DFMA 2012

27th International Forum on Design for Manufacture and Assembly

Advancing R&D Competitiveness With Metrics

June 12, 2012

GGI PO Box 350 Dedham, MA 02027 Phone 781-444-5400
GGI 1346 South Street Needham, MA 02492 Fax 781-444-5475
www.goldensegroupinc.com

Advancing R&D Competitiveness With Metrics

by
Bradford L. Goldense

From WWII to the late 1990s, "measurement science" in R&D and Product Development centered on project management, systems engineering, and product quality and reliability in the industrialized countries of the time. This was not surprising. Mature economies were competing with other mature economies using almost purely execution parameters. For the next few decades, that landscape will be changing as significant new players emerge to take their place alongside established economies. The volume of competition is much greater. Geopolitical dynamics, already known to be different, are complicating the basis of competition as well.

Best measurement practices for companies hailing from mature economies are changing more rapidly than at any time in history. There is a need to be more innovative, and additionally to position the resultant intellectual property both defensively and offensively. Global knowledge is now doubling every two years, while at the same time Baby Boomers are retiring at an accelerating rate. Retaining existing knowledge, and keeping pace with new knowledge, are both challenges as never before. Organizations are flattening out. Managers now direct knowledge workers whose individual and collective competencies create competitive advantage. CEOs are being asked new questions by Wall Street and by large corporate customers. Confidence is built by having credible responses to questions affecting corporate valuations. Initial measurement approaches, and specific metrics, to address these new and real challenges are now at hand.

A single essay on a subject of this scope necessarily has to make some leaps and assumptions to associate information from often disparate sources. However, with the information explosion taking place, it will likely not be too many more years before all the data will be connected. "Management Science" and "Measurement Science" are becoming more closely related in the information age, and global data is increasingly available.

The Playing Field

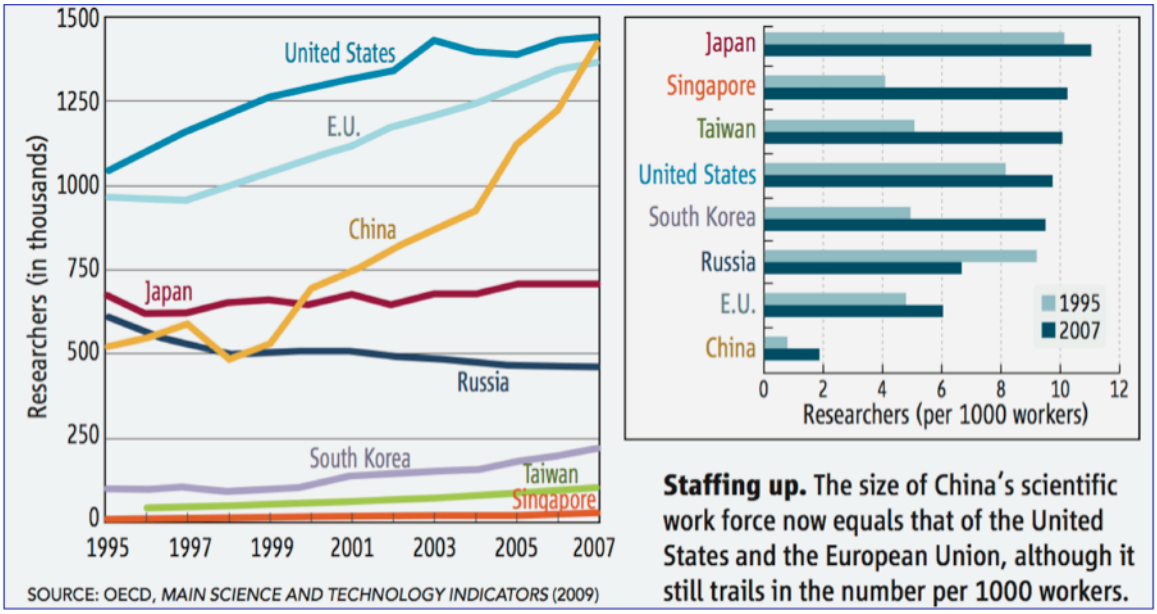
Outside of Europe and North America, the bulk of the world's population has been leveling the playing field for two decades. Soon, the world will see what a level playing field looks like. After centuries of steady change, the past three decades have been tumultuous. The thirst for information, enabled by the internet, now makes it possible to get a global view of each major discipline in science and engineering. The centers of excellence around the world are largely known. There is often enough information available about government philosophy on an area or

T90 ADVANCING R&D COMPETITIVENESS WITH METRICS – An Essay
ISBN13 978-1-937115-00-5
BOOTHROYD-DEWHURST, INC. 27th International Forum on DFMA
Providence, Rhode Island
June 12, 2012

industry to project a country's future status from its current status. Building R&D centers of excellence is a fairly expensive undertaking and the targeting of the right labor force and competencies are increasingly critical.

There will be examples following this research example, indicating analogous management science exists for product development and the resultant intellectual property. In the earlier stages of basic and applied research, there are now an equal number of professionals in China as there are in the United States and the EU. In "pure research," there is now an effective triad [Figure 1].

Figure 1: Research Workforce[1]



