics.

Camtronics is highly unskilled labor–intensive and highly dependent on the economic performance of the U.S. market. Figure 12 shows the evolution of the company's performance during the last decade. Camtronics shows fluctuation, not only of its annual sales (in USD), but also of its total number of employees. This shows Camtronics' ability to adapt its headcount to changes in the market demand. Its recent history shows two contraction periods, one in 2004 and 2005, and the other one in 2009, which is directly related to the most recent international crisis.

Figure 12

Total Annual Sales and Number of Workers



Source: Camtronics.

Total sales in 2010 were a little higher than in 2002, showing that it has been difficult to grow and consolidate itself as an EMS. It might be evidence of relying heavily on one single market, lack of proactive action to get more clients, and little diversification toward counter-cyclical products.

Due to the profile of the workers of this company, it is not surprising that their wage levels are relatively low (Table 12), with only one employee earning between USD 40,000 and USD 60,000 per year.

Table 12
Wages by Business Function

Business functions	**# employees**	**% less than USD 40,000**	**% USD 40,000 to less than USD 60,000**	**Total**
Primary business function	71	100%		100%
Research & development	1	100%		100%
Marketing & sales	2	50%	50%	100%
Transportation, logistics, and distribution	2	100%		100%
Customer and after sales service	1	100%		100%
Management, administration, and back office	8	100%		100%
Facilities maintenance	4	100%		100%
TOTAL	**89**			

Source: Camtronics.

Most business functions are carried out in Costa Rica by the company itself, except for transport, logistics, and distribution functions that are subcontracted mainly to independent companies in Costa Rica. Maintenance of the information technology system is also outsourced. International outsourcing is mainly carried out in the field of equipment maintenance, where specialized services of certified engineers from American companies are required. Airfare and accommodations are also outsourced (Table 13).

Table 13
Location by Business Function as % of Costs of Services Sold

Business functions	**by your organization**	**by an independent supplier or suppliers**	**by an independent supplier or suppliers**	**Total**
	DOMESTICALLY	**DOMESTICALLY**	**INTERNATIONALLY**	
Primary business function	58%	27%	15%	100%
Research & development	100%			100%
Marketing & sales	79%		21%	100%
Transportation, logistics, and distribution	20%	80%		100%
Customer and after sales service	100%			100%
Management, administration, and back office	100%			100%
Information technology systems		100%		100%
Facilities maintenance	30%		70%	100%

Source: Camtronics.

Table 14 shows that the core business is delivered from Costa Rica. There is no other subsidiary or affiliate outside of the country.

Table 14
Offshoring by Type of Location (as % of Costs of Services Offshored)

Type of location	**%**
Industrialized countries where costs **ARE ABOUT THE SAME OR HIGHER** than the United States	100%
Emerging countries where costs **ARE MODERATELY LOWER** than the United States	0%
Developing countries where costs **ARE MUCH LOWER** than the United States	0%
TOTAL	**100%**

Source: Camtronics.

Finally, based on previous results, it seems that Camtronics does not show significant vertical or horizontal integration with companies abroad, but only with a few Costa Rican companies in areas of basic services (see Table 15).

Table 15

In Which Countries Has Your Organization Sourced Activities?

Business functions	USA	Costa Rica
Primary business function		100%
Marketing & sales	100%	
Transportation, logistics, and distribution		100%
Customer and after sales service		100%
Management, administration, and back office		100%
Facilities maintenance		100%

Source: Camtronics.

Camtronics' experience helps us understand how difficult it is to integrate in the global value chains as a local electronic manufacturing supplier (EMS) with little commercial presence in target markets. It also shows that for EMSs to increase their participation in the GVC, the appeal of being close to the market is not enough.

Besides, Camtronics' CEO (Ortiz, pers. comm.) explains that in order to grow, they require more flexible and longer-term credit lines as well as larger loans from local banks. Tier 1 suppliers are increasingly demanding and require their EMSs to finance all the raw materials and inventory in a given contract. Today, almost 60% of Camtronics clients finance their raw materials to guarantee better prices on high volume. The remaining 40% forces Camtronics to increase its working capital.

4. Summary of Policy Implications

Both firms in this study belong to the Tier 2 supplier link in the aeronautic GVC. They are both serving Tier 1 subsystems integrators from Costa Rica (see Table 4 and Figure 1). The relationship of these two companies to their Tier 1 customers highly resembles that of a modular chain, as expected.[11] The main clients of both companies in this case study started developing everything at home. Then, they outsourced some of the activities in their productive processes, and finally offshored them, thus lowering their costs even more. Despite the similarities between

[11] Suppliers in modular value chains make products or provide services to a customer's specifications. Suppliers in modular value chains tend to take full responsibility for process technology and often use generic machinery that spreads investments across a wide customer base.

Avionyx and Camtronics, their participation in the GVC is different. Most of Camtronics' headcount is unskilled workers, which are not scarce in the country, whereas at Avionyx, the employees are engineers who are fiercely sought after by other software companies. A different organizational structure implies a demand for different profiles of employees. This difference must be considered by the policymakers.

