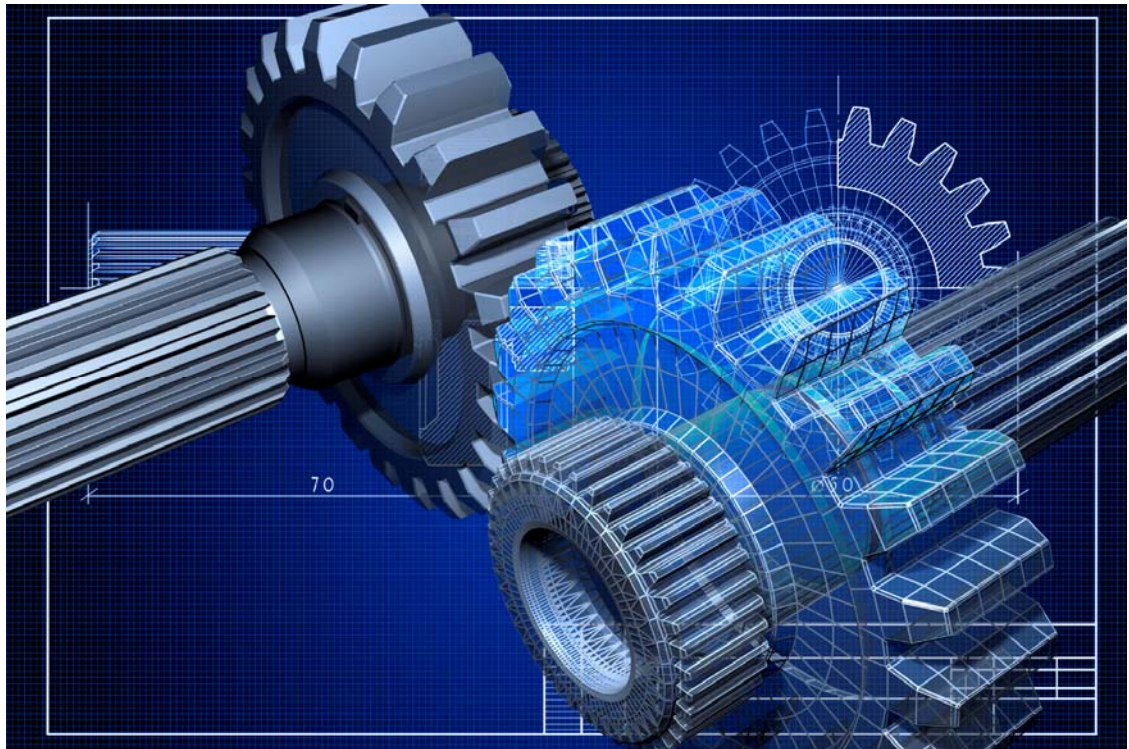


# ENGINEERING SERVICES IN THE AMERICAS



July 1,  
2010

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\* This report was commissioned by the Inter-American Development Bank & the Chilean Economic Development Agency (CORFO)

## Acronyms

ABET	Accreditation Board for Engineering and Technology
ANTAQ	National Maritime Administration Agency
BMI	Business Monitor International
BRIC	Brazil, Russia, India and China
CENPES	Center for Petroleum Research, Brazil
CODELCO	Corporación Nacional del Cobre, Chile
CONFEA	Conselho Federal de Engenharia e Arquitetura e Agronomia, Brazil
EBOPS	Extended Balance of Payments Services Classification
ECLAC	Comisión Económica para América Latina y el Caribe
EMIS	Emerging Markets Information Service
EPC	Engineering, Procurement & Construction
EPCM	Engineering, Procurement, Construction Management
ESO	Engineering Services Outsourcing
FARC	Fuerzas Armadas Revolucionarias de Colombia
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
IDC	International Data Corporation
IPEA	Instituto de Pesquisa Econômica Aplicada, Brasil
ISIC	The International Standard Industrial Classification
ISO	International Organization for Standardization
IT	Information Technology
LAC	Latin American Countries
MNC	Multinational Corporation
NAICS	The North America Industry Classification System
NASSCOM	The National Association of Software and Services Companies, India
OECD	Organization for Economic Co-operation and Development
OHSAS	Occupational Health & Safety Advisory Services
PAC	Programa de Aceleração do Crescimento, Brasil
PPP	public-private partnerships
R&D	Research & Development
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
WEF	World Economic Forum
WTO	World Trade Organization

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## I. INTRODUCTION

Global demand for engineering services is on the rise. The rapid growth of a number of emerging economies and the commodity boom that has accompanied their development has provided a new impetus for these types of activities. These services were once provided principally by engineers from developed nations; however, improvements in education in developing countries, the expansion of large engineering firms to emerging economies and the advent of communication technologies has opened the door for the increased trade in all disciplines of engineering services, both to and from developed nations as firms and countries alike seek to improve their competitiveness.<sup>1</sup> While the United States continues to be the world's leading exporter of engineering services, exporting approximately four times as much as it imports today, other nations around the world have developed engineering expertise in different sectors and are becoming increasingly important competitors. Trade in these services is occurring between developed and emerging economies as well as between developing nations. This report focuses on the growth of the industry as well as opportunities for intraregional trade in Latin America.

Within the past few years, consistent with this global growth, countries across Latin America have seen an increase in engineering services trade. Improvements to telecommunications and transport infrastructure have allowed for the rapid movement of both information and personnel across borders. Chile, for example, saw engineering exports rise from US\$31 million in 2005 to \$230 million in 2008. Over 60% of exports in 2008 went to Argentina, Brazil, Peru and Colombia (Asociación de Empresas Consultoras de Ingeniería de Chile, 2010). Given the level of development of the region, engineering has been focused principally in the exploitation of natural resources as well as in low technology sectors in infrastructure development. Key countries in the region are undergoing rapid economic growth, requiring major investments in transport, energy and communications infrastructure, while globally the growth of the large BRIC countries has increased world demand for oil, metals and minerals resulting in increased investments in mining and oil extraction in many Latin America countries.

The growth in these sectors has attracted many of the world's leading engineering companies to establish operations in Latin America, leveraging offices in key countries such as Chile to cover the regional market. The transfer of knowledge and technology as a result of the presence of these large

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<sup>1</sup> 16 of the 23 OECD nations reporting trade data for architectural, engineering and other technical services from 2000 to 2007 noted increases in both imports and exports of those services, while three nations noted increases in exports alone. Brazil, India and the Russian Federation also noted increases in both imports and exports of these services (OECD 2008; United Nations 2009).

multinational engineering firms in the local market has quickly and significantly helped to support the development of local engineering talent and regionally domestic firms have developed areas of expertise focused on resolving specific engineering challenges they face in the local market.

The growing demand for engineering services is unlikely to abate, and will continue to increase the demand for more engineers at a global level. This holds an important opportunity for the developing countries of Latin America that offer competitive labor costs in engineering. However, at the same time, these countries must overcome a number of challenges before they can become important players in the global engineering services market. Engineering skills are already in short supply in the region creating pressure on labor costs. Additionally new universities are providing low quality skills making engineers unemployable and unable to compete at the global level. Engineering schools in Latin America need to prepare global engineers with strong technical skills, while at the same time, with solid interpersonal and management skills and a firm grasp of several languages including English.

This report is focused specifically on the engineering services market within the Americas, analyzing the growth of intraregional trade in these services and offering insight into both the regional demand and supply. A brief overview of the evolution of engineering services at the global level, identifying the engineering services project value chain and highlighting the twenty leading global firms, is employed to provide a broader context for the study of five countries within the region. These include Brazil, Chile, Colombia, Peru and the United States. The Latin American nations were selected due to their emerging market status within the continent. Selection was based on economic growth, foreign direct investment (FDI) expansion and market size within the region, with all five countries registering strong progress within the five-year period prior to the crisis and growth post crisis is expected to be strong. As a result of this development, these countries are likely to continue to provide important sources of demand for as well as supply of engineering services. The United States was selected in order to provide a developed country comparison for the region.

The report is organized as follows. Section II provides an overview of global engineering services providing insight into how the industry is organized, including classifications standards and identifying the key stages of the engineering services project value chain. Section III includes an analysis of the world's twenty leading firms and provides an overview of the current level of their operations in Latin America. Section IV provides comparative analysis at the country level for regional demand and supply of engineering services in the five countries analyzed in this report, followed by individual

country sections that highlight the leading industries demanding engineering services as well as an analysis of the current state of the supply of engineering services in the country. Supply is analyzed by the number of engineering graduates, leading universities and engineering firms and the regulatory framework governing the sector.



## II. OVERVIEW

### A. Global Engineering Services

Trade in engineering services has increased steadily over the past decade, primarily supported by new technologies that facilitate the transmission of information across borders and also by new business strategies that include outsourcing a growing number of firm activities. In the past, the majority of the engineering services were generated by only a few nations, with the United States as the leading export supplier. Recently, a growing number of developing countries have begun to provide these services and today, in this globalized economy, engineering services activities are being supplied from all parts of the world.

Regional trade of engineering services in Latin America has increased in the recent years. In the past, only developed countries were able to export this type of services.

In Latin America, regional trade in engineering services has also increased. For example, Colombia is emerging as a platform to export engineering services to Central America and Caribbean countries and Peru is demanding engineering services from abroad, particularly in two key sectors - mining and infrastructure. Brazil provides infrastructure services and Chile offers its expertise in mining engineering.

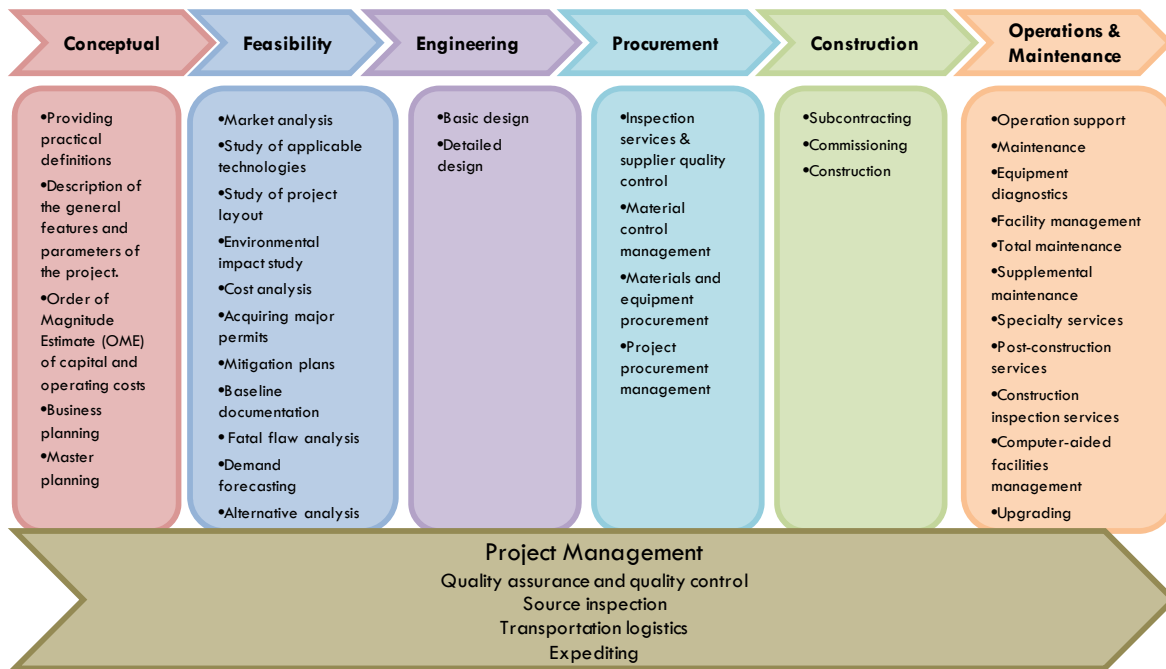
This report adopts the definition of the engineering services industry provided by the US Census Bureau: “an industry comprised of establishments primarily engaged in applying physical laws and principles of engineering in the design, development, and utilization of machines, materials, instruments, structures, processes, and systems” (US Census Bureau, 2008).

#### 1. Engineering Services Project Value Chain<sup>2</sup>

Six phases have been identified in the engineering service project value chain: Conceptual Design; Feasibility; Engineering; Procurement; Construction and Operations & Maintenance. These phases are identified in Figure 1.

<sup>2</sup> This value chain is based on activities performed by leading firms in the engineering services sector and draws on in-depth interviews with industry leaders. A full analysis of the global value chain requires further research of all firms in the sector both on the demand and supply side of the industry.

Figure 1. Engineering Services Project Value Chain



Source: CGGC

Some large companies are vertically integrated and offer all phases in an engineering project while others only specialize in particular activities. Generally, the construction part of the project is subcontracted to other firms, with construction management being provided locally; however, many engineering services companies also have large construction divisions.

Activities provided by engineering companies include, but are not limited to:

- Project management
- Order of Magnitude Estimate (OME)
- Feasibility studies such as study of applicable technologies and Environmental Impact studies
- Basic and Detailed design
- Materials and equipment procurement
- Construction
- Operations support and facility management
- Post-construction services
- Maintenance

Multinational companies are usually contracted for “Engineering, Procurement and Construction Management (EPCM)” projects due to both their expertise in specific sectors as well as their considerable experience managing large projects. This category of firms includes leading companies Bechtel and Fluor, amongst others. These engineering firms typically handle large projects related to infrastructure including energy, transportation, communications and water, as well as sectors such as forestry, mining and oil & gas among others. These large infrastructure projects include mining plants, dams, airports, tunnels, processing plants, pipelines, offshore facilities and hydro-electric plants among others. These projects draw engineers from a broad range of disciplines including: civil, mechanical, industrial, mining-metals-metallurgy, chemical, forestry, construction, electrical, electronic, environmental, aquaculture, agricultural and petroleum engineering. This report excludes the engineering fields related specifically to Information Technology (IT), computer science and systems engineering.

## 2. The Changing Face of the Industry

Engineering companies have evolved from providing all engineering services from the headquarters to opening key operations and centers of excellence in developing countries. As the industry has evolved from a domestic to global domain, it has forced the companies to create global systems of delivery<sup>3</sup> in their business strategy. The world’s two largest engineering firms, Fluor and Bechtel, both of which are headquartered in the United States and have 100 years of experience in the field, have each established a presence in countries on every continent and provide a comprehensive range of engineering services, excelling in all stages of the engineering services value chain. Today, both firms operate using a global approach for many of their large projects, allowing multiple offices to work on the project around the clock (Fluor, 2010b). “Around the Clock, Round the World,” as the approach is referred to at Bechtel, allows complex design and construction processes to span numerous time

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<sup>3</sup> Indian firms, new entrants to the industry, have followed the reverse strategy. Having mastered the Global Delivery Model offering IT services, these firms began offering engineering services. The rise of India in the export of engineering services and the emergence of a so called new industry, Engineering Services Outsourcing (ESO) has captured the attention of the popular media over the last two years. Indian companies have successfully leveraged the skill sets, tools and experience from outsourcing IT software and services, to gain a strong foundation in outsourced product design and engineering. The Global Delivery Model mastered by the Indian offshore services providers such as Tata Consultancy Services and HCL have given these companies full advantages in the provision of engineering services to large MNCs. The Global Delivery Model involves the deployment of resources from different parts of the world to provide maximally efficient service delivery. It also involves having the right volume of skills and the right skills mix in the right place at the right time and the right price point (Tuck School of Business at Dartmouth – William F. Achtmeyer Center for Global Leadership, 2007). In India the scope of outsourced engineering services has expanded beyond product design to include industrial services (process engineering plant automation and enterprise asset management) (NASSCOM, 2008b). Approximately 55% of the ESO market in India is controlled by Indian IT service providers, 40% is with the captives, and the rest is catered by the niche players. While engineering services as a segment is multi-disciplinary - automotive, aerospace and high-tech/telecom are the major thrust areas in India. Aerospace, auto and telecom verticals comprise around 55-60% of the market (NASSCOM, 2008a). This report refers to engineering services that involved large infrastructure projects, while India provision of engineering services involve mainly product and process development. In just one decade, India has increased the export of these services, surpassing the United States (World Trade Organization 2008).

zones every day, using its nine engineering hubs around the world: Houston, Frederick (Maryland), New Delhi, Shanghai, London, Brisbane, Santiago, Taipei and Warsaw (Bechtel, 2008).

WorleyParsons, the top Australian engineering firm, also involves different global offices according to the scale and type of project. For example, in a current project related to improving the extraction of molybdenum in Russia, offices from Russia, London, Sydney, Melbourne, Santiago and Toronto are working together in this project with the goal to double the client's production of molybdenum per annum (WorleyParsons, 2009). The leading Canadian engineering firm, SNC-Lavalin established centers of excellence around the world; copper in Santiago, iron ore in Belo Horizonte and Montreal, nickel in Perth and gold in Canada. The Center of Excellence for Copper in Santiago-Chile has provided complete lifecycle implementation services, including basic and detailed engineering for a variety of copper projects in the Andes, Central Africa and tropical Australia (SNC Lavalin, 2010a, 2010b, 2010c, 2010d).

## B. Classification of Engineering Services

Measuring trade in engineering services is a complex task. There are different definitions of what the field of engineering services encompasses, which is further complicated by the lack of data to quantify the industry. There have been numerous attempts to clarify and quantify these activities, although there is still no international consensus (See Table 1). The International Standard Industrial Classification (ISIC) of all economic activities classified by the United Nations refers to this category as **'architectural and engineering activities and related technical consultancy'**. The ISIC classification is relevant for economic activities within national boundaries. The North America Industry Classification System (NAICS) (US, Canada & Mexico) refers to 'engineering services' and the classification of the industry for international trade purposes proposed by the OECD and European Union under the Extended Balance of Payments Services Classification (EBOPS) is **'architectural, engineering and other technical services'**.

Engineering services classification and quantification is an important, outstanding international task. Currently, only a few countries report this data.

The International Standard Industrial Classification (ISIC) has a specific category for these services; however, only few countries report data, which makes it difficult to use it for analytical purposes. The other popular classification in the Americas is the North America Industry Classification System (NAICS)

that created a special code for “Engineering Services”, separating these from architectural activities or other related technical consultancy; however this only covers three countries; the United States, Canada and Mexico.

**Table 1. Classifications of Engineering Services**

Extended Balance of Payments Services Classification (EBOPS)	International Standard Industrial Classification (ISIC)	North America Industry Classification System (US, Canada & Mexico) NAICS
Extended Balance of Payments Services Classification (EBOPS) The United Nations Statistics Division, the Statistical Office of the European Communities, the International Monetary Fund, The OECD and the WTO agreed on using this classification for the trade of these services.	International Standard Industrial Classification (ISIC) of all economic activities classified by the United Nations ISIC Rev.4 7110 'Architectural and engineering activities and related technical consultancy'	NAICS Code 541330 'Engineering Services' North America Industry Classification System (US, Canada & Mexico). In 1997 NAICS replaced the Standard Industrial Classification (SIC) system. 'Engineering Services' has the code 541330 and SIC 8711.
<b>Hierarchy</b> <b>9. Other Business Services</b> <b>9.3 Miscellaneous business, professional, and technical services</b> <b>9.3.4 Architectural, engineering and other technical services- Code 280</b>	<b>Hierarchy</b> - Section: <b>M</b> - Professional, scientific and technical activities - Division: <b>71</b> - Architectural and engineering activities; technical testing and analysis - Group: <b>711</b> - Architectural and engineering activities and related technical consultancy - Class: <b>7110</b> - Architectural and engineering activities and related technical consultancy	<b>Hierarchy</b> - <b>Sector 54--Professional, Scientific, and Technical Services</b> - <b>5413 Architectural, Engineering, and Related Services</b>
Architectural, engineering and other technical services covers transactions between residents and nonresidents related to architectural design of urban and other development projects; planning and project design and supervision of dams, bridges, airports, turnkey projects etc.; surveying; cartography; product testing and certification; and technical inspection services. Mining engineering is excluded and included in mining services.	This class includes the provision of architectural services, engineering services, drafting services, building inspection services and surveying and mapping services and the like.	This industry comprises establishments primarily engaged in applying physical laws and principles of engineering in the design, development, and utilization of machines, materials, instruments, structures, processes, and systems. The assignments undertaken by these establishments may involve any of the following activities: provision of advice, preparation of feasibility studies, preparation of preliminary and final plans and designs, provision of technical services during the construction or installation phase, inspection and evaluation of engineering projects, and related services.

Source: (United Nations, 2002, 2010; US Census Bureau, 2008)

The most widely adopted classification to track trade data is the Extended Balance of Payments Services Classification (EBOPS) (see table 2). Many international organizations have agreed to use this classification, including the United Nations Statistics Division, the Statistical Office of the European Communities, the International Monetary Fund, the OECD and the WTO. However, the data is mostly incomplete although some organizations have collected information for some countries over several years. By 2010, only 75 countries were reporting service trade data in this category (see Appendix 1) (United Nations 2009). Out of these five countries included in this study (Brazil, Chile, Colombia, Peru and the United States) trade data is available only for Brazil and the United States (see Table 2). Brazil shows a positive trade balance; in 2008 it exported US\$5,595 million and imported US\$2,954 million in engineering services. Brazilian exports have grown rapidly since 2006 with US\$3,033 million in exports to US\$5,595 million in 2008 (OECD 2008; United Nations 2009; World Trade Organization 2008). In 2008, the United States exported US\$5,918 million and imported US\$

1,086 million, a notable increase from two years earlier when the country exported US\$4,991 million and imported US\$263 million. On the other hand, in 2008, Chile exported US\$275 million mainly in the engineering services related to mining.

**Table 2. Trade in Architectural, Engineering and Other Technical Services**

		WTO (2006) (US \$ million)	UN Service Trade (2008) (US \$million)	OECD (US \$million)		IDC (2008) (US \$million)
				2006	2008	
United States	Export	5,020		4,991	5,918	
	Import	280		263	1,086	
Brazil	Export	3,033	5,595	3,034		
	Import	1,708	2,954	1,711		
Colombia	Export	Data not available				
	Import	Data not available				
Chile	Export	Data not available				275.6 <sup>a</sup>
	Import	Data not available				
Peru	Export	Data not available				
	Import	Data not available				

Note: The services included in this table are classified under the Extended Balance of Payments Services (EBOPS) Classification (see table 1).

<sup>a</sup>: This figure principally includes engineering services related to mining, which are included with Mining Services in the EBOPS Classification.

Sources: (OECD 2008; United Nations 2009; World Trade Organization 2008).

A 2005 report by NASSCOM and Booz Allen Hamilton (2005) estimates that worldwide spending on engineering services<sup>4</sup> will increase from US\$750 billion in 2004 to more than US\$1 trillion by 2020 (see Table 3). In 2004, only US\$10-15 billion of this US\$750 billion was outsourced. Engineering Services Outsourcing (ESO) however, is expected to reach US\$80 billion in 2010 and between US\$150 and US\$225 billion by 2020. Datamonitor (2009c) reported that global revenues of the combined “Construction & Engineering Industry” reached US\$2,323 billion in 2008 and that this figure will increase to US\$2,762.7 billion in 2013 as both the engineering and construction sectors expand.<sup>5</sup>

<sup>4</sup> The report does not provide an explanation regarding the activities included in engineering services.

<sup>5</sup> The global construction and engineering industry is composed of civil engineering companies and large-scale contractors and includes all construction companies with the exception of those in the home-building sector. Revenues in the construction business are significantly larger than those of the engineering services sector.

**Table 3. Size of the Global Engineering Services and Engineering Services Outsourcing (ESO) Industries**

		Revenues (USD Billion)	Revenue Prediction (USD Billion)		
Engineering Services Industry	Global	750 (2004)	1000 (2020)		
Engineering Services Outsourcing (ESO)	Global	10-15 (2004)	2007	2010	2020
			40	80	150-225

Source: (NASSCOM & Booz Allen Hamilton, 2005)

### C. Growing Global Demand for Quality Engineers

Demand for engineering services is growing rapidly and the human capital with the correct skills is in

Globally engineers are in short supply. In order to take advantage of the growing demand for offshore engineering services, developing countries must close the education quality gap.

short supply. Businesses from developed countries are finding it increasingly difficult to recruit and retain skilled employees and as a result a global war for talent has begun (Economist Intelligence Unit, 2008b). This presents both a great opportunity and at the same time, a tremendous challenge for developing nations. Some emerging economies have a large number of engineering

graduates; however, there are difficulties in finding employees with the correct skills mix.

A survey of business executives prepared by the Economist Intelligence Unit (2008a) explains that there is a knowledge gap in developing countries in technical skills and it is difficult to find people with interpersonal skills. This is supported by the Duke University report, "Where the Engineers are", which explains that while a country's supply of engineers is important, the quality of its engineers is much more relevant. For example, the quality of engineering education in China and India is not as good as the US. In China, the quality of engineering education drops off drastically after a few top-tier universities. The multinational and local technology companies in China revealed that they felt comfortable hiring graduates from only 10 to 15 universities across the country. Most of the institutes in India also face similar quality issues and firms have to provide extensive in-house training programs. Unlike in China, the firms' abilities to train their own staff internally to meet company needs means that representatives of local companies and multinationals in India feel comfortable hiring the top graduates from most universities in India (Wadhwa et al., 2007).

This quality issue is also prevalent amongst Latin American engineering programs. In the past ten years, a large number of new universities have been established, augmenting the number of engineering graduates; however, the quality of the education provided is not the top priority at these schools. This situation has impacted the engineering field across the continent. In Peru, for example, engineering companies hired only from the few traditional universities (Gallegos, 2010) and a number of engineering companies from Brazil and Chile relocate their staff to Peru rather than hiring local talent. At the same time, engineering education in most countries in the region lacks the interpersonal skills training that is essential to work with multicultural teams and deal with clients from all over the world.

As can be inferred from the previous section, globalization of engineering services is adding a great pressure on countries' education systems. Now, these nations are facing the question of how to create global engineers who are able to engage in a project on the other side of the world, dealing with different cultures, speaking many languages while, at the same time, maintaining excellent technical qualifications. Some global engineering companies like Bechtel and Fluor have developed online training programs in order to keep their employees at global quality standards. In this sense, in Latin America, as in India, the private sector is beginning to help meet the skills gap using firm resources to provide ongoing education. However, due to financial and other resource constraints, these training programs are generally only provided by large foreign firms, and many domestic firms do not have the same training practices. This, in turn, makes it difficult for domestic firms to compete in the global arena. There may be opportunities for public-private partnerships to develop further education opportunities to help improve the competitiveness of local firms.



### III. COMPANY ANALYSIS – LEADING GLOBAL ENGINEERING SERVICES FIRMS

The majority of the leading global engineering services firms are vertically integrated providing all services in the engineering services project value chain. These firms are principally Engineering, Procurement, Construction Management (EPCM) companies with long business trajectories and a global presence. Of the top 20 engineering firms (See Table 4), nine are from the United States, six from Europe, two from Canada, one from Australia, one from Japan and one from Brazil. Constructora Norberto Odebrecht, from Brazil is the only firm from both Latin America and the developing world as a whole.

In 2008, the leading engineering services firm, Bechtel, reported annual revenues of US\$31,400 million and 49,000 employees. Founded more than 100 years ago, this US firm is well known for the construction of the Hoover Dam, the Channel Tunnel, Kuwait Oil Fires and the Aircraft Test Center in Florida among others. In the second place is Fluor, which in 2008 reported revenues of US\$22,326 million and 42,119 employees. Founded in 1812, the firm has specialized in the Oil and Gas sector and has a presence in more than 70 countries. The third company in the list is the British Balfour Beatty founded in 1909 with sales of US\$15,142 million and over 41,000 employees (See Box. 1 for more description of Bechtel and Fluor).

The companies listed in Table 4 provide a range of services for different clients and industries. Governments, private sector and institutions demand services in many areas including chemical and petrochemicals, communications, defense, environment, forestry, health care, manufacturing, metals, mining, power and transport, among others. All of these companies offer their services at global level, with established operations (branches) in selected countries.