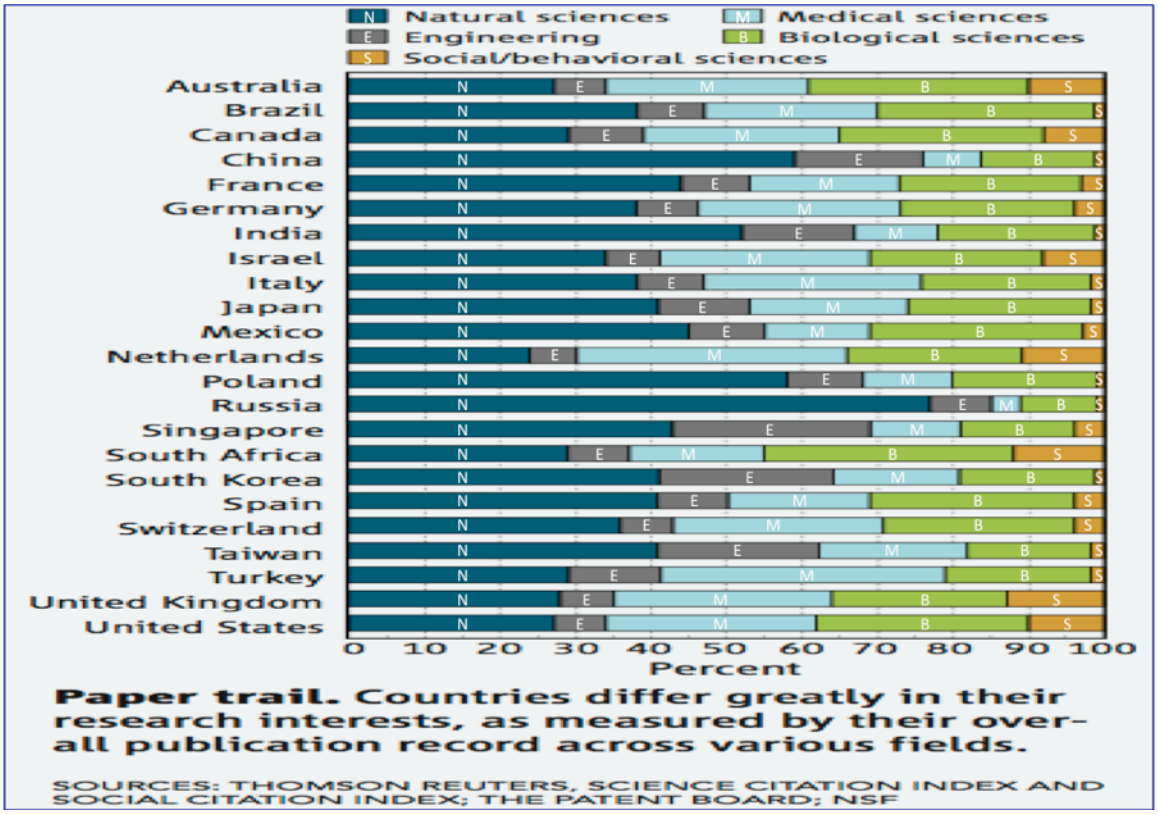
Countries and corporations, whose intentions are to compete on the basis of innovation, are paying close attention to this information. It is these investments that will pay out a decade to two decades from now. Interest is palpable for both offensive and defensive purposes.

Because of the keen level of competition today, countries are picking their spots just as corporations do for strategic purposes. Is your company locating its planned new R&D facility in the right place based on what it hopes to achieve from that facility? Achieving local content as the sole objective for locating a facility may not result in the optimum outcome for the investment. In some cases, there may be choices that could be improved by knowing what is actually being done versus being said.

[1] Source: Jeffrey Mervis, "Science Indicators: Trends Document China's Prowess," Science Magazine, American Association For The Advancement Of Science [AAAS], 1200 New York Avenue NY, Washington, DC, USA, ISSN 0036-8075, Volume 327, January 22, 2010, Page 407, Chart: Workforce

One of the measurable outputs from professionals involved in research is publications. By measuring publications, one can see what is actually being done [Figure 2].

Figure 2: Research Publications[2]



For example, if you were running a company in the medical research business, you might be interested in looking closely at the Netherlands or Turkey.

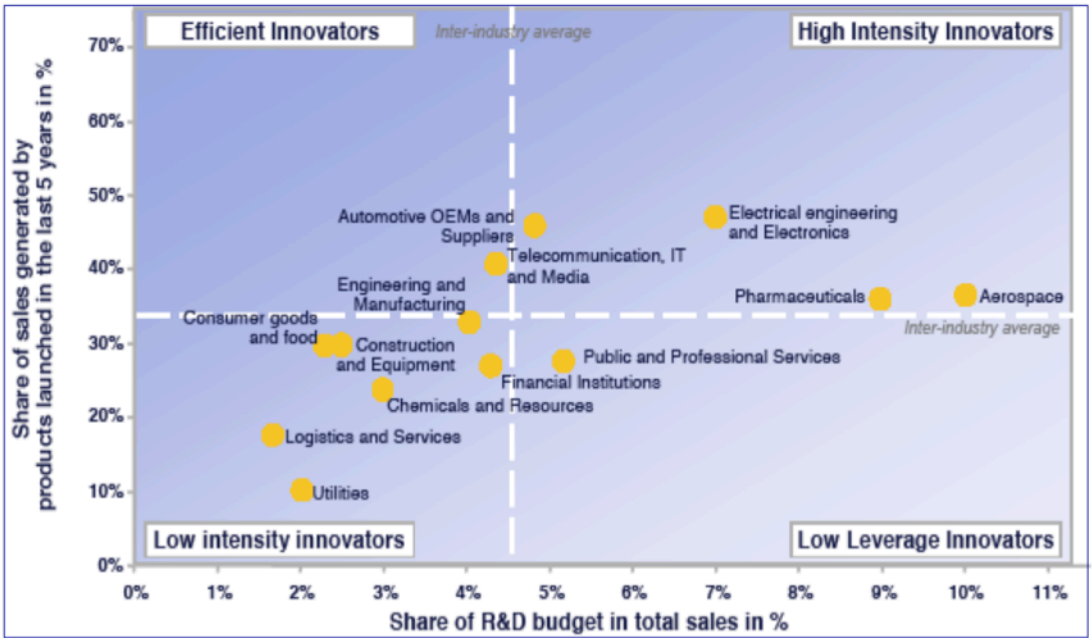
The Right Strategy

Strategy. Now there is another highly quantifiable subject. In its simplest form, a good strategy means only that you outperform the average of your industry. In its most complex form, it has thousands of facets.

[2] Source: Jeffrey Mervis, "Science Indicators: Trends Document China's Prowess," Science Magazine, American Association For The Advancement Of Science [AAAS], 1200 New York Avenue NY, Washington, DC, USA, ISSN 0036-8075, Volume 327, January 22, 2010, Page 407, Chart: Publications.

A good starting point is to know the characteristics of the industry in which you compete. Some industries spend large amounts of money and get little return. Some spend small amounts and get big returns [Figure 3]. Measurement science has resulted in defining operating envelope for the management science of each industry. Competitive advantage is rarely achieved by going with the flow of the industry. However, a characterized industry enables precise strategies and a better expected value of decision making.