It must be taken into account that Avionyx is the company that has trouble finding bilingual engineers to meet the increase in demand, whereas Camtronics does not have this problem. Camtronics suffers from potential lack of demand to cover idle capacity in its assembly process of parts and pieces for the aeronautic industry. This difference also affects the type of public policy to be recommended.

For Avionyx, being close to their customers (same time zone and three hours away by plane) gives them a competitive advantage over their competitors in India. For Camtronics, this advantage does not seem to be enough to consolidate its operations in Costa Rica. Neither company explicitly stated that having preferential access to the markets (via FTA and ITA) was an advantage for Costa Rica. A possible explanation is that Avionyx exports services, so these agreements are less important; and Camtronics already exported to the United States with preferential access before CAFTA (through the Caribbean Basin Initiative). This becomes relevant when trying to understand which public policy deserves priority. Obviously, having an FTA network is important to increase Costa Rica's participation in the GVC; therefore, this network is expected to be strengthened by including new agreements with emerging markets.

The activities that Avionyx develops today are very sophisticated. However, there is always room to improve efficiency and to control the development costs of embedded software via new automated processes. For Camtronics, increasing productivity and reducing costs helps them improve their technology and processes. They deliver the level of sophistication that their clients demand. Also, it is clear that if direct incentives for innovation existed, beyond the self-motivation to compete for new clients, the level of sophistication of the activities carried out by these companies in Costa Rica would very likely increase.

Multinational companies like Avionyx and Camtronics are encouraged by CINDE, the Costa Rican Investment Promotion Agency, to start up operations under the Export Processing Zones (EPZ). This regime is the mainstay of Costa Rica's export and investment promotion strategy. The EPZ is a set of tax incentives and benefits granted by the Costa Rican government to companies making new investments in the country, as stated in EPZ Act #7210, Act #8794, and in its Bylaws (CINDE 2010).

The main incentives granted to EPZ companies are: full exemption from income tax, full exemption from import tariffs (intermediate and capital goods, raw materials, and other inputs), and full exemption from local taxes (sales, value added, municipal, and royalties). A full history of how EPZ has evolved since the mid1980s can be found in Monge-González, Rivera, and Rosales-Tijerino (2010). Act #8794 came into force in January 2010. This amendment is only relevant for manufacturing projects (it does not apply to services or agriculture-related projects). Basically, Act #8794 eliminates export performance as a requisite to grant EPZ, as the WTO requires members to do before the end of 2015.

In the amendment approved in 2010, it is stated that companies that spend at least 0.5% of the Costa Rica subsidiary's sales in R&D could have access to all EPZ incentives. However, both companies studied agree that these incentives are important for their operation in Costa Rica, but that they are not enough to move from efficiency-driven activities to innovation-driven ones.

Most firms in Tier 2 are focused on efficiency-driven activities rather than innovation-driven activities. This means that specific policies to strengthen the competitiveness of firms should be applied. In particular, policies that increase and consolidate the availability of highly skilled and easily trainable workers, and policies that make access to local financial systems easier, would provide strong support for the efficiency on which the competitive advantage of these firms rests. Besides, all policies aimed at improving the business climate would certainly help to enhance the productive efficiency of these firms vis-à-vis the efficiency that they could achieve in other countries.

The main challenge for policymakers will be to identify and implement policies that can effectively create conditions for firms (some of the ones currently operating in Costa Rica and many others that may arrive in the country in the future) to engage in innovation-driven activities, thus increasing Costa Rica's exports participation in Tier 2 of the GVC. Economic upgrading can be sustained continuously by creating highly skilled jobs, producing world-class exports, and fueling high industry growth, all of which are outcomes of an innovation-driven economy.

Building a supply chain is not the same as joining it. In the latter, industrialization is easier and faster, but is less meaningful. It became faster and easier because the supply chain makes industry less bumpy and more interconnected domestically; it became less meaningful for the same reasons. It is important to note that exporting sophisticated manufactured goods is no longer the hallmark of having arrived. It may simply reflect a country's position in a global value chain (Baldwin 2011).

Costa Rica has been successful in attracting software and IT-enabled international companies in the last decade. Today, there are more than one hundred of them, generating around forty thousand jobs. Of these, 95% of jobs are held by locals, with wages 60% higher than the national average. The greatest appeal is the availability of qualified bilingual human capital. However, the more sophisticated the service, the higher the need for computer and electronic engineers. A skills shortage[12] exists in technology areas (INCAE 2012). Costa Rica should move toward a demand-driven educational system to guarantee the appropriate supply of human resources needed in the high technology sector. Still, this might not be enough.

The government must create, together with the private sector and educational institutions, strategies or programs to improve math skills in primary and secondary education, vocational orientation programs toward math and science, scholarship programs for outstanding high school students to study engineering and other programs of high demand, and graduate scholarship programs in key areas.