Table 4. Top 20 Global Engineering Companies

	Company - Headquarters	Sales USD (mil) 2008	Employees	Main Activities
1	Bechtel Group Inc - US	31,400	49,000	Bechtel is one of the most prominent engineering, construction and project management companies. The company handles projects related to energy, transportation, communications, mining, and oil and gas industries. The company also handles projects related to government services.
2	Fluor Corporation - US	22,326	42,119	Fluor delivers engineering, procurement and construction management (EPCM) projects as well as maintenance and project management to governments and clients in diverse industries around the world. Energy & Chemicals; Industrial & Infrastructure; Power; Chemicals and Petrochemicals; Commercial and Institutional; Government Services; Health-care; Life sciences; Manufacturing; microelectronics; Mining; oil and gas; Renewable energy; Telecommunications; and Transportation.
3	Balfour Beatty PLC - UK	15,142	41,030	Balfour Beatty plc is focused on Professional Services, Construction Services, Support Services and Infrastructure Investments.
4	KBR - US	11,581	57,000	KBR is a leading global engineering, construction and services company supporting the energy, hydrocarbon, government services, minerals, civil infrastructure, power and industrial markets.
5	Jacobs Engineering Group Inc - US	11,252	38,900	Project Services (engineering, design, architectural), Process, Scientific and Systems Consulting, Construction, Technology Services, Management services, Environmental, Health and Safety Services, Operations and Maintenance.
6	URS Corporation - US	10,086	45,000	URS Corporation is a provider of engineering, construction and technical services. The company offers a range of program management, planning, design, engineering, construction and construction management, operations and maintenance, and decommissioning and closure services to public agencies and private sector clients worldwide.
7	SNC-Lavalin Group Inc. - Canada	6,657	21,948	The Company provides engineering, project and construction management, construction, and operations and maintenance services through its network of offices located across Canada and in over 35 other countries. <b>Key market sectors:</b> Infrastructure, Environment, Chemical and petroleum, Power, Mining and Metallurgy, operations and maintenance, Infrastructure concession, Investments, Agrifoods.
8	CH2M HILL - US	6,400	25,744	CH2M Hill is an employee-owned firm that provides engineering, construction and related technical services for public and private clients. The company serves the water, energy, environmental, transportation, communications, construction and industrial sectors.
9	AECOM Technology Corp. - US	5,200	45,000	AECOM is a global provider of professional technical and management support services to a broad range of markets, including transportation, facilities, environmental, energy, water and government.
10	JGC CORP. - Japan	4,821	4,723	JGC is a Japan-based company mainly engaged in the engineering business. <b>Services:</b> 1. Consulting, planning, basic and detailed design, materials and equipment procurement, construction, commissioning, operation and maintenance services for various plant and facilities; 2. Investment in oil and gas field development projects and utility business; 3. Technology development services
11	AMEC Plc - UK	4,777	21,000	AMEC is a focused supplier of high-value consultancy, engineering and project management services to the world's natural resources, nuclear, clean energy, water and environmental sectors. <b>Divisions:</b> Natural Resources, Power & Process and Earth & Environmental businesses.
12	WorleyParsons Limited - Australia	4,176	32,200	Worley Parsons is a provider of professional services to the resources and energy sectors, and process industries. The Company operates in four business segments: hydrocarbons, power, minerals and metals, and infrastructure and environment.
13	Atkins - UK	2,636	17,270	WS Atkins plc is engaged in providing professional design and engineering consultancy services. The Company operates in six business segments: Design and Engineering Solutions; Highways and Transportation; Rail; Middle East, China and Europe; Management and Project Services, and Asset Management.
14	Black & Veatch - US	2,358	9,600	Black & Veatch is a worldwide engineering, consulting and construction company that specializes in infrastructure development in energy, water, telecommunications, and federal, management consulting and environmental markets.
15	Parsons Brinckerhoff Inc. - US <sup>b</sup>	2,343	13,010	Parsons Brinckerhoff is a planning, engineering, program and construction management organization. <b>Services:</b> Construction Management; Design and Engineering; Environmental; Operations and Maintenance; Planning; Program Management; Strategic Consulting; Sustainability; E-Business and E-Media.
16	HATCH - Canada	1,761	8,500	Hatch provides customized process design and construction management services. It serves the mining, manufacturing, energy and infrastructure industries. The firm offers a range of business consultation and information technology services. It provides technical and strategic services, including operational support and project management.
17	ARCADIS NV - Netherlands	1,700	14,000	ARCADIS is an international company that provides consultancy, planning, architectural design, engineering and management services for infrastructure, environment and buildings.
18	Construtora Norberto Odebrecht S.A. - Brazil	1,134 <sup>a</sup>	43,859	Areas of Operation: Construction, Engineering, Management, Environment, Financing and Project Development, Quality, Supply, Workplace, Health and Safety
19	Poyry Oyj - Finland	1,212	7,000	Poyry Plc, formerly Jaakko Poyry Group Oyj, is a Finland-based company engaged in consultancy and engineering. <b>Divisions:</b> Energy; Forest Industry; Transportation; Water and Environment, and Construction Services.
20	Ramboll Group - Denmark	1,022	8,848	Ramboll is multi-disciplinary engineering, design and consultancy company providing services under seven main <b>service areas:</b> Building & Design, Infrastructure & Transport, Energy & Climate, Environment & Nature, Industry & Oil & gas, IT & Telecom, Management & Society.

Source: OneSource, company websites and annual reports. <sup>a</sup> Private Company. Revenue estimated by OneSource. <sup>b</sup> Parsons Brinckerhoff Inc. was acquired by Balfour Beatty PLC in February 2010.

Most of these leading engineering companies have operations in Latin America (see Table 5). Only three of them, Balfour Beatty PLC, Jacobs Engineering Group Inc and Ramboll Group do not have presence in the region. The main attraction of Latin America is the high demand for engineering services in extractive industries. Generally, local engineering companies in Latin America do not have the capabilities to provide all activities in the value chain in these industries which provides

A number of the global engineering companies have established operations in Latin America attracted by the high demand for engineering services in extractive industries.

opportunities for international firms. Many of these firms have opted to establish operations in Brazil, Chile and Mexico and most projects are related to oil and gas and mining.

In Chile, companies including Bechtel, Fluor, SNC Lavalin, AMEC, WorleyParsons and Hatch initially established operations in the country to support the mining industry. Local companies lacked the

capacity to meet the demands of the large international mining corporations, particularly in terms of managing the large projects required to establish new mines. After the arrival of these international firms, different modalities of engineering services began to be offered including Engineering, Procurement, Construction Management (EPCM) contracts. Today, the engineering capacity in Chile allows the country's firms to export engineering services related to mining all over the world. In general, across the continent as in Chile, engineering services capabilities at the country level are clearly correlated to the level of infrastructure development and the sophistication of national productive sectors, as local engineers develop expertise by designing solutions for local needs (for example, Colombia have expertise in hydroelectric engineering projects as a result of adapting to the geographical conditions of the country).

Development of engineering services within Latin America is also closely related to the number of multinationals engineering companies in the country. The expansion of these companies in Latin America has followed a process of acquisitions, mergers and joint ventures. It is not common to see greenfield operations as the association with local firms provides numerous benefits including knowledge of the country regulations and implicit codes of conduct. In time, these global engineering companies further expand their operations, drawing on local engineering talent.<sup>6</sup>

<sup>6</sup> For example, by the end of the 1980s in Chile, 99% of the engineering services were provided by Chilean personnel (Arze, 2009).

This process generates knowledge transfer in which local engineers learn extensively from foreign practices. These top global engineering companies introduce their own work style and many of them provide special training programs in order to standardize the skills around the globe. Once local engineering personnel develop expertise in new engineering practices or sectors, these skills are leveraged for export. Today, many of the engineers not only work on projects for the local market but also in projects that involve the interaction with offices all over the world.

### **Box 1. Leading Engineering Firms in the World**

**Bechtel Corporation** operates within engineering, construction and project management domain through supporting technical and management services. The company employs 40,000 people, connected with customers, partners and suppliers over various projects in more than 60 countries. Bechtel Corporation has completed substantial number of projects counted close to 22,000 in 140 countries, including Hong Kong International Airport and the San Francisco Bay Area Rapid Transit system. The company has distinctly spelled family-driven values and ethics and is headquartered in San Francisco.

**Fluor Corporation** provides professional services related to engineering, procurement, construction and maintenance. The company has expertise and interest in project management services worldwide. The services include oil and gas, chemicals and petrochemicals, transportation, mining and metals, power, life sciences and manufacturing. Fluor is one of the main federal contractors in the US with the net income of \$136.6M in 2010. International staff of more than 35,000 employees proposes cost-effective, intelligent solutions in a timely manner. Above all the structural peculiarities of the company it has network of offices in more than 25 countries throughout six continents.

Source: (Bechtel, 2010; Fluor, 2010a)

Table 5. Leading Engineering Companies, Operations &amp; Activities in Latin America

	Company - Headquarters	Latin America & Caribbean Branches	Latin America & Caribbean Projects
1	Bechtel Group Inc - US	Chile, Brazil, Peru	<b>Chile:</b> Collahuasi Copper Concentrator and Expansion; <b>Los Pelambres Mine:</b> Expanding the capacity of a large copper mine in Chile; <b>Los Brances Mine:</b> Building a new concentrator at a copper mine in Chilean Andes; Nueva Renca power plant. <b>Brazil:</b> Roundup® herbicide plant project.
2	Fluor Corporation - US	Argentina, Peru, Chile, Venezuela, México, Trinidad & Tobago, Puerto Rico	<b>Trinidad &amp; Tobago: Poinsettia</b> - Program management, engineering, procurement, construction, and installation (EPCI), of the 4,267-ton topsides, for an offshore gas production platform for BG Trinidad & Tobago, Limited <b>Chile: Industrial &amp; Infrastructure</b> - Codelco Gabriela Mistral Copper Mining Project Calama, Chile. <b>Mexico:</b> PEMEX Refinación Lázaro Cardenas Refining Complex Minatitlán (oil&gas). <b>Peru:</b> The Yanacocha gold mill.
3	Balfour Beatty PLC - UK	No branches	
4	KBR - US	Mexico	<b>Mexico:</b> KBR provides maintenance and rehabilitation services to PEMEX offshore oil and gas facilities located in the Gulf of Campeche through the Mantenimiento Marino de Mexico (MMM) project initiative.
5	Jacobs Engineering Group Inc - US	No branches	
6	URS Corporation - US	Argentina, Bolivia, Jamaica, Panama, Brazil, Mexico	<b>Mexico:</b> Los Alamos National Laboratory: URS is part of a team that manages and operates the U.S. Department of Energy's (DOE) Los Alamos National Laboratory (LANL) in northern New Mexico. <b>Bolivia - Brazil:</b> Gas TransBoliviano Natural Gas Pipeline - Environmental/Cultural Management Program: URS applied award-winning environmental planning and management expertise to reduce adverse environmental and social impacts of the Bolivia-Brazil Natural Gas Pipeline.
7	SNC-Lavalin Group Inc. - Canada	Mexico, Ecuador, Brazil, Chile, Colombia, Haiti, Honduras, Panama, Peru, Dominican Republic, Venezuela	<b>Brazil:</b> Serra Sul Iron Ore Project;Alumar Alumina Project;Itabirito Iron Ore Project. <b>Chile:</b> specialized in mining geotechnical work, Centre of Excellence for Copper in Chile; Alto Norte Copper Project; Chuquicamata Copper Project. <b>Mexico:</b> New chocolate plant; Sulphuric Acid Plant; Milpillas Copper Project. <b>Ecuador:</b> 45 MW Apaqui Hydroelectric Projects. <b>Venezuela:</b> Las Cristinas Gold Project. <b>Argentina:</b> Veladero Gold Project; Brisas Project. <b>Peru:</b> Alto Chicama Gold Project.
8	CH2M HILL - US	Argentina, Brazil, Mexico, Panama	<b>Argentina:</b> Cargill Soya Oil Processing Plant, ExxonMobil Campana Refinery. <b>Brazil:</b> Sulphur Recovery Facility Engineering design Canoas; Monsanto Seed Improvement Plants. <b>Mexico:</b> Mexico City International Airport Expansion; Cargill and Solar Turbines - Cogeneration Plant Engineering and Procurement Support. <b>Chile:</b> HFC Network Engineering Design
9	AECOM Technology Corp. - US	Brazil, Colombia, Peru, Venezuela, Bolivia	<b>Chile: Carbon Footprint Assessment-</b> AECOM has been selected to work with Chile's largest forest products company to develop a carbon footprint assessment of greenhouse gas (GHG) emissions. <b>Puerto Rico:</b> Rail System. <b>Brazil:</b> Leading a project that analyzes the socio-economic character of 15 fishing communities along the Rio de Janeiro coast.
10	JGC CORP. - Japan	Venezuela	
11	AMEC Plc - UK	Brazil, Chile, Peru	<b>Chile:</b> managing and engineering a Chilean mine; Teck's Carmen de Andacollo Hypogene project in Chile is the latest landmark project in South America <b>Brazil:</b> Provides engineering and consulting services to pulp and paper industry. <b>Peru:</b> AMEC has full service engineering and environmental consulting operation designed to Peru's mining industry.
12	WorleyParsons Limited - Australia	Chile, Trinidad & Tobago, Mexico, Brazil, Colombia & Peru	<b>Chile:</b> Hydro-Electric Power Plant, Lithium Carbonate Plant Expansion; <b>ARA Worley Parsons</b> extensive Minerals & Metals expertise in Chile and other South American countries. <b>Brazil:</b> Mexilhao Gas Export Pipeline; The Petrobras COMPERJ project in Brazil. <b>Colombia-Peru:</b> New operations have also recently been established in Colombia, supporting Ecopetrol and BHP Billiton, and in Peru, supporting a copper project for Southern Peru Copper.
13	Atkins - UK	Puerto Rico, Trinidad & Tobago	
14	Black & Veatch - US	Mexico, Puerto Rico	
15	Parsons Brinckerhoff -US <sup>b</sup>	Argentina	<b>Argentina:</b> Independent Power project , with 500kV power lines
16	HATCH - Canada	Chile, Brazil, Peru	<b>Brazil:</b> Alumar Refinery Expansion; Vale Onça Puma Nickel Smelter. <b>Chile:</b> Anglo Platinum's RBMR expansion project will feature a fully automated nickel electrowinning tank house in the world. The detailed design of the tank house is being undertaken in Santiago, Chile. The world's largest copper mine, in Chile, relies on Hatch Operations Support
17	ARCADIS NV - Netherlands	Brazil ,Chile	<b>Chile (ARCADIS Geotécnica):</b> Merval railway line; Specialized in mining services in Chile. <b>Brazil (ARCADIS Logos):</b> São Paulo subway - Lot 2 of the green line ; São Paulo metro, linha 5 ; In Brazil, ARCADIS Logos is developing a portfolio of small hydropower projects of which two were sold in the fourth quarter of 2008.
18	Construtora Norberto Odebrecht S.A.- Brazil	Brazil (HQ), Chile, Peru, Mexico, Colombia, Bolivia; Costa Rica; Ecuador, Panama, Paraguay, Uruguay, Dominican Republic, Argentina, Venezuela	<b>Chile:</b> Arauco Pulp Plant; Arturo Merino Benitez Airport; Deviation Tunnel on the Maule river to the Colbún-Machicura Hydro Plant. <b>Peru:</b> Charcani V Hydroelectric Power Plant; Chimbote Drinking Water System; Ilo-Desagüadero Highway; Tingo María-Aguaytía Highway. <b>Argentina:</b> General San Martín Oil Pipeline; Pichi Picún Leufú; Hydroelectric Plant; Western Access to Buenos Aires City. <b>Colombia:</b> Cañaveralejo Waste Waters Treatment Plant; La Loma - Santa Marta Railroad; Miel I Hydroelectric Power Plant
19	Poyry Oyj - Finland	Argentina, Brazil, Peru, Colombia, Venezuela, Mexico	<b>Chile:</b> La Confluencia Hydropower Scheme, Chile. <b>Brazil:</b> Horizonte project (VCP), Brazil (Greenfield pulp mill); Veracel Celulose S.A., Brazil (900.000 t/a greenfield bleached kraft pulp mill). <b>Uruguay:</b> Botnia's pulp mill (Greenfield pulp mill project). <b>Colombia:</b> TransMilenio Bus Rapid Transit System (Transportation)
20	Ramboll Group - Denmark	No branches	

Source: OneSource, company websites and annual reports. <sup>a</sup>: Parsons Brinckerhoff Inc. was acquired by Balfour Beatty PLC in Feb.2010.

## IV. COUNTRY CASE STUDIES INTRODUCTION

For this study of Engineering Services in the Americas, five countries cases were selected for analysis: Brazil, Chile, Colombia, Peru, and the United States. The South American nations were selected due to their emerging market status within the continent. Each of these nations experienced impressive growth of their gross domestic product (GDP) within the five-year period (2004-2008) prior to the crisis and initial estimates with respect to their post-crisis growth indicate that recovery has been strong and growth will continue at significant levels. These countries have also led the region as destinations for Foreign Direct Investment (FDI) over the past 5 years (see Appendix 2) (United Nations & ECLAC, 2008). As a result of this development, these countries are likely to continue to provide important sources of demand for engineering services. At the same time, as participation in higher education continues to strengthen in these developing countries and more top global engineering services companies establish operations in these countries, they will play an increasingly important role in the supply of these services not only in the region but also at global level. The United States was selected in order to provide a developed country comparison for the region.

### A. General Overview

Over the past decade, economic growth has been accompanied by an overall improvement in the political stability in these Latin American countries. Brazil and Chile continue to show strong political and economic leadership within the region. Colombia emerged from the civil war that had ravaged the country for almost twenty years and President Uribe, elected in 2002 has helped to vastly improve the political situation in the country and in Peru, after the extremely corrupt years under the Fujimori presidency, the governments of Alan Garcia and Alejandro Toledo have shown marked improvements in political stability and the rebel movement there has to some extent been controlled.

Table 6 below provides an overview of selected indicators of the macroeconomic and political situation of the countries selected for this study.

**Table 6. Selected Economic Indicators, 2008**

		Brazil	Chile	Colombia	Peru	US
<b>GDP per capita (US\$)(2007)</b>		6,938	9,989	3,676	3,972	45,963
<b>GDP per capita (US\$)(PPP)</b>		10,387	14,517	8,692	8,448	47,496
<b>GDP growth (Annual %)</b>	<b>2004</b>	5.72%	6.04%	4.98%	4.66%	3.65%
	<b>2005</b>	3.16%	5.56%	6.83%	5.72%	3.08%
	<b>2006</b>	3.97%	4.59%	7.74%	6.94%	2.87%
	<b>2007</b>	5.67%	4.68%	8.86%	7.55%	2.00%
	<b>2008</b>	5.08%	3.16%	9.84%	2.53%	1.10%
<b>Foreign Direct Investment Flows (US\$ million)</b>		45,059	17,083	10,564	4,079	325.3 billion
<b>Ease of Doing Business (out of 183 countries)</b>		129	49	37	56	4
<b>Labor Force (m)</b>		99.5	6.8	19.3	10.26	153.1
<b>Population (m)</b>		189.6	16.8	48.3	29.15	304.1
<b>Political Stability (Percentile Rank (0-100))</b>		38.3	66.0	8.1	19.1	68.4
<b>Corruption Perceptions Index (CPI) Ranking<sup>a</sup></b>		80	23	70	72	18

Source: (ECLAC, 2008; Economist Intelligence Unit, 2009, 2010a, 2010b; The World Bank Group, 2010b; Transparency International, 2010). <sup>a</sup> CPI Rank Out of 180 countries.

As can be seen in Table 6, FDI flows have increased throughout the region in the past decade reflecting general improvements in investment conditions and new business opportunities. Brazil attracted the largest FDI flow in 2008 with US\$45 billion, followed by Chile with US\$17 billion in 2008 (ECLAC, 2008). FDI in Peru reached US\$4 billion in 2008 while investment grade improvements for Colombia saw FDI increase to US\$10,5 billion in 2008 (ECLAC, 2008). Foreign investments in Chile, Colombia and Peru are subject to “national treatment” and there is no discrimination between foreign and domestic investments and foreigners are allowed to invest in all industries with few exceptions. Brazil continues to prohibit foreign investment in certain industries that are considered to be key to national security.

Regarding the business environment in the region, Colombia has made significant advances in improving the regulatory structure of investing and establishing businesses, and now outranks Chile as the easiest country in which to do business in Latin America (The World Bank Group, 2010a). Strong growth of FDI in Brazil demonstrates that the enormous potential of the Brazilian domestic market, which was ranked 9<sup>th</sup> in the world by the World Economic Forum, outweighs the complexities and costs of doing business in the country (World Economic Forum, 2009). Brazil ranks poorly as 129<sup>th</sup> out of 186 countries in the ease of doing business ranking (The World Bank Group, 2010a). The tax and customs systems continue to place an enormous burden on companies operating in and with Brazil (Business Monitor International Ltd., 2010a) and the labor market is highly regulated, discouraging employers from hiring more employees and impeding improvements in unemployment in the formal sector (Datamonitor, 2009a).

Corruption and security problems have been significant deterrent factors in business in Latin America. In particular, in Peru, corruption is rife and the country ranks 72<sup>th</sup> out of 180 countries in Transparency International's Corruption Perception Index (The World Bank Group, 2009; Transparency International, 2010). This is a particularly important problem in the engineering and construction sector (PriceWaterHouseCoopers, 2009). The World Bank Indicators for political stability place Peru in the bottom quintile (The World Bank Group, 2009); while in Colombia, despite improvements since the election of Uribe in 2002, the ongoing activities in rural areas of rebel groups such as FARC, Colombia's rank remains very low in political stability (Datamonitor, 2009b). Brazil also has to improve issues of corruption, ranking 80<sup>th</sup> in the Corruption Perception Index. Chile is exemplary in the region in terms of both control of corruption and political stability.

## B. Regional Demand for Engineering Services

Infrastructure development is a key demand driver for engineering services in the Americas, both in the developing nations of Latin America and in the United States. The United States will require approximately US\$2.2 trillion of investment to upgrade its aging and inadequate infrastructure (The Urban Land Institute and Ernst & Young, 2010).

Brazil, Colombia and Peru rank 8<sup>th</sup>, 9<sup>th</sup> and 10<sup>th</sup> respectively in the World Economic Forum's Infrastructure Quality Gap Index for Latin America,<sup>7</sup> highlighting the urgent need to establish roads, ports, airports and energy systems to support strong economic growth rates (Mia et al., 2007). Since privatization and liberalization of these Latin economies in the 1990s, most infrastructure projects are operated

Over the next five years, infrastructure development will be a key driver of demand for engineering services in the Americas region as a whole. These projects will mostly be operated as public-private partnerships.

as public-private partnerships (PPP), with concessions being awarded for typical periods of 20-25 years. Chile, which pioneered the establishment of PPP arrangements in LAC in infrastructure development, continues to perform well with respect to a well-established infrastructure, although the significant damage caused to the national infrastructure system by the February 2010 earthquake has been estimated at US\$8,431 million (Gobierno de Chile, 2010).

<sup>7</sup> El Salvador, Uruguay, Guatemala, Mexico and the Dominican Republic all rank higher than these three key countries (Mia et al., 2007).



Prior to the economic crisis, Colombia, Peru and Brazil all announced large infrastructure plans, which

FDI has increased across the region with improvements in investment conditions in most countries. Corruption and security, however, continue to deter investment and development in certain sectors.

will drive engineering services demand in the region. Demand will be further compounded by expected increases following large stimulus packages in all countries which allocated significant proportions to infrastructure development, while Brazil will see the additional impact on demand due to its hosting the World Cup in 2014 and the Rio Olympic Games in 2016.

The demand for large infrastructure projects in Latin America has concentrated in few sectors: Hydrocarbons, Energy and Transport (see Table 7). The largest of these projects for 2010, in Mexico will require an investment of US\$7.5 billion.

**Table 7. 15 Largest Infrastructure Projects in Latin America in 2010**

	Project Name	Country	Sector	Investment (US\$ Millions)
1	New Refinery Train*	Mexico	Hydrocarbons	7.464
2	Río Madeira Hydroelectric Project*****	Brazil	Energy	6.200
3	Expansion of the Panama Canal**	Panama	Transport	5.250
4	Los Andes Railroad Project***	Argentina-Chile	Transport	4.800
5	HidroAysén Hydroelectric Project*	Chile	Energy	3.200
6	Highway "Transversal de las Américas"***	Colombia	Transport	3.050
7	Inter-ocean Highway Chile-Argentina***	Chile-Argentina	Transport	3.000
8	Highway "Autopistas de la Montaña"*	Colombia	Transport	2.800
9	Highway Ruta del Sol****	Colombia	Transport	2.600
10	Reconfiguration of the Salina Cruz Refinery ****	Mexico	Hydrocarbons	2.517
11	Topolobampo I, II and III and the Coal Terminal *****	Mexico	Energy	2.164
12	Binational Bolivia – Brasil Hydroelectric Project*****	Bolivia- Brazil	Energy	2.000
13	Reconfiguration of the Tula Refinery ****	Mexico	Hydrocarbons	1.937
14	Pécem Central Thermoelectric Project *****	Brazil	Energy	1.853
15	Garabí Hydroelectric Project****	Argentina- Brazil	Energy	1.700

Source: (América Economía, 2010c)

\*Feasibility Studies /\*\*Approved /\*\*\*Open Bidding /\*\*\*\*Design Phase /\*\*\*\*\*In Construction

In addition to infrastructure, improvements in rural security in both Peru and Colombia have led to an increased interest in the mining industry. While Peruvian mining investments have seen steady growth over the past two decades, commercial mining is a new growth area for Colombia and it is quickly attracting foreign direct investment to the country. Chile continues to have a very strong mining sector. In addition to mining, the oil and gas sector in Latin America has gained new importance with key new discoveries in Peru and Brazil along with increased production in Colombia, which currently produces 8% of the regional supply. These finds have resulted in an increased demand for refinery and pipeline development as well as research and development projects for deep sea drilling in Brazil.

### C. Trade in Engineering Services in Latin America

Service trade in engineering has increased across all countries in this study. A large number of Colombian and Chilean firms have a presence in the Peruvian market, particularly in energy and mining projects. Brazilian engineering and construction firms are present throughout the region and participate in a significant proportion of large infrastructure projects. Panama is a particularly competitive market owing to its lack of engineering talent and is contested by Peruvian, Colombian and Brazilian firms. In addition, due to its relative cost advantages and high number of engineering graduates, Colombia is emerging as an engineering services platform to serve the Latin America and Caribbean region. While Chile generally exports engineering services globally, in 2008 35% of these services were exported to Peru. However, the size and destination of the country's exports varies from year to year based on projects.

### D. Expertise

In Brazil, engineering expertise lies in infrastructure development. The tremendous size of the country and a broad social policy has resulted in engineering skills being focused on building roads, energy plants, housing etc.<sup>8</sup> Chile has developed a significant level of expertise in mining engineering, in both open-pit and underground mining as a result of the extensive copper and gold operations in the country. As a leader in public-private partnerships in infrastructure development in the region, the country has also established significant expertise in that area. In addition, due to the country's location over an important tectonic fault line, Chilean engineers have developed important skills in seismic engineering. Colombia's engineering strengths lie in hydroelectric power installations, which draw on high levels of expertise in both electrical and civil engineering, which have developed as a result of adapting to the country's rivers and mountainous landscape. Given the limited size of the Peruvian market, in order to remain competitive engineering firms in Peru have emerged as multidisciplinary operations rather than developing expertise in any specific field of engineering, although the country's leading engineering schools excel in civil engineering. The large domestic market in the

Engineering service trade in Latin America is on the rise. While Chile exports mining services globally, Colombia is opening the Central American infrastructure markets. Brazil has emerged as a leading regional supplier of engineering services for the infrastructure sector. The country's expertise lies in civil engineering.