Figure 3: Range Of Industry Innovation Practices[3]



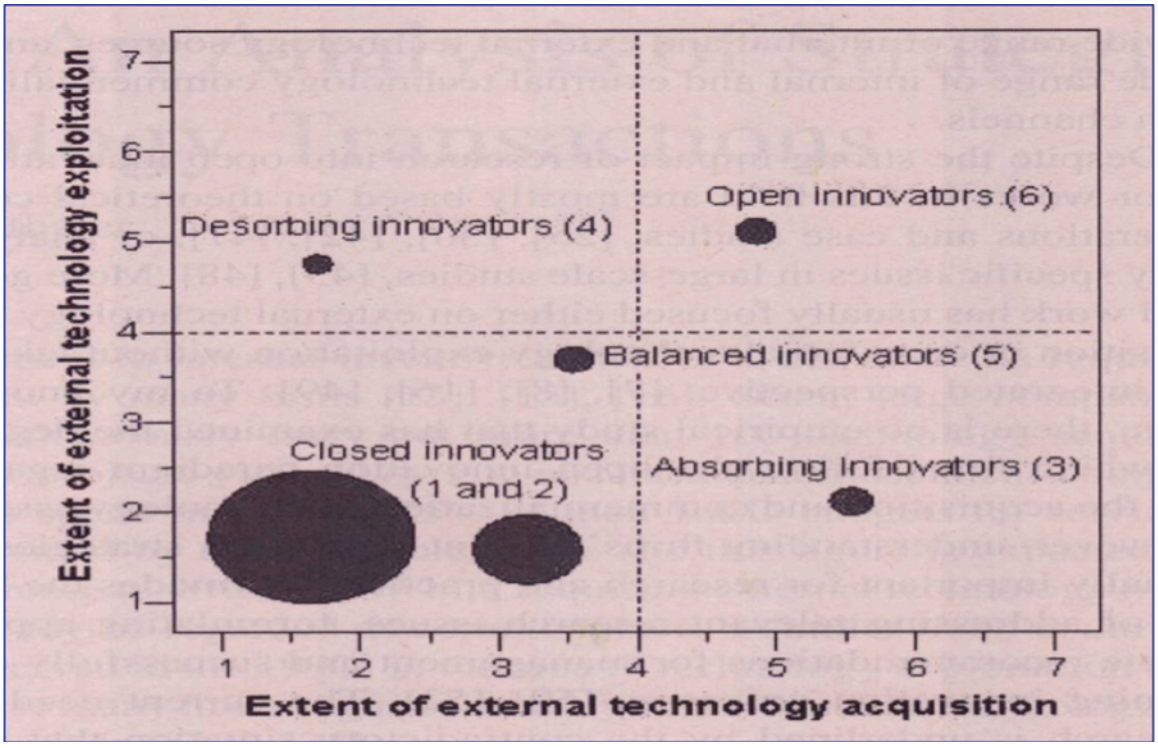
Since the era of benchmarking began in the 1980s, and corporations began to open their doors to outsiders for comparative purposes, the once impenetrable corporate shields have come way down. The need of companies to be global to compete, and the need of countries to have global companies to compete, has further softened corporate walls. This has expanded the range of R&D strategies that companies now have available [Figure 4].

Open innovation has been maturing for a decade. Industry trends are emerging. When a given trend achieves a critical mass, a new industry pops up to service the trend. Today, companies hire "scouts" to look for ideas. They hire "innovation intermediaries" when they cannot initially or ever talk directly with their potential partner or ally. There are "proprietary networks" that now exceed what used to be generally accessible "industry portals." In-Licensee experts and Out-Licensee experts now move technologies and prototypes, and their associated intellectual property, as if they were exchangeable currency.

[3] Press Release, *Innovation Excellence Study 2005, Exhibit 1: Innovation investment and new product share by industry cluster.,* Arthur D. Little, May 25, 2005, Page 2.

ISBN13 978-1-937115-00-5
BOOTHROYD-DEWHURST, INC. 27th International Forum on DFMA
Providence, Rhode Island
June 12, 2012

Figure 4: Strategic Innovation Approaches[4]



Good strategy is now more important than ever. R&D spending and financial investment decision making will augment in sophistication.

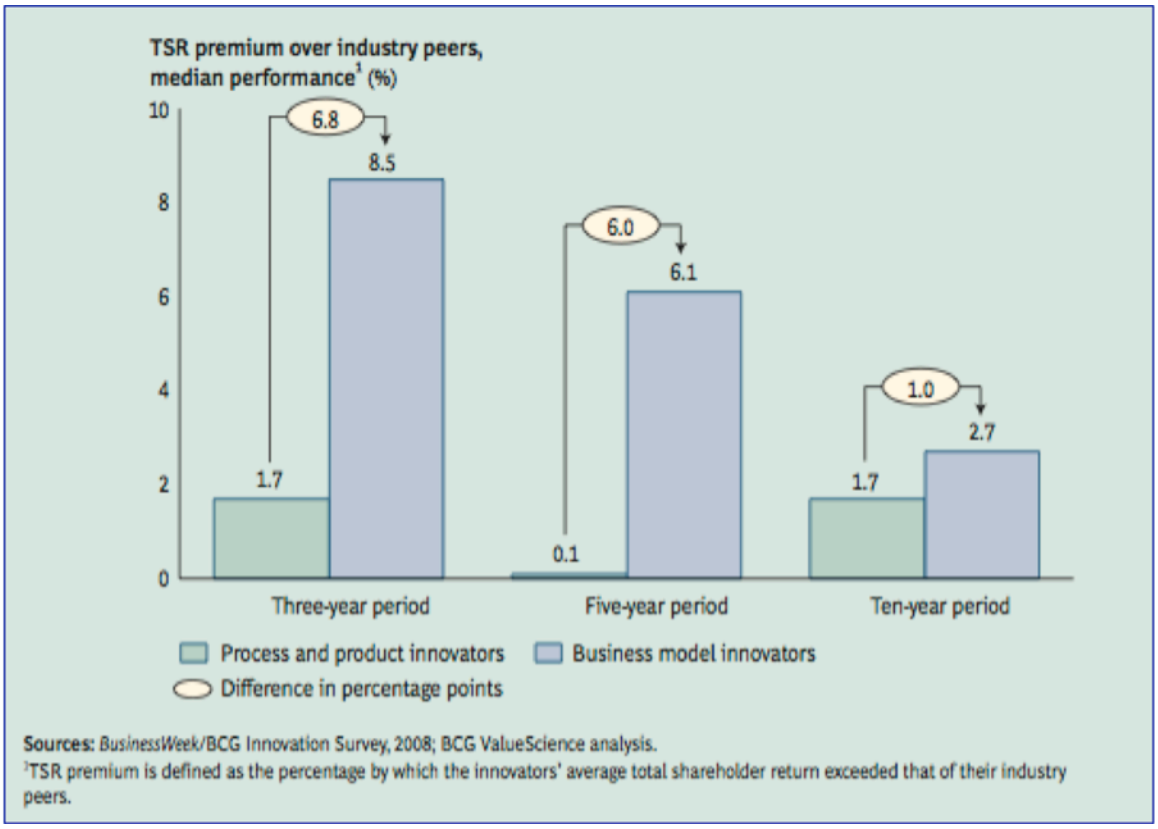
With traditional "Organic" innovation, there was little to discuss on the subject of duration. Companies worked to have a good time-to-market, but all generally available alternatives were limited to the company's own ecosystem. Today, duration might be zero in some cases. Have the cash today and own your desired outcome tomorrow. Or, form a strategic relationship and you are in business immediately. The liquidity of R&D, IP included, is accelerating. Soon, we will have "generally globally available make vs. buy R&D."