Avionyx brings yet another problem to the table. All the engineers they hire come from two of the largest and most prestigious public universities in the country—Universidad de Costa Rica (UCR) and Instituto Tecnológico de Costa Rica (TEC)—despite the fact that the number of computer engineers that graduate from private universities is larger than the sum of these two public universities. Private university graduates usually do not pass the recruitment test used by Avionyx to determine the knowledge and quality of the candidate, which demonstrates a skills gap.[13] The quality of private universities' IT engineering programs must be adjusted and improved.

[12] Skills shortage: A skill shortage exists when the demand for workers for a particular occupation is greater than the supply of workers who are qualified, available, and willing to work under existing market conditions (Shah and Burke 2003).

[13] Skills gap: Occurs when existing staff do not have the skills for the required positions (Shah and Burke 2003).

High technology companies such as Avionyx are knowledge intensive. If the new knowledge cannot be seized by these companies, who made the investment, there will be a tendency to underinvest in R&D because the innovation benefits will not reflect the cost of production. The government must strive to mitigate this market failure through direct incentives for innovation besides the EPZ incentives.

Costa Rican software firms do not often have relationships with industry associations or chambers, the national government's trade promotion agency, or government ministries. When those relationships exist, they are concentrated in the areas of training, information, organizational change consulting, and, to a lesser degree, technical assistance (Monge-González, and Hewitt 2010). Neither Avionyx nor Camtronics belong to any industrial chamber. They only have a close relationship with CINDE, the private investment promotion agency. CINDE provides support to solve problems or carry out processes before local public institutions. One way to introduce their problems in the political agenda is for companies to become active members of industry associations. Governments must promote these relationships in order to find solutions to problems that affect collective interests, not just one company's problem.

Local SMEs have little support from the financial system in Costa Rica. State banks dominate the market with more than 50% of assets, but they act as commercial banks. There is virtually no development banking, except in the case of Banco Nacional, which has a successful program for SMEs in BN Desarrollo (Monge-González 2009). Although there is a program to promote innovation (Propyme), its performance has not been outstanding (Monge-González and Hewitt 2010). Besides, no seed capital is in place for new start-ups.[14] All of this makes it more difficult to have productive backward linkages or to become direct suppliers of plants located in the United States because they cannot finance technology changes, not even the necessary certifications to face quality and price demands to be part of any GVC from Costa Rica. In all these three areas, there is an important agenda to work on.

Unfortunately, these two case studies do not let us see clearly what else Costa Rica needs to be attractive for NME (non-equity mode to enter a new market). However, during meetings with CINDE, a few of the largest EMS players have expressed that since important distributors of electronic parts and pieces (such as Arrow and Avnet) are not in Costa Rica, they would have

[14] The Government of Costa Rica is developing the first seed capital for start-ups, which is expected to begin operations during the first semester of 2013.

to import everything, adding logistical problems to their everyday operations. Besides, many local suppliers are not certified and do not have experience handling large volumes. Perhaps that is why CINDE has targeted its efforts toward greenfield operations, so that these new companies can put pressure on their suppliers to set up operations in the country, thus creating an agglomeration effect. In turn, the government could promote the creation of a local supplier cluster in the aeronautic sector by providing funding for certifications, purchase of new technology, training, and promotion of the services to be offered from the country.

Costa Rica's appeal to FDI is based on talented human capital availability, strategic location, and preferential access to markets (FTA network). Another attractive feature is the legal certainty provided by the fact that EPZ incentives are granted by law and not at the discretion of the government on duty. Nevertheless, there is still much to improve. Policymakers must be willing to introduce amendments to allow reductions in public utility service rates, number of procedures, and response time of public institutions.

Multinational companies are likely to continue to come, seeking not only efficiency, but also innovation, and thus allowing for Costa Rica's participation in GVC to get deeper and broader. Clearly, Costa Rica must make a qualitative leap in its GVC participation and try to follow the steps taken by countries like Korea, whose exports of domestically designed car engines contributed to its developed-nation status (Baldwin 2011).

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Exhibit 1
100 Top Global Aeronautic Companies

Rank 2010 (2009)		Company / Division	Country	Aero Sales (USD millions) 2010	2009	Growth*	Total sales (USD millions) 2010	Operating result (USD millions) 2010	2009
1	**(1)**	**Boeing**	**USA**	**64,306**	**68,281**	**-5.8%**	**64,306**	**4,971**	**2,096**
		Commercial airplanes					31,834	3,006	-583
		Boeing Defense, Space & Security					31,943	2,875	3,299
		Boeing Military Aircraft					14,238	1,258	1,528
		Network and Space Systems					9,455	711	839
		Global Services Support					8,250	906	932
		Boeing Capital Corp/other/accounting differences					529	-910	-620
2	**(2)**	**EADS**	**Netherlands**	**60,608**	**59,544**	**6.8%**	**60,608**	**1,572**	**-528**
		Airbus Commercial					36,659	350	505
		Airbus Military					3,556	25	-2,442
		Eurocopter					6,398	241	364
		Cassidian					7,860	596	608
		Astrium					6,628	370	357
		Other business (and HQ)					1,604	-9	79
3	**(3)**	**Lockheed Martin**	**USA**	**45,803**	**43,995**	**4.1%**	**45,803**	**4,097**	**4,415**
		Aircraft					13,235	1,502	1,577
		Electronic systems					14,363	1,712	1,660
		IS&GS (Information Systems & Global Services)					9,959	890	895
		Space systems					8,246	972	972
4	**(4)**	**General Dynamics**	**USA**	**32,466**	**31,981**	**1.5%**	**32,466**	**3,945**	**3,675**
		Aerospace					5,299	860	707
		Combat systems					8,878	1,275	1,262