<sup>8</sup> Brazil has also developed considerable expertise in the aeronautical and automobile industries as a result of focused industrial policy. Canadian airplane manufacturer Bombardier has begun recruiting engineers at the prestigious Brazilian Instituto Tecnológico de Aeronáutica (Aeronautical Technical Institute) (Fleury, 2010).

United States, combined with a well-developed education system has led to the country gaining expertise in most engineering disciplines.

## E. Education

Engineering education in Latin America has undergone several changes over the past ten years. There has been a shift from six-year programs to those of four to five years that are more closely aligned to the United States education system. Chile continues to follow a six-year program at the university level, with a growing number of four-year programs being offered from professional institutes. Colombia and Peru have seen program lengths reduced to four and five years respectively.

Engineering education has also been affected by a more general trend in Latin America of declining quality that has characterized the emergence of a large number of private universities across the continent.<sup>9</sup> In most countries, “traditional” universities, such as established federal or state universities and those in the Catholic Universities network, continue to be considered the best engineering schools. In addition, an increasing number of technical schools are emerging across the region to provide two to four year technical diplomas in different engineering disciplines. In Chile, professional institutes cater to most engineering disciplines, as do technical institutes in Brazil. Peru still offers limited vocational training in engineering, which is mainly focused on mechanical and electronic engineering.

Engineering education across Latin America has been affected by the rapid expansion of private universities and a resulting decline in quality. Accreditation programs are necessary in all countries to provide quality assurance.

There are two main issues regarding the education of engineers in Latin America. The first refers to the quantity of engineers. In Colombia, the number of engineers is declining; while in the other countries analyzed there are shortages in specific areas. Brazil has a limited number of mining engineers and the state-owned mining company has had to recruit professionals in Australia in recent years. Colombia is also facing an increasing demand for mining engineers; a sector that has been inactive for many years and is showing strong signs of reactivation. In Chile, which has a well developed and highly productive mining sector, also confronts low number of mining engineers (SONAMI : Sociedad

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<sup>9</sup> For a detailed discussion of the challenges facing higher education in Latin America see (Holm-Nielsen et al.).

Nacional de Minería - Chile, 2009). An industry study carried out in 2004 estimated a global shortfall of 10% for engineering positions in the mining sector (Davison, 2008).

The second concern refers to the quality of engineering graduates as mentioned earlier in the report. Companies do not face significant problems with quality when hiring from top tier universities, however, in recent years the rapid expansion of new private universities with less rigorous academic programs has led to an increasing number of engineering graduates entering the market with lower skill levels. Many Latin American countries lack a formal accreditation system to guarantee a graduate's skills. Only a few countries, such as Chile have compulsory accreditation regulation.<sup>10</sup> Another concern in the engineering education in Latin America is the lack of interpersonal skills development opportunities in the curriculum, especially managerial abilities and working on teams. Languages are also relevant, especially when engineers have to work in multicultural environments.

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<sup>10</sup> In the US, accreditation is still voluntary although there is considerable pressure from the market for university programs to seek accreditation to facilitate job placement and entrance of alumni to graduate programs (ABET Inc, 2010).

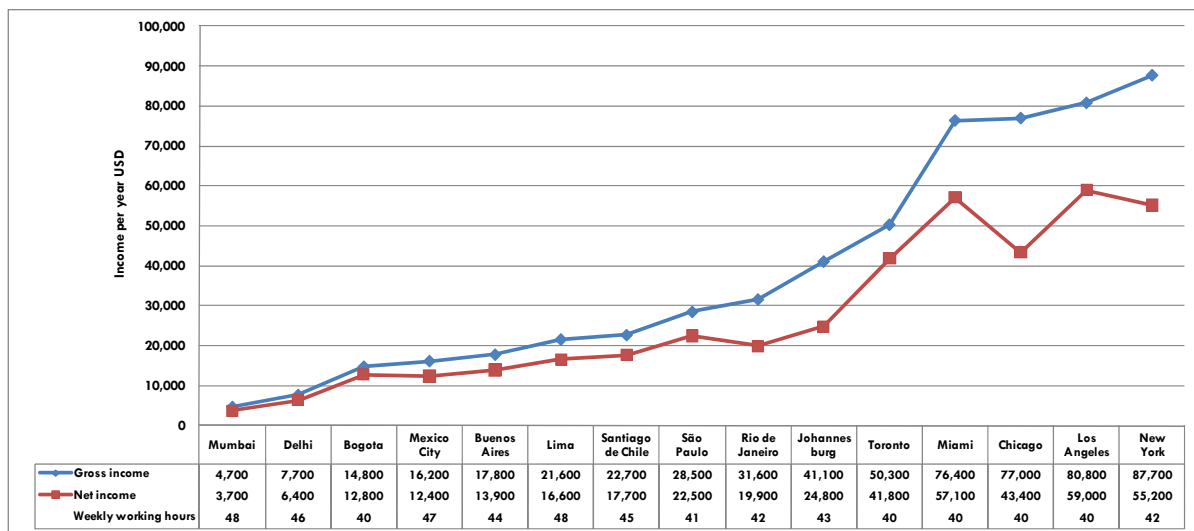
## F. Salaries

While salaries vary between the different engineering disciplines, general salary trends can be identified within the region. The most expensive engineers are those in the United States with annual average gross salaries of approximately US\$80,000 (UBS, 2009). Within Latin America, salaries show a clear cost advantage over the United States, with labor costs approximately 50% of those in the United States (UBS, 2009).

Colombia's competitive labor costs have been identified by leading multinational firms as a potential platform for engineering service exports in the region.

Brazilian engineers, the most expensive in Latin America, have significantly lower salaries than those in the US, with salaries in Sao Paulo and Rio de Janeiro averaging slightly over US\$30,000 and have increased significantly within recent years (UBS, 2006). With annual gross salaries of approximately US\$22,700 annually, Chilean engineers cost marginally more than Peruvian engineers (US\$21,600). Colombian salaries are amongst the cheapest in the region at US\$14,800 per year (UBS, 2009). Colombia has a strong labor cost advantage over other countries in the region and as macroeconomic and political conditions have improved in the country, it has been identified by leading multinational firms as a potential platform for engineering service exports in the region. Figure 2. below provides an overview of both gross and net incomes for engineering services in key cities in Latin America and the United States. Globally, India continues to be the cheapest location to hire engineers.

**Figure 2. Engineering Salaries in Key Global Markets**



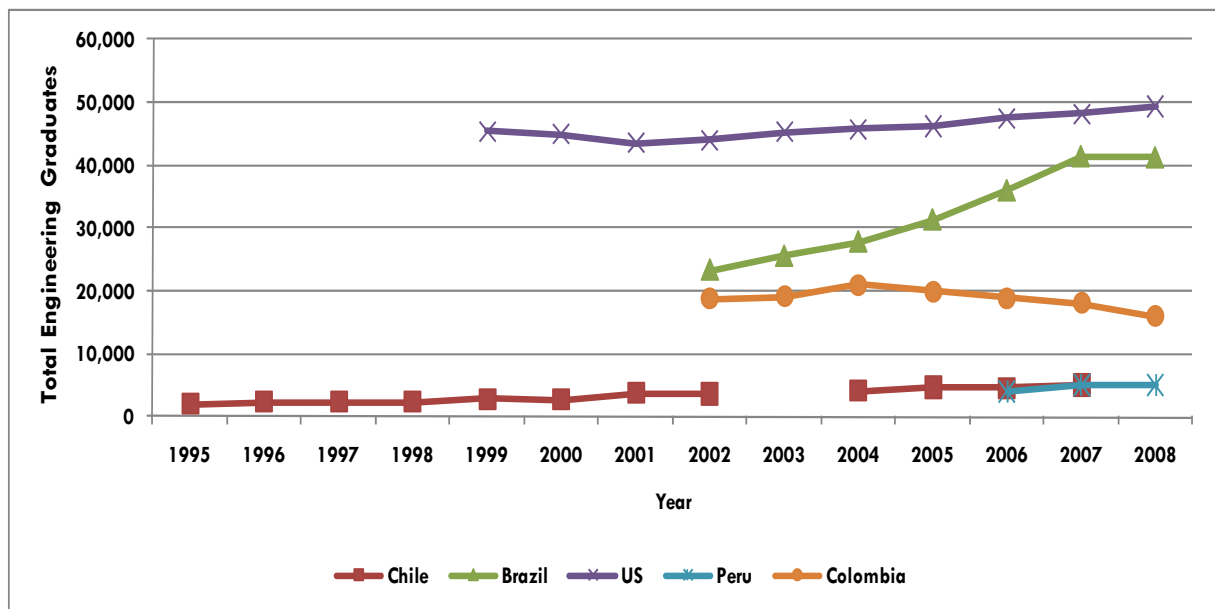
Source: (UBS, 2009)

Note: Gross income: Annual gross income, including bonuses such as profit sharing, performance bonuses, holiday pay, additionally monthly salary payments and family allowances. Net income: Gross income after taxes and social security contributions.

## G. Supply of Engineers

Figure 3 provides a comparison of the number of engineers from selected disciplines graduating annually over the past decade.<sup>11</sup> With the exception of Colombia, all countries continue to expand their stock of engineering talent and have steadily increased the number of engineering graduates each year since 2002. The United States has the largest number of engineers, with approximately 1.6 million jobs in the engineering field and graduates just under 50,000 engineers annually. Brazil steadily increased its number of engineering graduates between 2002 and 2007 to 41,000 in 2007 and 2008. Peru and Chile both graduate a limited number of engineers per year, with approximately 5,500 university degrees awarded annually.

**Figure 3. Total Annual University Engineering Graduates, per Year- Selected Disciplines**



Source: (Bureau of Labor Statistics 2009; Colegio de Ingenieros del Perú, 2010; Gibbons, 2009; Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira, 2002-2008; Ministerio de Educación de Chile, 2009; Ministerio de Educación de Colombia, 2009).

Engineering graduate growth rates leveled off in Brazil in 2008 and there are some concerns that this will compound the pending shortage of engineers in the country, particularly given the country's new industrial policy which is driving the establishment of new foreign-owned industrial R&D centers (Fleury, 2010). In Colombia, the arrival of a host of MNCs has attracted a growing number of students to economics, business administration and law, which has combined with high education costs

<sup>11</sup> Engineers from the following fields were included in this comparison: Civil, Mechanical, Industrial, Metals-Metallurgy, Chemical, Mining, Forestry, Construction, Electrical, Environmental, Aquaculture, Agricultural and Petroleum Engineering.

and low salaries to significantly reduce the number of engineering graduates (Parra, 2010). In the long term, this is expected to impact wages and reduce the impressive cost advantages that currently characterize Colombian engineering services. Peru continues to produce a relatively small number of engineers considering the size of its labor force, which is almost twice the size of that of Chile. This has prompted the Colegio de Ingenieros de Peru to launch a program to attract more students to the field of engineering.

## H. Firm Type

Multinational firms typically enter new Latin American market through joint ventures or alliances with local partners in order to meet engineering needs primarily in the oil and gas and mining sectors.

There is a high degree of variation in firm type across the countries studied. The Chilean market is amongst the most consolidated in the region, with a large number of both medium to large domestic and foreign firms. The Peruvian market is generally characterized by small engineering firms with a high presence of foreign firms in all engineering sectors, but specifically in mining, petroleum and energy.<sup>12</sup>

Significantly, there are a large number of Chilean, Colombian and Brazilian firms operating in Peru. The Colombian market has a core group of large leading domestic firms and foreign firms, until recently, have been present principally in the mining and petroleum sectors. The Brazilian market is dominated by leading domestic firms, although foreign firms entering the country are showing rapid growth in mining, petroleum and energy sectors. Firms from the United States are present in a large number of countries. Engineering companies in the region are actively seeking International Organization for Standardization (ISO) and Occupational Health & Safety Advisory Services (OHSAS) certifications in order to provide quality services (See Appendix 4. for a list of mayor ISO and OSHAS certifications.)

Where there is a significant presence of multinational firms, there is a rapid transfer of knowledge to the local market, which is then leveraged for exports to the region as in the case of Chile. In the case that foreign firms are largely absent as a result of security concerns or low domestic demand, the limited size of local engineering firms generally requires these firms to join together in consortiums in order to meet the demands of large projects. This model has been more prevalent in Colombia.

<sup>12</sup> Peru has just two large domestic engineering firms, Graña y Montero Ingenieros and Cesel S.A (see Table 17 for more information regarding engineering firms in Peru.)

## V. BRAZIL ENGINEERING SERVICES

### **In Brief**

The recent rapid growth of the Brazilian economy, combined with the government's social policies focused on improving housing and basic services, has led to strong demand for engineering services over the past five years. This increase in demand has led to a corresponding rise of engineers' wages. In addition, major new oil discoveries and a rapidly expanding mining industry are going to further drive demand for highly specialized petroleum and mining engineers which are already in short supply. While the top tier engineering schools continue to produce high quality graduates with expertise in engineering fields related to infrastructure development rather than hi-tech industries, little has been done to increase the number of engineers at those schools. This is expected to lead to a shortage of quality engineers in the medium to long term.

### **A. Overview**

Brazil is among the world's fastest growing and most important emerging economies. Growth rates recovered from the 1998 crisis and continued steady through the global financial crisis in 2008 and 2009, driven by strong domestic demand and a tight fiscal policy (Economist Intelligence Unit, 2010a). During the past two decades, the economy has become increasingly liberalized with more private sector involvement and foreign direct investment with the exception of a few sectors that are considered of national strategic importance (Datamonitor, 2009a). This privatization began under the Cardoso (1995-2003) administration and continued under Lula's government (2003-current) who reduced the public expenditure particularly in infrastructure to provide space for private sector investment. It is expected that the macroeconomic stability that characterized Lula de Silva's Presidency is likely to continue under the next President, regardless of who wins the 2010 elections (Economist Intelligence Unit, 2010a). Nonetheless, despite increased liberalization across certain sectors, Brazil continues to be one of the most difficult destinations in which to operate in Latin America. Corruption is perceived to be widespread and businesses are expected to encounter corruption in government bids (Datamonitor, 2009a), while violence also remains a key problem. Sao Paulo experienced the highest homicide rate in a single day recently, and the rampant violence in the slums in the large cities continues to raise security questions in the country (Datamonitor, 2009a).

The Brazilian economy relies heavily on its natural resources, although the manufacturing industry has benefited from industrial policies implemented in the past. The domestic market has become a



significant driver of the Brazilian economy, with GDP per capita rising steadily from US\$2,815 in 2002 to US\$8,205 in 2008(The World Bank Group, 2010b).<sup>13</sup>Exports are also key, accounting for approximately 23% of Brazil's GDP. Table 8 below shows Brazil's key export sectors.

**Table 8. Brazilian Merchandise Trade by Product, 2007-2008 (USD billion)**

Products	2007	2008
<b>Agricultural</b>	<b>54.52</b>	<b>69.50</b>
Food	47.28	61.16
Raw materials	7.24	8.34
<b>Petroleum and Mining</b>	<b>57.92</b>	<b>80.30</b>
Ores and other minerals	16.52	24.54
Fuels	33.38	47.82
Non-ferrous metals	8.03	7.94
<b>Manufacturing</b>	<b>129.91</b>	<b>166.76</b>
Iron and steel	11.78	16.49
Chemicals	30.45	41.76
Other manufactures	24.30	27.30
Machinery and Transport Equipment	60.87	78.63
Textiles/Clothing	2.50	2.58
<b>Others</b>	<b>36.07</b>	<b>49.94</b>
<b>Total merchandise</b>	<b>278.42</b>	<b>366.50</b>

Source: (World Trade Organization 2009)

As can be seen above, Brazil has strong competitive advantages in agriculture and its leading exports are in primary materials including fuels and mineral ore, although automobile and airplane manufacturing (listed as Machinery and Transport Equipment) also feature strongly. New discoveries and development in the petroleum and mining sectors are also gaining attention from foreign investors. Foreign investment in general has picked up since 2003 as the economic openness has improved. In 2007, FDI reached US\$35 billion (ApexBrasil, 2010) and \$45 billion in 2008 (ECLAC, 2008).

## B. Engineering Demand

### 1. Extractive Industry

Brazil has considerable reserves of both hydrocarbons and minerals. It is amongst leading producers of bauxite, iron ore, graphite and manganese in the world and has the largest coal reserves in Latin America (Business Monitor International Ltd. , 2010; Gurmendi, 2009a). It has proven oil reserves of 12.6 billion barrels (BP, 2009). Oil production is rising fast, although the country still has significant unexploited reserves potential (Business Monitor International Ltd. , 2010). In 2006, state-owned Petrobras and its partners encountered a major new oil province with the potential to catapult Brazil

<sup>13</sup> Gross Domestic Product per capita at current prices. Not adjusted for inflation and converted to US dollars applying market exchange rates.

to one of the top ten oil producing countries in the world. This is already attracting attention from large MNCs; GE announced plans in 2010 to establish a research and development center focused on equipment related to deep sea oil extraction in Brazil to help the country exploit this pre-salts discovery (Emerging Markets Information Service (EMIS), 2010).

New offshore oil and gas reserves discovered in 2006 by Petrobras and its partners have the potential to catapult Brazil into the top ten oil producers in the world.

The exploitation of these reserves is likely to drive demand for new infrastructure such as refineries and pipelines to support the tremendous growth. Brazil currently only has 12 refineries and there are already plans to establish more.

Brazil's vast iron-ore industry is also attracting both foreign and domestic investments, with mining largely being driven by the growth in Chinese demand. The Departamento Nacional de Producao Mineral reported that investments in mineral exploration increased from US\$284 million in 2006 to US\$400 million in 2007 (Gibbons, 2009). In November 2009, Chinese firm Wuhan Iron and Steel Company announced investments in Brazilian mining firm, MMX which is expected to increase production tenfold. Nacional Mineros S.A. has announced the development of new iron ore plants worth US\$1.3 billion. While reserves suggest that growth will continue to be strong in the mining sector, the near future demand for mining will depend on pending changes to the mining code, which by increasing mining royalties, may make Brazil less competitive (Business Monitor International Ltd. , 2010). Business Monitor International forecasts that the industry will be expanding at 5.6% per annum by 2014. The country is already facing shortage of mining engineers; one company went as far as Australia to recruit engineers in order to overcome this shortage.

## 2. Infrastructure

Infrastructure in Brazil has suffered from years of underinvestment (Datamonitor, 2009a). To mitigate these shortages from slowing export growth, in 2007, the Accelerated Growth Program (*Programa de Aceleracao do Crescimento*, PAC) was launched to improve the country's infrastructure. The PAC program allocated US\$250 billion for infrastructure development between 2007 and 2010. Of particular importance is the development of the country's transport infrastructure, which requires significant investments in roads, railroads, bridges, airports and ports. Brazil's port infrastructure, for example, is ranked 127 out of 133 countries in the World Economic Forum's 2010 Global Competitiveness Report (2010). Brazil's National Maritime Administration Agency (ANTAQ) forecasts total throughput at the country's ports to reach 1.2 billion tons a year by 2023, an increase of about 85% on 2008 levels driving a huge need for investment in new port infrastructure (between 1998

and 2008 only \$4.7 billion was invested in the 37 public ports). In 2008, the government thus opened public ports up to private concessions for 25 years to both domestic and foreign investors (Business Monitor International Ltd., 2010a).<sup>14</sup> Another important infrastructure development includes the high speed rail project between Rio, Sao Paulo and Campinas that opened for bidding at an estimated cost of \$19 billion at the end of 2009 (Business Monitor International Ltd., 2010a).

Furthermore, progress needs to be made with respect to the country's energy infrastructure which is

Demand for improvements and expansion of Brazil's infrastructure will increase significantly within in the next 2-4 years as a result of the Accelerated Growth Program II, the World Cup (2014) and the Rio de Janeiro Olympics (2016).

said to be holding back the nation's development (Datamonitor, 2009a). In November 2009, a weak transmission infrastructure led to major blackouts. Brazil's energy generation comes from hydro (82%), gas (5%) and coal, nuclear and oil (3%), renewable (5%) (Business Monitor International Ltd., 2010a). Proposed projects for improving energy supply include the controversial Belo

Monte dam in northern Brazil which was given the go-ahead by Brazil's Environment Minister in February 2010. This hydro electrical project represents what will be the 3<sup>rd</sup> largest in the world (Phillips, 2010).

Importantly, Brazil was awarded the bid for both the 2014 World Cup and the 2016 Olympics. This is the first time the Olympics will be held in Latin America and the first time in 36 years that the World Cup returns to the continent. The two tournaments will require significant new infrastructure development. In January 2010, federal, state and municipal governments signed an agreement to cooperate in the investment of \$11.3 billion in development of infrastructure for the 2014 World Cup (Business Monitor International Ltd., 2010a). Furthermore, the budget for development for the 2016 Olympics in Rio de Janeiro account for an additional \$14.4 billion. In particular in Rio, likely investments will require a new subway, improvements in urban highways, water systems and electricity supply (Business Monitor International Ltd., 2010a).

The government increased public spending on infrastructure by 50% in 2008 as part of the stimulus package to continue to drive economic growth and plans for the second wave of infrastructure spending (PAC II) are also underway for continued development from 2011 to 2014 (Business Monitor

<sup>14</sup> Private-public agreements in infrastructure accounted for 95% of all infrastructure development in Brazil between 2003-2007.

International Ltd., 2010a). It is expected that infrastructure development, government house-building incentives and private investment will lift construction in 2010-2011 and the 54,000 new jobs created in January 2010 in the construction sector indicate that the country is rebounding from the economic crisis (Economist Intelligence Unit, 2010a).

### 3. Industrial Growth

During the first decade of the 21<sup>st</sup> century, heavy industry in Brazil experienced tremendous growth largely due to foreign investments. Including aircraft, automobile (most of the major automobile manufacturers in the world have set up plants in Brazil), industrial equipment and chemicals (Datamonitor, 2009a), the industry sector represents approximately 28.5% of the GDP, registering annual growth rates of over 10% since 2002. This sector is driving demand for production engineers which had slumped over the past few years (Fleury, 2010).

## C. Engineering Supply

### 1. Engineering Firms

Brazil's engineering services have evolved to a large degree within the construction sector and today, there are four large domestic civil engineering firms that dominate engineering services within the country. Foreign engineering firms began to enter the market in the 1990s, despite the challenges posed by the regulatory system in Brazil. These regulations require foreign firms to work in joint ventures with a local firm or to establish a branch within the country. Import duties on services make it expensive to provide services from abroad (World Economic Forum, 2009) and it is rare for a company to establish greenfield operations in Brazil, largely due to the complex local business environment (Fleury, 2010).

There are four leading domestic firms in Brazilian engineering, Odebrecht S.A., Camargo Corrêa,<sup>15</sup> Queiroz Galvão S.A. and Andrade Gutierrez. These firms are focused in construction and heavy engineering. All firms have an international presence, both in Latin America and further afield (Business Monitor International Ltd., 2010a; Fleury, 2010; Maciente, 2010; Salerno, 2010). These firms largely influence policy in the sector as well (Fleury, 2010). Table 9 provides an overview of these four leading firms.

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<sup>15</sup> Camargo Correo sold its engineering subsidiary, CNEC Engenharia, to Australian firm Worley Parsons in early 2010 (WorleyParsons, 2010).

**Table 9. Leading Engineering Services Companies in Brazil**

Company Name	Revenue - USD million (2008)	Employees	Activities
<b>Construtora Norberto Odebrecht S.A</b>	NA	43,859	Areas of Operation: Construction, Engineering, Management, Environment, Financing and Project Development, Quality, Supply, Workplace, Health and Safety
<b>Camargo Corrêa</b>	4,660	54,000	Holding company with interests in the construction, civil engineering, ship-building, cement, footwear, textiles, electrical energy, and transport. The company holds a minority share in many leading Brazilian enterprises.
<b>Queiroz Galvão S.A.</b>	3,009	29,873	The Queiroz Galvão Group was created in 1953 as a construction company and is currently active in various segments of the economy, such as: drilling and production of oil and gas, production and processing of foodstuffs, association with companies in the concession of public services in Brazil, steel plants and environmental engineering services.
<b>Andrade Gutierrez</b>	2,438	NA	Founded in 1948 in Belo Horizonte, Brazil, The Andrade Gutierrez Group is one of the largest private groups in Latin America, with operations in Engineering and Construction, Telecommunications, Power, and Public Concessions.

Source: Company Websites, One source, ISI Emerging markets website

<sup>a</sup> WorleyParsons, the Australia-based engineering and construction management firm, has announced a deal to acquire CNEC Engenharia, the engineering and project management arm of Brazil's Camargo Correa, for \$98 million (ENR.com, 2010).

Ten of the world's top twenty leading multinational engineering firms have established a presence in Brazil, including Bechtel, SNC-Lavalin, WorleyParsons and Hatch.<sup>16</sup> Recently, Worley Parsons aggressively consolidated its position in the market with the purchase of CNEC Engenharia S.A., the engineering subsidiary of Camargo Correa, one of the country's four top firms. SNC Lavallin have also made two major acquisitions in the country within the past three years, buying Minerconsult and Marte Engenharia and bringing their office size to 1,600 engineers with expertise in mining and the energy sector (SNC Lavalin, 2007; Torres, 2010). Hatch opened an office in 2004, for which Hatch Chile provides extensive support for metals mining. Given the size of the Brazilian market and projected growth rates in engineering demand, the company expects the Brazilian office to continue to be a net importer of services within the Hatch family (Pino, 2009).

## 2. Expertise

Brazil's key engineering strengths lie in **civil and construction engineering**, including roads, energy infrastructure and housing (Fleury, 2010; Salerno, 2010). Due to the tremendous size and varied geography, the country has developed considerable skills in civil engineering to build the required infrastructure and

Engineering expertise in Brazil lies in civil and construction engineering. Given the tremendous infrastructure needs of the country, it has been slow to move into hi-tech engineering sectors and is unlikely to do so without a clear industrial policy.

<sup>16</sup> See Table 4 for a list of the world's leading engineering firms.

primarily focused in the low technology segments. Much of this infrastructure development took place in the early 1960s and 1970s (Fleury, 2010) while more recently Brazil has been focused on using these skills to solve social policy issues such as building houses, roads, hospitals, etc. Brazil also has considerable strength in petroleum engineering, as state owned company, Petrobras works with federal universities to conduct research and development and thus the area is in constant evolution. CENPES, the Center for Petroleum Research, for example, is based at the Federal University of Rio (Fleury, 2010). Mining strengths have also developed through the state owned company Vale Rio do Doce (known as Vale), although the supply of mining engineers is more limited. Engineering in the telecommunications sector is also a particularly acute weakness for the country. The specialty solicited the fewest applications in 2009 for university entry (Salerno, 2010).

### 3. Salaries

Brazilian engineers are considerably more expensive than their counterparts in other countries in Latin America and, in some specialties, salaries are comparable to those of the United States (Carter, 2010). The cost of engineering is highest in Rio de Janeiro where average annual gross salaries for engineers with five years of experience are approximately US\$31,600 (UBS, 2009). With respect to salaries of different engineering disciplines, information lacks consistency, although most reports suggest that engineers in the oil and gas sector earn significantly higher salaries, on par with the those in the United States.<sup>17</sup> Table 10 shows salaries based on census data from 2000.