Companies have classically competed on the basis of product and process innovation. In a less globally dispersed organization environment, it worked quite well as a differentiator. In the global and multi-cultural R&D environment that exists today, it is increasingly difficult to have a consistent set of rules that all interpret the same. The more deterministic an activity, the more that product and process are a basis of competition. R&D, marketing, and the corporation as a

[4] Ulrich Lichtenthaler, "Open Innovation In Practice: An Analysis of Strategic Approaches to Technology Transactions," IEEE Transactions on Engineering Management, A Publication Of The IEEE Technology Management Council, 312 Technology Management Research Center, 111 Washington Street, Newark, New Jersey 07102, USA, February 2008 Volume 55 Number 1 IEEMA4, ISSN 0018-9391, Pages 150, Figure 1. Illustration of results of cluster analysis (Ward's method with standardized variables and squared Euclidean distance).

whole are probabilistic in nature. The era of Open Innovation is driving the next era of corporate competitiveness. Having the right "business model" is emerging as the solution to get the most advantage out of a globally far-flung and locally sound corporate empire [Figure 5].

Figure 5: Process/Product versus Business Model Innovators[5]



From both a business perspective and an R&D perspective, the structure of approaching the subject of strategy is increasing. The ability to "map a path" and "calculate an expected" value is maturing. The value of having the right strategy is evermore becoming a corporate differentiator.

The Right Places

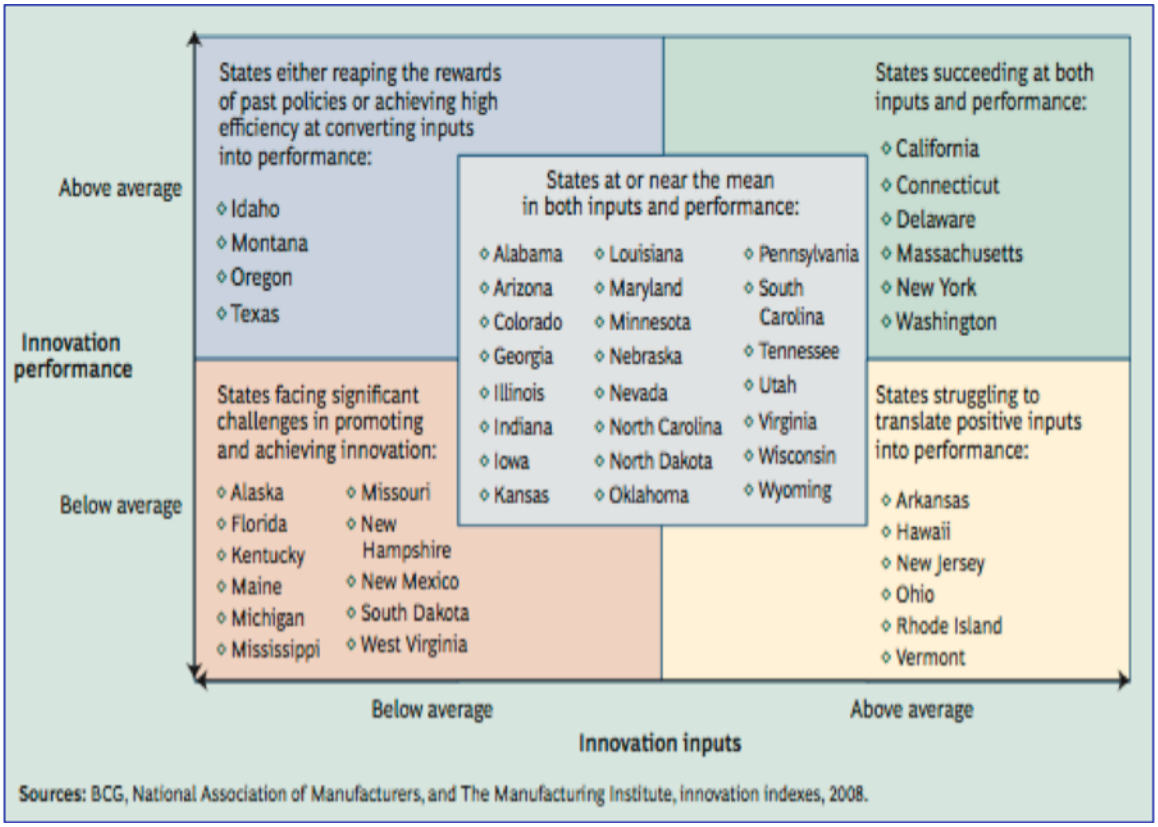
Management science is leaping forward globally in the characterization of states and sovereign entities. If organic and/or open innovation is your goal, there are better states and countries than others. Global rankings of the most innovative R&D countries are readily available and are a subject of television programs and news announcements. The capabilities of states [Figure 6] are

[5] Zhenya Lindgardt, Martin Reeves, George Stalk, and Michael S. Deimler, "Business Model Innovation: When The Game Gets Tough, Change The Game," The Boston Consulting Group, Exchange Place, 31st Floor, Boston, MA., USA, December 2009, Page 3, Exhibit 2: Business Model Innovators Out Perform Traditional Innovators Over Time.

