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The Global Engineering Consultancy Market.

Andrew C. Gross
Cleveland State University, a.gross@csuohio.edu

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The purpose of this paper is to assess and analyze the size and characteristics of the engineering consultancy market in select Western nations and worldwide. A secondary goal is two-fold: to look briefly at the training required for careers in this field and to evaluate the strategies of the participating firms. This sector has grown in the past half-century to about U.S.\$550 billion revenue globally, with nearly 3 million establishments and about 500,000 employees. There are giant, multinational firms that span across regions; but the sector is still highly fragmented, and the top 10 firms have less than 15 percent of the global market share. The typical firm in the industry in most major countries consists of around five or six professional associates. The data problems in analyzing this sector are formidable. The paper offers guidelines to using these statistics. It also describes steps necessary for effective marketing.

Keywords: engineering consulting, services, global markets, civil engineering

The industry described and analyzed here is defined by the North American Industry Classification System (NAICS) code #541330: Engineering Services (1) 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." These services are offered on a consultancy basis, rather than being provided by in-house engineering staffs. Every attempt has been made to find the equivalent code and scope for the sector in the other nations covered in this paper.

As the definition suggests, there are engineering fields that encompass virtually the entire range of man's interaction with nature. These include civil engineering, chemical engineering, electrical engineering (including electronics), mechanical engineering, industrial engineering, automotive engineering, marine engineering, aeronautical engineering, software engineering, bioengineering, and other engineering fields.

This paper assesses the size and characteristics of the engineering consultancy industry in select Western nations and worldwide. The size of each national market is difficult to determine, and so is the precise nature of service offerings, the regional markets served, and end-use patterns. One of our goals here is to show how the statistics differ owing to diversity in terminology, data collection, and subsequent interpretation. Although both national statistical bureaus and many private publishers are dedicated to offering reliable data, their surveys are often ad hoc and/or lack sufficient details for analysis. We offer guidelines on how to steer around such problems. In concluding, we suggest strategic steps and specific advice on promotion schemes for large and small enterprises. The keys to success are sharing knowledge within the firm, enhancing reputation, smart bidding, and forging strong relationships with clients.

Section 1 of the paper describes the sector's history and scope. Section 2 describes current issues in the engineering consultancy industry and how they are being resolved. Section 3 describes the industry in each of the world's major regions. Section 4 describes business strategy and marketing. Section 5 offers some concluding remarks. Appendix I describes the methods used in the data assembly and analysis. Appendix II is an annotated bibliography for those who wish to conduct their own investigations into this sector.

1. History and Methodology

Among the engineering disciplines, civil engineering is the oldest--as ancient as humanity: even primitive shelters involved design and the understanding of the materials from which they were constructed and the environment in which they had to function. Next came the design of harbors and fortresses; followed by the design of bridges, canals, roads, and railways. (2) Other engineering fields developed in the wake of scientific discoveries and the determination to adapt them to human use. Recently, electrical and computer engineering have taken center stage, while bioengineering and biological engineering are examples of the cutting edge of engineering consultancy.

Although engineering in general is ancient, formal education in the field is relatively new. In North America, engineering programs can be traced back to mid-nineteenth century. Today, there are thousands of courses offered across this continent as well as in all other regions. Table 1 shows recent trends in bachelor's degrees in engineering awarded in the United States, China, and India. Engineering education is rigorous, but debates continue about what a "proper" engineering curriculum should be at the undergraduate and graduate level. Associations, government agencies, and educator groups differ in their emphasis on the role of science, design, and craftsmanship courses, with no clear resolution in sight. There is still concern with enrollment, retention, and accreditation.

Table 1. Bachelor Degrees in Engineering, Computer Science, and Information Technology Awarded in the [United States](#), India, and China (4-year degrees, in thousands)

| Country | 1999 | 2001 | 2003 | 2005 |
|---------------|-------|-------|-------|-------|
| United States | 110.0 | 114.2 | 134.4 | 133.9 |
| India | 45.0 | 82.1 | 129.0 | 170.0 |
| China-A | -- | -- | 282.6 | -- |
| China-B | 200 0 | 219.6 | 352.5 | 517.2 |

Sources: Wadhwa, V., and: others 2007. "Where the Engineers Are," *Issues in Science and Technology*, Spring. No pagination [available at: www.ssues.org/23.3/wadhwa.html]; Gereffi, G and others 2008 "Getting the Numbers Right Engineering Education," *Journal of Engineering Education*, January: 13-25

Notes: China-A series from Ministry of Education and China Education and Research Network; China-B series from Ministry of Education Yearbook. There are definitional and methodology problems with both series. See notes in the sources cited for further elaboration

Graduates of accredited engineering programs are sought after by engineering consultancies as well as other knowledge-intensive businesses. Many firms promise a parallel path of advancement where those staying with the technical route can earn as much as those who move into managerial ranks. However, many firms pay lip service to this credo, and so we find engineers making a transition into management in search of better remuneration and career

advancement, but seeking to avoid obsolescence. Our research shows high levels of job satisfaction by engineers in North America, regardless of the path chosen.

Large and small engineering consultancy firms have gone global, establishing offices abroad; but trade is flourishing too. For example, the "headcount" for the largest international design firms by country are shown in Table 2, and we can see a definite shift from the United States toward Australia-Asia.