**Table 10. Monthly Engineering Salaries in Brazil, 2000 and 2005**

Engineering Program	2000 Average Monthly Salary	Employability 1 year out (Ages 20/24)	2005 Average Salary Monthly Inflation adjusted *1.55	2005 in US *Exchange 2.5 R to US\$
Engineer with Masters or Doctorate	R\$ 6.938,39	0.95 <sup>a</sup>	R\$ 10,754.50	\$4,301.80
Other Engineering programs	R\$ 6.141,05	0.87	R\$ 9,518.63	\$3,807.45
Mechanical Engineering	R\$ 5.576,49	0.88	R\$ 8,643.56	\$3,457.42
Civil Engineering	R\$ 5.476,85	0.90	R\$ 8,489.12	\$3,395.65
Geology	R\$ 5.285,77	0.92	R\$ 8,192.94	\$3,277.18
Electric & Electronic	R\$ 5.231,07	0.89	R\$ 8,108.16	\$3,243.26
Industrial & Chemical Engineering	R\$ 4.844,92	0.90	R\$ 7,509.63	\$3,003.85
Agronomy	R\$ 4.356,56	0.88	R\$ 6,752.67	\$2,701.07
Architecture	R\$ 3.835,08	0.92	R\$ 5,944.37	\$2,377.75

<sup>a</sup>Ages 25-29

Source: (FGV Centro de Políticas Sociais, 2000)

After engineers in the extractive industry (not included in the table), mechanical and civil engineers continue to be amongst the highest paid in the field. According to an upcoming study from the Instituto

<sup>17</sup> Petroleum engineers appear to be highly mobile in the global labor force and thus developing countries are forced to compete with salaries equal to those offered in developed nations. Within Latin America, Colombia faces similar challenges with respect to retaining engineers in the oil and gas sector.

de Pesquisa Econômica Aplicada, Brasil (IPEA), salaries across all engineering field experienced a significant increase in 2006, with some salaries increasing by more than 50% (Maciente, 2010).<sup>18</sup>

### D. Engineering Education

Engineering education in Brazil is divided into technical and university training. Technical training is carried out at technology institutes across the country and programs last between three and four years. University engineering programs are five years long and the system is closely linked to the European engineering educational system. In 1995, PRODENGE, the Brazilian National Program for Engineering Development was created to foster the restructuring and modernization of engineering education and research in Brazil (Longo et al., 1996). In particular, this program has been focused on redesigning engineering curriculum to include a broader range of interpersonal and management skills and to increase the interdisciplinary nature of the teaching, as well as fostering the development of collaborative networks between the private sector and research institutes (Longo et al., 2000).

The state engineering schools in Brazil are generally very good, and Brazilian engineers graduating from these top tier programs are considered to be competitive abroad. These large schools, most of which are federally owned, typically dominate engineering, as can be seen in Table 11 below where the leading university engineering programs are all at state universities (Salerno, 2010).

**Table 11. Leading University Engineering Programs, Brazil**

Leading Universities-Engineering Department
Instituto Tecnológico de Aeronautica (ITA)
Universidade do Estado de Sao Paulo (USP)
Universidade de Campinas (Unicamp)
Universidade Federal de Sao Carlos (Ufscar)
Universidade Federal do Rio de Janeiro (UFRJ)
Universidade Federal de Minas Gerais (UFMG)
Universidade Federal de Itajuba (UNIFEI)
Universidade Federal do Rio Grande do Sul (UFRS)

Sources: (Fleury, 2010; Salerno, 2010)

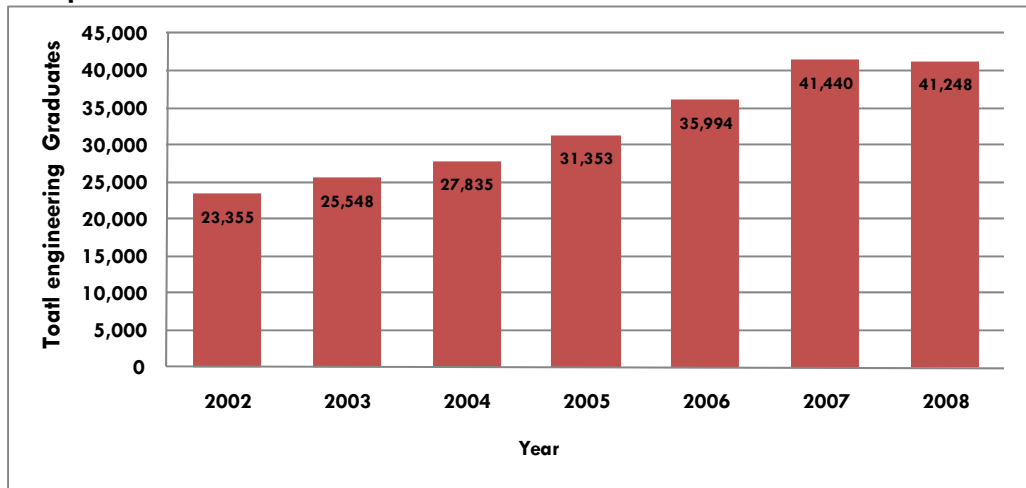
As in other Latin American countries, there has also been an explosion in private universities offering engineering programs. Today in Brazil, there are approximately 300 engineering faculties. However, the quality at many of the new schools is considered to be very poor (Fleury, 2010; Longo et al., 2000; Salerno, 2010). Datamonitor highlighted the challenges for education in Brazil emphasizing the

<sup>18</sup> This information is consistent with a study produced by UBS between 2006 and 2008, electrical engineers with five years of experience in Brazil saw average salaries increase by 30% (UBS, 2006, 2009).

lack of preparation of the teaching faculty who often do not have the required qualifications to be teaching at university level (Datamonitor, 2009a).

Demand for engineering graduates in the engineering sector has picked up within the past four years in Brazil beginning in 2006 when the GDP began to grow dramatically.<sup>19</sup> Previously a large number of engineers went primarily into civil engineering and the banking sector; however, today, new demand is being driven by industrial multinational corporations such as General Electrical that are establishing R&D centers in Brazil (Fleury, 2010). In 2010, GE alone has plans to establish a central R&D Center in Brazil focused on technology transfer to Latin America, as well as a new medical and diagnostics factory, an airplane engine maintenance plant, a locomotive plant and a deep sea drilling equipment factory (Emerging Markets Information Service, 2010). This growth in demand has yet to be matched by an increase in enrollment in engineering degrees. As can be seen in Figure 4, growth in the number of engineering graduates was marginal between 2007 and 2008 and, in the long term, this will likely lead to a shortage of engineers in the country (see Appendix 3. for detail information on engineering graduates by disciplines) (Fleury, 2010; Salerno, 2010). High labor costs currently highlight the existing limited supply of engineers in the country.<sup>20</sup>

**Figure 4. Total Annual Engineering Graduates, Undergraduate Programs Brazil- Selected Disciplines**



Source: (Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira, 2002-2008)

In Brazil, there is little interaction between the private sector and universities, which limits the education sector from adequately catering to the needs of the business community. While this interaction typically only happens between state owned enterprises and federal schools as a result of industrial

<sup>19</sup> For an overview of Brazilian economic growth, see Table 6.

<sup>20</sup> See Figure 2 for an overview of salaries in Latin America.



policy, this marks a higher level of involvement between education institutes and the business sector than in most other Latin American countries. It is more usual to find Brazilian universities working in collaboration with foreign universities from the US and Europe to further enhance capabilities than with local firms (Fleury, 2010). Three new laws that were recently passed to help promote interactions at the research level may help forge closer relations in the long term: the Innovation Law, which has made it easier for public universities to sign contracts with private sector firms to conduct research; tax incentives are now available for firms engaged in research through the universities while another new law has also been passed that provides companies with incentives to donate money to universities to conduct research (Salerno, 2010).

Brazil will likely experience a shortage of engineers in the coming years as existing engineering programs have not expanded to meet the new demand being driven by the country's rapid economic development.

## E. Regulatory Framework

Engineering work in Brazil generally does not require any special certification with the exception of civil planning; however there are two other important regulations that limit foreign engineers from working in the field. Firstly, there is a very restrictive immigration policy in Brazil, and it is very difficult for foreigners to obtain a work permit to work in the country. Secondly, there are policies in certain industries, such as the oil industry, where Petrobras, as a state-owned company can only import foreign engineering services in very special circumstances when the capabilities are not available in the Brazil. Civil planning is strictly regulated and before participating in public works construction, engineers must obtain a certification from CONFEA, Conselho Federal de Engenharia e Arquitetura e Agronomia.

Brazil's complex tax structure, particularly with respect to importing and exporting services creates difficulties for the internationalization of the operations (World Economic Forum, 2009). The government recently launched Siscoserv, a new database to track the type, nature and value of cross-border service transactions. The information gathered through this system is to be used to help guide policy formation with respect to service imports and exports (Pinho, 2009). However, companies are being warned that they need to ensure that they are paying all corresponding taxes and using transfer pricing. The implementation of this new service is likely to increase scrutiny of services traded between subsidiaries of companies (Weiss & Jeffrey, 2010).

## VI. CHILE ENGINEERING SERVICES

### In Brief

The Chilean engineering services industry is amongst the most mature in the region as a result of strong demand driven by the country's continued economic growth over the past thirty years. The country has a well-established infrastructure, although this was recently damaged by the large earthquake of February 2010. There are a number of strong engineering programs that produce highly qualified graduates, although the small size of the labor force and comparatively longer engineering programs (6 years) does limit the number of engineering graduates with respect to Chile's larger neighbors. The country has a large number of both domestic and foreign firms and the country's engineering expertise lies in mining thanks to the abundant supply of copper.

### A. Overview

Chile has been in many respects become a model for successful macroeconomic management among emerging market economies. Real per capita income has increased by 3 percent per annum on average over the past 12 years, the poverty rate has been more than halved over the same period, the public sector has become a net creditor and Chile has recently joined the ranks of the OECD. Chile's economic prosperity has relied heavily on natural resource-based industries, like mining, forestry, fishing and food processing. While the country's export base has been diversified, copper still has the dominant share, at an annual average 55.7% of merchandise export earnings in 2006-07 (inflated by record high copper prices). Cellulose, fruit, wood, salmon and wine have emerged as important new export items. Others, including methanol, processed-wood products, white and red meat, certified seeds and metal processing equipment, are becoming increasingly significant. Some traditional exports, such as gold, nitrates and fishmeal, have also increased strongly (The Economist Intelligence Unit, 2008).

The World Economic Forum ranked Chilean infrastructure as the best in Latin America in 2009; however, damage from the February 2010 earthquake will require an estimated US\$8 billion in investment to restore this.

Regarding foreign direct investment, Chile has achieved widespread international recognition for its success in attracting foreign direct investment. According to the 2008 World Investment Report, published by the United Nations Conference on Trade and Development (UNCTAD, 2008), the stock

of FDI in Chile reached 64.4% of GDP in 2007, up from 48.1% in 1990. By comparison, the world average in 2007 was 27.9% and, in developing countries, was running at 29.8%. Between 1974 and 2007, the mining sector accounted for 32.7% of gross inflows of FDI in the country. This was followed by the electricity, gas and water sector (20.0%), services (19.9%), manufacturing (12.3%), transport and communications (11.4%), construction (2.2%) and agriculture, forestry and fishing (1.5%). In the services sector, the most important segments were investment companies (21.0%), banking (20.2%), insurance (16.3%), retail (12.3%) and other financial services (10.0%).

## B. Engineering Supply

### 1. Evolution of the Chilean Engineering Services Industry

Engineering has a long history in Chile, with the first engineering faculty opening in 1853 at the Universidad de Chile. In the 1950s, engineering firms as we know them today in Chile began to emerge and by 1967, the industry had developed sufficiently to warrant the formation of an industry association. Firms were enterprising, and following a period of stagnation of domestic demand in the 1960s, three leading Chilean firms, ARA, CADE and BER joined forces as INDEC to export services within the region, becoming one of the first regional firms to do so. By the 1970s, the firm had exported services to Venezuela, Bolivia and Ecuador (Arze, 2009). The sector has continued to grow in strength and by 2010; Chilean engineers have become globally recognized for their capabilities.

Domestic demand for engineering services was driven by changes in economic policies that opened the economy to foreign direct investment at the end of the 1980s. In particular, the industry began to experience tremendous demand in the mining sector, as international mining firms arrived to explore Chile's mineral wealth. In addition, significant public-private investments were made in infrastructure expanding road networks, developing ports and airports as well as significant networks for basic services such as water and sanitation. Chile is currently considered to have the best infrastructure in Latin America (Mia et al., 2007). Many of these companies entering Chile at the time initially established operations with the support of large international engineering partners. However, wage differentials and local regulation quickly made working with Chilean firms more profitable, and many of the international firms began subcontracting with the local Chilean firms or forming joint ventures.<sup>21</sup> The result of this arrangement in the 1980s and 1990s was a tremendous transfer of engineering knowledge, and Chilean engineers slowly began to take on more and more of the sophisticated engineering required for the projects.

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<sup>21</sup> Fluor and Bechtel were amongst the few firms that established greenfield operations and grew their offices organically (Arze, 2009).

## 2. Engineering Firms

Chilean offices of large multinational engineering firms quickly gained autonomy from their Headquarters as local teams developed expertise throughout the engineering services value chain. Much of the major decision-making was initially conducted abroad, however, today, Chile is host to a number of global Centers of Excellence and firms draw on their Chilean staff to make decisions on projects around the world (Sanchez & Boolan, 2009). The multinational firms interviewed in the course of this study indicated that due to the maturity of the Chilean capabilities, the Santiago offices often work closely with other branches in the firm's global network, taking advantage of advances in communications technologies. Fluor noted that their Chilean office works seamlessly with offices in Houston, Australia and South Africa, taking on workloads where they are able to offer the best and most efficient solution to their clients (Julio, 2009). SNC Lavalin noted that during the global commodities boom, they opted not to expand their staff significantly, but rather to use the opportunity to further integrate their offices around the world.

The Chilean office thus had the opportunity to work on a range of new projects, including nickel, allowing the Chilean offices to develop new capabilities (Merino, 2009).

Most of the leading engineering firms in Chile are foreign firms; nine of the world's top 20 firms have established operational offices in the country.

As a result of this transfer of knowledge, there are a large number of small, medium and large domestic engineering firms that have grown to meet demand in a broad cross section of industries typically not served by the foreign firms, including energy, agrofoods and infrastructure. Certain domestic firms, such as Poch S.A., have developed substantially and today have offices in Mexico, Peru, Colombia, Brazil and Argentina (Poch & Asociados, 2008). On the other hand, a number of local firms sold to larger international firms during the past ten years, mainly because they could no longer retain staff that were attracted to foreign firms that offered better compensation packages (Maiz, 2009).<sup>22</sup> These smaller firms also had difficulty competing with foreign firms for multinational clients given their limited reputations.

As can be seen in Table 12, foreign firms, including Fluor, Hatch, SNC Lavalin and AMEC, dominate the list of leading engineering firms. ARA, a Chilean firm, was the exception to this rule until recently when it formed a joint venture with WorleyParsons becoming Ara- WorleyParsons. These leading firms typically have over 500 employees, although employee count tends to vary considerably as new projects are signed.

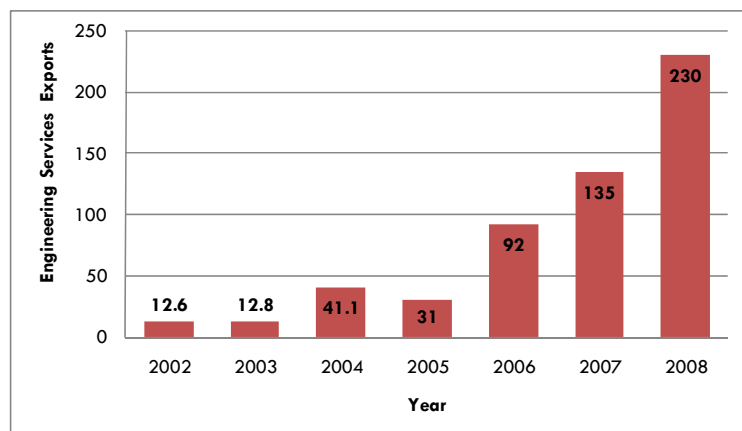
<sup>22</sup> It is common for firms to poach staff from other firms in Chile. In 2008, Bechtel hired 400 engineers, many of whom left Fluor and Hatch to join the firm (Julio, 2009; Sanchez & Boolan, 2009).

**Table 12. Leading Engineering Services Companies in Chile**

Company Name	Export Revenue (2008) <sup>c</sup>	Employees	Export Destinations
Fluor TechInt SRL (Fluor Chile S.A.)	69,269,832	550	Argentina, Peru, Bolivia
Ingenieros Y Consultores Hatch Ltda.	56,517,648	400	South Africa, Barbados, Argentina
SNC-Lavalin Chile S.A.	20,628,084	350 <sup>b</sup>	Canada, Peru, Australia
Amec International (Chile) S.A.	20,017,812	600 <sup>a</sup>	Peru, Brazil, Canada
Ara Worley Parsons S.A.	4,799,664	473 <sup>d</sup>	Peru, Ecuador, UK
Bechtel Chile Ltda.	4,369,416	500 Engineers	Peru
SKM Minmetals		745 <sup>d</sup> (281 Engineers)	
JRI Ingeniería S.A.	2,408,196	241 <sup>a</sup> (140 Engineers)	Congo, Peru, Isle of Man, USA
Coprim Ingeniería S.A.	2,309,532	38	Peru
Arcadis <sup>e</sup>		249 (131 Engineers) <sup>d</sup>	
Ingendesa		692 (335 Engineers)	
Indec S.A.	2,084,616		Thailand, Peru, Zambia
Golder		143(89 Engineers) <sup>d</sup>	

<sup>a</sup> Sourced from company website; <sup>b</sup> Company interviews; <sup>c</sup> Information from Servicio Nacional de Aduana (Prochile, 2009). Export revenues were aggregated per year and averaged to provide comparable information between companies and allowing for different invoicing cycles; <sup>d</sup>Information sourced from Asociación de Ingenieros (AIC); <sup>e</sup>Not known to be exporting.

As shown in Figure 5, engineering services have grown tremendously to become the country's leading offshore service export. According to a report published by IDC in 2009, with approximately US\$275 million in exports in 2008, the engineering services, sector far surpasses information technology (IT) with US\$169.7 million in exports and business process outsourcing (BPO) services with US\$ 198.9 million in exports and currently accounts for one third of all offshore service exports in the country (IDC Latin America, 2009). The leading industry association, Asociación de Empresas Consultoras de Ingeniería report similarly high numbers of US\$230 million in service exports for 2008 (Asociación de Empresas Consultoras de Ingeniería de Chile, 2010).

**Figure 5. Chile Engineering Services Exports (USD million)**

Source: (Asociación de Empresas Consultoras de Ingeniería de Chile, 2010)

As previously described, firms within the Chilean industry have matured, offering increasingly sophisticated services for export. Client countries include both developing and developed countries. In 2008, Latin America received the majority of these exports; Peru accounted for 32% of exports, while the United States and Canada together accounted for over 10% (Asociación de Empresas Consultoras de Ingeniería de Chile, 2010). The percentage of firms' revenue from exports tends to vary dramatically, primarily due to the large size of projects that they take on. For example, a firm providing detailed engineering for a large domestic engineering project will quickly see its export revenues drop compared to domestic revenue as the firm's resources are tied up.

### 3. Expertise

The local market has developed key areas of expertise in mining and metals, including both small and large firms, and today in Chile, engineering services are being driven principally by the mining sector.<sup>23</sup> . 95% of all engineering services exports in 2008 were related to the mining sector

Chilean engineers are recognized across the region for their excellent technical skills, while globally they are considered leaders in mining engineering. Engineering services in mining accounted for one third of all service exports from Chile in 2008.

(Asociación de Empresas Consultoras de Ingeniería de Chile, 2010). Santiago is host to five Centers of Excellence for copper of leading international engineering companies, and many of the projects in copper mining around the world are led by Chilean teams. Other areas of expertise, including civil engineering and infrastructure, have been

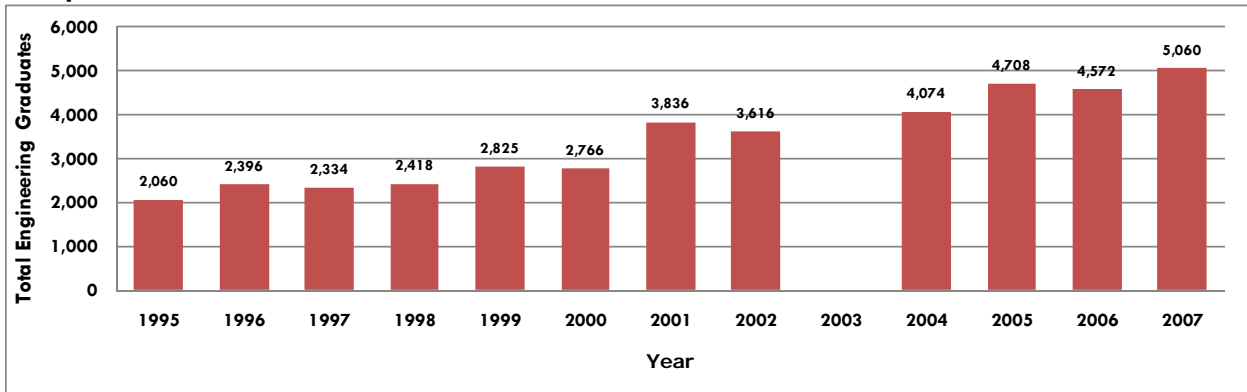
developed through a range of domestic firms, although more recently, as a result of the tremendous volatility of commodity prices and the economic crisis between 2008 and 2009, a number of foreign firms that previously dedicated most resources to mining have also begun to diversify into infrastructure and renewable energy projects (Pino, 2009). The 2010 earthquake, which caused limited structural damage to constructions built within the past fifty years, highlighted the country's expertise in civil engineering. This is largely attributed to the development of a strong base in seismic engineering at the University of Chile and a subsequently well-developed seismic code. Following the earthquake, engineers from around the world have focused on Chile, examining the engineering and building codes to develop a deeper understanding of how to build to sustain the enormous stress put on constructions by a release of energy accompanying an earthquake measuring 8.8 on the Richter scale (América Economía, 2010a).

<sup>23</sup> The Law for the Development of Non-Conventional Renewable Energy passed in 2008 created a new demand for engineering in the alternative energy sector. The law requires that by 2010, 5% of all energy supplied in the country must be from renewable sources. In 2024, this amount must be 10%.

**4. Supply of Engineers**

The number of graduates in the field continues to grow in Chile, and has more than doubled in size since 1998. According to recent government figures, in 2008, a total of 15,200 students graduated from university and technical programs in engineering, industry and construction related fields (Ministerio de Educación de Chile, 2009). Figure 6 below includes engineering graduates at the undergraduate level receiving degrees in Civil Engineering<sup>24</sup> and Forestry Engineering (See Appendix 3. for more detailed information.)

**Figure 6. Total Annual Engineering Graduates, Undergraduate Programs Chile- Selected Disciplines**



Source: (Ministerio de Educación de Chile, 2009) Engineering Graduates – six year degree programs.  
 Note: Year 2003 is not included due to unreliable data.

Despite this general growth, the number of mining engineering graduates each year remains low, with approximately 200 students graduating annually at the university level (SONAMI : Sociedad Nacional de Minería - Chile, 2009). This reflects a similar trend at a global level where demand for mining engineers at even the low rate of approximately 800 engineers per year is not being met (Davison, 2008). When Bechtel decided to hire extensively in 2007, the labour pool for engineers in the mining sector did not have a sufficient supply, they thus brought in people from pulp and paper, from their suppliers and from other industries (Sanchez & Boolan, 2009).

<sup>24</sup> In Chile, Engineering programs are generally referred to as “Ingeniería Civil” or Civil Engineering. Full titles of different degree fields are Mechanical Civil Engineering, Chemical Civil Engineering, Industrial Civil Engineering, Mining Civil Engineering (Letelier & Carrasco, 2004). Degrees that are not awarded with this title include agricultural engineering or agronomy (*agronomía*) and forestry engineering (*ingeniería forestal*).

## 5. Salaries

The field is amongst one of the highest paid in the Chilean labor force. Of the ten highest paid professions in the country, seven are in engineering. This trend is also apparent with respect to graduates of technical schools (Meller & Brunner, 2009). Table 13. provides salary and probability of finding a job information for the graduating cohorts of 2000 and 2001, and measurements are taken at 2006 salary levels. However, according to some companies, salaries in the engineering field have increased 40-50% over the past few years (Maiz, 2009).

Engineering is the highest paid profession in Chile. Of the ten highest paid professions in the country, seven are related to engineering. This is also true for graduates of technical programs.

**Table 13. Engineering Income and Probability of Finding a Job in Chile, 2006**

Engineering Field	Average Monthly Income (5 Years after graduation)	Probability of Finding a Job (First year)
Mining	US\$5,760	0.96
Civil	US\$3,605	0.94
Industrial	US\$3,634	0.93
Electrical	US\$3,454	0.95
Mechanical	US\$3,130	0.91
Electronics	US\$3,130	0.92
Construction	US\$2,408	0.89
Forestry	US\$1,929	0.72

Source: (Meller & Brunner)

Note: 1. Average monthly income was calculated at an average exchange rate of 500 pesos to the US dollar.

2. Probability of finding a job related to field of study within one year of graduation.

Demand is highest amongst engineering degrees associated with the mining sectors in which Chile is considered to be a leader at both the regional and global level. Mining engineers with just five years of experience receive annual salaries that are approximately twenty times the country's minimum wage. Both engineers with university degrees and technical degrees are the highest paid professions for their respective levels of education, earning approximately 20-30% more than the next best-paid professions (Meller & Brunner, 2009).



## C. Engineering Education and Human Capital for Service Exports

Engineering education in Chile is divided into two key segments: University degree level (*Licenciatura*) and Technical Schools (*Ingeniería en Ejecución*). University programs are typically six years long, while technical programs are four years. University programs place a strong emphasis on technical expertise in specific engineering areas. Programs focus on theoretical knowledge, and students are required to submit a thesis following their coursework as well as complete a summer internship (*prácticas*). Leading engineering universities include principally the large, traditional universities as can be seen in Table 14. University of Chile is widely recognized as the leading school for civil engineering (Brunner & Uribe, 2007; Sanchez & Boolan, 2009), while Pontificia Universidad de Católica in Santiago and Valparaíso are also recognized as top schools. Universidad Técnica Federico de Santa María is considered to be particularly strong in systems engineering and has made concentrated efforts to put increased emphasis on new technological developments. Technical schools offering four year degree programs have also been acknowledged by leading firms for their high quality and more practical curricula.

Ongoing workforce development is a key characteristic of the engineering field in Chile. The majority of engineering firms provide considerable on the job, online and program training.

**Table 14. Leading University Engineering Programs, Chile**

Leading Universities- Engineering Programs
Universidad de Chile
Pontificia Universidad Catolica Santiago
Pontificia Universidad Catolica Valparaiso
Universidad Tecnica Federico Santa Maria
Universidad de Santiago de Chile
Universidad de Concepción
Universidad de Temuco

Source: (América Economía, 2009; Brunner & Uribe, 2007; Sanchez & Boolan, 2009)

The quality of Chilean engineering education is considered to be strong within the region (Gallegos, 2010; Maiz, 2009; Pino, 2009; Salerno, 2010; Sanchez & Boolan, 2009).<sup>25</sup> This quality is maintained by an accreditation law, the Higher Education Quality Assurance Law (Letelier & Carrasco, 2004). Bechtel noted that the six-year engineering program in Chile, provides a distinct advantage over four-year undergraduate programs in the US given that the engineers entering the labor market in Chile are already more mature and focused on their careers in engineering (Sanchez & Boolan, 2009). In addition, in Chile, education continues beyond undergraduate programs with a strong tradition of workforce development training. New engineers are regularly paired with experienced engineers to provide constant on-the-job instruction (Julio, 2009), while at the same time a broad range of courses in both technical and interpersonal skills are available.

