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Summary

Scientists and engineers create the scientific and technological knowledge to generate societal and individual wealth and related economic growth. The article explores wealth creation, worldwide research and development (R&D) expenditures, US R&D expenditures by business, government, and academic organizations and economic sectors, and profiles the US science and technology workforce including recruiting and compensation costs. The process of recruiting scientists and engineers is profiled. Many technology based companies are currently using artificial intelligence algorithms to assess applicants' technology knowledge and select the optimal job candidate. Are there non-technical personality traits which are equally important in recruiting scientists' and engineers performance? What non-technical personality traits should a research and scientific organization assess to decide among position candidates? Five non-technical character traits to evaluate candidates in hiring decisions are intelligence, imagination, initiative, interpersonal skills, and integrity are explored. Specific questions to ask candidates are suggested to investigate each trait.

Keywords: engineers, intelligence, imagination, initiative, interpersonal skills, integrity, research and development, science, staff, stem, technology

The staffing of scientific and research organizations ultimately determines the organization's success in achieving its mission. It is relatively straight forward to measure a candidate's scientific and technical credentials and knowledge but very difficult to assess a candidate's character and personality traits which facilitate social and organizational relationships and related success.

The article delineates the societal role of scientific and research organizations in wealth creation, explores worldwide research and development expenditures, US research and development expenditures by business, government, and academic sectors as well as research and development (R&D) expenditures by basic and applied research, US science and technology workforce profile including number employed as well as compensation and average organization tenure, and technology organizations' process to recruit scientists and engineers. These topics provide context for the importance of optimal staff of scientific and research organizations.

Five character traits for success are identified. The 5I traits are intelligence, imagination, initiative, interpersonal skills, and integrity. Specific questions are suggested to probe the candidate's background and perspectives on each trait. For candidates who share similar technical skills, the 5I questions help to determine the optimal candidate for the position based on character traits. The organization's staffing objective is to select the best candidate for the position and organization.

Perspectives on Scientific and Research Organizations

Scientific and research-based organizations are the fundamental engines of global growth and standard of living increases. Growth is driven by creating new knowledge which is translated into new technology-based products and services. In 1957, Robert Solow, a MIT researcher and economics professor, published a seminal paper "Technical Change and Aggregate Production" which argues that seven-eighths (87.5%) of the world's wealth increase is due to "technical

change". Robert Solow was awarded the 1987 Nobel Prize in economics for his insight.

Successful technology-based companies create both individual and societal wealth as evidenced by the fact that 8 out the top 10 companies as measured by market value are technology-based companies (Zehner, Pletcher, and Williams, 2016). On August 2, 2018 Apple became the first US Company to achieve a market valuation over $1 trillion (Nicas, 2018). In 2017, Facebook was the most profitable company in the world generating $599,000 in profit per employee (Desjardins, 2017). Facebook's profitability made Mark Zuckerberg the 5th wealthiest person globally with a net worth of $71 billion (Dolan and Kroll, 2018).

Technology firms rely on their human capital to create wealth. It is crucial that technology firms make strong staff hiring decisions for success. In a recent study of 693 public companies, Wartzman and Crosby (2018) concluded that "the key factor driving a company's results (is) its people". Using the 5I method, technology firms can assess the candidates' non-technical traits important to long term candidate and organizational success.

Worldwide Research and Development Expenditures

The US National Science Board reported in the 2018 *Science and Engineering Indicators that Research and Development* (R&D) expenditures worldwide were $1.918 trillion in 2015, up from $722 billion in 2000 (*Indicators*, Chapter 4). R&D represents approximately 2% of the world's economy and is dominated by four countries and a handful of companies. The top four countries accounted for 62% of worldwide R&D expenditures. The US R&D expenditures were $497 billion, followed by China with R&D expenditures of $409 billion, Japan with $170 billion in R&D, and Germany with $115 billion in R&D (*Indicators*, Highlights). Of the 2500 companies globally that spend significantly on R&D, the top 10% of spenders account for 71% of the research and development spending (Veugelers, 2018).

US Research and Development Expenditures by Major Organizations & Sectors

Based on 2015 R&D investment in the US, the business sector performed approximately 72% of the R&D, the government sector performed approximately 15% of R&D, and the academic sector performed the remaining 13% of the R&D (*Indicators*, Highlights).