Table 2. Distribution of Top International Design Firms, by Country of Origin, 1978-2010 and Share of Global Revenue. 1996-2010

| Country | Number of Firms | | | | Share of Revenue | |
|----------------|-----------------|------|------|------|------------------|-------|
| | 1978 | 1985 | 1992 | 2010 | 1996 | 2010 |
| United States | 49 | 21 | 67 | 65 | 40.2% | 31.0% |
| Canada | 8 | 7 | 11 | 8 | 7.4 | 7.2 |
| France | 10 | 7 | 10 | 8 | 3.6 | 3.6 |
| Germany | 5 | 9 | 17 | 7 | 4.8 | 0.9 |
| United Kingdom | 8 | 17 | 20 | 10 | 13.5 | 14.6 |
| Netherlands | 3 | 6 | 11 | 6 | 11.8 | 10.9 |
| Other Europe | 9 | 16 | 11 | 33 | 8.3 | 10.4 |
| Australia | 1 | 1 | -- | 10 | -- | 8.1 |
| Japan | 2 | 8 | 14 | 10 | 4.2 | 2.1 |
| China | -- | -- | -- | 21 | -- | 3.7 |
| S. Korea | | 2 | | 6 | | 0.8 |
| All other | 5 | 6 | 39 | 16 | 6.0 | 6.7 |
| Total firms | 100 | 100 | 200 | 200 | -- | -- |
| Total revenue | | | | | 100% | 100% |
| Bil (U.S.\$) | | | | | | 57.6 |

Source: All data are from ENR

Note: Big shift from 100 to 200 firm between 1985 and 1992

The history of the consultancy aspect of engineering has a parallel in management consulting. Both fields date their origin to the mid-nineteenth century in England. The building of railways and bridges combined engineering and managerial skills. Project engineers then began to work in specific areas as [consultants](#). After World War II, large engineering consultancies in many engineering fields were established in the United States, with a major cluster in California.

2. Issues in Engineering Consultancy and Resolutions

There are many factors that impact education, graduates, the types of careers, and the character of firms in the field of engineering. Some have been solved, while others are under review and may never be fully resolved. Space allows only brief comments on these topics and we offer the remarks under three headings.

Historical and social factors in engineering

In the distant past, engineers were first-generation college males. They were encouraged in their quest by their blue-collar fathers who worked as foremen in factories. The male image persisted, but with concerted efforts universities increased the share of females to the 12-24 percent range in North America and even higher elsewhere. As for dropout rates, engineering programs now retain just as many students as other programs, with no appreciable difference between men and women. Yet another concern, for many years, has been international migration and "brain drain" with migrating engineers facing discrimination. This issue is more legal than social now, owing to governmental rules about visa permits and qualification rules by accrediting boards.

Economic and legal factors

Since the launching of satellites and humans into space in the late 1950s, there has been a strong debate about a possible shortage of engineers, especially in the United States, with concern about innovation and growth. However, a rigorous economic analysis of the [labor market](#) for engineers in the United States, using a dynamic model of occupational choice, found that demand responds well to wage levels and other "demand-shifters," while supply is responsive to career prospects. A more recent, controversial topic has been the outsourcing of technical work by Western companies and the emphasis by emerging economies on their pool of technical talent at a much lower level of remuneration.

Government oversight of engineering practice varies country-by-country and even within a nation. Thus, in the United States, there are qualifying national examinations for professional engineers, but the 50 state registration boards determine standards for passing them and eligibility to take them. Some states in the United States restrict practice by disciplines, while others do not. Canada does not have restriction by discipline, but provincial boards and associations encourage a code of ethics. At the firm level, a licensed professional engineer must be in "responsible charge" when a project is executed. The majority of engineering graduates or firms do not seek such approval and yet they still carry out technical assignments. In the United Kingdom, the term "chartered engineer" is in use and is protected by boards; but the practice of engineering is not restricted, and indeed many mechanics call themselves engineers. In much of Europe, the "Eur.ing." title is in wide use and a federation (FEANI) assists in oversight and mobility of qualified professionals.

Conceptual and statistical issues

Who is an engineer and what constitutes a consultancy? Does professionalism reside with the individual or the organization? At the core of these questions is the idea of a profession that

involves highly skilled work and technical expertise. Its characteristics are formal qualifications, based on education and examination, accompanied by regulation and some monopoly powers. In engineering, as in other professions, there are associations for individuals and for organizations protecting their rights, lobbying, and conducting research. In small firms, individuals seek status via licensing or other means; in the case of large consultancies, the firms see themselves as embodying professionalism. This is also the case for management consultancies, about which we reported in this journal in October, 2008.

National statistical organizations serve as agencies for their respective governments in census and related data collection. Attempts at harmonizing national data do proceed, but as can be seen from Table 3, major differences still exist in industrial classification schemes. In the case of service statistics, an intergovernment panel, known as the Voorburg Group, has been meeting "on using country resources to improve the international standards development process." They concluded that a global classification scheme would fail and that national approaches are still necessary. Thus, it is not possible at present to do truly rigorous quantitative international comparisons.