Rank 2010 (2009)		Company / Division	Country	Aero Sales (USD millions)			Total sales (USD millions)	Operating result (USD millions)	
				2010	2009	Growth*	2010	2010	2009
		Marine systems					6,677	674	642
		Information systems and technology					11,612	1,219	1,151
		Corporate						-83	-87
5	**(5)**	**Northrop Grumman**	**USA**	**28,038**	**27,542**	**1.8%**	**34,757**	**3,070**	**2,483**
		Aerospace systems					10,910	1,256	1,071
		Electronic systems					7,613	1,023	969
		Information systems					8,395	756	624
		Shipbuilding					6,719	325	299
		Technical services					3,230	206	161
		Intersegment eliminations					-2,110	-240	-195
6	**(7)**	**United Technologies**	**USA**	**25,227**	**24,239**	**4.1%**	**54,326**	**7,186**	**6,377**
		Engines (Pratt & Whitney)					12,935	1,987	1,835
		Flight systems (Sikorsky, Hamilton Sundstrand)					12,292	1,634	1,465
7	**(6)**	**Raytheon**	**USA**	**25,183**	**24,881**	**1.2%**	**25,183**	**2,607**	**3,042**
		Integrated Defense Systems					5,470	879	859
		Intelligence and Information Systems					2,757	-150	259
		Missile Systems					5,732	654	604
		Network Centric Systems					4,918	701	674
		Space and Airborne Systems					4,830	686	647
		Technical Services					3,472	300	215
		Corporate and eliminations					-1,996	-463	-216
8	**(8)**	**BAE Systems**	**UK**	**23,651**	**21,348**	**11.9%**	**32,580**	**2,324**	**1,215**
		Electronics, intelligence, and support					8,529	981	1,157
		Land & armaments					8,929	460	-688
		Programs and support					9,729	598	1,022

Rank 2010 (2009)		Company / Division	Country	Aero Sales (USD millions)			Total sales (USD millions)	Operating result (USD millions)	
				2010	2009	Growth*	2010	2010	2009
		International business					5,105	689	633
		HQ and other businesses					287	-130	-546
9	**(9)**	**Finmeccanica**	**Italy**	**20,831**	**20,778**	**5.2%**	**24,766**	**1,632**	**1,936**
		Aircraft					3,721	189	334
		Space					1,225	49	60
		Helicopters					4,827	502	506
		Defense and security electronics					9,454	750	855
		Defense systems					1,603	136	172
		Energy					1,872	152	197
		Transportation					2,599	54	-13
		Other activities					322	-201	-177
		Eliminations					-858		
10	**(10)**	**General Electric**	**USA**	**15,680**	**15,615**	**0.4%**	**150,211**	**16,247**	**15,160**
11	**(11)**	**L-3 Communications**	**USA**	**15,680**	**15,615**	**0.4%**	**15,680**	**1,750**	**1,656**
		C3 and ISR					3,399	395	344
		Government services					3,963	344	394
		Aircraft modernization and maintenance					2,781	229	243
		Electronic systems					5,537	782	675
12	**(15)**	**Thales**	**France**	**13,190**	**13,589**	**1.9%**	**17,387**	**-229**	**72**
		Aerospace/transport					7,338	-293	-146
		Defense and security					9,955	204	457
		Other, elim. and non alloc.					94	-32	-102
		PPA						-109	-138
13	**(12)**	**Safran**	**France**	**12,821**	**13,211**	**1.9%**	**14,254**	**1,146**	**965**
		Aerospace propulsion					7,424	878	914
		Aircraft equipment					3,754	166	3