ISBN13 978-1-937115-00-5
BOOTHROYD-DEWHURST, INC. 27th International Forum on DFMA
Providence, Rhode Island
June 12, 2012

less well publicized, likely because producers do not want to cause negative publicity to their customer base.

Figure 6: Five Clusters Of The Innovation Performance Of The United States[6]



When discussing the global playing field in the first section, the point was made that good characterization of the basic and applied research fields now exists by country. The characterization of R&D innovation is on television. The ability to generally differentiate the innovation propensity of a state is at hand as well. There can now be a good deal more precision in the decision making processes that determine the right places.

The Right IP

WD-40 is the spray can whose fluid would loosen any bolt. Everyone wondered how it worked, and like the Coke formula, it was a trade secret. Generally available commercial instrumentation can now identify the contents of WD-40, and the production process can be largely intuited from

[6] James P. Andrew, Emily Stover DeRocco and Andrew Taylor, "The Innovation Imperative In Manufacturing: How The United States Can Restore Its Edge", The Boston Consulting Group, Exchange Place, 31st Floor, Boston, MA., USA, March 2009, Page 13, Illustration: The State's Innovation Performance Falls Into Five Clusters.

the results. With so little left that cannot be separately discovered or reverse engineered, the importance of IP is paramount. The recent sweeping changes in aligning the USA with the rest of the world on a first-to-file basis certainly causes a change in tactics, and disadvantages some while giving advantage to others, but first-to-file legislation did not affect the importance of IP which has been on a steady rise since the early 2000s.

Patent Trolls, and other historically non-traditional companies in the IP area, espouse certain bling that causes some to look away. It is not clear if "patents" will ever be able to be quantified to the level that is necessary for GAAP [purchase price, amortization rate, liquidation value]. But, just as the market cap of companies is many times the book value, that patent has value. The same applies for all other categories of IP.

For years, corporations paid registration fees in order to protect the product revenues and profits they sought, but the patents themselves were costs. There was little liquidity to the patents themselves. The multi-million dollar exchanges or sales of patents since 2010 involving Microsoft, AOL, Google, Motorola, and others are the high end of a market that is taking shape at all levels. Public marketplaces for patents are now emerging. On-line services are on the way. IP auctions are already being held. Funds exist on Wall Street where you buy a group of companies because of their intellectual property. Why, because Wall Street has determined that a strong intellectual property position results in higher value companies when compared to the rest. This market is moving rapidly, but there is still plenty of time to position for competitive advantage.

When the "liquidity of IP" achieves a critical mass, which the "liquidity of innovation" discussed in the previous section will likely have already been achieved, there will likely be some shifting of industry wealth. The possession of the right IP will dwarf a general accumulation of IP without a focused IP strategy.

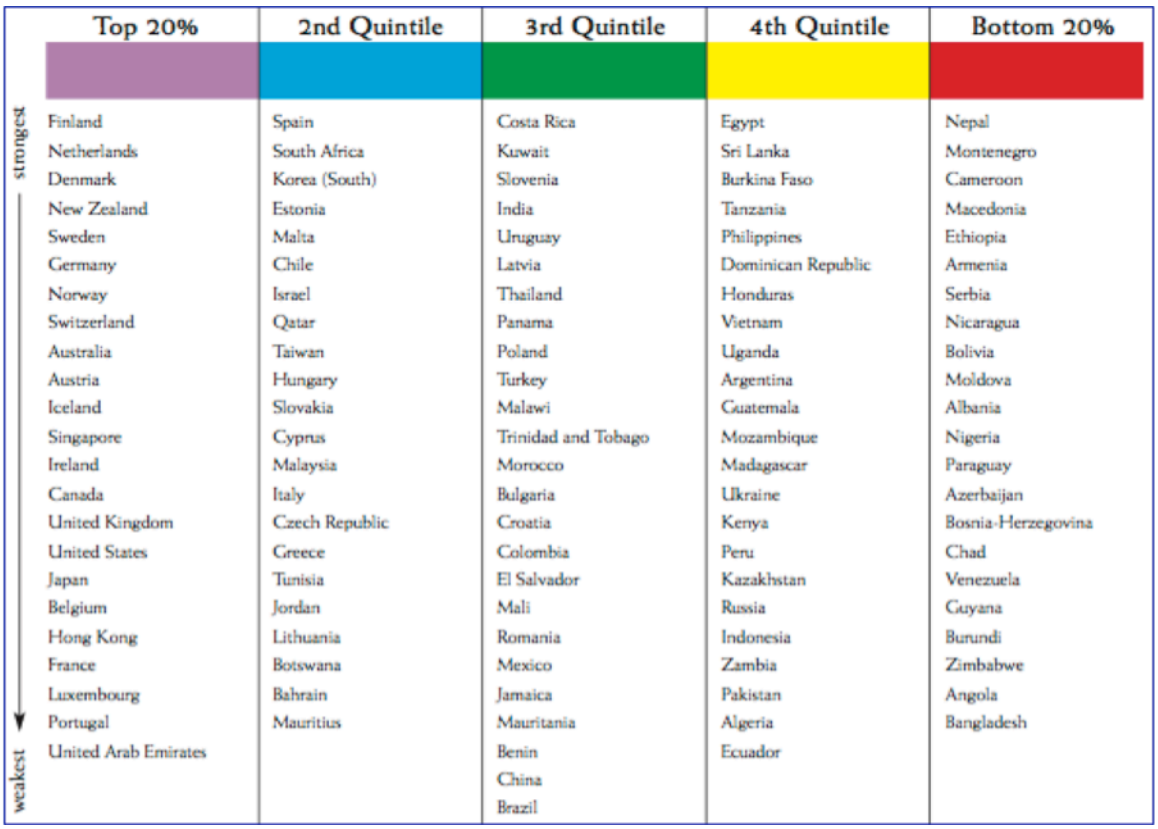
Companies are increasingly managing the places that their IP is located. Locating R&D centers in the wrong places can be devastating as global R&D pioneers found out. Few stayed with their initial strategies as they progressed along their learning curve.