The amount of investment in different types of research varied significantly by R&D sector. For example, approximately 80% of private sector research budget is spent on applied or developmental research, and 20% on basic research. Within public research the ratio is reversed outside of defense budgeting (Hourihan and Parkes, 2016). In the US only 2% of FY2019 Defense funds are dedicated to basic research (Hourihan and Parkes, 2018). Across public and private sector in the US in 2015, experimental and developmental research accounted for approximately 64% of total R&D expenditures; applied research approximately 19%; and basic research accounted for approximately 17% (*Indicators*, Highlights).

US Science and Technology Workforce Profile

Scientists and engineers account for about 5% of the total US workforce (Indicators, Chapter 3). In 2016, there were approximately 6.9 million scientists and engineers employed in the US with approximately 58% in computer-related occupations (Sargent, 2).

At the bachelor's and master's degree level 72% of scientists and engineers work in business / industry, 17% in educational institutions, and the remaining 11% in government. For individuals holding a doctoral degree in science or engineering, 50% work in universities, 40% are employed in industry, and the remaining 10% are in government.

The mean wages for all scientists and engineers was $94,500 annually versus the mean wages for all other occupations of $49,630

annually. Using mean wages, scientists and engineers earned nearly twice as much in compensation as other occupations. In addition to mean wages, scientists and engineers receive social benefits from their employers which add an additional 25% to 35% to the employer's costs.

The total costs to hire a mid-level scientist or engineer with a $100,000 annual salary is approximately 50% to 60% of the annual salary on a "full cost" basis. The cost of the recruiting using an executive search firm is approximately $30,000. The cost of the organization's staff time to interview candidates and the candidates' travel expenses can easily add another $10,000. It takes a scientist or engineer approximately 2 to 3 months to "get up to speed" by developing relationships with the other members of the technical team and this equates to another $20,000 in "lost productivity".

The US Bureau of Labor Statistics (2016) reported that the average median years with the current employer for the following occupations of computer and mathematical occupations, engineering occupations, and life, physical, and social science occupations was 4.4 years, 5.5 years, and 4.9 years, respectively, or 4.9 years on average.

Technology Organizations' Recruiting of Scientists and Engineers Process

The recruiting of scientists and engineers is critical for continued organizational success since they ultimately create the technology-based new products and services for customers to purchase. The recruiting costs and the annual salaries of scientists and engineers are significantly higher than the organization's typical employee.

Highly successful US technology-based organizations such as Amazon, Apple, Facebook, Google, Netflix, etc. utilize similar approaches to recruiting. The following recruiting process is simplified in the table 1:

Table 1. Major Organizational Actions to Recruit Staff

Step	Major Organizational Actions
1	Need for additional technical staff is identified by manager
2	A position description is written which delineates desired skills and experience. For research universities, the desired skills and experience are minimized since the organization will train the new employee for specific tasks and help them develop specific technical skills. For mid-level employees, the candidates are expected to have specific skills and experiences. This ranges by area of research but can include knowledge of specific computer languages, lab techniques, or engineering systems.
3	Potential candidates are sourced by the company recruiters, either through job search boards such as Monster, Indeed, etc., through direct submissions to the company website, or through internal referrals. The position is also advertised via social media, at job fairs, and at universities.
4	Once resumes are submitted they are often screened for keywords. This is done automatically by rule-based engines or by slightly more sophisticated machine learning models. Machine algorithms are refining daily the fit between the job description and the job candidate. (Hint: If you are applying for a position at a technology-based organization, your resume should contain exactly the same words as the position description). Once resumes are screened for the match to the job positions, the computer sends the recruiter a prioritized list of candidates' resumes and assessment of the top 10 or 12 candidates to contact. Given the significant recruiting expense for scientists and engineers, US technology-based organizations frequently offer their current employees a "bonus" ranging from $1,000–$5,000 when they recruit a colleague into the technology organization. Besides helping to control recruiting expenses, the "sponsoring" employee frequently assists the new employee as a mentor, helping them onboard and become productive more quickly.
5	Once a "short list" of potential candidates is completed, the human resources specialists contact the candidates via phone or email to assess the candidates interesting in joining the organization and screen them for skills needed for the role. Assuming the candidate is interested in exploring the opportunity and passes this first round of screening, the next step is likely a "video interview" via Skype or a similar technology. Then, the finalist candidates are invited to physically visit the organization for in person interviews.
6	Most technology-based companies are team based. A team of individuals create the processes, products, and services offered to customers. It is critical that the candidate "fit" the team to minimize conflict. Ching (2013) points out in his study of "310 engineers of a large R&D Institute" that conflict around tasks per se improved individual performance and job satisfaction. The converse was true when the conflict focused on team relationships; it negatively impacted performance. Technology based organizations recognize that smoothly functioning teams are critical to organization's effectiveness, efficiency, and ultimate success. The final step in the recruiting process is to have the technology team interview in person the top 3 candidates and rank order the candidates. Then, the team arrives at a consensus of the best individual to extend an employment offer. Obviously, this is a complex calculus involving each candidate's unique technology expertise and experience versus team social and relationship skills.