Rank 2010 (2009)		Company	Country	Aero Sales (USD millions)			Total sales (USD millions)	Operating result (USD millions)	
		Division		2010	2009	Growth*	2010	2010	2009
		Defense					1,643	73	13
		Security					1,379	164	120
		Holding					54	-135	-83
14	**(14)**	**Rolls-Royce**	**UK**	**10,875**	**10,124**	**8.5%**	**17,119**	**1,745**	**1,828**
		Civil aerospace					7,596	605	769
		Defense aerospace					3,279	477	395
15	**(13)**	**Honeywell**	**USA**	**10,683**	**10,763**	**-0.7%**	**33,370**	**4,616**	**4,097**
		Aerospace					10,683	1,835	1,893
16	**(16)**	**Bombardier**	**Canada**	**8,614**	**9,357**	**-7.9%**	**17,712**	**1,050**	**1,098**
		Aerospace					8,614	448	473
17	**(17)**	**Textron**	**USA**	**7,783**	**8,061**	**-3.4%**	**10,525**	**416**	**311**
		Bell					3,241	427	304
		Cessna					2,563	-29	198
		Textron Systems					1,979	230	240
18	**(18)**	**Goodrich**	**USA**	**6,967**	**6,686**	**4.2%**	**6,967**	**998**	**929**
		Actuation and landing systems					2,492	273	267
		Nacelles and interior systems					2,340	556	515
		Electronic systems					2,136	325	276
		Corporate expenses						-156	-129
19	**(18)**	**ITT Corporation**	**USA**	**6,228**	**6,355**	**-2.0%**	**17,619**	**3,304**	**3,923**
		Technology infrastructure—aviation					10,995	900	894
		Fluid technology					3,670	479	393
		Defense electronics and services					5,897	752	761
		Motion and flow control					1,441	179	118
		Eliminations					-13	-510	-378
20	**(23)**	**Dassault Aviation**	**France**	**5,547**	**4,757**	**22.4%**	**5,547**	**783**	**592**

Rank 2010 (2009)		Company / Division	Country	Aero Sales (USD millions) 2010	2009	Growth*	Total sales (USD millions) 2010	Operating result (USD millions) 2010	2009
		Defense 1,270					1,270		
		Falcon (executive jets)					4,276		
21	**(21)**	**Mitsubishi Heavy Industries**	**Japan**	**5,376**	**5,343**	**-5.6%**	**33,061**	**1,152**	**701**
		Aerospace					5,376	-39	-68
22	**(20)**	**Embraer**	**Brazil**	**5,364**	**5,498**	**-2.4%**	**5,364**	**392**	**379**
		Commercial aviation					2,889	241	118
		Defense					670	90	57
		Executive aviation					1,145	59	96
		Aviation services					564	13	97
		Others					97	-11	12
23	**(24)**	**Harris**	**USA**	**4,755**	**4,470**	**6.4%**	**5,206**	**913**	**794**
		RF communications					2,067	707	572
		Government communications systems					2,688	337	303
24	**(25)**	**Rockwell Collins**	**USA**	**4,665**	**4,470**	**4.4%**	**4,665**	**822**	**885**
		Government systems					2,861	606	602
		Commercial systems					1,804	293	353
25	**(26)**	**Spirit Aero Systems**	**USA**	**4,172**	**4,079**	**2.3%**	**4,172**	**357**	**303**
		Fuselage systems					2,035	292	288
		Propulsion systems					1,062	138	123
		Wing systems					1,067	101	21
		All other					8	-2	-1
		Unallocated corporate and R&D						-172	-126
26	**(22)**	**Alliant Techsystems**	**USA**	**3,913**	**4,046**	**-3.3%**	**4,842**	**526**	**512**
		Aerospace systems					1,433	131	145
		Armament systems					1,806	212	168
		Missile systems					674	69	59

Rank 2010 (2009)		Company / Division	Country	Aero Sales (USD millions)			Total sales (USD millions)	Operating result (USD millions)	
		Division		**2010**	**2009**	**Growth***	**2010**	**2010**	**2009**
		Security and sporting					930	128	108
		Corporate						-14	32
27	**(27)**	**MTU Aero Engines**	**Germany**	**3,586**	**3,630**	**3.7%**	**3,586**	**355**	**343**
		OEM: commercial and military					2,204		
		MRO: commercial maintenance					1,423		
		Other consolidated entities					-40		
28	**(32)**	**Precision Castparts**	**USA**	**3,572**	**2,991**	**19.4%**	**6,220**	**1,503**	**1,423**
		Aerospace					3,572		
29	**(28)**	**Saab**	**Sweden**	**3,389**	**3,221**	**-0.9%**	**3,389**	**135**	**180**
		Aircrafts					899	26	1
		Dynamics					645	45	35
		Defense electronics					467	14	3
		Security and defense					844	19	36
		Support and services					428	49	54
		Corporate					107	-17	51
		Eliminations							
30	**(35)**	**Israel Aerospace Industries**	**Israel**	**3,148**	**2,881**	**9.3%**	**3,148**		
31	**(34)**	**Ishikawajima-Harima**	**Japan**	**3,064**	**2,957**	**-2.8%**	**13,518**	**699**	**504**
		Aero-Engines & Space Operation					3,064	66	75
32	**(33)**	**Cobham**	**UK**	**2,939**	**2,932**	**1.2%**	**2,939**	**355**	**448**
		Avionics and surveillance					690		
		Defense electronics					1,327		
		Mission systems					531		
		Aviation services					423		
		Other activities					0		
		Intercorporate					-34		