Multinational companies provide access to both e-learning and online courses and on-site courses both in Chile and abroad (Julio, 2009; Sanchez & Boolan, 2009) as well as introducing professional performance evaluation to continue employee development (Julio, 2009). According to companies in the industry, the additional training received post graduation provides Chilean engineers with a significant competitive advantage over engineers in both Brazil and Argentina (Maiz, 2009). A large number of engineers working in engineering sectors in Chile have also completed graduate engineering degrees either in Chile or abroad (Comisión de Educación, 2005). In 2007 and 2008, 405 and 411 engineers graduated with postgraduate degrees from universities in Chile, while a staggering 2,303 students began their graduate studies in engineering in 2009 in Chile and a further 20 students were awarded scholarships to pursue further graduate studies in engineering in Australia and New Zealand (Sistema Nacional de Información de Educación Superior, 2008, 2009).

#### D. Regulatory Framework

Chile has a very open immigration policy, which encourages foreign professionals to work in the country. Work visas are of minimal expense and are provided for one year following which workers may apply for permanent residency. Labor legislation limits the percentage of foreigners working in a firm of 25 or more employees to 15%, although highly specialized labor is excluded from this limit if local expertise is not available.<sup>26</sup> All foreign engineers must hold an engineering degree and these qualifications are assessed by the Ministry of Foreign Affairs and the University of Chile to ensure they meet local engineering education standards. In addition, many engineering companies require

<sup>25</sup> Quality control in engineering is also driven largely by demand in the private sector. A 2005 survey carried out by the Chilean Institute of Engineers found that employers prefer graduates from Universidad de Chile and Pontificia Universidad Católica over other schools. Furthermore, both the Institute of Engineers and the Colegio de Ingenieros de Chile only extend membership to engineers from certain school and faculties.

<sup>26</sup> Foreigners with permanent residency are also excluded from this limit.

employees to register with the Colegio de Ingenieros de Chile. This registration includes requirements such as language tests and a working contract with the company based in Chile (Colegio de Ingenieros de Chile A.G. , 2008).

Regulation concerning the import and export of services has also evolved tremendously within recent years, driven by initiatives of the Global Services cluster (Fernandez-Stark et al., 2010). Engineering services that are exported from Chile are no longer subject to value-added tax (in 2010 ,this tax was 19%) which has helped to maintain the country's competitiveness (Servicio Nacional de Aduanas-Chile, 2007)

## VII. COLOMBIA ENGINEERING SERVICES

### In Brief

Colombia is emerging as a regional platform for engineering services given its large number of engineers, ease of doing business and low labor costs. Due to its geographical characteristics, the country has gained considerable strength in hydroelectric projects and draws on its expertise in civil, electrical and mechanical engineering. Limited local demand and strong local firms have resulted in few foreign firms establishing operations in the country. Colombian firms, in turn, expanded abroad to compensate for weak domestic demand and already have a substantial presence in the engineering markets in Central America and Peru. New demand is emerging for infrastructure as security conditions improve as well as demand from the expansion of new commercial mining interests.

### A. Overview

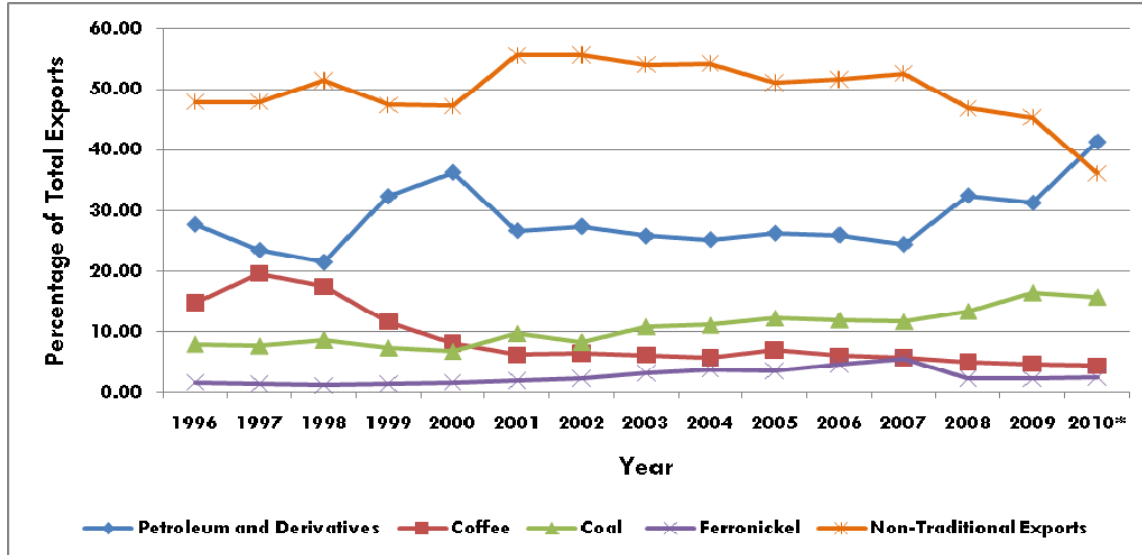
Over the past ten years, the macroeconomic and political situation in Colombia has changed dramatically. Since his election in 2002, President Uribe (2002-2010) has implemented policies directed at establishing political stability and improving national security (Datamonitor, 2009b). While the terrorist group FARC (*Fuerzas Armadas Revolucionarias de Colombia*) continues to threaten security in some regions, improvements in urban safety have helped drive strong economic growth and investment. Growth in the five-year period prior to the economic growth was strong, particularly in 2007 when it reached higher than 7% (Economist Intelligence Unit, 2009).

Following the 1998 economic crisis, the government initiated a privatization program and opened up the petroleum industry to foreign capital. In addition, restrictions were lifted on foreign capital, which now receives national treatment (Datamonitor, 2009b). As a result of these economic liberalization initiatives and improved safety, foreign direct investment has increased rapidly and in 2009, FDI reached \$10.583 billion (*Invierta en Colombia*, 2010). This has been further facilitated by efforts by the government to streamline the tax process (Datamonitor, 2009b). Manufacturing, mining and energy are the three areas that currently receive the largest share of FDI (Datamonitor, 2009b).

Figure 7. provides an overview of key export sectors in Colombia over the past 15 years. Petroleum and its derivatives continue to be the country's leading exports sector and is expected to increase dramatically to over 40% of exports in 2010, following a slight decline in 2009 that is largely

related to a decline in global oil prices during the economic crisis. Coal exports reached an all time high point in 2009 accounting for 16.5% of all exports.

**Figure 7. Exports by Sector, Colombia 1996-2010**



Source: (DANE, 2010)

Coffee continues to be a leading sector with real exports growing in the past five years to US\$1.8 billion in 2008 (DANE, 2010). The decline in coffee's share of total exports has declined in recent years mostly as a result of the increase in production in mining and hydrocarbon sectors and related food processing is the largest industrial sub-sector. The industrial sector as a whole represented 38% of all exports in 2009 (DANE, 2010), with large private conglomerates accounting for most industrial output, with many small and medium size businesses with low productivity (Economist Intelligence Unit, 2009).

## B. Engineering Demand

### 1. Extractive Industry

Hydrocarbons is the leading extractive industry in Colombia accounting for \$6.9 billion and 4.8% of the GDP in 2008 and production of national gas and crude petroleum increased by 18% and 11% respectively (Wacaster, 2010). The country provides 8.3% of the supply of oil in Latin America and the country is expected to pump 895,000 barrels per day by 2014 with overall sector growth by 2019 of 38% (Business Monitor International, 2010). State owned Ecopetrol increased its 2010

budget by 11% with two thirds destined to exploration and production, highlighting the company's strong focus on output growth (Business Monitor International, 2010).

Colombia has also shown its commitment to becoming a significant player in the mining industry with the establishment of the National Plan for Mining for 2019 (Wacaster, 2010). Mining has become an attractive new investment sector for foreign capital in Colombia, although growth continues to be tempered by challenges to security that have prevented exploitation of natural resources for the past 25 years (Lobo-Guerrero, 2010). The lack of foreign investment in this sector for 25 years meant that production was based on outdated technologies and there is limited human capital with the expertise required for commercial mineral exploitation. Rapid technology transfer is now accompanying new investments. Exploration is underway on a number of new

After thirty years of stagnation, the Colombian mining sector has begun to expand. FDI in mining has increased by over 70% year on year since 2007 and is estimated to reach US\$3 billion in 2010.

projects by companies including Anglo American and BHP Billiton (Invierta en Colombia, 2009) and FDI in the sector continues to strengthen. Year on year increases in FDI for 2007-8 and 2008-9 were over 70% in the mining sector, which remained strong despite the crisis, and estimates for 2010 is that the investment in mining in 2010 will increase further, accounting for US\$3 billion and one third of all FDI (Invierta en Colombia, 2010; Wacaster, 2010).

Colombia's key mineral resources are coal – the country produces 1.4% of the world production and it is Colombia's second largest export sector - gold uranium and platinum (DANE, 2010; Parra, 2010; Wacaster, 2010). It is also one of the top ten nickel producers in the world (Wacaster, 2010). The Instituto de Fomento Industrial started extracting operations of Coal and Nickel and later these operations were sold to the private sector. Today, there are a large number of international companies extracting coal, including firms from Brazil, Korea, India and China (Lobo-Guerrero, 2010). There are currently a number of new exploration projects under way for gold resources and Colombia is expected to triple its gold production to 150 tons by 2012. Key new mines include those in Valle del Cauca and Antioqui regions.

The Ministry of Mines and Energy also took measures in 2008 to begin to organize and license artisan mining operations that have been common across the country in the past two decades (Wacaster, 2010). Mining development, however, continues to be complicated by environmental legislation as

many of the reserves are in protected areas (Lobo-Guerrero, 2010; Parra, 2010). With the establishment of new mines in more remote regions, the government is proposing the construction of new railway lines (Eastern Trunk Line) that would connect those mines with Buenaventura port (Cooper, 2010).

## **2. Infrastructure**

In January 2009, President Uribe's government announced a \$24.9 billion infrastructure plan, partly a measure to stem the impact of the economic crisis and partly a long overdue amalgamation of numerous badly needed public infrastructure projects. These include 19 highway concessions, port construction and maintenance, investment in water works and railway lines (Economist Intelligence Unit, 2009). These projects are being run as public-private partnerships, with concessions awarded for between 20 and 25 years and opened for tender in December 2009, with the first project – Ruta del Sol, worth approximately \$2.5 billion. The Ruta del Sol project, one of the ten biggest infrastructure projects in Latin America in 2010,<sup>27</sup> has attracted construction and engineering consortiums from Spain, Brazil and the US, in addition to local Colombian firms (Economist Intelligence Unit, 2009).

Despite these initiatives, infrastructure continues to remain weak in Colombia, and the country ranks 83<sup>rd</sup> out of 133 countries for infrastructure development in the WEF Global Competitiveness Report (2009). Furthermore, security risks in expanding highways to the west have slowed down the development and have placed additional pressure on air transport. There is also a shortage of electricity capacity and transmission lines and oil pipelines are frequently the target of guerilla attacks and it appears that the implementation of these infrastructure projects will be slow (Datamonitor, 2009b).

One infrastructure area, however, that has made progress is that of the telecommunications sector. The average growth rate of the sector has been 47% per year since 2002, yet there continues to be room for further expansion, as penetration rate, particularly in mobile phones is still low compared to the region (Datamonitor, 2009b). Colombia however relies on external engineering resources for most of its development, as this is a weakness in the country's communication engineering supply (Santamaria, 2010).

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<sup>27</sup> See table 4 for a list of the largest fifteen infrastructure projects in Latin America.

## C. Engineering Supply

### 1. Engineering Firms

The Colombian engineering services market is characterized by a group of medium and large engineering firms, with a low presence of foreign firms (Torres, 2010). The top twenty firms bill approximately 60% of all sales. Colombian firms tend to be cheaper and thus are more competitive for local projects (Carter, 2010; Santamaria, 2010; Torres, 2010; UBS, 2009). Given slow demand in Colombia in recent decades, many of these engineering firms have expanded to work on projects outside of Colombia, including Peru, Panama, Ecuador, Bolivia and Venezuela (Torres, 2010). Central America has become a particularly interesting market for Colombian firms and they are working on a growing number of projects in this region. While some of these firms initially opened operations centres in these countries, general experience was that it made more sense for them to run the operations directly from Colombia, sending engineers on site as appropriate (Santamaria, 2010). Table 15 below provides an overview of the leading engineering firms in the country.

There have only been a few foreign firms that have forayed into engineering in Colombia in the past two decades and currently only five of the top twenty global engineering firms (SNC-Lavalin, AECOM Technology Corp, WorleyParsons, Poyry and Odebrecht) are present.<sup>28</sup> A number of factors have contributed to this, principally low domestic demand largely met by more competitive local firms and security risks for personnel. Demand for infrastructure has been unpredictable due to the lack of general development in the country. In addition, safety issues have played a significant role in the past. SNC Lavalin, for example, were present in Colombia in 1999, but withdrew after two of their engineers were kidnapped (Torres, 2010). Odebrecht also withdrew from the country in 2000 following a spate of kidnappings (Abrew, 2010). With the improvement in security today, this situation is changing. A number of firms are beginning to establish operations there and this trend is likely to continue, driven by demand in oil and gas, mining and infrastructure development. SNC Lavalin reentered Colombia in 2007, purchasing one of the leading engineering firms, ConCol. Their operation already has 250 employees. Their goal is to tap into the rich engineering talent in Colombia to export services regionally, in particular to Central America (Carter, 2010; Torres, 2010).

Colombian firms have strong hydroelectric engineering capacity and export these skills regularly.

<sup>28</sup> See Table 4 for the complete list of the top twenty global engineering firms.



**Table 15. Leading Engineering Services Companies in Colombia<sup>29</sup>**

Company Name	Employees	Exports Destinations	Description
Ingetec S.A. <a href="http://www.ingetec.com.co">www.ingetec.com.co</a>	1200	Argentina, Bolivia, Canada, Chile, China, Costa Rica, Ecuador, Haiti, Mexico, Panama, Peru, Spain, Turkey	Ingetec was founded in 1947. The firm provides consultancy services to companies both in the public and private sector, for all stages of project development. Company experience includes engineering projects in the areas of thermal and hydropower, oil, mining, and water amongst others. It has a wide presence in Latin America.
Schrader Camargo Ingenieros Asociados S.A. <a href="http://www.schradercamargo.com.co">www.schradercamargo.com.co</a>	897	Dominican Republic, Ecuador, Guatemala, Honduras Jamaica, Peru, Trinidad Tobago, Venezuela	Schrader Camargo Ingenieros Asociados S.A. was founded in 1963. The company offers engineering services to industrial and commercial electrical installations in Colombia. The company has clients in Colombia, Jamaica, Mexico, Honduras, Ecuador Guatemala and Peru.
Integral Ingenieros Consultores <a href="http://www.integral.com.co">www.integral.com.co</a>	NA	Costa Rica, Dominican Republic, Ecuador, Panama, Peru	The company was founded in the 1950s. It has a presence in South and Central America. Integral specializes in engineering services related to hydroelectricity and water supply. It offers a range of services from feasibility studies to operations management.
Gomez Cajiao Y Asociados S.A. <a href="http://www.gomca.com">www.gomca.com</a>	500	Costa Rica, Ecuador, Nicaragua, Mexico, Panama, Peru	The company was founded 40 years ago and has expanded throughout Latin America. The mayor services offered include: feasibility studies; basic engineering studies; conceptual engineering/architectural designs; detailed design blueprints; construction supervision and project management.
Arquitectos E Ingenieros Asociados S.A. <a href="http://www.aia.com.co">www.aia.com.co</a>	350	Panama	The company offers architectural and construction design services. It has offices in Colombia and Panama.
Concol <a href="http://www.concol.com">www.concol.com</a>	288	Argentina, Guatemala, Peru, Panama,	The company has developed projects in different countries in Central America. The services offered include feasibility studies, conceptual, basic and detail engineering, regulatory, economic studies and environmental and social assessment among others. This firm was purchased by SNC Lavalin in 2007.
Sedic <a href="http://www.sedic.com.co">www.sedic.com.co</a>	NA	Ecuador	The company has operations in Central and South America, offering services in the areas of design, supervision, feasibility studies and consultancies for hydroelectric generation plants, thermal generation plants, substations and transmission lines, highway projects, water supply and sewerage, buildings, irrigation, drainage and flood control, plants general industry and in all fields of engineering.
Hmv Ingenieros <a href="http://www.h-mv.com">www.h-mv.com</a>	NA	One of two company branches in Colombia and the US	The company offers services in projects related to electrical energy, water treatment and sanitation, transportation infrastructure, industrial facilities, environmental, and telecommunications sectors.
Cal y Mayor y Asociados S.C. <a href="http://www.calymayor.com.mx">www.calymayor.com.mx</a>	NA	Colombian branch of a Mexican company	Cal y Mayor y Asociados is a Mexican company with a long trajectory in Colombia. The firm specializes in engineering services for transport and urban development.
Restrepo Y Uribe Ltda. <a href="http://www.restrepoyuribe.com">www.restrepoyuribe.com</a>	NA	Peru	The company was founded 1955. Services include feasibility studies, master plans, procurement management and oversee technical, financial, administrative and operational during the construction of concession projects among others.
Silva Carreño & Asociados S.A. <a href="http://www.silcarsa.com">www.silcarsa.com</a>	NA	Ecuador	The company was founded in 1981 providing a variety of engineering services such as feasibility studies, basic and detail engineering, management and construction supervision among others.

Source: OneSource, LexisNexis, Hoover's and Company Websites and Cámara Colombiana de la Infraestructura.

WorleyParsons also recently opened a new office in Colombia focused on the oil and gas sector, as well as minerals and metals (Carter, 2010). Chilean firm, Poch, won a large industrial project through a Chilean client linked to the mining sector and have established a new office in Bogota (Poch &

<sup>29</sup> ISA [www.isa.com.co](http://www.isa.com.co), Colombia's largest electrical transmission firm is not included in this table given the range of products and services they provide. However, the firm provides extensive services in electrical engineering across Latin America, particularly in transmission and distribution electricity networks. The company is present in Brazil, Peru, Ecuador, Panama and Central America and has 2,883 employees.

Asociados, 2008). Odebrecht have recently returned to Colombia after a ten year absence and recently won the concession for the design and construction of Sector 2, the longest stretch of the new Ruta del Sol Highway (Abrew, 2010). Soletanche Banchy, a French firm, also has a large established branch in Colombia. They are experts in tunnels and they have undertaken a large project to decontaminate rivers in Bogota. The company has created many large tunnels in Bogotá (Parra, 2010).

Project development in Colombia is largely done through Engineering, Procurement & Construction (EPC) contracts assigned to construction companies and engineering firms are then sub-contracted. It is also common for firms to establish consortiums or joint ventures in order to meet the demands of these large contracts.<sup>30</sup> This contracting system, however, has led to problems with respect to deadlines for project completion. Some firms would prefer the system to go back to traditional contracting processes where each firm is hired for respective parts of the project to help reduce risk (Santamaria, 2010).

## 2. Expertise

Colombian engineering strengths lie in civil, electrical and mechanical engineering (Parra, 2010; Santamaria, 2010). In particular, in civil engineering, they have strong engineers in the field of hydroelectric projects, having gained expertise as a result of adapting to the geographic conditions in the country (Santamaria, 2010). One of the country's leading engineering firms, Ingetec S.A. (see Table 15), draws over 70% of their revenues from hydroelectric projects and has provided engineering services for projects as important as the Three Gorges Dam in China (Santamaria, 2010).<sup>31</sup>

Industrial engineering is a new area in the country with little expertise (Santamaria, 2010). In addition, railway engineering and industrial plant engineering (processing paper for example) are also very weak. When local firms do not have the technical know-how to complete a project, they will bring in a specialist whose dual role will be to provide advice on the project and transfer know how to the local team (Santamaria, 2010).

<sup>30</sup> There are two types of legal arrangements that govern these interactions – “Consortios y Uniones Temporales”. Under “Uniones temporales”, the design firm and the construction firm are only liable for their respective areas of work, whereas in a “consorcio”, all firms are liable for all aspects (Santamaria, 2010).

<sup>31</sup> Approximately 50% of Ingetec's revenue comes from service exports in hydroelectric projects. The company exports to Turkey, Canada, Peru, Ecuador and Mexico (Santamaria, 2010).

### 3. Salaries

Engineering salaries have seen a decline, and a civil engineer with 5 years of experience earns between US\$500 and US\$750 per month (Portafolio.Com.Co, 2008). Average engineering salaries in the country are the lowest in Latin America with annual gross income levels of US\$14,800 in 2009, down from US\$15,100 in 2006 (UBS, 2006, 2009). This decline in earning potential has been reflected in a decline in the number of engineers graduating annually in Colombia (see Figure 8 below), and there are concerns that, in the long term, foreign firms will increase their presence in the country to fill this growing void (Molina, 2008).

Given that Colombian salaries are the most competitive in the region, foreign firms are strongly considering the country as a destination for establishing an offshoring services platform.

#### D. Engineering Education

Engineering education programs have seen a shift from six year programs to four year programs within the past few years (Molina, 2008). As in other countries in Latin America, tertiary education has been impacted by the rising number of private universities. By 2009, there were 87 engineering faculties in the country according to the Colombian Asociación de Facultades de Ingeniería, more than twice as many as in Peru (ACOFI Colombia, 2008). There is considerable concern in Colombia with respect to the quality of the engineering programs in these schools, which lack both qualified faculty and the necessary infrastructure to produce well-trained engineers (Parra, 2010). The relationship between the private sector and universities is weak, providing little feedback for improvement (Molina, 2008; Santamaria, 2010) and in some areas, universities compete with the private sector which has led to a degree of hostility between the two. Given that they are not for profit, they are able to avoid value added tax, which makes them considerably more competitive than private firms (Torres, 2010).

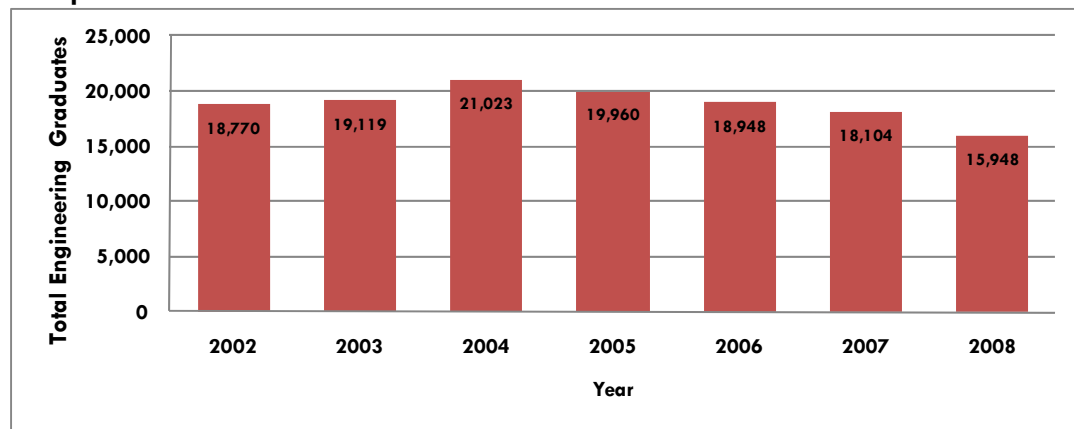
Universidad de Los Andes is widely considered to provide the strongest engineering degrees in the country. Other leading schools, listed in Table 16, include those that have long legacies such as Universidad Nacional and Universidad Javeriana.

**Table 16. Leading University Engineering Programs, Colombia**

Leading Universities- Engineering Programs
Universidad de Los Andes
Universidad Javeriana
Universidad Nacional de Colombia
Universidad Industrial de Santander
Universidad del Norte
Universidad del Valle
Universidad de Antioquia
Escuela de Administración, Finanzas y Tecnologías (EAFIT)
Universidad Pontificia Bolivariana
Escuela de Ingeniería de Antioquia (EIA)

Source: (Parra, 2010; Santamaria, 2010; Torres, 2010).

Significantly, there has been a decline in the number of students attracted to engineering programs as is shown by the total annual number of engineering graduates in Figure 8 (See Appendix 3. for detailed information) (Ministerio de Educación de Colombia, 2009). Colombia is the only country analyzed in this report that has seen a decline rather than a rise in the number of engineering graduates in recent years. Furthermore, participation in higher education remains low compared to other Latin American countries and the OECD (Datamonitor, 2009b). This is largely the result of continued inequality in the Colombian society in which many potential students are unable to finance expensive university careers (Parra, 2010).

**Figure 8. Total Annual Engineering Graduates, Undergraduate Programs Colombia- Selected Disciplines**

Source: (Ministerio de Educación de Colombia, 2009)

Colombia's economic growth since 2002 has been accompanied by the arrival of a large number of multinational firms offering attractive compensation packages for economists, students of business administration and law. Sectors such as petroleum engineering are already experiencing a shortage, and Ecopetrol, Colombia's largest petroleum company, is offering salary increases of up to 30% and has developed a program with universities to attract more students to those careers

(Portafolio.Com.Co, 2008). The engineering profession in general, is facing problems of “brain drain”. The Dean of the Engineering Faculty at Icesi, Cali, Gonzalo Ulloa estimates that at least 25% of their engineering graduates go abroad to work upon completing their studies (Portafolio.Com.Co, 2008). Nonetheless, companies looking to establish service platforms in the country consider this a plus for the industry and are counting on many of these engineers who have been working abroad to come back to Colombia as the political and economic situation improves in the country (Torres, 2010). Many of these engineers will have considerable work experience in a developed country, and their return now that violence is abating would be a significant opportunity for knowledge transfer back to the country (Torres, 2010).

## E. Regulatory Framework

Regulation of Colombia’s engineering field is well-established and centralized. The Asociación Colombiana de Ingenieros has a well developed system for resolving disputes and licenses are awarded to new engineers through one institution, el Consejo Nacional de la Profesión de Ingeniería (Santamaria, 2010).<sup>32</sup> Foreign engineers must obtain a license from this institution in order to work in the country. There is a limit on the number of foreigners allowed to work in firms of 10 or more employees. While in most Latin American countries there are no limits on specialized labor, in Colombia only 20% of a firm may be made up of foreign specialists (Datamonitor, 2009b).

For national infrastructure projects, institutionality is weak and the rules for participation are unclear, but, in general, bids that include domestic companies are considered more favorably than bids exclusively by foreign firms, as this helps to foster technology transfer (Parra, 2010). This means that for a company to be awarded a large project they must have either an established branch in Colombia or a joint venture with a local company. Nonetheless, the procedures for establishing a firm in the country are relatively straight forward in Colombia, and it ranks higher than Chile, Peru and Brazil in the Ease of Doing Business Index (The World Bank Group, 2010a). Difficulties, however, in closing down a business do provide some deterrent effects for investment (World Economic Forum, 2009).

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<sup>32</sup> According to the website, it takes a minimum of 45 days for a newly graduated engineer to receive their license and 12 days for a foreign engineer to obtain their license (Consejo Profesional Nacional de Ingeniería COPNIA, 2010).

## VIII. PERU ENGINEERING SERVICES

### In Brief

Peru has experienced tremendous economic growth over the past five years and has consolidated its position as an important global mining location. This growth has driven demand for engineering services in infrastructure, housing and mining. Peru graduates a relatively small number of engineers each year considering the size of its labor force, and much of the engineering expertise employed in the country is foreign. There are two leading domestic engineering companies which are competitive at a regional level and the remaining demand is met by foreign firms including those from Brazil, Chile, Colombia, the US and other developed countries.