Table 3. Major Industrial Classification Schemes by Region and Sponsor

| Scheme | Sponsor | Criterion/Unit | Digits/Node count | Issued |
|--------|------------------|----------------|------------------------|---------|
| ISIC | United Nations | Establishment | 4 21/88/238/419 | 1948- |
| NAICS | Can + U.S. + Mex | Establishment | 6 17/99/313/724/... | 1987- |
| SIC | United States | Establishment | 4 1004 categories | 1937-87 |
| NACB | EC/EU | Establishment | 4 (Rev, 2.0 mode) | -- |
| ANZSIC | AU +. NZ | Establishment | 4 | -- |
| ICB | FTS'E | Market/company | 10/20/41/114 | -- |
| GICS V | S&P, Morgan | Market/company | 2-8 10/24/68/154 | -- |
| TRBC | Thomson-Reuters | Market/company | 10/25/52/124 | -- |

Sources: 1. Wikipedia, industry classification systems

2. Contact with national statistical bureaus

3. Primary research by the author

Notes: 1. SIC was replaced by NAICS in 1987 in the United States.

2. Other systems exist. for example JSIC for Japan

3. Definitions of "engineering services" differ among systems,

regions, or even individual nations

3. Western Markets, Other Regions, and the Global Scene

How do we find reliable statistics to build a consistent picture about regional and global trends? Many national statistical bureaus are under severe budgetary restraints, and there are serious problems of definition and accuracy. Still, it seems clear that one should begin the analysis of the engineering consultancy industry by examining data from national statistics bureaus.

International agencies, such as the OECD and the World Bank, provide helpful data, but they rely on submissions from national governments. National governments and international agencies have strengthened their collection and timeliness of data. One positive step in harmonizing industry classification and accounting standards is that NAICS now applies to Canada, the United States, and Mexico. Associations and for-profit data-gathering companies have stepped in with major efforts, though usually with specific, narrow coverage, although some of these data are suspect. So let us now take a look at select Western markets and the global scene for engineering consultancy.

The United States

The engineering consultancy sector in the United States has prospered in recent years, with its revenue doubling from 1997 to 2009--a growth rate of 6.1 percent per year. We estimate that revenue in 2012 is near or already at the U.S.\$200 billion mark, as shown in Table 4. In 2009, the employee-to-company ratio was around 17, if we count firms with paid employees; if we add the solo practices to both numerator and denominator, then the average size firm had only seven staff members. As for revenue per employee, it was U.S.\$180,000 when we count paid employees, dropping to U.S.\$170,000 when we include all sole proprietors. These numbers should increase with domestic economic recovery; however, the U.S. share of the global market keeps shrinking and is now at 31 percent.

Table 4 The U.S. Market for Engineering Services

| Item | 1997 | 2002 | 2007 | 2009 |
|--------------------------------------|-------|-------|--------|----------|
| Number of establishments (thousands) | 52.5 | 55.3 | 58.4 * | 59.0 ** |
| Revenue (billion U.S.\$) | 88.2 | 116.9 | 187.5* | 178.8 |
| Number of employees (thousands) | 730.0 | 859.6 | 977.0 | 995.0 ** |
| Payroll (billion U.S. \$) | 35.3 | 49.8 | 71.8 | NA |

Sources: 1 .U.S. Census Bureau, Economic Census (every 5th year survey) and Annual Survey for Services: Professional, Scientific and Technical Services (1999, 2004, 2009, and 2011). See also:

<http://www.census.gov/services/index.html>;
<http://factfinder.census.gov/servlet/iBQTable?>

2. Statistical. Abstract of the United States, 2012, 13 1st ed. (2012)

Notes: * Figures are for businesses with paid employees. In 2007 there were an additional 91.4 thousand establishments with only U.S.\$5.3 billion revenue; this was 2.7 percent of total revenue. ** estimate by IBIS World

1. Industry code is NAICS #54133

2. Product line breakdown available, but it is really end-users

3. Trade is estimated at about U.S.\$6 billion [exports](#) and U.S.\$1 bil [imports](#)

United Kingdom

Both engineering and management consulting started in the United Kingdom as early as the mid-nineteenth century, but now both fields have matured. The figures shown in Table 5 reveal stability and practically no growth in number of enterprises, turnover (revenue), or employment. The employee-to-establishment ratio is between 6 and 7, largely because there are many small firms. Turnover per staff is about 108,000 pounds (approximately U.S.\$180,000) per year--similar the United States. Compared with the United States, where the payroll to revenue ratio ran around 38 percent, it is about 31 percent in the United Kingdom. We estimate that the United Kingdom's share of the global market is about 7 percent, but holding steady. Given the maturity of the market, we expect consolidation in the sector in the coming years.

Table 5. The UK. Market for Engineering Activities and Related Technical Consultancy

| Item | 2008 | 2009 | 2010 |
|-----------------------------------|-------|-------|-------|
| Number of enterprises (thousands) | 55.5 | 55.2 | 54.3 |
| Total turnover (billion pounds) | 37.0 | 37.0 | 36.8 |
| Total employment (thousands) | 337.0 | 352.0 | 341.0 |
| Employment costs (billion pounds) | 11.5 | 11.7 | 11.5 |

Source: Annual Business Survey, Section M: Professional, Scientific and Technical Activities, June 14, 2012, Office of National Statistics (United Kingdom). See also:

<http://www.statistics.gov.uk/hub/economy/index>

Note: 1. Industry code is # 71.12; differs from other

2. Tables for these 3 years have other useful data: gross value added, purchases, net capital spending, and so on, but no data on trade, end-use, product lineup

Canada

This resource rich, highly urbanized country offers many opportunities for engineering consultancy services, ranging from shale oil and tar sands exploration in Alberta to urban renewal efforts in major cities, such as Montreal, Toronto, and Vancouver. Export is also part of the scene, though the data reveal that its share of operating revenue has declined from 18 to 13 percent in recent years. There has been stability in operating revenues and expenses in recent years, as shown in Table 6, although profit margin still shows strength, with a 14 percent figure for 2010. The labor cost to revenue ratio is almost identical to the U.S. figure at 38 percent in 2010. We were not able to obtain establishment data.