Rank 2010 (2009)		Company	Country	Aero Sales (USD millions)			Total sales (USD millions)	Operating result (USD millions)	
		Division		2010	2009	Growth*	2010	2010	2009
33	**(51)**	**Triumph**	**USA**	**2,905**	**1,295**	**124.4%**	**2,905**	**314**	**155**
		Aerostructures					2,126	268	102
		Aerospace systems					513	75	68
		Aftermarket services					273	29	11
		Corporate/other					-7	-58	-26
34	**(31)**	**Alcoa**	**USA**	**2,864**	**3,000**	**-4.5%**	**21,013**	**1,042**	**-1,028**
		Aerospace							575
35	**(30)**	**Zodiac**	**France**	**2,848**	**3,067**	**-2.5%**	**2,848**	**318**	**347**
		Aerosafety and technology					674	83	83
		Aircraft systems					637	49	100
		Cabin interiors					1,537	191	163
		Zodiac Aerospace						-4	0
36	**(38)**	**Hindustan Aircrafts**	**India**	**2,843**	**2,345**	**14.0%**	**2,843**	**592**	**550**
37	**(29)**	**Hawker Beechcraft**	**USA**	**2,805**	**3,199**	**-12.3%**	**2,805**	**-174**	**-712**
38	**(36)**	**Elbit Systems**	**Israel**	**2,670**	**2,832**	**-5.7%**	**2,670**	**207**	**263**
		Airborne					791		
		Land					363		
		C4ISR					1,019		
		Electro-optics					369		
		Other					128		
39	**(37)**	**Avio**	**Italy**	**2,322**	**2,367**	**3.0%**	**2,322**	**225**	**230**
		Aeroengines					1,884	266	262
		Space					379	48	52
		AvioService					60	1	5
		Other activities						-90	-90
40	**(40)**	**Kawasaki Heavy Industries**	**Japan**	**2,262**	**2,018**	**5.2%**	**13,970**	**485**	**-14**

Rank 2010 (2009)		Company / Division	Country	Aero Sales (USD millions) 2010	2009	Growth*	Total sales (USD millions) 2010	Operating result (USD millions) 2010	2009
		Aerospace					2,262	34	40
41	**(39)**	**GKN**	**UK**	**2,241**	**2,318**	**-2.4%**	**7,851**	**595**	**61**
		Aerospace					2,241	250	264
42	**(41)**	**B/E Aerospace**	**USA**	**1,984**	**1,938**	**2.4%**	**1,984**	**316**	**296**
		Consumables management					773	153	151
		Commercial aircraft					998	149	121
		Business jets					214	14	24
43	**(46)**	**BBA**	**UK**	**1,827**	**1,686**	**9.5%**	**1,827**	**155**	**128**
		Flight support					1,146	113	96
		Aftermarket services					681	74	76
		Corporate						-17	-15
		Exceptional items						-15	-28
44	**(44)**	**Meggitt**	**UK**	**1,794**	**1,794**	**1.0%**	**1,794**	**340**	**363**
		Aircraft braking systems					479	108	117
		Control systems					283	59	73
		Polymers and composites					241	28	36
		Sensing systems					321	60	50
		Equipment/group					471	86	84
45	**(42)**	**Parker Hannifin**	**USA**	**1,744**	**1,883**	**-7.4%**	**9,993**	**858**	**795**
		Aerospace					1,744	208	262
46	**(48)**	**Ruag**	**Switzerland**	**1,721**	**1,562**	**5.9%**	**1,721**	**94**	**-104**
47	**(45)**	**Teledyne Technologies**	**USA**	**1,644**	**1,652**	**-0.5%**	**1,644**	**179**	**171**
		Instrumentation					573	114	96
		Digital imaging					123	5	12
		Aerospace and defense electronics					615	58	60
		Engineered systems					334	30	31

Rank 2010 (2009)		Company	Country	Aero Sales (USD millions)			Total sales (USD millions)	Operating result (USD millions)	
		Division		2010	2009	Growth*	2010	2010	2009
		Corporate/other						-29	-27
48	**(50)**	**CAE**	**Canada**	**1,580**	**1,337**	**6.7%**	**1,580**	**251**	**201**
		Civil					741	108	109
		Military					839	144	122
		Restructuring charge						1	-30
49	**(47)**	**Eaton**	**USA**	**1,536**	**1,602**	**-4.1%**	**13,715**	**1,171**	**444**
		Aerospace					1,536	220	245
50	**(49)**	**Esterline**	**USA**	**1,527**	**1,407**	**8.5%**	**1,527**	**188**	**145**
		Avionics and control					790	126	99
		Sensors and systems					299	34	32
		Advanced materials					438	69	54
		Corporate						-40	-39
51	**(54)**	**Kongsberg**	**Norway**	**1,498**	**1,089**	**32.1%**	**2,562**	**349**	**201**
		Defense systems					558	35	15
		Protech Systems					940	164	70
52	**(52)**	**Singapore Technologies Engineering**	**Singapore**	**1,371**	**1,287**	**-0.1%**	**4,388**	**430**	**334**
		Aerospace					1,371	172	138
53	**(53)**	**Orbital Sciences**	**USA**	**1,295**	**1,125**	**15.1%**	**1,295**	**73**	**52**
		Launch vehicles and advanced programs					435	21	14
		Satellites and related space systems					497	34	27
		Advanced space programs					424	21	11
54	**(59)**	**Loral Space & Communications**	**USA**	**1,159**	**993**	**16.7%**	**1,159**	**81**	**20**
		Satellite services					0	0	0
		Satellite manufacturing					1,159	81	20
55	**(55)**	**Panasonic**	**Japan**	**1,139**	**1,068**	**0.0%**	**98,973**	**3,476**	**2,034**
		Panasonic Avionics							