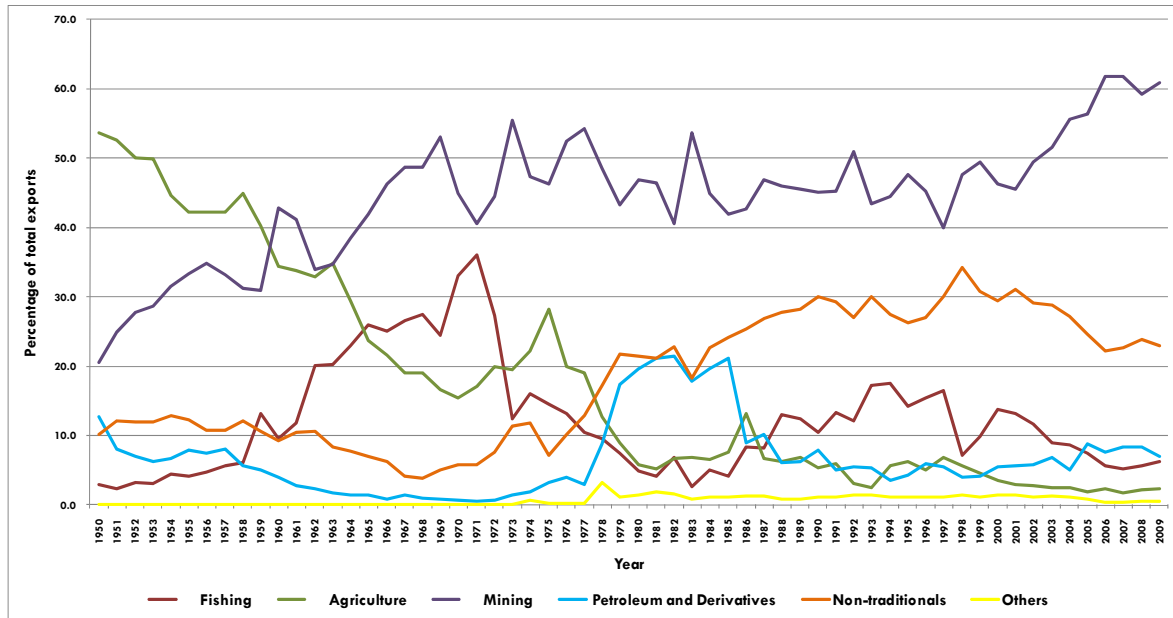
### A. Overview

During the first decade of the 21<sup>st</sup> century, Peru enjoyed considerable economic and political stability. The Presidential terms of President Alejandro Toledo (2001-2005) and Alan Garcia (2006-2011) were characterized by domestic strategies based on improving security and maintaining stability while actively promoting foreign direct investment. The economy grew strongly over the past five years, sustaining growth rates of well over 5% per annum prior to the economic crisis. Foreign direct investment also increased by 46% between 2000 and 2008 (ProInversion, 2010a). Growth was stimulated by an extensive privatization campaign that began in the 1990s, as well as increased economic openness. The improvements to security in rural areas and a general decline of activities by terrorist groups such as the Shining Path have also helped to drive growth in the extractive sector (Economist Intelligence Unit, 2010b). Continued economic development led to new demand for infrastructure during the period, including roads, ports, airports and new sources of energy supply (Mia et al., 2007). In addition, in 2009 a large proportion of the US\$13.2 billion Peruvian government stimulus package to face the global economic crisis was allocated to infrastructure development (Razo & Calderón, 2010; Reuters, 2008).

Figure 9 below indicates Peru's export sectors over the past fifty years. Mining continues to be the leading contributor to growth, buoyed by high commodities prices, agriculture and fishing continues to lose ground to other sectors, while petroleum and its derivatives are slowly beginning to increase in importance. Non-traditional services accounted for just over 20% of exports, particularly in the

offshore services business process outsourcing sector which Peru has been actively promoting in recent years (ProInversion, 2010a)

**Figure 9. Exports Sectors as a Percentage of Total Exports in Peru**



Source: (Banco Central de Reserva del Perú, 2010)

The regulatory environment evolved to continue fostering investment. The economy is very open, listed 6<sup>th</sup> out of 29 countries in Latin America and the Caribbean for economic freedom (The Heritage Foundation, 2010). A double taxation agreement has made the country a more attractive place to invest for certain countries. For example, boosted by the double taxation agreement signed in 2004, Peru has become one of Chile's main target countries for FDI. Net FDI flows from Chile to Peru increased from US\$42.2 million in 2005 to US\$809,5 million in 2008 (Razo & Calderón, 2010).

## B. Engineering Demand

### 1. Extractive Industry

The mining sector has played a key role in Peru's economic growth in the past ten years. From 2000 to 2010, it grew from an average of approximately 47% of annual GDP to an average sustained participation of 60% of GDP over the past five years (Banco Central de Reserva del Perú, 2010). The country has incredible mineral wealth. It is the world's largest producer of silver, second largest producer of copper and a significant producer of gold, zinc and lead (Gurmendi, 2009b)). In 2009, mining accounted for US\$16.4 billion in export revenue, despite the economic crisis (Banco Central de

Reserva del Perú, 2010).<sup>33</sup> The minerals industry is likely to continue to expand significantly in the coming years. In 2009, Peru continued to be ranked in the top fifteen best global destinations for mining exploration by the Fraser Institute (Gurmendi, 2009b). In 2008, a greater area of land was under exploration than was already being exploited with an estimated US\$475 billion invested in 276 distinct projects (Isasi, 2008).

Petroleum, once a key leading export sector in Peru is likely to see growth in the next few years. In 2009, the sector accounted for US\$1.8 billion in exports (Banco Central de Reserva del Perú, 2010) and by the end of 2008, the country was producing 120,000 barrels per day (BP, 2009). At the

Peru's mining sector continues to attract multinational engineering firms to the country. A number of these firms are establishing fully operational offices there to take advantage of local engineering talent. However, major decisions continue to be made outside of the country.

beginning of the decade, there was speculation that the Peruvian petroleum industry was on the decline as existing oil fields matured with no new discoveries. However, in May 2003, conditions governing operating terms and royalties were revised resulting in the attraction of new firms. A number of important discoveries have since been made. In 2008, Petrotech Peru made Peru's first offshore discovery estimated

at 1.3 trillion barrels, while another find in Northern Peru is estimated at 1.13 billion barrels (Reuters, 2008). Other significant discoveries include CNPC and Plus Petrol in the Amazon. As a result of these finds and other new exploration concessions, estimates suggest that Peru will be producing approximately 130,000 barrels per day by 2012/2013, marking an 8% increase from current production (Business Monitor International Ltd., 2010b). Both exploration and demand for infrastructure to exploit new discoveries are expected to continue to drive demand for engineering services in this sector (Business Monitor International Ltd., 2010b). Petroperu awarded the front-end engineering design for the Talara Refinery Modernization project to Tecnicas Reunidas S.A. of Spain, and the EPC to ABSG Consulting Inc. 57 companies bid on the FEED project (Proyecto Modernización de Refinería Talara, 2010).

<sup>33</sup> Mining exports accounted for US\$18.7 billion in 2008, thus reflecting a slight decline in revenues in 2009. This effect shows the decline in commodities prices at a global level as a result of the economic crisis. Notably, mining revenues in 2009 were almost twice those accrued in 2004 (Banco Central de Reserva del Perú, 2010).



## 2. Infrastructure

The demand for infrastructure necessary to support continued general economic development is visible in the growing number of concessions that have been awarded within recent years. Concessions in Peru are typically awarded for periods of 20-25 years. These include development of new highways, ports, airports, sanitation systems and extensive new railway lines (ProlInversion, 2010b). In 2007, ProlInversión estimated that the infrastructure gap amounted to US\$22,9 billion and ranks ahead of only Bolivia and Venezuela in infrastructure quality in Latin America (Mia et al., 2007), highlighting significant potential opportunities for public-private associations.

In particular, considerable attention has been paid recently to the potential for hydro-electrical development opportunities in Peru. There are an estimated 60 rivers that flow down from the Andes through Peru to the Pacific that can be tapped for hydro-electric projects (The Economist Intelligence Unit, 2009). A five-year moratorium on new hydro-electrical projects put in place in 2001 due to environmental and community relations concerns were lifted in 2006, opening the doors for new investment. However, the expected boom is yet to occur with only one company bidding in the government's most recent concession auction in late 2009. Investment is expected to continue to be slow in the public sector until the government reviews investment terms and tariffs for energy projects (Power, 2010). Continued growth of industry and other economic sectors is likely to force this in the short term.

In addition to its own mounting infrastructure needs, Peru is under increasing pressure from Brazil – both to facilitate the Latin giant's access to Asia as well as to help provide energy exports to support Brazil's already overloaded energy grid.

In addition to meeting growing domestic demand for infrastructure development, Peru is under increasing pressure from Brazil, both to facilitate the Latin American giant's access to Asia as well as to help provide energy exports to support Brazil's already overloaded energy grid. In 2009, the new Inter-Oceanic, 2,600km highway was finished linking the Atlantic ports of Brazil with the Peruvian port cities of Ilo, Matarani and San Juan de Marcona (Greengard, 2009). In addition, a new hydroelectric plant is being planned for high in the Amazon jungle close to the border between Peru and Brazil. The project being promoted by Brazilian firms and government will provide 2,200MW of installed capacity with four generation units of 550MW (Power, 2010). Brazil is also eager to integrate its railway system with that of Peru (Poder 360, 2010).

Peruvian infrastructure is also due for significant investments in **housing and basic services**, including electricity, water and sanitation systems. According to a UNHabitat Report (2008), the 2005 Census revealed that over 1 million homes were still needed to provide adequate housing for families, a number that is likely higher if an examination of the quality of the buildings is carried out and that 30% of existing dwellings in Peru do not have access to basic services (UN-Habitat, 2008). In the days following the Chile 8.8 earthquake, the Peruvian President, Alan Garcia launched a program to review the quality of houses with respect to their ability to hold up to an earthquake of similar magnitude this is likely to lead to a further demand for anti-seismic housing (El Comercio, 2010). While a significant factor in this shortage of housing is the mismatch between supply (expensive houses) and demand (low income houses), this indicates a need for growth in the sector. The construction industry recovered from the economic slowdown in late 2009, with an increase of 14% from the same period in 2009. In addition to housing, new office building and retail malls are also driving growth in this industry (Salas, 2009).

### C. Engineering Supply

The Peruvian engineering services sector is undergoing a transition. It has until recently been characterized by a small number of large domestic firms, a number of small domestic firms and a significant presence of regional firms, particularly those from Brazil and Chile. Over the past two to three years, a growing number of multinational engineering firms have begun to open operations offices in the country. These offices have been mainly focused on exploiting the new opportunities in the mining sector in the country. In the past, the presence of foreign firms has to a large degree been limited to commercial offices with services being provided from other regional centers such as Chile.

Domestic firms in Peru developed as multidisciplinary organizations in order to remain competitive in the small market rather than developing expertise in any specific area.

Due to the limited size of the Peruvian economy in past decades, domestic engineering firms were forced to evolve as multidisciplinary organizations in order to remain competitive (Delgado, 2010). As a result, the country's engineering services firms are generalists providing a broad range of services rather than specializing in specific areas of expertise. Nonetheless, the two leading domestic firms,

Graña y Montero Ingenieros and Cesel S.A, each of which employ over 1,000 people, do participate to a large degree in infrastructure development (América Economía, 2010b; Delgado, 2010) (See Table 17). While these firms have experience exporting services, strategically given the tremendous opportunities for growth domestically, exports have not exceeded 20% of revenues. Facing large internal demand and limited by the lack of available credit facilities for projects abroad, Peruvian engineering services firms have tended to favor the local market rather than expand beyond its boundaries (América Economía, 2010b; Delgado, 2010). In general, smaller Peruvian firms tend to have a strong presence in housing and building construction, whilst large projects focused on infrastructure development, mining and petroleum are dominated by foreign firms.

**Table 17. Leading Engineering Services Companies in Peru**

Company Name	Employees	Description
Graña y Montero <a href="http://www.granaymontero.com.pe">www.granaymontero.com.pe</a>	1,500	Graña y Montero is a conglomerate of 6 companies focus on engineering services and infrastructure. The company have projects in 4 countries in Latin America.
CESEL <a href="http://www.cesel.com.pe/">www.cesel.com.pe/</a>	1,100 (480 engineers)	CESEL is a private Peruvian engineering consulting company started in 1972, offers specialized services in studies, design, work supervision, project management of overall projects in practically all the engineering areas. The company has presence in many countries in South and Central America.
Odebrecht Perú Ingeniería y Construcción S.A.C. <a href="http://www.odebrecht.com.pe">www.odebrecht.com.pe</a>	900	This Brazilian company started operation in 1979 in Peru. The company offers services related to management and coordination of engineering, procurement, construction, civil engineering and specialized technology into integrated projects for the energy, infrastructure, mining, construction and public services sectors.

Source: OneSource, LexisNexis, Hoover's, Company Websites, America Economía and Interviews.

As happened in the early stages of internationalization of the Chilean market, major decisions regarding projects in Peru are still being made abroad, either in Chile or in North America, where a large number of the big engineering firms have their headquarters (Power, 2010). Firms establishing an operational presence in Peru include Hatch, who in 2010 embarked on a plan to transform their commercial office in Lima to a fully functional office. This office was previously supported by the Chilean team in Santiago (Pino, 2009). AMEC grew its Peruvian team from 70 to 190 people between 2007 and 2008 (Engineering & Mining Journal (E&MJ), 2008). Other firms have continued to operate their projects in Peru out of their Chilean offices (Carter, 2010; Julio, 2009). In 2008, 34.9% of Chilean engineering services exports went to Peru (Asociación de Empresas Consultoras de Ingeniería de Chile, 2010).

Peru graduates just over 5,000 engineers per year and with rising demand for the engineering sector, firms are already experiencing difficulty in finding a sufficient number of qualified personnel.

While the marginal cost advantage of Peruvian engineers over Chilean engineers currently makes it more competitive to operate from Peru (Carter, 2010; Merino, 2009; Torres, 2010), engineering firms looking to expand their workforces in the context of economic growth are having difficulty hiring 300 new engineers to support that expansion (América Economía, 2010b). Furthermore, “labor shortages of highly skilled workers are common and wages for professional trained staff may be comparable with wages in the US, especially in managerial and consulting positions” (Business Monitor International, 2009, p. 43). There is already a shortage of qualified electrical engineers in Peru, and according to UBS, salaries for these engineers increased almost 50% from 2006 to 2008 (Power, 2010; UBS, 2006, 2009).

#### D. Engineering Education

Engineering education in Peru is offered through university degrees and diplomas from technical institutes. Engineering programs are five years long and provide for a broad range of engineering disciplines, although civil engineering is the most popular program (see Appendix 3 for a breakdown of engineering graduates by discipline). The traditional universities, Universidad Nacional de Ingeniería and Pontificia Universidad Católica de Peru, continue to produce the highest quality engineers (see Table 18 for a list of the leading university engineering programs). Many of engineers from these schools have also gone on to obtain graduate degrees abroad (Delgado, 2010).

**Table 18. Leading University Engineering Programs, Peru**

Leading Universities – Engineering Programs
Universidad Nacional de Ingeniería
Pontificia Universidad Católica de Peru
Universidad Nacional de Minería
Universidad Ricardo Palmer
Universidad Nacional de Cuzco
Universidad Peruana de Ciencias
Universidad de Lima

Source: (Delgado, 2010; Gallegos, 2010)

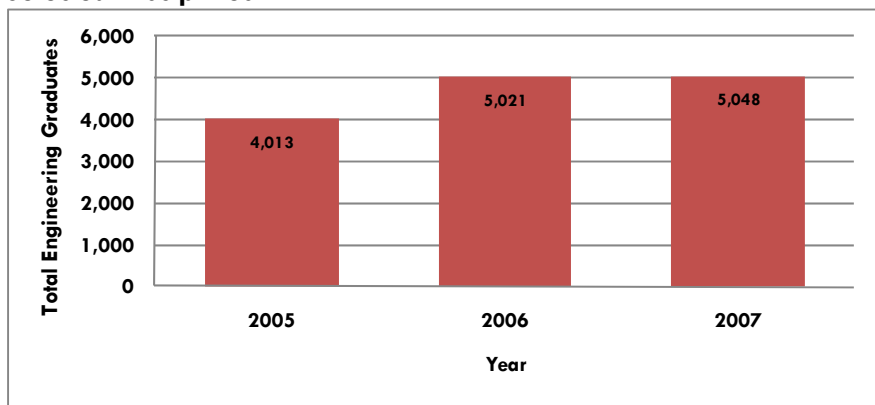
The quality of engineering graduates in the country has deteriorated within the past decade with the emergence of a large number of private universities (Gallegos, 2010).<sup>34</sup> Research in engineering at the University level in Peru was limited principally due to a lack of funding. There are no doctorate degrees in engineering offered in the country, and only a small number of master’s degrees. The small numbers of professionals that pursue doctorate studies abroad find limited returns on their investment,

<sup>34</sup> In the 1990s, there were two leading universities in the field of engineering, Universidad Nacional de Ingeniería and Pontificia Universidad Católica de Chile. Today there are over 25 engineering faculties offering programs in Peru (Delgado, 2010; Gallegos, 2010). This dramatic increase has been largely uncontrolled owing to the lack of a national accreditation system for higher education institutes.

and those that remain in the country typically go into low paying teaching positions. Limited interactions between universities and the private sector at the research level combine with a declining interest in the academic field to undermine the country's long term potential to contribute to engineering both within its borders and abroad. These factors have combined to dramatically reduce interest in this career alternative and in turn undermines the expansion of quality engineering programs (Gallegos, 2010).

Peru saw the total number of engineering graduates rise by 20% between 2005 and 2006 (Colegio de Ingenieros del Perú, 2010). However, at just over 5,000, the number of engineering graduates entering the workforce each year is low compared to neighboring countries.<sup>35</sup> The continued growth of the local economy is putting enormous pressure on the local education system to supply more human capital, particularly in the field of engineering. Thus, in an effort to boost graduation numbers, the Colegio de Ingenieros de Peru launched a program in 2010 to promote careers in engineering in the country (La Republica, 2009). Much of this anticipated additional supply will come from the expansion of private universities. These universities currently do not require accreditation and this has drawn into question the quality of the qualifications of many of these new engineers. It is likely that both local and foreign firms with operations in Peru will be under growing pressure to hire foreigners or import services to meet demand (Delgado, 2010).

**Figure 10. Total Annual Engineering Graduates, Undergraduate Programs Peru, 2005-2000- Selected Disciplines**



Source: (Colegio de Ingenieros del Perú, 2010)

Senati and the Instituto Superior Tecnológico Privado provide four year programs similar to the Ingeniería en Ejecución programs in Chile (Instituto Superior Tecnológico IDAT, 2010; SENATI, 2010).

<sup>35</sup> Chile graduates approximately 5,000 engineers annually, with a total labor force six tenths the size of that of Peru. Colombia graduates three times the number of engineers as Peru, for a labor force twice the size (See Tables 6 and Appendix B).

However, these programs are limited to mechanical and electronic engineering. These programs cater to 1,000 students per year (Economist Intelligence Unit, 2010b).

### **E. Regulatory Framework**

The engineering services sector does benefit from a lenient immigration policy that allows foreign engineers to work in the country without meeting any certification requirements. While this has the potential to negatively impact quality, it has made it easy for foreign firms, such as Chilean and Brazilian firms, to establish a strong representation in the country, in turn, leading to an increase in knowledge and technology transfer to local engineers. Foreign engineers with existing contracts do not have to meet any further requirements to work in the engineering sector in Peru.

## IX. UNITED STATES ENGINEERING SERVICES

### **In Brief**

The United States is the leading provider of engineering services in the world. A long history of demand for engineering services has resulted in the country's firms developing multiple areas of expertise. The country boasts an impressive number of strong university programs that are considered amongst the leading engineering programs in the world. The country exports four times as much as it imports in engineering services and 10 of the world's leading firms are headquartered there. Domestically, demand remains high for engineering in most fields, with significant increased demand for infrastructure development as aging and overstretched infrastructure requires replacing.

### **A. Overview**

America was transformed in a variety of ways in the nineteenth century by engineering and technology. From a primarily agriculturally based and largely unexplored nation at the turn of the 18<sup>th</sup> century, the United States by 1900 was the world's leading industrial nation and on its way to becoming a more urbanized and mechanized country (Herrin, 2002). Falling prices, reduction in tariffs and a boom in the production of iron and steel led to a sharp rise in the world demand for industrial products from the United States, fueling the rapid evolution of the engineering industry in the country (Floud, 1974; Irwin, 2003). From small machinery through automobile, aeronautical and aerospace engineering, the U.S. industry expanded and diversified rapidly. At the turn of the twenty-first century, when production engineering had moved abroad to cheaper destinations, engineering related to the IT industry also began to boom.

Driven by constant national development, firms in engineering and construction services in particular grew in number to meet demand for growing infrastructure, energy, transportation and other needs to support continued economic growth. During the late 1990s and early 2000s, these firms consolidated and grew as clients grew increasingly comfortable with EPC and EPCM contracts that helped reduce client risk. In fact, EPC and EPCM contracts jumped more than 20 percent in 2000 to garner a 35 percent share of the nonresidential construction market, compared to 25 percent in the mid-1990s.

## B. Engineering Demand

### 1. Infrastructure

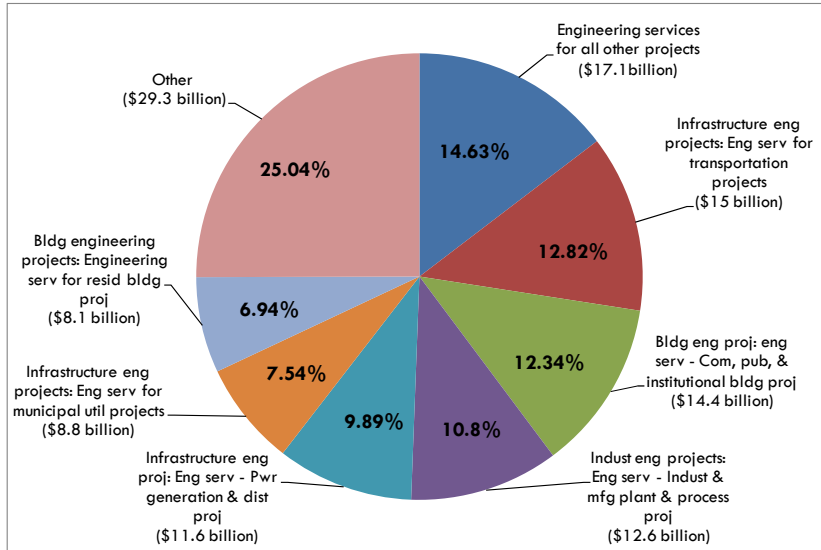
The United States is falling behind other major international markets in its level of investment in new infrastructure projects, and there is growing concern that unless changes are made, this will begin to hinder future growth and will be unable to support America's burgeoning population (The Urban Land Institute and Ernst & Young, 2010)). The American Society of Civil Engineers 2009 Report Card for America's Infrastructure, that provides an analysis of the current state of infrastructure and the necessary investments to improve it, noted that with a cumulative grade D, the state of infrastructure had not improved in the four years since its previous report and estimate an investment of US\$2.2 trillion is required in the next 5 years (American Society of Civil Engineers (ASCE), 2010). Investments are required in almost every sector, including energy, road, air and rail transport, water supplies and sanitation systems. Estimates suggest that up to 20% of the country's water treatment systems currently fail drinking water safety standards, and the cost for upgrading the water system alone will amount to over US\$10 billion within the next twenty years (The Urban Land Institute and Ernst & Young, 2010). While new efforts are being made by the Obama Administration to improve coordination and planning for infrastructure at the federal level (approximately US\$132 billion was allocated to infrastructure projects through the 2009 Federal stimulus bill), the lack of available funding in national, state and local budgets suggests that unless governments increase the number of public-private partnerships, little progress will be made within the next years. On the other hand, current power generation capacity exceeds domestic demand, providing a surplus for exports; however some states such as California have experienced significant problems in meeting demand. In addition, the Obama administration has made a clear policy decision to foster the development of renewable energy sources.

Required investment in repairing and improving America's decaying infrastructure is estimated to be as high as US\$2.2 trillion within the next five years.

Nonetheless, despite the large investments needed in infrastructure, the sector has typically accounted for a significant portion of all engineering services in the United States. As is shown in Figure 11, transportation, energy and municipal infrastructure projects accounted for 30.3% of all engineering services in 2002.



**Figure 11. Product Lines for Engineering Services in the United States, 2002**



Source: (US Census Bureau, 2008)

**2. Other Industries**

Other industry sectors are expected to grow moderately within the next 10 years. Oil and gas production increase is expected to be 4.46% between 2009 and 2019, with numerous new exploration leases for coastal regions of Alaska and California (Business Monitor International Ltd., 2010c). Mining is a relatively small sector of the US economy, accounting for US\$71 billion in 2008 (Business Monitor International Ltd., 2010c), although the industry does represent the key growth sector in certain central states such as Wyoming (Bureau of Economic Analysis (BEA), 2009). Industrial engineering projects accounted for 10% of engineering services in 2002 (see Figure 11.)

The US is the world's leading exporter of engineering services. It exports approximately four times as much as it imports.

**C. Engineering Supply**

The US engineering services industry includes approximately 60,000 companies with combined annual revenue of about \$260 billion (Market Research.com, 2010). According to ENR, the Top 500 engineering firms generated design revenue of \$90.58 billion in 2008, up 12.36% from 2007's mark of \$80.62 billion (Engineering New-Record, 2009). Major companies include Fluor, Bechtel, URS and Jacobs Engineering. The industry is highly fragmented with the 50 largest firms accounting for about 35 percent of industry revenue (Market Research.com, 2010). Table 19 below includes the leading

engineering firms in the United States. Notably, these firms are also amongst the twenty leading global firms.

**Table 19. Leading Engineering Services Companies in the United States**

Company	Revenue (USD mil 2008)	Employees	Main Activities
<b>Bechtel Group Inc</b>	31,400	49,000	Bechtel is one of the prominent engineering, construction, and project management companies. The company handles projects related to energy, transportation, communications, mining, and oil and gas industries. The company also handles projects related to government services. Ex: Airports and seaports, Communications networks, Defense and aerospace facilities, Environmental cleanup projects, Fossil and nuclear power plants, Mines and smelters, Oil and gas field development, Pipelines, Roads and rail systems, Refineries and petrochemical facilities.
<b>Fluor Corporation</b>	22,326	42,119	Delivers engineering, procurement, construction, maintenance (EPCM), and project management to governments and clients in diverse industries around the world. Energy & Chemicals; Industrial & Infrastructure; Power; Chemicals and Petrochemicals; Commercial and Institutional; Government Services; Health-care; Life sciences; Manufacturing; microelectronics; Mining; oil and gas; Renewable energy; Telecommunications; and Transportation.
<b>KBR</b>	11,581	57,000	KBR is a leading global engineering, construction and services company supporting the energy, hydrocarbon, government services, minerals, civil infrastructure, power and industrial markets
<b>Jacobs Engineering Group Inc</b>	11,252	38,900	Project Services (engineering, design, architectural), Process, Scientific and Systems Consulting, Construction, Technology Services, Management services, Environmental, Health and Safety Services, Operations and Maintenance
<b>URS Corporation</b>	10,086	45,000	URS Corporation is a provider of engineering, construction and technical services. The Company offers a range of program management, planning, design, engineering, construction and construction management, operations and maintenance, and decommissioning and closure services to public agencies and private sector clients worldwide. Key market sectors: power, infrastructure, federal/national governments, and industrial and commercial.
<b>CH2M Hill</b>	6,400	25,744	CH2M Hill is an employee-owned firm that provides engineering, construction and related technical services for public and private clients. The company serves the water, energy, environmental, transportation, communications, construction and industrial sectors.
<b>AECOM Technology Corp.</b>	5,200	45,000	AECOM is a global provider of professional technical and management support services to a broad range of markets, including transportation, facilities, environmental, energy, water and government.
<b>Black &amp; Veatch</b>	2,358	9,600	Black & Veatch is a worldwide engineering, consulting and construction company that specializes in infrastructure development in energy, water, telecommunications, and federal, management consulting and environmental markets.
<b>Parsons Brinckerhoff Inc.</b>	2,343	13,010	Parsons Brinckerhoff is a planning, engineering, program and construction management organization. Services: Construction Management; Design and Engineering; Environmental; Operations and Maintenance; Planning; Program Management; Strategic Consulting; Sustainability; E-Business and E-Media.