Table 6. The Canadian Market for Engineering Services

| Item | 2007 | 2008 | 2009 | 2010 |
|---|-------|-------|-------|-------|
| Number of establishments (000s) | 25.4 | 24.8 | NA * | NA * |
| Operating revenue (billion C\$) | 19,7 | 22.3 | 21.4 | 22.5 |
| Operating expenses (billion C\$) | 17.2 | 19.5 | 19.1 | 19.9 |
| Salaries; wages, benefits (billion C\$) | 7.3 | 8.5 | 8,2 | 8.8 |
| Operating profit margin. (%) | 12.7% | 12.8% | 11.0% | 14.2% |
| Exports as % of operating revenue (%) | 17.7% | 15.6% | 15.2% | 13.3% |

Sources: Statistics Canada, (2012) Cat. #63-258-X Service Bulletin Engineering Services NAICS #54133, see related bulletins: Cat #360-0005, 360-0012, 360-0013 and also: www.statcan.gc.ca with good search, options

Notes: * Data not available except for expensive fee Figure is likely to be about 2K as in previous 2 years

(1.) Quote from #63-258-X: "This is a sample survey, data come from two different sources: a. sample of all businesses with revenue above or equal to a certain threshold (note: threshold varies between surveys) and those below the specified threshold ... the effective sample size for reference year 2009 was 708 collection entities"

Australia

This nation has shown the fastest growth in the engineering consultancy sector, with much of it connected to the boom in infrastructure and mining. We show key statistics for 1995-2005 in Table 7; more recent figures were not available as surveys are taken only every 4-6 years. However, two good supplementary sources, with up-to-date and detailed information, are Consult Australia and IBISWorld. From 1995 to 2005, the sector experienced a phenomenal 23 percent annual growth, with labor costs rising at 18 percent per year. Average annual remuneration in 2001 was A\$104,000 and we think the figure is now around A\$150,000 (about U.S.\$157,000). Ratio of labor expense to total revenue was around 38 percent in 1995 and 2005, but it declined sharply to 25 percent in 2005. Worley Parsons is the largest firm by far with U.S.\$5.7 billion revenue in 2010-11.

Table 7. The Australian Market for Consultant Engineering Services

| Item | 1995-1996 | 2001-2002 | 2005-2006 |
|-------------------------------|-----------|-----------|-----------|
| No. of businesses (thousands) | 5.5 | 11.0 | 22.0 * |
| Revenue (billion A\$) | 3.2 | 9.3 | 25.3 |
| Employment (000s) | 30.7 | 64.5 | NA |
| Labour costs (billion A\$) | 1.2 | 3.6 | 6.4 |
| Operating profit margin (%) | 11.0% | 12.5 | 12.0% |

Sources: Australian Bureau of Statistics, Survey Reports, Australian Industry. #8155.0 for 2005-06 and Consultant Engineering Services #8693.0 for 1995-96 and 2000-01 See also #8165.0 (new). See also: <http://www.abs.gov.au/websitedbs>

Notes: 1. No additional survey on this sector since 2007

2. Industry code for this sector is ANZSIC #7823

3. In a February 2012 report IBISWorld estimates the size of the AU market at about A\$29.2 billion and exports at U.S.\$1.2 billion and imports at U.S.\$2.5 billion

* Our estimate; based on 31K reported for 2011

Continental Europe

Our search did not yield sufficient material to build tables such as those shown for the United States, the United Kingdom, Canada, and Australia. We did locate short reports from CBI, a centre affiliated with the Ministry of Foreign Affairs in the Netherlands. CBI is dedicated to assist exporters from emerging economies to enter the EU. How this would be accomplished in the case of engineering [consulting services](#)--an area requiring reputation and expertise, with thousands of domestic firms already in place--is not clear, though it does identify specific market segments. In its country reports, CBI estimates the engineering consultancy markets in 2009, in billions of

euros, as follows: Germany at 30, France at 20, United Kingdom at 20, Spain at 8, and the Netherlands at 7. We think these figures are low, based on a comparison with official data for the United Kingdom (see data in Table 5) and our preliminary research for France, Germany, and Spain. A report on the Scandinavian market was issued by STD, the Swedish Confederation of Consulting Engineers and Architects; there are good details, by country, but the focus is on top firms rather than on market size.

Other regions

For South America, there is a 2010 report, Engineering Services in the Americas, by CGGC, a research unit at Duke University. This report looks at engineering education, demand, trade, regulatory framework, and top firms, but again market size is not revealed for the region or the four nations mentioned (Brazil, Chile, Colombia, Peru).

The global scene

Proper methodology first requires the collection of national statistics, then grouping them into regional totals to arrive at a global estimate. This was not possible on a primary basis, but we have at our disposal earlier world studies of high-level manufactured goods as well as some services by private sector publishers. In the past it was possible to argue that, roughly, North America accounts for one-third, the EU for another third, and all other regions for the remaining one-third of a "global total" in many product markets; however, there is contrary evidence as well. Thus, for global security services, the distribution was 37 percent, 25 percent, and 38 percent in 2009 for the three regions, explained in part by lack of gun control in the United States. In the case of global management consulting, in 2007, a consensus view showed a 49 percent, 33 percent, and 18 percent breakdown, explained in part by management feeling comfortable with consultants in the United States.