In the next decade, the field of intellectual property will undergo rapid transformation. As IP becomes monetizable, many will learn the lingo that view it as a green eyeshade exercise today. Corporations will increasingly bring IP in-house and will dedicate resources to manage tangible assets. An IP software module that fits into your ERP system will take place alongside Fixed Assets and Inventory. The legal profession will shift to focus on defense, offense, and deal making and less on administration. In many senses, IP will become contiguous with R&D, and product and process development. Fewer discoveries will be moved into products. Discoveries will be sold or licensed at very early stages. Market makers and intermediaries will be involved in activities that only some imagined a few years ago.

As this wave of "IP comfortableness" overtakes industry, and IP becomes an internationally traded commodity, country hygiene will generally improve [Figure 7].

ISBN13 978-1-937115-00-5
BOOTHROYD-DEWHURST, INC. 27th International Forum on DFMA
Providence, Rhode Island
June 12, 2012

Figure 7: Intellectual Property Rights Quintiles[7]



	Top 20%	2nd Quintile	3rd Quintile	4th Quintile	Bottom 20%
strongest	Finland	Spain	Costa Rica	Egypt	Nepal
	Netherlands	South Africa	Kuwait	Sri Lanka	Montenegro
	Denmark	Korea (South)	Slovenia	Burkina Faso	Cameroon
	New Zealand	Estonia	India	Tanzania	Macedonia
	Sweden	Malta	Uruguay	Philippines	Ethiopia
	Germany	Chile	Latvia	Dominican Republic	Armenia
	Norway	Israel	Thailand	Honduras	Serbia
	Switzerland	Qatar	Panama	Vietnam	Nicaragua
	Australia	Taiwan	Poland	Uganda	Bolivia
	Austria	Hungary	Turkey	Argentina	Moldova
	Iceland	Slovakia	Malawi	Guatemala	Albania
	Singapore	Cyprus	Trinidad and Tobago	Mozambique	Nigeria
	Ireland	Malaysia	Morocco	Madagascar	Paraguay
	Canada	Italy	Bulgaria	Ukraine	Azerbaijan
	United Kingdom	Czech Republic	Croatia	Kenya	Bosnia-Herzegovina
	United States	Greece	Colombia	Peru	Chad
	Japan	Tunisia	El Salvador	Kazakhstan	Venezuela
	Belgium	Jordan	Mali	Russia	Guyana
	Hong Kong	Lithuania	Romania	Indonesia	Burundi
	France	Botswana	Mexico	Zambia	Zimbabwe
	Luxembourg	Bahrain	Jamaica	Pakistan	Angola
	Portugal	Mauritius	Mauritania	Algeria	Bangladesh
weakest	United Arab Emirates		Benin	Ecuador	
			China		
			Brazil		

The availability of management science enabled by measurement science will enable companies to understand the profiles of each country's capability and propensity in research, product development, and intellectual property - the pillars of innovation.

The Right Organization

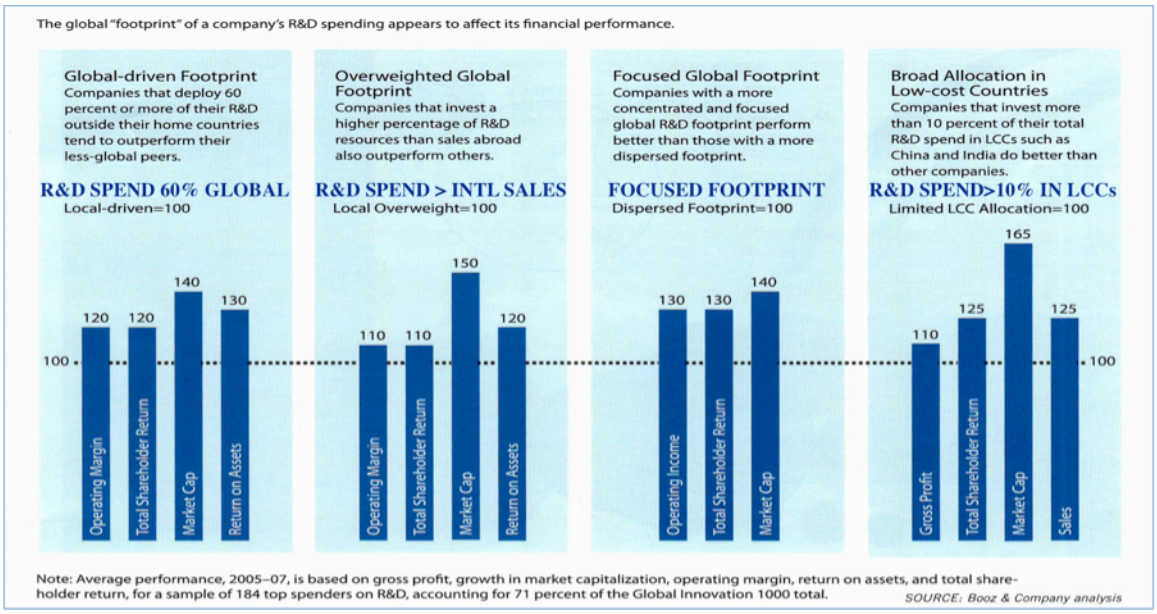
Business models are emerging as a preferred basis of competition. Business models cover a variety of subjects, from technology development models to sales models to organization models. It is complex enough to decentralize or distribute R&D with all the global variables, right-sizing the organization and its facilities are among the most complex of these decisions. Bricks and mortar is very expensive.

[7] Anne Chandima Dedigama, 2008 Hernando de Soto Fellow, "International Property Rights Index 2009 Report," Property Rights Alliance, 1920 L Street, NW Suite 200, Washington, DC, USA, February 1, 2009, Page 22, Exhibit 4: IPRI Ranking By Quintile.