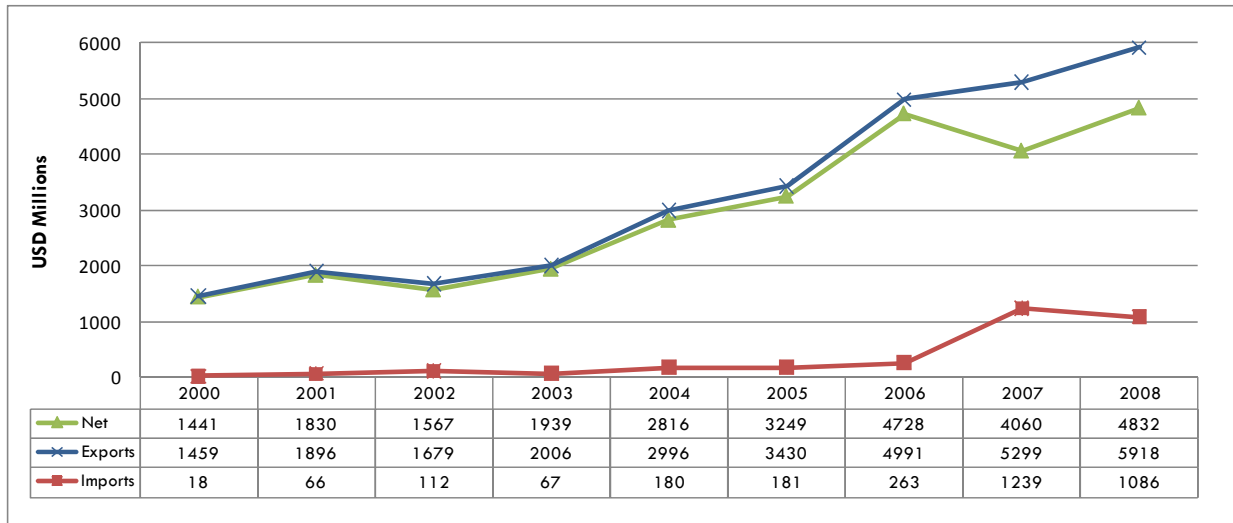
Sources: OneSource, Annual Reports and Company websites

Major engineering services include product and industrial process design, construction design and management, systems engineering, and maintenance and operations (Market Research.com, 2010).

The United States is a net exporter of engineering services, with firms exporting four times more than they import (Cox, 2010). As can be seen in Figure 12 below, growth rates have however been varied, with some years seeing significant growth (45% and 46% in 2003 and 2005 respectively).<sup>36</sup>

<sup>36</sup> Note this data includes all architectural, engineering and construction services, as well as other technical services. As mentioned in Section 1, the lack of availability of good data is a challenge that must be addressed.

**Figure 12. US Trade in Architecture, Engineering and Other Technical Services**



Source: (OECD 2008)

### D. Engineering Education

Engineering programs at the University level in the United States are based on a four-year curriculum, with many programs offering a joint Bachelor-Master degree alternative in five years. The first year of engineering in the United States is common to all engineering disciplines, following which students elect their area of specialization. At the community college level,<sup>37</sup> two year Associate Degrees are offered, which generally cover the curricula of the first two years of a Bachelors degree in

Accreditation of Engineering and Science programs in the United States is voluntary; however, market pressure from firms and graduate schools provides sufficient impetus for schools to seek accreditation in order to remain competitive.

(See Box 2 for accreditation information.)

engineering, thus providing students with the opportunity to transfer to a four-year program. Some schools provide more focused training for two-year engineers to directly enter the workforce.

Engineering and science programs in the United States are regulated by the Accreditation Board for Engineering and Technology (ABET), a non-governmental peer-review board and

accreditation must be repeated every 6 years. While this is a voluntary process, many graduate schools and employers require that applicants hold a degree from an accredited institution(ABET Inc, 2008). In 2008, close to 2,000 engineering programs were offered across all non-computer science

<sup>37</sup> In the United States, community colleges fill the role of providing vocational training. In Latin America, this training is provided mostly by technical or professional institutes.

disciplines at 346 accredited universities in the United States (ABET Inc, 2008). The leading engineering schools, listed in Table 20, include both public and private institutions, with the Massachusetts Institute of Technology leading the field, which is particularly strong in mechanical engineering. Interdisciplinary programs have also become more common since the 1990s and most of the top ten schools excel in fields such as robotics (integration of mechanical and electronic engineering) and engineering science.

**Table 20. Leading University Engineering Programs, United States**

Rank	Institute	Key area of expertise
1	Massachusetts Institute of Technology	Mechanical Engineering
2	Stanford University	Electrical & Electronics, Environmental Engineering
2	University of California – Berkeley	Civil & Mechanical Engineering
4	California Institute of Technology	Engineering Science (Interdisciplinary)
5	Georgia Institute of Technology	Civil & Industrial Engineering
5	University of Illinois- - Urbana –Champaign	Civil Engineering
7	Carnegie Mellon University	Industrial & Electronics Engineering
7	University of Michigan- Ann Arbor	Industrial & Mechanical Engineering
9	Cornell University	Engineering Science (Interdisciplinary)
9	Purdue University	Civil Engineering

Source: (U.S. News & World Report, 2010)

### 1. Number of Engineers

The two leading engineering disciplines in the United States, according to the National Employment Matrix, are Electrical and Electronics engineering, with a stock of approximately 301,500 engineers, and Civil engineering with a stock of 278,400 engineers (Bureau of Labor Statistics 2009). In 2008, engineers held about 1.6 million jobs, approximately 36 percent were found in manufacturing industries, and another 30 percent were in the professional, scientific, and technical services industries, primarily in architectural, engineering, and related services. Many engineers also worked in the construction, telecommunications, and wholesale trade industries (Bureau of Labor Statistics 2009). Overall engineering employment is expected to grow by 11 percent over the 2008–18 decade, as highlighted in Table 21 below, about as fast as the average for all occupations. The three key disciplines expected to see significant growth in employment by 2018 are environmental engineering (42%), civil engineering (24%) and petroleum engineering (18%).

**Table 21. Projected Employment for Engineers in the United States in 2018**

Occupational Title	Employment, 2008	Projected Employment, 2018	Change, 2008-18	
			Number	Percent
Environmental engineers	54,300	70,900	16,600	31
Civil engineers	278,400	345,900	67,600	24
Petroleum engineers	21,900	25,900	4,000	18
Mining and geological engineers	7,100	8,200	1,100	15
Industrial engineers, including health and safety	240,400	273,700	33,200	14
Industrial engineers	214,800	245,300	30,600	14
Agricultural engineers	2,700	3,000	300	12
Nuclear engineers	16,900	18,800	1,900	11
Aerospace engineers	71,600	79,100	7,400	10
Health and safety engineers	25,700	28,300	2,600	10
Materials engineers	24,400	26,600	2,300	9
All other engineers	183,200	195,400	12,200	7
Marine engineers and naval architects	8,500	9,000	500	6
Mechanical engineers	238,700	253,100	14,400	6
Electrical engineers	157,800	160,500	2,700	2
Electrical and electronics engineers	301,500	304,600	3,100	1
Electronics engineers, except computer	143,700	144,100	400	0
Chemical engineers	31,700	31,000	-600	-2
<b>Total Engineers</b>	<b>1,571,900</b>	<b>1,750,300</b>	<b>178,300</b>	<b>11</b>

Note: Projections Data from the National Employment Matrix, United States.

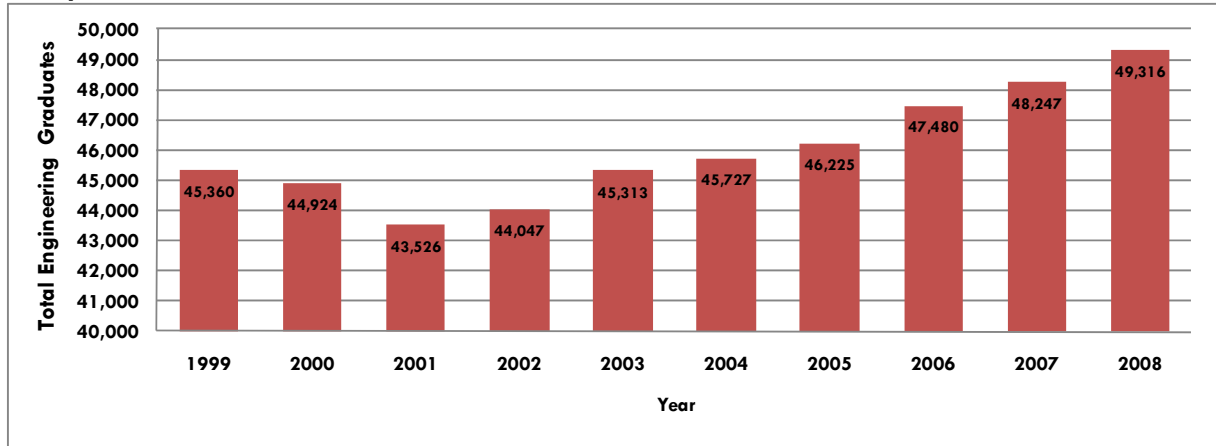
Source: (Bureau of Labor Statistics 2009)

The annual total of engineering graduates in the United States has continued to grow over the past decade, although at a modest pace of 1-3% per year as can be seen in Figure 13 (See Appendix 3. for detail information).<sup>38</sup> While strong growth in employment is expected in environmental engineering over the next eight years, graduation rates in the discipline have actually fallen. The number of petroleum engineers, on the other hand, has increased significantly, particularly in 2007 which saw a 26% increase.

It should be mentioned that foreign nationals earn approximately 7.5% of undergraduate engineering degrees at U.S. universities, and these numbers are even higher at the graduate level (39.8% and 61.7% respectively of Masters and Doctorate degrees awarded in 2006) (Gereffi et al., 2008). As a result of immigration changes in 2001 following 9/11 and improved work opportunities in the field of engineering abroad, there are rising concerns that a large proportion of these foreign graduates will return to their home nations, reducing the total stock of US engineers (Gereffi et al., 2008).

<sup>38</sup> These figures are based on data from the American Society of Engineering Education (Gibbons, 2009) which provides information with respect to the number of graduates in individual engineering disciplines. Only engineering fields related to non-computer science or biomedical engineering have been included in this information. The total number of engineers in the United States including these other disciplines reached 74,170 in 2008. The number of biomedical engineering graduates has more than doubled since 2001.

**Figure 13. Total Annual Engineering Graduates, Undergraduate Programs United States- Selected Disciplines**



Source: (Gibbons, 2009)

## 2. Salaries

Earnings for engineers in the United States are the highest in the Americas (Carter, 2010; UBS, 2009). Nonetheless, salaries do vary significantly by specialty, industry, education and location in the US. As a group, engineers earn some of the highest average starting salaries among those holding bachelor's degrees (Bureau of Labor Statistics 2009). Average starting salary offers for graduates of bachelor's degree programs in engineering, according to a July 2009 survey by the National Association of Colleges and Employers are shown in Table 22 below. However, given the size of the United States, salaries vary across the country. For example, the gross income for electrical engineers with five years of experience in New York City is US\$87,700 while in Chicago it is US\$77,000 (UBS, 2009).

**Table 22. Wage Distribution for Recent Engineering Graduates in the United States, May 2008**

Sectors	Wages (USD)
Petroleum	83,121
Chemical	64,902
Mining and Mineral	64,404
Nuclear	61,610
Electrical/Electronics and Communications	60,125
Mechanical	58,766
Industrial/Manufacturing	58,358
Materials	57,349
Agricultural	54,352
Civil	52,048

Source: (Bureau of Labor Statistics 2009)

### 3. Quality of Engineers

The quality of technical skills of the engineers in the US is among the highest in the world. The most common complaint by science and engineering firms is not with respect to technical skills, but that schools are not adequately preparing engineers with interpersonal skills that prepare them to work in multi-cultural, global organizations (Lowell & Salzman, 2007). Following changes in the accreditation process in 1996, a 2006 study by ABET found that improvements were seen in the number of active learning opportunities available to students, such as development of professional and interpersonal skills (Lattuca et al., 2006).

#### E. Regulatory Framework

All 50 States and the District of Columbia require licensure for engineers who offer their services directly to the public.<sup>39</sup> Engineers who are licensed are called professional engineers (PEs). This licensure generally requires a degree from an ABET-accredited engineering program (although engineers without a degree or who hold a non-ABET degrees may substitute this with corresponding years of work experience), 4 years of relevant work experience, and completion of a state examination. Several states have imposed mandatory continuing education requirements for re-licensure. Engineers who work for the Federal Government usually must also be U.S. citizens. When services, be they imported or provided locally, are not rendered by a PE, these services must be supervised by a licensed U.S. engineer (National Society of Professional Engineers, 2010).

The immigration system in the United States is limits the ability of foreign engineers to work within the country. Firms considering hiring foreign engineers must apply for an H1-B Temporary Visa for Professionals and file a Labor Conditions Application with the Department of Labor which ensures that there are no US professionals available for that position. The number of these visas issues each year for all specialized professionals, is capped at 65,000 for those with Bachelor's degrees and 20,000 for those that hold US Masters degrees (U.S. Citizenship and Immigration Services, 2010).<sup>40</sup>

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<sup>39</sup> Engineers who have not yet attained this title must have their work supervised by a Professional Engineer.

<sup>40</sup> As part of bilateral trade agreements signed with the United States, 6,800 of these work visas are reserved for Chile and Singapore (U.S. Citizenship and Immigration Services, 2010).

**BOX 2. ABET (Accreditation Board for Engineering and Technology)**

Since 2005, ABET has offered accreditation to non-US based institutions. Foreign institutions are subject to the same review process as US institutions. All institutions seeking accreditation must be approved by national authorities within their respective countries and they must have sound foundations in mathematics and science. The evaluation process consists of a self-study report presented by the institution regarding curriculum, faculty, student and graduation information, followed by an evaluation visit by a team from ABET focused on assessing the accuracy of the information provided and an analysis of the institution's strengths and weaknesses. ABET works with accreditation agencies in both Chile (Accredita) and Peru (Instituto de la Calidad en la Acreditación en las Carreras de Ingeniería y Tecnología) among others, to help with quality assurance of engineering and science degrees in these countries. (ABET Inc, 2008).



## X. CONCLUSION

Engineering services trade in both Latin America and globally has increased over the past decade, presenting the Americas region with an important opportunity for growth in the services export sector. Within the region, certain countries have focused on exporting low technology engineering services to neighboring nations, based on limited expertise and financial opportunities, while others, such as Chile, have leveraged their considerable skills in specific sectors to export a higher value added service.

The engineering services industries within these countries are characterized by two extremes, either a consolidated presence of foreign firms or those that are just emerging as potential locations. These firms typically have established local operations to serve needs in respective markets where they were not being met by local supply. This has specifically occurred in the extractive industries of mining and oil & gas. Initially staffed by foreign personnel positions, knowledge and technology transfers are used to build local management and technical engineering capacity. In the countries with limited presence of foreign firms in the sector, local engineering firms often have to form consortiums in order to meet the demand needs of large projects. Demand within the region is being driven by the growing extractive industries and the essential need to expand infrastructure, in particular transport, energy and communication networks in order to support continued economic development. The large multinational firms serve the mining and oil & gas sectors, while domestic firms focus on infrastructure projects. Further demand is being generated by the agricultural and forestry sectors.

The region faces important challenges to meet the growing demand for engineering services. Firstly, the number of engineering graduates remains low, and rising salaries across the region highlight the underlying short supply of engineers. Secondly, the quality of second-tier engineering programs should be monitored to ensure that institutions meet the standards of engineering education in developed countries. This will ensure that engineers from Latin America can compete globally. Third, modifications to engineering curricula should be made to include greater emphasis on essential non-technical competencies, including managerial, language, leadership and teamwork skills.

The global knowledge economy has fragmented industries providing new opportunities for developing nations, and the engineering services industry is no exception. In the past ten years, the door has opened for Latin American countries to participate in this sector. Today, each of these nations must

actively engage in developing their engineering capabilities in order to remain competitive and participate not only in intraregional trade but exporting engineering services to the world.

## XI. APPENDIX

### Appendix 1. Classification Systems

#### a) International Standard Industrial Classification (ISIC) Class: 7110 - Architectural and Engineering Activities and Related Technical Consultancy

International Standard Industrial Classification (ISIC) of all economic activities classified by the United Nations <b>ISIC Rev.4 'Architectural and engineering activities and related technical consultancy'</b>	
<b>Hierarchy</b>	
<ul style="list-style-type: none"> <li>• Section: <a href="#">M</a> - Professional, scientific and technical activities</li> <li>• Division: <a href="#">71</a> - Architectural and engineering activities; technical testing and analysis</li> <li>• Group: <a href="#">711</a> - Architectural and engineering activities and related technical consultancy</li> <li>• <b>Class: 7110 - Architectural and engineering activities and related technical consultancy</b></li> </ul>	
<b>This class includes the provision of architectural services, engineering services, drafting services, building inspection services and surveying and mapping services and the like.</b>	
<p><b>This class includes:</b></p> <ul style="list-style-type: none"> <li>- architectural consulting activities:</li> <li>- building design and drafting</li> <li>- town and city planning and landscape architecture</li> <li>- engineering design (i.e. applying physical laws and principles of engineering in the design of machines, materials, instruments, structures, processes and systems) and consulting activities for:</li> <li>- machinery, industrial processes and industrial plant</li> <li>- projects involving civil engineering, hydraulic engineering, traffic engineering</li> <li>- water management projects</li> <li>- projects elaboration and realization relative to electrical and electronic engineering, mining engineering, chemical engineering, mechanical, industrial and systems engineering, safety engineering</li> <li>- project management activities related to construction</li> <li>- elaboration of projects using air conditioning, refrigeration, sanitary and pollution control engineering, acoustical engineering etc.</li> <li>- geophysical, geologic and seismic surveying</li> <li>- geodetic surveying activities:</li> <li>- land and boundary surveying activities</li> <li>- hydrologic surveying activities</li> <li>- subsurface surveying activities</li> <li>- cartographic and spatial information activities</li> </ul>	<p><b>This class excludes:</b></p> <ul style="list-style-type: none"> <li>- test drilling in connection with mining operations, see 0910, 0990</li> <li>- development or publishing of associated software, see 5820, 6201</li> <li>- activities of computer consultants, see 6202, 6209</li> <li>- technical testing, see 7120</li> <li>- research and development activities related to engineering, see 7210</li> <li>- industrial design, see 7410</li> <li>- interior decorating, see 7410</li> <li>- aerial photography, see 7420</li> </ul>

Source: (United Nations, 2002)

**b) North America Industry Classification System (NAICS.) Code 541330 'Engineering Services'**

<p><b>NAICS Code 541330 'Engineering Services'</b>                  North America Industry Classification System (US, Canada &amp; Mexico). In 1997 NAICS replaced the Standard Industrial Classification (SIC) system. 'Engineering Services' has the code 541330 and SIC 8711</p>	
<p><b>Hierarchy</b>  <b>Sector 54--Professional, Scientific, and Technical Services</b>  <b>5413 Architectural, Engineering, and Related Services</b></p>	
<p>This industry comprises establishments primarily engaged in applying physical laws and principles of engineering in the design, development, and utilization of machines, materials, instruments, structures, processes, and systems. The assignments undertaken by these establishments may involve any of the following activities: provision of advice, preparation of feasibility studies, preparation of preliminary and final plans and designs, provision of technical services during the construction or installation phase, inspection and evaluation of engineering projects, and related services.</p>	
<p><b>Engineering services include:</b></p> <p>Acoustical system engineering design services                  Boat engineering design services                  Chemical engineering services                  Civil engineering services                  Combustion engineering consulting services                  Construction engineering services                  Consulting engineers' offices                  Consulting engineers' private practices                  Electrical engineering services                  Engineering consulting services                  Engineering design services                  Engineering services                  Engineers' offices                  Engineers' private practices                  Environmental engineering services                  Erosion control engineering services                  Geological engineering services                  Geophysical engineering services                  Heating engineering consulting services                  Industrial engineering services                  Logging engineering services                  Marine engineering services                  Mechanical engineering services                  Mining engineering services                  Petroleum engineering services                  Traffic engineering consulting services</p>	<p><b>Cross Reference. Establishments primarily engaged in:</b></p> <ul style="list-style-type: none"> <li>• Planning and designing computer systems that integrate computer hardware, software, and communication technologies--are classified in U.S. Industry <a href="#">541512</a>, Computer Systems Design Services;</li> <li>• Performing surveying and mapping services of the surface of the earth, including the sea floor--are classified in Industry <a href="#">541370</a>, Surveying and Mapping (except Geophysical) Services;</li> <li>• Gathering, interpreting, and mapping geophysical data--are classified in Industry <a href="#">541360</a>, Geophysical Surveying and Mapping Services; Creating and developing designs and specifications that optimize the use, value, and appearance of products--are classified in Industry <a href="#">541420</a>, Industrial Design Services;</li> <li>• Providing advice and assistance to others on environmental issues, such as the control of environmental contamination from pollutants, toxic substances, and hazardous materials--are classified in Industry <a href="#">541620</a>, Environmental Consulting Services; and</li> <li>• Both the design and construction of buildings, highways, and other structures or in managing construction projects--are classified in, Sector 23--Construction, according to the type of project.</li> </ul>

Source: (US Census Bureau, 2008)

**c). Extended Balance of Payments Services Classification (EBOPS)**

<p><b>Extended Balance of Payments Services Classification (EBOPS)</b>                  'Manual on services Manual on Statistics of international trade in services', The United Nations Statistics Division, the Statistical Office of the European Communities, the International Monetary Fund, The OECD and the WTO) The types of services are presented according to the services classification of the 1993 Fifth edition of the Balance of Payments Manual of the International Monetary Fund (BPM5) and its detailed extension, the Extended Balance of Payments Services (EBOPS) Classification.</p>
<p><b>Hierarchy</b>  <b>9. Other Business Services</b>  <b>9.3 Miscellaneous business, professional, and technical services</b>  <b>9.3.4 Architectural, engineering and other technical services- Code 280</b></p>
<p><b>Architectural, engineering and other technical services</b> covers transactions between residents and nonresidents related to architectural design of urban and other development projects; planning and project design and supervision of dams, bridges, airports, turnkey projects etc.; surveying; cartography; product testing and certification; and technical inspection services. Mining engineering is excluded and included in mining services.</p>

Source: (OECD 2008)

## Appendix 2. United Nations Service Trade Data. Category 280: Architecture, Engineering and Other Technical Services

Country	2000		2003		2006		2008	
	Export	Import	Export	Import	Export	Import	Export	Import
Albania	NA	NA	380,000	160,000	60,000	780,000	40,921,886	28,299,041
Argentina	8,419,786	38,789,762	53,417,026	28,228,718	99,207,216	96,193,328	129,367,472	168,720,673
Australia	570,170,614	311,153,447	523,869,416	294,187,377	954,569,721	370,564,227	1,620,771,897	1,595,544,818
Austria	NA	NA	NA	NA	2,281,815,944	829,395,746	3,294,661,889	1,188,385,975
Bangladesh	NA	NA	4,159,470	33,852,700	4,456,280	83,423,000	34,355,500	65,998,900
Brazil	NA	NA	NA	NA	NA	NA	5,595,482,000	2,954,396,000
Bermuda	NA	NA	NA	NA	1,021,250	2,648,838	NA	6,527,849
Bosnia Her.	NA	NA	NA	NA	NA	1,903,610	NA	2,619,489
Bulgaria	NA	NA	2,263,001	2,262,688	98,258,814	288,529,187	149,985,279	521,004,905
Canada	1,570,870,911	841,297,617	2,556,546,557	1,493,399,929	3,459,130,588	1,974,252,711	4,607,879,925	2,694,183,865
Hong Kong	23,000,000	19,000,000	76,000,000	27,000,000	153,000,000	39,000,000	NA	NA
Costa Rica	18,392	689,016	NA	NA	NA	525,960	NA	11,000
Côte d'Ivoire	193,843	NA	259,923	NA	315,547	NA	NA	NA
Croatia	79,847,797	65,346,928	126,728,030	142,888,757	213,857,419	NA	373,857,112	303,944,071
Cyprus	NA	NA	6,789,002	4,525,376	20,983,660	12,943,600	21,089,376	41,821,762
Czech Rep.	85,649,886	131,614,236	55,443,513	214,955,375	265,876,792	264,526,977	833,399,030	356,810,312
Denmark	NA	NA	NA	NA	1,354,639,741	716,296,326	1,934,323,426	1,340,799,790
Estonia	NA	NA	5,657,501	5,656,720	18,344,996	16,713,581	NA	NA
Ethiopia	1,475,810	23,232,000	1,129,930	26,004,200	664,853	10,252,100	5,653,330	39,521,700
Fiji	1,400,000	1,598,994	581,405	NA	1,271,008	2,194,497	1,566,849	1,571,827
Finland	268,922,222	79,152,617	307,768,072	87,113,494	357,476,121	198,677,981	NA	NA
France	2,110,855,251	1,834,315,884	NA	NA	NA	NA	NA	NA
Georgia	NA	NA	NA	1,059,110	NA	613,957	1,016,107	16,364,940
Germany	2,707,641,552	3,856,389,139	6,891,968,106	5,820,765,298	12,211,987,423	9,182,416,238	NA	NA
Hungary	NA	NA	NA	NA	157,817,226	250,955,046	NA	NA
India	NA	NA	NA	NA	5,753,619,579	2,508,468,610	NA	NA
Greece	83,807,953	114,127,029	NA	NA	NA	NA	NA	NA
Ireland	208,138,432	1,183,607,741	262,508,061	119,922,473	731,286,828	397,104,630	NA	NA
Italy	1,589,588,204	1,965,009,740	1,740,247,405	1,692,490,746	2,832,165,825	1,763,094,291	NA	NA
Kazakhstan	17,470,030	171,879,490	11,793,905	687,764,983	47,207,582	1,288,726,578	74,484,650	1,796,147,890
Kyrgyzstan	NA	20,422,446	NA	23,907,258	1,212,790	1,163,753	NA	NA
Latvia	3,683,866	8,283,413	6,789,002	12,444,785	12,690,716	27,018,195	NA	NA
Lithuania	3,683,866	6,442,655	11,315,003	13,576,129	9,926,402	35,814,816	NA	NA
Luxembourg	NA	NA	65,627,015	79,194,086	75,767,347	142,505,269	NA	NA
Malaysia	374,000,000	619,000,000	413,000,000	947,000,000	566,000,000	925,000,000	805,000,000	1,052,000,000
Malta	11,051,598	18,407,585	38,471,009	9,050,753	18,847,599	36,820,144	NA	NA
Montenegro	NA	NA	NA	NA	4,756,636	3,885,903	9,953,861	34,608,208
Mozambique	NA	24,269,817	28,528,080	42,145,420	32,116,621	82,582,069	47,751,421	46,307,528
Neth. Antill	1,000,000	450,000	3,790,000	620,000	7,170,000	830,000	7,030,000	1,170,000
Netherlands	1,972,710,274	2,099,385,114	1,060,215,747	923,176,770	896,140,491	455,539,330	NA	NA
New Zea.	46,653,100	43,349,500	NA	NA	NA	NA	NA	NA
Niger	35,114	NA	NA	NA	5,737	NA	NA	NA
Norway	686,120,053	386,559,293	829,389,693	200,247,902	2,143,097,618	579,069,030	NA	NA
Pakistan	13,000,000	62,000,000	25,000,000	54,000,000	NA	NA	NA	NA
Panama	NA	NA	NA	NA	700,000	1,400,000	NA	NA
Paraguay	15,700,000	200,000	14,400,000	2,000,000	18,117,662	NA	19,600,000	NA
Poland	93,017,618	323,053,124	150,489,535	476,295,858	495,440,543	703,855,390	NA	NA
Portugal	97,622,451	198,801,922	155,015,536	188,934,462	352,827,047	249,195,722	NA	NA
R. Korea	NA	NA	NA	NA	250,100,000	528,400,000	440,600,000	597,200,000
R. Moldova	NA	NA	NA	NA	NA	20,000	2,830,000	2,660,000
Romania	30,391,895	69,028,445	85,994,020	188,934,462	168,874,484	175,681,099	NA	NA
Russia	NA	NA	904,123,300	871,593,000	1,571,818,000	1,611,757,000	3,250,000,000	4,245,000,000
Serbia	NA	NA	21,470,000	18,563,000	42,722,000	64,792,000	137,113,239	124,785,860
Sierra Leo.	NA	NA	NA	515,443	98,887,068	NA	NA	NA
Slovakia	NA	NA	NA	NA	NA	252,840,037	NA	75,986,018
Slovenia	NA	NA	49,786,012	53,173,172	68,982,211	60,445,357	86,864,631	NA
Swaziland	NA	843,086	172,386	2,192,073	2,338,119	23,108,088	23,587,949	43,942,494
Sweden	1,104,238,851	2,070,853,356	888,227,707	603,006,395	1,378,764,667	574,545,053	1,847,901,230	786,661,447
Tajikistan	NA	150,000	55,500	341,500	764,300	248,200	1,126,200	3,649,800
Macedonia	NA	NA	13,391,090	19,196,407	23,196,720	29,002,648	57,143,020	50,303,280
Turkey	NA	NA	NA	NA	NA	11,058,610	NA	7,952,025
Ukraine	35,000,000	45,000,000	88,000,000	124,000,000	189,000,000	168,000,000	310,000,000	281,000,000
U.Kingdom	NA	NA	8,723,867,032	2,485,562,947	9,973,144,003	3,266,436,914	11,462,591,793	3,591,370,157
Venezuela	49,000,000	80,000,000	31,000,000	76,000,000	44,000,000	121,000,000	71,000,000	431,000,000

Note: Only countries reporting more than one data point for the respective years 2000, 2003, 2006 and 2008 were included in this list. 75 countries have reported one or more data point during this period.