Rank 2010 (2009)		Company / Division	Country	Aero Sales (USD millions) 2010	Aero Sales (USD millions) 2009	Aero Sales (USD millions) Growth*	Total sales (USD millions) 2010	Operating result (USD millions) 2010	Operating result (USD millions) 2009
56	**(63)**	**Korea Aerospace Industries**	**South Korea**	**1,112**	**954**	**16.6%**	**1,112**	**106**	**44**
57	**(57)**	**Ultra Electronics**	**UK**	**1,096**	**1,015**	**9.1%**	**1,096**	**170**	**152**
		Aircraft and vehicle systems					293	36	36
		Information and power systems					355	43	37
		Tactical and sonar systems					510	91	80
58	**(62)**	**Moog**	**USA**	**1,082**	**938**	**15.4%**	**2,114**	**188**	**150**
		Aircraft controls					757	76	52
		Space and defense controls					325	36	40
59	**(56)**	**Volvo**	**Sweden**	**1,069**	**1,020**	**-1.2%**	**36,722**	**2,497**	**-2,223**
		Aero					1,069	40	7
60	**(65)**	**Hexcel**	**USA**	**956**	**855**	**11.8%**	**1,174**	**130**	**104**
		Commercial					645		
		Space					311		
61	**(58)**	**Fuji Heavy Industries**	**Japan**	**943**	**996**	**-11.2%**	**17,996**	**958**	**292**
		Aerospace					943	26	51
62	**(68)**	**Chemring**	**UK**	**922**	**786**	**18.5%**	**922**	**167**	**168**
63	**(67)**	**GenCorp**	**USA**	**851**	**787**	**8.1%**	**858**	**38**	**78**
		Aerospace and defense					851	67	90
64	**(69)**	**TransDigm**	**USA**	**828**	**762**	**8.7%**	**828**	**363**	**335**
65	**(66)**	**Stork**	**Netherlands**	**816**	**837**	**2.3%**	**2,211**	**78**	**24**
		Fokker Aerospace					816	44	6
66	**(61)**	**Indra**	**Spain**	**787**	**948**	**-12.9%**	**3,387**	**334**	**397**
		Defense and security					787		
67	**(74)**	**Amphenol**	**USA**	**782**	**649**	**20.5%**	**3,554**	**700**	**489**
		Aerospace					782		
68	**(70)**	**Woodward Governor**	**USA**	**759**	**698**	**8.7%**	**1,457**	**181**	**153**

Rank 2010 (2009)		Company / Division	Country	Aero Sales (USD millions) 2010	2009	Growth*	Total sales (USD millions) 2010	Operating result (USD millions) 2010	2009
		Aerospace and defense					759		
69	**(93)**	**Diehl**	**Germany**	**718**	**715**	**5.4%**	**718**		
		Diehl Aerospace					265		
		Diehl Aircabin					397		
		Dasell cabin interiors							
70	**(71)**	**Ball**	**USA**	**714**	**689**	**3.6%**	**7,630**	**765**	**654**
		Aerospace and technologies					714	70	61
71	**(73)**	**FLIR Systems**	**USA**	**661**	**655**	**0.9%**	**1,385**	**361**	**347**
		Government systems					661	252	286
72	**(80)**	**Pilatus**	**Switzerland**	**659**	**571**	**11.0%**	**659**	**84**	**72**
73	**(78)**	**Aeroflex**	**USA**	**655**	**599**	**9.3%**	**655**	**68**	**-19**
74	**(72)**	**ITP**	**Spain**	**640**	**666**	**0.8%**	**640**		
75	**(81)**	**Heico**	**USA**	**617**	**538**	**14.7%**	**617**	**109**	**88**
		Flight support					412	68	60
		Electronic technologies					206	56	40
76	**(76)**	**Latécoère**	**France**	**615**	**624**	**3.3%**	**615**	**60**	**-143**
77	**(77)**	**Magellan Aerospace**	**Canada**	**608**	**596**	**-7.9%**	**711**	**51**	**39**
78	**(79)**	**Crane**	**USA**	**577**	**590**	**-2.2%**	**2,218**	**235**	**208**
		Aerospace and electronic					577	109	96
79	**(86)**	**Firth Rixson**	**UK**	**531**	**490**	**9.6%**	**701**	**105**	**92**
80	**(84)**	**Senior**	**UK**	**516**	**498**	**4.6%**	**876**	**96**	**95**
		Aerospace					516	77	61
81	**(88)**	**Curtiss-Wright**	**USA**	**511**	**452**	**13.0%**	**1,893**	**180**	**169**
		Aerospace defense					265		
		Aerospace commercial					246		