For the case of global engineering consultancy, we turn to two respected sources, ENR, a flagship journal in engineering related to construction, and IBISWorld, a major publisher of multiclient studies. Their estimates in the two columns of Table 8 differ sharply as to geographic distribution, which can be explained by the scope of each survey. ENR is looking only at the top 150 design firms in its annual report and is not interested in global data for all firms. Conversely, IBISWorld looks far wider and therefore reports large-scale revenues for all size and type of firms in the mature regions of Europe and North America. In Table 9 we use the same two sources again to show the major end-user sectors or market segments. In this case, even the row headings are difficult to compare, though both lists point to the dominance of infrastructure and energy as big users.

Table 8. The World Market for Engineering Design/Services by Major Regions, 2011, via Two Key Publishers

| Region | Source: | Source: |
|--------------------|---------|-----------|
| | ENR | IBISWorld |
| Asia and Australia | 23.1% | -- |
| Oceania | -- | 3.2% |
| South East Asia | -- | 0.8 |

| | | |
|----------------------|------|----------|
| North Asia | -- | 18.9 |
| India + Central Asia | -- | 3.4 |
| Europe | 23.0 | 30.4 |
| United States | 11.8 | 41.8 |
| Canada | 10.8 | combined |
| Middle East | 16.6 | 0.5 |
| Africa | 8.1 | combined |
| South America | 6.6 | 1.0 |
| Total (percent) | 100 | 100 |
| Bil (U.S.\$) | 57.7 | 515.0 |

Sources: 1. ENR, Global Sourcebook, December 12, 2011, p.62

2. Global Engineering. Services, Report #L6722-G (Melbourne: IBISWorld, 2012), p.19

Note: ENR survey: only top 150 international design firms

Table 9. The World Market for Engineering Services/Design by Major End-users, 2011, per Two Key Sources

| End Use (ENR) | % distribution | End Use (IBIS) | % distribution |
|------------------|----------------|-----------------------|----------------|
| Petroleum | 31.3% | Heavy infrastructure. | 40.0% |
| Transportation: | 18.4 | & Construction | -- |
| General Building | 15.4 | Industrial & | 25.0 |
| Power | 9.4 | Resources | |
| Industrial | 7.6 | Nonresidential | 20.0 |
| Water | 5.4 | building | -- |
| Other | 3.8 | Public Infrastructure | 15.0 |

| | | | |
|-------------------|------|----|-------|
| Sewer and Waste | 3.6 | -- | -- |
| Hazardous Waste | 3.4 | -- | -- |
| Manufacturing | 0.8 | -- | -- |
| Telecommunication | 0.6 | -- | -- |
| Total (percent) | 99.7 | | 100.0 |
| Bil (U.S.\$) | 57.7 | | 515 |

Source: 1. ENR, Global Sourcebook, December 12, 2011, p.68

2. Global Engineering Services, Report #L6722-GL (Melbourne: IBISWorld, 2012), p. 17

Note: ENR survey: only top 150 international design firms; this tradition has been maintained for decades

In assessing the global scene, ENR's coverage focuses on large firms, which seek fast-growth regions and end-use sectors to take advantage of their established expertise and far-flung project offices. IBISWorld's global reporting, on the other hand, relies on its own, already-published national reports (which include several, but by no means all major countries) as well as on surveys by FIDIC, a Geneva-based federation of engineering consultancies with 80 national chapters. FIDIC attempts to tie engineering service expenditures to nonresidential construction and gross fixed capital formation. Such a sequence or chain seems "natural" though others claim that design and consulting services are much more global in character, but construction is fully local. Further, FIDIC's latest nation by nation assessment was in 2003; it is currently starting a new one.

In Table 10, we omit the far narrower scope of ENR, pick up the FIDIC data for the "global total" in the past decade, and introduce another source, Booz & Company. We tried to obtain 'global total' figures from the UN, OECD, and IHS Global Insight, but did not succeed; the figure was not available or came at a truly high price. Finally, we did not seek data from two market research publishers, Icon Group and Barnes Reports, even though they offer global reports on engineering and construction because their methodology was not transparent. As for the Booz study, we still await word on the reasons for their rather high numbers compared with other sources.

Table 10. The World Market for Engineering Services ("Global Total") per Three Key Sources

| Item | 2002 | 2005 | 2007 | 2010 | 2012 | 2020 |
|--------------------------|------|------|------|------|------|------|
| Revenue (billion U.S.\$) | | | | | | |
| 1. FIDIC | 397 | 432 | -- | -- | -- | -- |
| 2. Booz Allen & ... | -- | -- | 560 | -- | -- | 886 |

| | | | | | | |
|---------------------|----|----|----|------|------|----|
| 3. IBISWorld | -- | -- | -- | 492 | 530 | -- |
| No. of firms (000s) | -- | -- | -- | 480 | 500 | -- |
| No. of staff (000s) | -- | -- | -- | 2800 | 2900 | -- |

Sources: 1. A White Paper on Engineering Design Services Out-sourcing
Baker & McKenzie, Booz & Co, 2008