Primary research, conducted by GGI in conjunction with APQC in the mid-2000s, indicated that a slight leaning towards centralization[8] when pursuing an innovative strategy is advised. At the time, there was not enough bricks and mortar overseas to postulate the subject globally. Enough cycles of learning had not yet been achieved.

In the last several years, initial indications of business models for global R&D organizations are coming to light. Initial management science is in the area of budgets and the location of spending [Figure 8]. Again, there is also a slight leaning towards centralization in the deployment models.

Figure 8: R&D Organization Considerations[9]



Technical and functional competency are underlying issues in organization models. Much of manufacturing is "equipment facilitated by people." R&D is "people facilitated by equipment." With innovation as the basis of competition, competency management must be actively managed. Large corporations have been developing comprehensive competency models and testing mechanisms for several years now. It is no longer just a great war story that Microsoft and Google employees get to tell to everyone's amazement. Personality testing is almost generally accepted at this time, with competency testing soon to follow. Expect a next generation global organization business model to integrate the optimization of competency acquisition and maintenance into the model, alongside structure and the degree of distribution.

[8] APQC, "R&D Productivity Study: Understanding the Drivers and Enablers," Consortium Learning Forum Best-Practice Report, 2005, Pages 29-43.

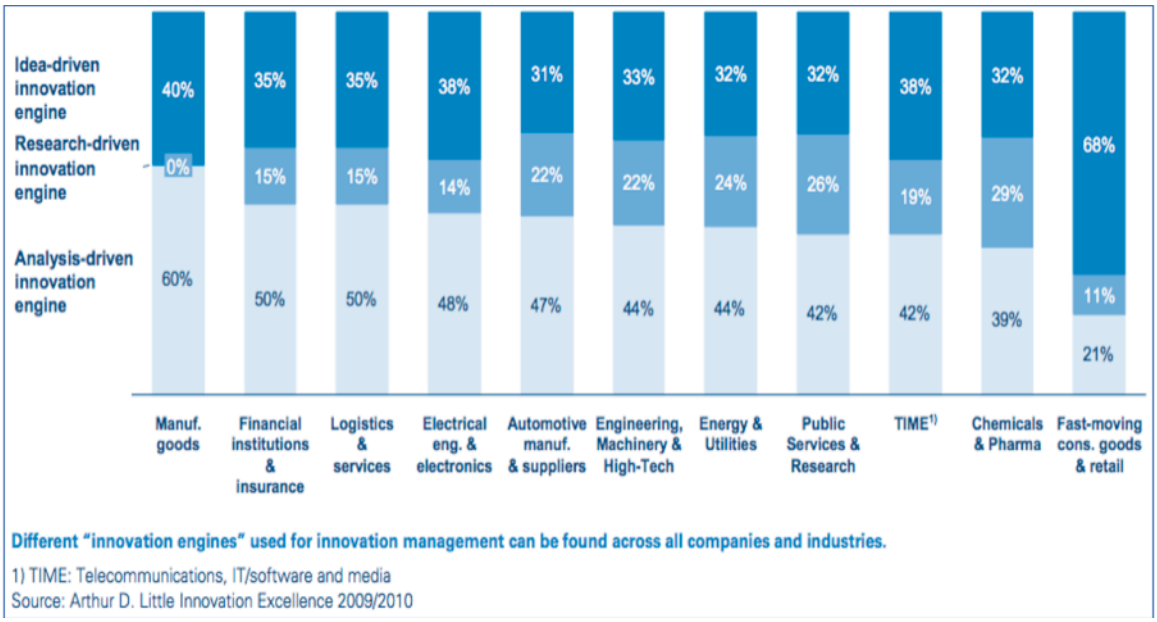
[9] Barry Jaruzelski and Kevin Dehoff, "Booz & Company 2008 Report: Beyond Borders -The Global Innovation 1000 Study Reveals A Global Shift In R&D Spending," Visions Magazine, PDMA – Product Development & Management Association, October 2009, Page 30, Exhibit 2: The Performance Payoff Of Global R&D.

ISBN13 978-1-937115-00-5
BOOTHROYD-DEWHURST, INC. 27th International Forum on DFMA
Providence, Rhode Island
June 12, 2012

The Right Tactics

When the right strategy is in place in the right places and IP and organization considerations are provided for, the question arises as to the specific methods of value creation [Figure 9]. Should we look for blue oceans? The next great idea? Should we look to build it and hope the customers come? Technology push? Should we carefully analyze what is needed versus what is offered and look to fill the gaps or outperform a competitor directly? Market pull? What should be the tactics by which we pursue our Organic/Open innovation strategy?

Figure 9: Innovation Tactics[10]



Being conscious and consistent in the pursuit of a given tactic will improve the specificity of practice, improve focus, reduce cost, and increase return on innovation. Achieving competitive-advantage global R&D environments requires significant attention to the detail in a business model.

The Right Metrics

With product life cycles already short across most industries, a company's innovation engine must consistently replace existing revenues after a short period of time. It used to be that companies won based on time-to-market or exceptional quality. It is more difficult to differentiate on those attributes these days. What counts now is what is put into the pipeline and the accuracy of the

[10] Per I. Nilsson, Markus Achtert and Hanno Groseschmidt, "Pathways To Innovation Excellence: Results Of A Global Study, Arthur D. Little, March 2010, Page 10, Figure 7: Innovation Engine Per Industry Cluster.

business estimates upon which decisions were made. As such, counting the sales from new products has emerged as the fastest rising metric of the past two decades. New product sales, which 3M [Figure 10] first popularized as the "Vitality Index" in 1988, is now used by over 55% of companies.[11] It is the most used indicator of R&D competitiveness.

The corporate pursuit of innovation, combined with the need to improve the ability to quantify and forecast R&D towards that end, are once again increasing the measurement science of R&D. Companies are now breaking new product sales into several sub categories.

At the same time, the corporate pursuit of innovation, is leading to some general shifting of R&D spending towards earlier R&D activities. While applied research funding has grown, the growth in what companies generally refer to as Advanced Development has shifted notably.