Rank 2010 (2009)		Company / Division	Country	Aero Sales (USD millions)			Total sales (USD millions)	Operating result (USD millions)	
				2010	2009	Growth*	2010	2010	2009
82	**(new)**	**Aernnova**	**Spain**	**498**	**526**	**-0.5%**	**498**		**23**
83	**(75)**	**Umeco**	**UK**	**494**	**455**	**9.8%**	**710**	**51**	**48**
		Aerospace and defense					494		
84	**(90)**	**Jamco**	**Japan**	**489**	**430**	**6.8%**	**489**	**10**	**10**
85	**(83)**	**Kaman**	**USA**	**487**	**501**	**-2.7%**	**1,319**	**63**	**54**
		Aerospace					487	67	75
86	**(87)**	**LISI**	**France**	**429**	**486**	**-7.3%**	**1,029**	**65**	**48**
		Aerospace					429	28	66
87	**(82)**	**SKF**	**Sweden**	**423**	**514**	**-22.5%**	**8,465**	**1,172**	**419**
		Aerospace					423		
88	**(89)**	**Ducommun**	**USA**	**408**	**431**	**-5.3%**	**408**	**26**	**16**
89	**(91)**	**Ladish**	**USA**	**342**	**307**	**11.4%**	**403**	**47**	**9**
		Aerospace components					143		
		Jet engines					199		
90	**(97)**	**Héroux-Devtek**	**Canada**	**322**	**260**	**11.7%**	**347**	**30**	**24**
		Landing gear					222		
		Aerostructures					100		
		Aircraft engine components							
91	**(96)**	**Hampson Industries**	**UK**	**305**	**264**	**16.8%**	**305**	**-36**	**52**
		Aerospace components and structures					62	6	6
		Aerospace composites and transparencies					243	-34	39
92	**(95)**	**Denel**	**South Africa**	**300**	**272**	**-4.0%**	**491**	**-22**	**-55**
		Aerostructures					56	-38	-53
		Aerospace systems					134	-6	-5
		Aviation					110	11	5
93	**(92)**	**Aerospace**		**294**	**321**	**-3.9%**	**294**		

Rank 2010 (2009)		Company	Country	Aero Sales (USD millions)			Total sales (USD millions)	Operating result (USD millions)	
		Division		2010	2009	Growth*	2010	2010	2009
94	**(94)**	**Doncasters**	**UK**	**276**	**284**	**-1.6%**	**1,039**	**-15**	**-84**
		Aerospace							
95	**(99)**	**Martin Baker**	**UK**	**275**	**234**	**18.7%**	**275**	**66**	**53**
96	**(98)**	**Garmin**	**USA**	**263**	**246**	**6.8%**	**2,690**	**637**	**786**
		Aviation					263	72	58
97	**(new)**	**Sonaca**	**Belgium**	**255**	**237**	**12.8%**	**255**	**-5**	**-53**
98	**(100)**	**Terma**	**Denmark**	**252**	**208**	**27.2%**	**252**	**16**	**0**
		Non-defense					96		
		Defense					156		
99	**(new)**	**Teleflex**	**USA**	**174**	**163**	**6.2%**	**1,802**	**274**	**257**
		Aerospace					174	23	10
100	**(new)**	**Circor International**	**USA**	**119**	**113**	**4.9%**	**686**	**15**	**4**
		Circor Aerospace					119	15	17

Note: * Excludes currency impacts.
Source: PricewaterhouseCoopers 2011.

Exhibit 2

Main EPZ Software Companies Operating in Costa Rica

Company	Started Operations	Number of Employees	Description
4 Thought Marketing	2009	< 50	Software that helps companies support their marketing campaigns (English)
Avionyx	2005	< 50	Avionics software engineering development and verification/testing to the aircraft industry (English)
Fiserv	2004	50–150	Banking and financial software development center (English)
Global Insurance Technology	2007	< 50	Insurance software developer and support center (English & Spanish)
Informatech	2010	< 50	Outsourcing IT services
JD Soft de CR	2002	< 50	ERP software development center (English)
Prosoft Nearshore	2008	< 50	Software testing and programming (English)
Ridge Run	2006	< 50	Embedded software engineering center (English)
Round Box Media	2006	50–150	Quality control, project management, design, and programming for e-learning companies (English)
Simple Software	2006	< 50	ERP software development (English)
Sistemas Galileo	2002	50–150	Banking and credit card application software development (English & Spanish)
Slim Soft	2006	< 50	Manufacturing process software development (English)
Softtek	2010	< 50	Software development specializing in SAP
Via Information Tools	2004	< 50	Spare part–tracking software systems for the automotive industry (English & Spanish)

Source: CINDE. 2011.