2. FIDIC Staff. Overview of Engineering Consultancy, FIDIC, 2003 and
2006, 4 pp. and 12 pp

3. Global Engineering Report #L6722-GL IBISWorld

Notes: 1. Source #1 is undertaking a new survey in 2012

2. Source #2 says authors departed; previous reports by Booz showed
higher figures for 2004 & 2020

3. Source #3 was cordial and cooperative

4. Studies by Global Industry Analysts, Icon Group and Barnes Reports
were not utilized owing to lack of clarity in description of content,
methodology

5. Still seeking other sources via database search

4. Structure, Strategies, and Relationship Marketing in Engineering Consultancy Related to Construction

We have so far emphasized the scope of national, regional, and global markets. But in the field of engineering services, as is the case for many other product and service categories, the emphasis is on gaining specific opportunities, building close relationships, capturing market share, and then executing all projects to the full satisfaction of an increasingly sophisticated client base.

In this section, we select engineering services related to the engineering-construction (E/C) sector which is concerned with the design, engineering and construction of buildings, infrastructure, mining, processing and energy projects--to illustrate characteristics of strategy, marketing and other facets of engineering consultancy. The EIC sector is selected because it is so pervasive and because so many engineering disciplines are swept into consultancy related to construction. Nonetheless, a computer-assisted search for "aeronautical engineering services" or "chemical engineering services" for two examples, make it clear that there are many engineering consultancies that offer many services not related to the built construction.

Industry structure

The E/C consulting sector is highly fragmented, despite recent moves toward consolidation. At the global level and within national markets, between two-third to four-fifth of all firms have less than 10 staff members. These firms often specialize as to their offerings and the end-users they

seek; in major countries, they are satisfied with a domestic clientele. On the other hand, the largest firms are truly multinational in their operations. Among the largest E/C consulting firms are AECOM, Bechtel, CH2MHill, Jacobs, Fluor, URS, and WS Atkins from the United States, SNC-Lavalin from Canada; Altran Technologies from France; Fugro NV and Arcadis Group from the Netherlands; AMEC and Mott McDonald from the United Kingdom. (3) Market share figures by IBISWorld show that the top 10 firms command just around 11 percent of the global market. So concentration is still low, though entry barriers in terms of competition are rated high. This situation prevails, because forging relationships and establishing expertise take time; because competitive bidding or tendering is a difficult process; and, finally, because the technology required service offerings, and end-users' needs can change rapidly.

Service categories, types of companies

Engineering students normally select a major or discipline such as civil, electrical, or mechanical, though often a combination of a major with a strong minor is a great route to success. Graduates can follow the discipline at the workplace, but within engineering service firms they will specialize by activities that the company pursues and/or the end-user categories the firm serves. These include such options as: feasibility studies, design, procurement, installation assist, technical advice, tendering, inspection, and evaluation. The specialization can be by application or end-use: energy, environmental projects, industrial processes, building operations, and so on.

We can classify E/C consulting companies on basis of size, age, geographical reach, legal structure, or specialization, but overall, there are only two distinct categories: pure service and hybrid. The former is often the hallmark of small to medium size firms in a domestic setting; the latter is descriptive of medium to large size companies that engage in construction projects for domestic and foreign clients. This distinction can be observed in many countries, but data collection and reporting focus on the big players that are hybrid in character. This can be seen in Table 11 that cites two ENR lists, one for design firms, one for contractors. But being hybrid, many companies appear on both lists. (Adding the two revenue streams, however, still does not yield the grand total for a given entity as ENR excludes "construction and project management.") Table 11 reveals that the revenues for large firms are far bigger from the construction than the design side.

Table 11 Total and International Revenue for Three Large U.S. Engineering Design/Engineering Contractor Firms, 2010 (billion US. dollars)

| Rank on List/Company | Total Revenue | of which Int'l Revenue |
|---|---------------|------------------------|
| Engineering Design, Global Top 150 List | | |
| #12 Bechtel | \$2.2 | \$1.2 |
| #4 Fluor | 3.2 | 2.1 |
| #14 KBR | 2.0 | 1.7 |
| Engineering Contractor, Global Top 225 List | | |

| | | |
|------------|--------|--------|
| #9 Bechtel | \$19.7 | \$12.5 |
| #14 Fluor | 17.2 | 11.6 |
| #28 KBR | 7.7 | 5.9 |

Source: ENR, Global Sourcebook, December 12, 2011 for top 150 design firms, p.81 and top 225 contractors, p.91

Note: These figures are computed by ENR, from corporate submissions, and annual reports. ENR registers only the figures shown above. For example, Bechtel had an additional U.S.\$6.0 billion in revenue for a total of U.S.\$27.9 billion in 2010 as reported in its annual report, the U S \$6.0 billion was "construction and project management." The ENR rationale is that this is neither design nor construction

Competition and cooperation

The competitive battle in E/C consulting, as is the case for management consulting, is not at the country level or even at the firm level; rather it is at the level of recruiting technical and managerial talent on the supply side, and at the level of attracting and maintaining customers on the demand side. In short, professionalism must prevail, with qualified persons executing tasks in a long-term, relationship mode for valued clients. We have emphasized market size by country, and the regulatory-economic framework is still applicable; but medium and large firms enter and expand across borders based on their reputation and expertise. They are eager to learn about on-going plans and future project possibilities. Keeping tabs on these is accomplished by reading news items, following calls for bids or tenders, and tapping databases such as GROAB of Germany. But cultivating social and political contacts in a networking mode is truly effective in the long run. A key example of this, openly cited, occurs when a chief executive of a large E/C consulting firm talks to a top government official at the World Economic Forum, which is held once a year in Davos, Switzerland.