Many companies now want to see the "footprint" that advanced R&D activities have on new product sales, and are adding the metric into their analysis of new product sales [Figure 10]. Some argue it is too hard to regularly determine when advanced projects impact sales and that the metric is porous. It was only two decades ago that industry had to shift its thinking as to when a new product became an old product and was no longer counted as new. Determining advanced development correlation is no more or less challenging and will become a regular practice.

With intellectual property transforming, two important points emerge. For the better part of seven years, research from multiple sources has shown a high correlation between IP and price premiums on products. It is generally believed at this time that IP-protected products have higher price premiums.

A new "IP-Protected" metrics area is emerging that will grow in adoption over the next two decades, just as new product sales grew in popularity over the last two decades. "IP-Protected Sales" [Figure 10] and "IP-Protected Profits" and "IP-Protected Market Share" will all individually become mainstream metrics.

For the better part of those same seven years, the ability to monetize IP has been increasing via separate channels. Today, most companies report "Licensing Revenue" separately from "New Product Sales" as a revenue line item. Licensing Revenue is also a fast rising metric, now used by 3% of companies.[11]

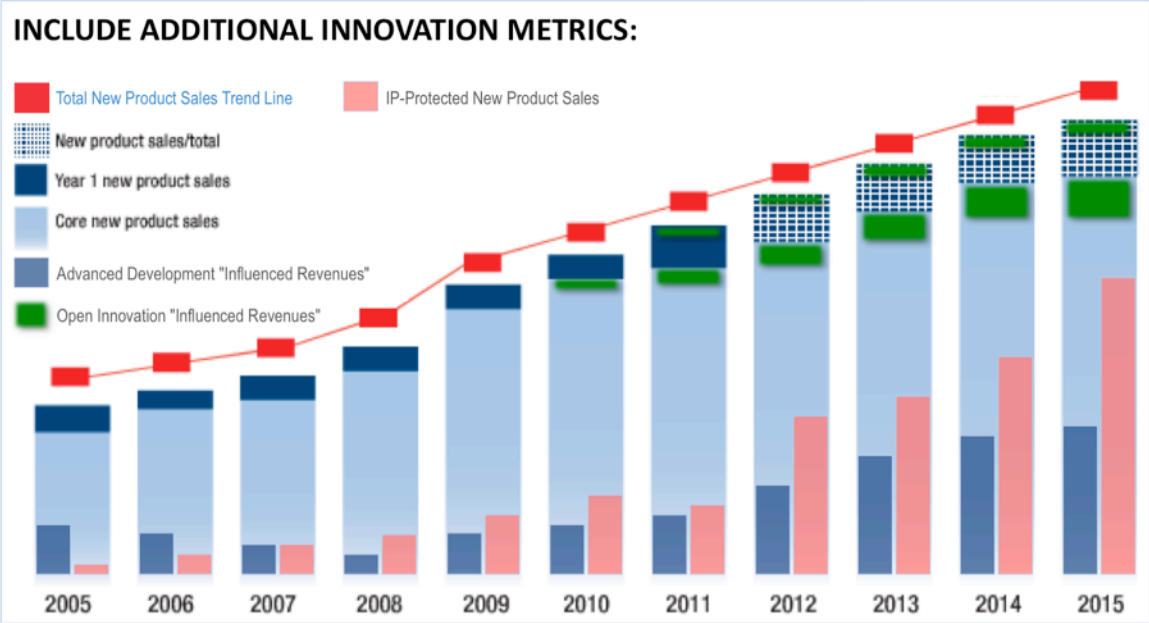
As IP becomes more liquid, companies will find more and more revenues coming from advanced activities and their associated IP. Fewer companies will choose to wait through the time-to-market and commercialization periods to begin to earn a return when there is money immediately at hand.

---

[11] Goldense Group, Inc., 2008 Biennial Product Development Metrics Survey, Needham, MA, ISBN13 978-1-932468-13-7, ISBN10 1-932468-13-7, ISSN 1549-9847.

[11] Goldense Group, Inc., 2008 Biennial Product Development Metrics Survey, Needham, MA, ISBN13 978-1-932468-13-7, ISBN10 1-932468-13-7, ISSN 1549-9847.

Figure 10: Measuring R&D and Product Development Short Term Contribution[12]



These developments will significantly blur the lines between prototypes and IP and physical products, and will change the way business leaders make decisions. It is hard to be certain if this trend will actually culminate to this level, but current trends easily lead to postulating that outcome.

As the quest for innovation enters its second decade, expect a number of new metrics to be created. The ability to measure innovation prowess and achievement is fueling a next wave of measurement science to improve the management science of R&D.

Summary

The globalization of R&D, the quest to increase corporate innovation, the acceptance of open innovation approaches, and the emergence of liquid IP are already relandscaping R&D and corporate playing fields. The subjects of strategy, innovation, invention, and intellectual property are all becoming more complex.

Companies with best practice business innovation models are being shown to outperform traditional product and process innovators. Does your company have a robust business innovation model?

---

[12] Goldense Group, Inc., "Additional Innovation Metrics" [Reference CPD-003803a1] text and artwork overlay [not to scale] **and** Editorial Staff, "Driving The New Product Vitality Index," 3M Stemwinder, 3M, May10-23, 2011, Page 1, Inset.

If your company is in a "smart industry," and your competitors are utilizing the improved decision making information that is available, then your company must study as hard and work to make better decisions than your competitor. If your company is in a "dumb industry," often characterized by having had little change in product or service over a number of years, then a great opportunity for competitive advantage is at hand.

Companies that have the best business models, and constantly drink from the emerging fountain of information that is refining and characterizing the Innovation Body of Knowledge, are likely to outperform their competitors on the playing field of the 21st century.

* *

A Note About The Author: Bradford L. Goldense NPDP, CMfgE, CPIM, CCP is president of GGI. Founded in 1986, the consulting-market research-education company is a pioneer of concurrent innovation practices and the metrics that drive corporate performance. Mr. Goldense has worked with 200 of the Fortune 1000 in over 500 manufacturing locations on four continents. GGI is based in Needham, Massachusetts.

ISBN13 978-1-937115-00-5
BOOTHROYD-DEWHURST, INC. 27th International Forum on DFMA
Providence, Rhode Island
June 12, 2012