Source: (United Nations 2009).

### Appendix 3. Engineering Graduates, by Country and Specialty

#### a) Brazil

Brazil, Total Annual Engineering Graduates							
Sector	2002	2003	2004	2005	2006	2007	2008
Electrical Engineering	3,886	4,008	4,011	4,400	4,851	4,965	4,762
Electronic Engineering	1,940	2,199	3,144	3,609	4,428	4,440	4,143
Civil and Construction Engineering	5,831	6,097	6,038	6,182	6,303	5,933	6,053
Engineering Science	4,486	5,396	6,014	8,181	10,167	12,841	13,176
Mechanical Engineering and Metals-Metallurgy	4,181	4,548	4,346	4,302	4,868	5,303	5,023
Materials Engineering	113	180	149	239	291	453	426
Mining Engineering	134	95	141	150	398	2,406	2,067
Food Processing Engineering	774	820	1,299	1,420	1,485	1,682	1,928
Chemical Engineering	1,235	1,285	1,694	1,726	1,746	1,899	1,954
Textiles, Clothes, Leather	135	135	199	198	205	206	406
Automotive and Aeronautical engineering	85	65	71	84	178	187	214
Forestry Engineering	447	578	576	679	882	937	893
Fishing Engineering	108	142	153	183	192	188	203
<b>Total Engineering Graduates</b>	<b>23,355</b>	<b>25,548</b>	<b>27,835</b>	<b>31,353</b>	<b>35,994</b>	<b>41,440</b>	<b>41,248</b>
<b>Engineering Graduates Growth Rate</b>		<b>9%</b>	<b>9%</b>	<b>13%</b>	<b>15%</b>	<b>15%</b>	<b>0%</b>

Source: (Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira, 2002-2008)

#### b) Chile

Chile, Total Annual Engineering Graduates												
Sector	1995	1996	1997	1998	1999	2000	2001	2002	2004	2005	2006	2007
Civil Engineering	1,538	1,756	1,698	1,834	2,170	2,186	2,925	2,790	3,298	3,773	3,602	4,096
Forestry Engineering	83	132	144	162	195	122	274	266	153	249	244	245
Agricultural Engineering	439	508	492	422	460	458	637	560	623	686	726	719
<b>Total Engineering Graduates</b>	<b>2,060</b>	<b>2,396</b>	<b>2,334</b>	<b>2,418</b>	<b>2,825</b>	<b>2,766</b>	<b>3,836</b>	<b>3,616</b>	<b>4,074</b>	<b>4,708</b>	<b>4,572</b>	<b>5,060</b>
<b>Engineering Graduates Growth Rate</b>		<b>16%</b>	<b>-3%</b>	<b>4%</b>	<b>17%</b>	<b>-2%</b>	<b>39%</b>	<b>-6%</b>		<b>16%</b>	<b>-3%</b>	<b>11%</b>

Source: (Ministerio de Educación de Chile, 2009)

## c) Colombia

Colombia, Total Annual Engineering Graduates							
Sectors	2002	2003	2004	2005	2006	2007	2008
Civil Engineering	4,059	4,205	4,992	4,407	3,421	2,545	2,016
Mechanical Engineering	1,627	1,458	1,635	1,664	1,706	1,701	1,811
Industrial Engineering	5,402	6,245	6,136	5,499	5,108	5,290	4,834
Chemical Engineering	851	728	817	1,021	898	1,132	827
Mining Engineering	369	454	462	441	407	584	434
Electrical Engineering	1,202	1,040	1,186	899	1,076	736	651
Electronic Engineering	3,625	3,677	3,608	3,866	4,143	4,113	3,464
Environmental Engineering	1,635	1,312	2,187	2,163	2,189	2,003	1,911
<b>Total Engineering Graduates</b>	<b>18,770</b>	<b>19,119</b>	<b>21,023</b>	<b>19,960</b>	<b>18,948</b>	<b>18,104</b>	<b>15,948</b>
<b>Engineering Graduates Growth Rate</b>		<b>2%</b>	<b>10%</b>	<b>-5%</b>	<b>-5%</b>	<b>-4%</b>	<b>-12%</b>

Source: (Ministerio de Educación de Colombia, 2009)

## d) Peru

Peru (80%+20%), Total Stock of Registered Engineers				
Sectors	2005	2006	2007	2008
Civil Engineering	26,450	28,369	30,295	32,308
Mechanical Engineering	3,358	3,598	3,907	4,268
Metals-Metallurgy	1,720	1,865	2,053	2,245
Chemical Engineering	8,902	9,211	9,636	10,099
Mining Engineering	3,463	3,668	3,964	4,435
Forestry Engineering	1,282	1,382	1,541	1,732
Electrical Engineering	3,028	3,300	3,572	3,866
Electronic Engineering	2,639	2,856	3,275	3,644
Environmental Engineering	1,200	1,393	1,697	1,954
Aquaculture Engineering	2,321	2,464	2,798	2,928
Agricultural Engineering	3,487	3,719	4,051	4,310
Petroleum Engineering	563	599	655	703
<b>Total Stock of Engineers</b>	<b>58,411</b>	<b>62,424</b>	<b>67,445</b>	<b>72,493</b>
<b>Total Engineering Graduates</b>		<b>4,013</b>	<b>5,021</b>	<b>5,048</b>
<b>Engineering Graduates Growth Rate</b>			<b>25%</b>	<b>1%</b>

Source: (Colegio de Ingenieros del Perú, 2010). These figures are adjusted based on the fact that the Colegio represents approximately 80% of engineering graduates in Peru (Delgado, 2010).

## e) United States

US, Total Annual Engineering Graduates										
Sector	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Civil Engineering	9,416	8,653	8,027	8,066	8,192	8,142	8,247	8,935	9,402	10,132
Mechanical Engineering	12,859	12,992	12,921	13,247	13,801	14,182	14,947	16,063	16,701	17,324
Industrial Engineering	3,524	3,555	3,474	3,575	3,769	3,790	3,647	3,664	3,503	3,367
Metals-Metallurgy	875	904	791	838	859	817	840	909	963	1,095
Chemical Engineering	6,199	6,023	5,740	5,529	5,233	4,801	4,521	4,452	4,551	4,850
Mining Engineering	173	164	150	112	96	85	92	120	119	153
Electrical Engineering	10,955	11,211	11,096	11,402	11,994	12,500	12,459	11,915	11,467	10,790
Environmental Engineering	604	588	510	465	516	576	522	437	454	486
Agricultural Engineering	536	583	549	556	603	601	635	646	659	623
Petroleum Engineering	219	251	268	257	250	233	315	339	428	496
<b>Total Engineering Graduates</b>	<b>45,360</b>	<b>44,924</b>	<b>43,526</b>	<b>44,047</b>	<b>45,313</b>	<b>45,727</b>	<b>46,225</b>	<b>47,480</b>	<b>48,247</b>	<b>49,316</b>
<b>Engineering Graduates Growth Rate</b>		<b>-1%</b>	<b>-3%</b>	<b>1%</b>	<b>3%</b>	<b>1%</b>	<b>1%</b>	<b>3%</b>	<b>2%</b>	<b>2%</b>

Source: (Gibbons, 2009)

## f) Total Engineering Graduates in Selected Countries, 2001-2008- Selected Disciplines

Total Annual Engineering Graduates								
Country	2001	2002	2003	2004	2005	2006	2007	2008
Chile	3,836	3,616		4,074	4,708	4,572	5,060	
Brazil		23,355	25,548	27,835	31,353	35,994	41,440	41,248
US	43,526	44,047	45,313	45,727	46,225	47,480	48,247	49,316
Peru						4,013	5,021	5,048
Colombia		18,770	19,119	21,023	19,960	18,948	18,104	15,948

Source: (Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira, 2002-2008)



## g) Total Engineering Graduates in Selected Countries, 2001-2008 by Discipline

	Chile	Brazil	Colombia	Peru	US
<b>Civil Engineering</b>	4,096	6,053	2,016	2,013	10,132
<b>Mechanical Engineering</b>		5,023	1,811	361	17,324
<b>Industrial Engineering</b>			4834		3,367
<b>Metals-Metallurgy</b>		5,023		192	1,095
<b>Chemical Engineering</b>		1,954	827	463	4,850
<b>Mining Engineering</b>		2,067	434	471	153
<b>Forestry Engineering</b>	245	893		191	
<b>Electrical Engineering</b>		4,762	651	294	10,790
<b>Electronic Engineering</b>		4,143	3464	369	
<b>Environmental Engineering</b>			1911	257	486
<b>Aquaculture Engineering</b>		203		130	
<b>Agricultural Engineering</b>	719	1,928		259	623
<b>Textiles, Clothes and Leather</b>		406			496
<b>Engineering Science</b>		13,716			
<b>Petroleum Engineering</b>				48	
<b>Total Graduates</b>	5,060	41,248	1,5948	5,048	49,316

Source: (Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira, 2002-2008)

Appendix 4. Engineering Companies ISO- OHSAS Certifications

Certifications	Details
<p><b>ISO 9001:2000</b></p>	<p>ISO 9001:2000 specifies <b>requirements for a quality management system</b> where an organization</p> <ol style="list-style-type: none"> <li>1. needs to demonstrate its ability to consistently provide product that meets customer and applicable regulatory requirements, and</li> <li>2. Aims to enhance customer satisfaction through the effective application of the system, including processes for continual improvement of the system and the assurance of conformity to customer and applicable regulatory requirements.</li> </ol> <p>All requirements of this International Standard are generic and are intended to be applicable to all organizations, regardless of type, size and product provided.</p>
<p><b>ISO 9001:2008</b> (new version of ISO 9001:2000)</p>	<p>ISO 9001:2008 specifies <b>requirements for a quality management system</b> where an organization</p> <ul style="list-style-type: none"> <li>• needs to demonstrate its ability to consistently provide product that meets customer and applicable statutory and regulatory requirements, and</li> <li>• Aims to enhance customer satisfaction through the effective application of the system, including processes for continual improvement of the system and the assurance of conformity to customer and applicable statutory and regulatory requirements.</li> </ul> <p>All requirements of ISO 9001:2008 are generic and are intended to be applicable to all organizations, regardless of type, size and product provided.</p> <p>Where any requirement(s) of ISO 9001:2008 cannot be applied due to the nature of an organization and its product, this can be considered for exclusion.</p> <p>Where exclusions are made, claims of conformity to ISO 9001:2008 are not acceptable unless these exclusions are limited to requirements within Clause 7, and such exclusions do not affect the organization's ability, or responsibility, to provide product that meets customer and applicable statutory and regulatory requirements.</p>
<p><b>ISO 9002</b></p>	<p>Quality systems -- Model for quality assurance in production, installation and servicing.</p>
<p><b>ISO/IEC 17025:2005</b></p>	<p>ISO/IEC 17025:2005 specifies the general requirements for the competence to carry out tests and/or calibrations, including sampling. It covers <b>testing and calibration</b> performed using standard methods, non-standard methods, and laboratory-developed methods. It is applicable to all organizations performing tests and/or calibrations. These include, for example, first-, second- and third-party laboratories, and laboratories where testing and/or calibration forms part of inspection and product certification.</p> <p>ISO/IEC 17025:2005 is applicable to all laboratories regardless of the number of personnel or the extent of the scope of testing and/or calibration activities. When a laboratory does not undertake one or more of the activities covered by ISO/IEC 17025:2005, such as sampling and the design/development of new methods, the requirements of those clauses do not apply.</p> <p>ISO/IEC 17025:2005 is for use by laboratories in developing their management system for quality, administrative and technical operations. Laboratory customers, regulatory authorities and accreditation bodies may also use it in confirming or recognizing the competence of laboratories. ISO/IEC 17025:2005 is not intended to be used as the basis for certification of laboratories.</p> <p>Compliance with regulatory and safety requirements on the operation of laboratories is not covered by ISO/IEC 17025:2005.</p>
<p><b>ISO/IEC 27001:2005</b></p>	<p>ISO/IEC 27001:2005 covers all types of organizations (e.g. commercial enterprises, government agencies, not-for profit organizations). ISO/IEC 27001:2005 specifies the requirements for establishing, implementing, operating, monitoring, reviewing, maintaining and improving a <b>documented Information Security Management System</b> within the context of the organization's overall business risks. It specifies requirements for the implementation of security controls customized to the needs of individual organizations or parts thereof.</p> <p>ISO/IEC 27001:2005 is designed to ensure the selection of adequate and proportionate security controls that protect information assets and give confidence to interested parties.</p>
<p><b>ISO/IEC 12207:2008</b></p>	<p>ISO/IEC 12207:2008 establishes a common <b>framework for software life cycle processes</b>, with well-defined terminology, that can be referenced by the software industry. It contains processes, activities, and tasks that are to be applied during the acquisition of a software product or service and during the supply, development, operation, maintenance and disposal of software products. Software includes the software portion of firmware.</p> <p>ISO/IEC 12207:2008 applies to the acquisition of systems and software products and services, to the supply, development, operation, maintenance, and disposal of software products and the software portion of a system, whether performed internally or externally to an organization. Those aspects of system definition needed to provide the context for software products and services are included.</p> <p>ISO/IEC 12207:2008 also provides a process that can be employed for defining, controlling, and improving software life cycle processes.</p> <p>The processes, activities and tasks of ISO/IEC 12207:2008 - either alone or in conjunction with ISO/IEC 15288 - may also be applied during the acquisition of a system that contains software.</p>

<p><b>ISO 14001</b></p>	<p>ISO 14001 is the world's most recognized framework for <b>environmental management systems (EMS)</b> – implemented from Argentina to Zimbabwe – that helps organizations both to manage better the impact of their activities on the environment and to demonstrate sound environmental management.</p> <p>ISO 14001 has been adopted as a national standard by more than half of the 160 national members of ISO and its use is encouraged by governments around the world. Although certification of conformity to the standard is not a requirement of ISO 14001, at the end of 2007, at least 154 572 certificates had been issued in 148 countries and economies.</p> <p>Other environmental management tools developed by ISO/TC 207 include: ISO 14004, which complements ISO 14001 by providing additional guidance and useful explanations.</p> <p>The very first two standards, <b>ISO 14001:2004</b> and <b>ISO 14004:2004</b> deal with environmental management systems (EMS). ISO 14001:2004 provides the requirements for an EMS and ISO 14004:2004 gives general EMS guidelines and its implementation, and discusses principal issues involved.</p>
<p><b>ISO 14001:2004</b> (new version of ISO 14001)</p>	<p>ISO 14001:2004 specifies <b>requirements for an environmental management system</b> to enable an organization to develop and implement a policy and objectives which take into account legal requirements and other requirements to which the organization subscribes, and information about significant environmental aspects. It applies to those environmental aspects that the organization identifies as those which it can control and those which it can influence. It does not itself state specific environmental performance criteria.</p> <p>ISO 14001:2004 is applicable to any organization that wishes to establish, implement, maintain and improve an environmental management system, to assure itself of conformity with its stated environmental policy, and to demonstrate conformity with ISO 14001:2004 by</p> <ol style="list-style-type: none"> <li>making a self-determination and self-declaration, or</li> <li>seeking confirmation of its conformance by parties having an interest in the organization, such as customers, or</li> <li>seeking confirmation of its self-declaration by a party external to the organization, or</li> <li>Seeking certification/registration of its environmental management system by an external organization.</li> </ol> <p>All the requirements in ISO 14001:2004 are intended to be incorporated into any environmental management system. The extent of the application will depend on factors such as the environmental policy of the organization, the nature of its activities, products and services and the location where and the conditions in which it functions.</p> <p>ISO 14001:2004 also provides, in Annex A, informative guidance on its use.</p> <p>An EMS meeting the requirements of ISO 14001:2004 is a management tool enabling an organization of any size or type to:</p> <ul style="list-style-type: none"> <li>• identify and control the <b>environmental impact</b> of its activities, products or services, and to</li> <li>• <b>improve</b> its environmental performance continually, and to</li> <li>• Implement a <b>systematic approach</b> to setting environmental objectives and targets, to achieving these and to demonstrating that they have been achieved.</li> </ul>
<p><b>ISO 7731:2003</b></p>	<p>ISO 7731:2003 specifies the <b>physical principles of design, ergonomic requirements and the corresponding test methods for danger signals</b> for public and work areas in the signal reception area and gives guidelines for the design of the signals. It may also be applied to other appropriate situations. ISO 7731:2003 does not apply to verbal danger warnings (e.g. shouts, loudspeaker announcements). ISO 9921 covers verbal danger signals.</p> <p>Special regulations such as those for a public disaster and public transport are not affected by this International Standard.</p>
<p><b>OHSAS 18001</b></p>	<p>OHSAS 18001 is an <b>Occupation Health and Safety Assessment Series</b> for health and safety management systems. It is intended to help organizations to control occupational health and safety risks. It was developed in response to widespread demand for a recognized standard against which to be certified and assessed.</p>

Source: CGGC based on (ISO, 2009, 2010a, 2010b, 2010c; OHSAS 18001 Occupational Health & Safety Zone, 2007).

Appendix 5. Major Engineering Certifications

Institutes	Certifications	Details
<b>Project Management Institute (PMI)</b> <a href="http://www.pmi.org/Pages/default.aspx">http://www.pmi.org/Pages/default.aspx</a>	Certified Associates in Project Management (CAPM®)	<ul style="list-style-type: none"> <li>- Understand the processes and terminology and have a fundamental knowledge of the <i>PMBOK® Guide</i></li> <li>- Demonstrate knowledge of project management practices</li> <li>- Contribute to project team as a Subject Matter Expert</li> </ul>
	Project Management Professionals (PMP®)	<ul style="list-style-type: none"> <li>- Are responsible for all aspects of the project for the life of the project</li> <li>- Lead and direct cross-functional teams to deliver projects</li> <li>- Demonstrate sufficient knowledge and experience to apply a methodology to projects</li> </ul>
	Program Management Professionals (PgMP)®	<ul style="list-style-type: none"> <li>- Are responsible for achieving an organizational objective by overseeing a program that consists of multiple projects.</li> <li>- Define and initiate projects and assign project managers to manage cost, schedule and performance.</li> <li>- Maintain alignment of program scope with strategic business objectives.</li> </ul>
	PMI Risk Management Professional (PMI-RMP <sup>SM</sup> )	<ul style="list-style-type: none"> <li>- Responsible for identifying project risks and preparing mitigation plans.</li> <li>- Supports project management and the team as a contributing member.</li> <li>- Minimum of three years of project risk management experience.</li> </ul>
	PMI Scheduling Professional (PMI-SP <sup>SM</sup> )	<ul style="list-style-type: none"> <li>- Responsible for creating and maintaining the project schedule.</li> <li>- Supports project management and the team as a contributing member.</li> <li>- Minimum of three years of project scheduling experience.</li> </ul>
<b>American Society for Quality (ASQ)</b> <a href="http://www.asq.org/">http://www.asq.org/</a>	<ul style="list-style-type: none"> <li>- Manager of Quality/Organizational Excellence - CMQ/OE - Pharmaceutical GMP Professional - CPGP</li> <li>- Quality Auditor - CQA</li> <li>- Quality Engineer - CQE</li> <li>- Quality Improvement Associate - CQIA</li> <li>- Quality Inspector - CQI</li> <li>- Quality Process Analyst - CQPA</li> <li>- Quality Technician - CQT</li> <li>- Reliability Engineer - CRE</li> <li>- Six Sigma Black Belt- CSSBB</li> <li>- Six Sigma Green Belt- CSSGB</li> <li>- Software Quality Engineer - CSQE</li> </ul>	
<b>Society of Manufacturing Engineering (SME)</b> <a href="http://www.sme.org">http://www.sme.org</a>	<ul style="list-style-type: none"> <li>- Certified Manufacturing Technologist (CMfgT) Certification</li> <li>- Certified Manufacturing Engineering (CMfgE) Certification</li> <li>- Lean Certification</li> <li>- Six Sigma Certification</li> </ul>	SME is the world's leading professional society advancing manufacturing knowledge and influencing more than half a million manufacturing practitioners annually.
<b>National Institute for Certification in Engineering Technologies</b> <a href="http://www.nicet.org">http://www.nicet.org</a>	<ul style="list-style-type: none"> <li>Civil Engineering Technology Certification</li> <li>Electrical and Mechanical Systems Engineering Technology Certification</li> </ul>	The <b>National Institute for Certification in Engineering Technologies (NICET)</b> is an organization that was established in 1961 to create a recognized certification for engineering technicians and technologist within the United States.
<b>Engineering Management Certification International</b> <a href="http://www.engineeringcertification.org/">http://www.engineeringcertification.org/</a>	Engineering Management Certification EMCI	Engineering Management Certification International is a certification program based on the EMCI™ Body of Knowledge (EMC-BOK™) in order to establish global standards in engineering management. Engineering Management Certification International, is a certification program that both facilitates and maintains competence in engineering management among qualified engineers, scientists and technologists
<b>American Society of Mechanical Engineers (ASME)</b> <a href="http://www.asme.org">http://www.asme.org</a>	<ul style="list-style-type: none"> <li>- Y14.5 Geometric Dimensioning and Tolerancing Professional Certification</li> <li>- PE and FE Exam Review Information and Products</li> </ul>	Founded in 1880, it is a not-for-profit professional organization that enables collaboration, knowledge sharing and skill development across all engineering disciplines, while promoting the vital role of the engineer in society.

Source: CGGC

## Appendix 6. International Engineering Industry Associations

International Industry Associations	Details
<b>American Society of Civil Engineers</b> <a href="http://www.asce.org/">http://www.asce.org/</a>	Founded in 1852, ASCE represents more than 147,000 members of the civil engineering profession worldwide, and is America's oldest national engineering society.
<b>IEEE (The Institute of Electrical and Electronics Engineers)</b> <a href="http://www.ieee.org/index.html">http://www.ieee.org/index.html</a>	IEEE is the world's largest professional association advancing innovation and technological excellence for the benefit of humanity.
<b>Institute of Industrial Engineers</b> <a href="http://www.iinet2.org/Default.aspx">http://www.iinet2.org/Default.aspx</a>	Founded in 1948, IIE is the world's largest professional society dedicated solely to the support of the industrial engineering profession and individuals involved with improving quality and productivity.
<b>Society of Manufacturing Engineering (SME)</b> <a href="http://www.sme.org/cgi-bin/getsmepg.pl?new-sme.html&amp;&amp;SME&amp;">http://www.sme.org/cgi-bin/getsmepg.pl?new-sme.html&amp;&amp;SME&amp;</a>	SME is the world's leading professional society advancing manufacturing knowledge and influencing more than half a million manufacturing practitioners annually.
<b>American Institute of Chemical Engineers</b> <a href="http://www.aiche.org/">http://www.aiche.org/</a>	AIChE is the world's leading organization for chemical engineering professionals, with over 40,000 members from over 90 countries. Conference, publication, education, training, government and industry information.
<b>The Association of Energy Engineers (AEE)</b> <a href="http://www.aeecenter.org/i4a/pages/index.cfm?pageid=1">http://www.aeecenter.org/i4a/pages/index.cfm?pageid=1</a>	AEE is a nonprofit professional society of over 11,000 members in 78 countries. The mission of AEE is "to promote the scientific and educational interests of those engaged in the energy industry and to foster action for Sustainable Development."
<b>The American Society of Mechanical Engineers (ASME)</b> <a href="http://www.asme.org/">http://www.asme.org/</a>	Founded in 1880, ASME is a not-for-profit professional organization that enables collaboration, knowledge sharing and skill development across all engineering disciplines, while promoting the vital role of the engineer in society.
<b>The Society of Automotive Engineers (SAE)</b> <a href="http://www.sae.org/">http://www.sae.org/</a>	<b>SAE International (SAE)</b> , formerly the <b>Society of Automotive Engineers</b> , is a professional organization for mobility engineering professionals in the aerospace, automotive, and commercial vehicle industries.
Latin American Associations	Details
<b>Asociación de Empresas Consultoras de Ingeniería de Chile (AIC)</b> <a href="http://www.aic.cl">www.aic.cl</a>	AIC is a nonprofit trade association that brings together engineering sector companies in Chile. The association works to promote the field of consulting engineering, fostering research and developing new markets both domestically and abroad,
<b>Colegio de Ingenieros de Peru (CIP)</b> <a href="http://www.cip.org.pe">www.cip.org.pe</a>	CIP is a nonprofit professional society that represents engineers from all fields in Peru. The organization represents approximately 80% of engineers in the country.
<b>Camera Colombiana de Infraestructura de Colombia (CCI)</b> <a href="http://www.infraestructura.org.co">www.infraestructura.org.co</a>	CCI was created in 2003 through the fusion of a number of traditional professional associations in Colombia in the engineering and construction sector. These include the Asociación Colombiana de Ingenieros Constructores (ACIC), la Asociación Colombiana de Empresas de Ingeniería y Consultoría (AICO), la Asociación de Consultores de Colombia (ASCOL) and la Asociación Colombiana de Concesionarios de Infraestructura y Servicios (CONCESIA).
<b>Associação Brasileira de Consultoras de Engenharia</b> <a href="http://www.abceconsultoria.org.br">http://www.abceconsultoria.org.br</a>	ABCE was founded in 1966 and comprises the most important engineering services companies in Brazil. ABCE objective is to promote and create an strategy to the Brazilian engineering.

Source: CGGC

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