Although competition prevails at the local or country level for smaller firms and at the regional or global level for large ones, cooperation is also common, ranging from informal alliances to formal joint ventures. One popular collaborative mode is a consortium where several firms join forces to tender or bid on a large project. One example among many is the Ivanpah project in the Mojave desert of California, where Bechtel joined Bright-Source Energy, NRG, and Google to build the world's largest solar electric generating facility. Bechtel has had partners in other big projects such as the new Hong Kong airport and refineries in China. URS has joined with Amec and Areva on decommissioning a large nuclear facility in the United Kingdom. Tetra Tech formed a consortium with Tokyo Engineering and Egis International in providing wastewater and drainage design for a public agency in Orissa, India. Parsons joined domestic and foreign partners in building Dubai's metro and Abu Dhabi's airport expansion in the UAE.

Strategies and tactics

Different ideas or "rules" apply to large and small firms, and strategy should differ between domestic and multinational markets. Large firms are almost always international, and they are then structured on the basis of cost or value-in-service. The cost-based organization closely watches expenditures whether in hiring the requisite talent or spending on the job site. A value-

conscious firm is able and willing to spend for highly qualified personnel and at the project location. In international projects, the usual practice is to share expert staff, problems/issues, and solutions across borders rather than merely opening an office in yet another country. Having built relationship and trust, the client will often ask the E/C consulting firms to continue in new foreign locations, especially in a given specialty, say mining.

Small firms can serve small clients in a similar manner to the large ones, but are more likely to embrace the cost base than the service/value base mode (and to remain domestic). That is because their ability to keep experts on the payroll is limited unless they can bill clients at a hefty hourly rate. To accomplish this, the small firms must become highly specialized in their offerings and in seeking niche markets. When successful in this, small firms bring their expertise and join with large design/contractor firms; this team arrangement can be exclusive or not, temporary or not. In either situation, clients are likely to insist that the qualifications of both vendor organizations be up-to-date.

On-going activities in E/C consultancies include making intangible and perishable offerings more meaningful and longer lasting. The first step here is cultivation of talent by offering continuing education opportunities, tuition refunds, and participation in conferences and exhibits. Also, the corporate website and brochures must be up-to-date, demonstrating technical and managerial competence. Fees can be cost or competition-based, but the value-in-service approach is making inroads on the other two. As for distribution, medium-size or large firms must weigh export, partnership, investment alternatives when considering foreign clientele: all three modes may be utilized in different settings. Exchanging key ideas with both partners and customers is one key to success. Finally, on the promotion or communication front, several techniques can be of value as demonstrated in the comments cited in Table 12. A mix of the possibilities cited can be assembled that will suit any organization; the key is to convey trust and expertise.

Table 12. Promotion Schemes Available to Engineering Consultancies

| Promotion Scheme | Comment #1 | Comment #2 |
|----------------------|------------------------------|-----------------------------|
| Client presentations | Front-line method; vital | Adjust to each client |
| Testimonials | Useful if unsolicited | Cite evidence if possible |
| Referrals | Can be effective | Best at same position level |
| Memberships | Corporate support vital | Allows networking |
| Seminars/Conferences | Strive to be speaker | Works best with experts |
| Trade shows/Exhibits | Just to be seen; recognition | Not too effective |
| Charities, grants, | Public clients | Private clients- |

| | | |
|-----------------------------|---------------------------|-------------------------------|
| donations | expect effort. | may work |
| Class lectures | Useful for recruitment | Prefer 3rd--4th year students |
| Professional networks | Highly useful, keep it up | Linkages best at same level |
| Advertising, print or elec. | Just for recognition | Not viewed as effective |
| Publishing, talk shows | Can gain name recognition | Useful for visible Issues |

5. Conclusion

In a complex and technologically sophisticated world, mining and energy facilities must be designed, office buildings must be planned and then built, wings for aircraft must be designed, chemical and biomedical processes must be designed, and infrastructure must be either renewed or put in place anew. In all of this, professional engineering consulting services play a key role. The thousands of organizations around the world in this sector together have now recorded around U.S.\$500 billion revenue with 3 million staff members working in half million establishments. The top 200 firms dominate in terms of payroll, projects, and multinational presence, but 1-10 person firms still account for about three-fourth of all establishments. Both competitive and cooperative schemes exist in both situations. Data on the sector are becoming more available and abundant through surveys by both national statistical organizations and private sector publishing firms. Free and for-fee databases will make collection and analysis easier in the coming years. The key to success in the field is to build new contacts, maintain trust with existing clients, and remain flexible in moving from project to project.

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APPENDIX I

Methods used in preparing this study

Primary research

In conducting this study, a three-pronged, primary task was undertaken, one formal and two informal. The first was revisiting engineering graduates from Canadian universities who received their B.Sc. in electrical engineering in 1954, 1959, and 1964. Originally, these three cohorts were interviewed in 1965 as a part of the author's doctoral dissertation. Now, near the end of their career, they were asked again to comment on their education, job satisfaction, and related

topics. The second part was visiting in person four major and two small national statistical organizations in the United States, United Kingdom, Canada, Australia, New Zealand, and Hungary. They were asked to share their survey forms and survey results for engineering service firms. These visits also made follow-up contacts, via phone or e-mail, much easier. The third part consisted of visiting officials at select large and midsize engineering consultancies to obtain their views on recruitment, marketing, and corporate strategies. They are MWH Global, Middough, Parsons, Tetra Tech, and URS (in the United States), Uvaterv, and others in Hungary.

Secondary research

This work consisted of a thorough review of the literature in both the technology and the business realm, tapping electronic databases. Among those yielding useful journal articles or abstracts were Business Source Complete, Lexis-Nexis, and Dissertation Abstracts. Major engineering associations, many of them international (for example FIDIC, FECA) as well as university groups were asked to share their findings. The databanks of international agencies such as Eurostat and OECD were also investigated. A well-regarded, Australian market research, IBISWorld kindly provided the author with its report on engineering consultancies. A few other publishers of multicient studies either did not respond or were not even asked because their methods and data seemed weak.

APPENDIX II

Select annotated bibliography

Association of Canadian Engineering Companies. 2006. *Selecting a Professional Consultant*. This 38-page guide is one in a series on best practices, with emphasis on value-based consulting procurement. Specific advice is given, and useful data are provided on engineering design costs.

Baker & McKenzie and Booz & Company. 2008. *A White Paper on Engineering Design Outsourcing*. This 37-page volume, by a law firm and a management consulting firm is a good discussion on the main topic, with illustrations and supporting evidence, emphasizing legal and managerial aspects.

Bryant, P. 2006. "Decline of the Engineering Class; Effects of Global Outsourcing on Engineering Services," *Leadership and Management in Engineering*, April, 59-71. The author complains that the topic has been ignored owing to the fragmented nature of the sector and calls for readjustment, reforms, and concerted action.

Cattaneo, O., M. Engman and L. Schmid 2010. "Engineering Services: How to Compete in the Most Global of the Professions", in Cattaneo, O., M. Engman, S. Saez and R.M. Stern eds., [International Trade](#) in Services: New Trends and Opportunities for [Developing Countries](#), The World Bank. The authors do a good job on trends in developing countries, various trade aspects, some examples, checklists; but they say little on market size, business strategies, nontrade competition.

Coviello, N. & Martin, K. 1998. "Internationalization of service SMEs: an integrated perspective from the engineering consulting sector," *Journal of International Marketing*, 7/4, 42-66. Four case studies of small New Zealand-based engineering consulting firms that decide to go abroad.

ENR Staff 2011. "ENR Global Sourcebook", ENR, December 12, 51-95. Excellent collection on top 150 design and 225 contractor firms, details by region, end-use, and so on. Terminology, however, can be tricky

Fernandez-Stark, Karina, Penny Bamber, and Gary Ger-effi.2010. Engineering Services in the Americas. Center on [Globalization](#), Governance & Competitiveness, Duke University. This 99-page volume has good details on Brazil, Chile, Colombia, and Peru, but not all the other nations. Good treatment of demand and supply, education, regulations, and engineering firms, but analysis on market size and business strategies is limited.

FIDIC Staff. 2003 and 2006. Overview OR the E.C. Industry Statistics. FIDIC. These are slim 4- and 12-page reports relying on interviews with a majority of its 75 national chapters. Only the latter has some country details and some of the column headings are not quite transparent. FIDIC is linking data on engineering services to GDP. GFCF, and nonresidential construction. Further explanation is needed for analysis. FIDIC is undertaking a new survey in summer, 2012.

IBISWorld Staff. 2012. Global Engineering Services, Industry Report L6722-GL. IBIS World. This is a fine 50-page report with good details on industry performance, products and markets, competitive landscape, major companies, and operating conditions. However, there are no country details. The report relies in part on previous editions and old FIDIC surveys.

Malhotra, N. and Morris T. 2009. "Heterogeneity in Professional Service Firms." *Journal of Management Studies*, September, 895-922. A solid analysis of three categories: legal, auditing, and engineering consulting firms; for each category, the authors discuss knowledge base, geographic reach, client interaction, and client capture.

Osegowitsch, T. 2003. The Relationship between Global Integration and Performance in Multinational Professional Engineering Consultancies. Unpublished Ph.D. thesis. University of Western Australia. A rigorous, analytical study using both qualitative and quantitative techniques, the author is able to demonstrate that global integration, rather than just organic growth or mere expansion into foreign markets, is associated with profitability.

Scheuer, M. 2003. "The International Competitiveness of German Consulting Engineering: Results of an International Benchmarking Study." *Journal of Services Marketing*, 23(1): 95-118. The author thinks Germany has not done well in this field and its weakness arises from lack of adaptation in world markets.

Yee, C. and C. Cheah. 2006. "Fundamental Analysis of Profitability of Large Engineering Companies," *Journal of Management in Engineering*, 22(4): 203-210. They find that there is no significant correlation between profitability and firm size.

(1.) "NAICS" is used by Canada, the United States, and Mexico in their governments' official statistics.

(2.) To be precise, military engineering--fortresses and the like--has been a separate discipline: hence the distinction of civil (nonmilitary) engineering.

(3.) Note that some of these firms--for example Bechtel and Fluor--offer construction as well as engineering services. To extent possible, we have tried to separate these two closely related activities.