Many *Fortune 500* companies are experimenting with artificial intelligence to understand candidates' personalities. San Francisco, California based DeepSense "helps hiring managers scan people's social media accounts to surface underlying personality traits" of position candidates (Schellmann and Bellini, 2018)." All nine members of DeepSense's scientific board are Polish. HireVue, headquartered in Salt Lake City, Utah, uses artificial intelligence to compare "candidates' tone of voice, word clusters, and micro facial expressions" with known high performers in the open position (Schellmann and Bellini, 2008).

If two or three candidates with different technical and relationship skills are deemed equally attractive by the evaluation and hiring team, what traits might the team focus on to decide between the two candidates?

The 5I Formula for Successful Staff Selection

To break the hiring dilemma between the top 2 or 3 candidates, one way to differentiate and to decide among the candidates is by utilizing the 5I formula to assess intelligence, imagination, initiative, interpersonal skills, and integrity. Selection of science and engineers is one of the most critical and most difficult tasks confronting a scientific and research organization.

Finding several qualified candidates for the position in the technical sense of education and experience is relatively easy. However, the difficult part of the selection process is differentiating among several seemingly equally qualified candidates. Probing each candidate with questions about the 5Is of intelligence, imagination, initiative, interpersonal skills, and integrity generally generates a different perspective on each of the final candidates' thought perspectives, personalities, and potential behaviors.

Intelligence

Intelligence is a very general trait of mental capacity. Intelligence involves the ability to think abstractly, comprehend complex ideas, reason, plan, resolve problems, act, and learn from experience. Intelligence reflects a broad and deep capability to comprehend and "to make sense" of the today's rapidly changing environment.

Change destroys old ways and simultaneously creates new opportunities. It takes intelligence to cope with change, to extrapolate its consequences, and to seize opportunities created. Does the candidate recognize changes in technology and the external environment and simultaneously conceptualize strategic responses to seize the created opportunities?

In a rapidly changing world, traditional experience soon becomes obsolete, but intelligence does not. Consequently, you may want to evaluate the candidate's raw intelligence and give it greater weight than current experience. It is critical that you be assess each candidate for promotion as the organization changes or grows.

A caveat for intelligence: Scientists and engineers are, in general, more intelligent than the average employee which sometimes leads to intellectual arrogance. Arrogant individuals create social interaction issues. The business philosopher, Dr. Peter F. Drucker, frequently reminded his MBA students that, "A little humility goes a long way in working with others."

There are multiple ways to evaluate intelligence. Intelligence is reflected by the individuals' willingness to learn, you might ask the candidate, "Tell me about something new you have recently learned, why you learned it, how you went about learning it, and having learned it what did you do?"

Imagination

Imagination is a trait that is hard to define but you know it when you see it. Imagination is the ability to think abstractly, analyze an issue, and

conceptualize how to address it. It is the ability to see a pragmatic fix to a problem or seize an opportunity effectively and efficiently.

There are two traits to identify imagination. The first trait is the ability to think conceptually at a relatively abstract level. This permits the candidate to get to the core of the issue. The second trait is the ability and willingness to think "outside the box" — to theorize new solutions to the issue at hand within the organization's resource constraints. Imagination is a critical success factor in an environment of rapid change.

You might ask the candidate, "Can you give me an example of what you consider an imaginative solution to a problem that you have never before confronted?"

Initiative

Initiative is important since having analyzed the issues and imagined a solution; it is now time to act. Action, not analysis, creates both scientific and shareholder value. You want your staff of scientists and engineers comprised of individuals who are going to lead, not pontificate. Managing individuals who you must "rein in" is easier than managing individuals who require constant "jump starting".

It takes a lot of energy and initiative to compete successfully in today's environment. Markets are global. Competitors are global. Has the candidate displayed a track record of initiating action to combat strategic threats and to seize opportunities? Once hired, the individual with initiative will make your life much easier since he or she will come to you with solutions, not problems.

You may explore with the candidate questions such as: "When you recognize a technical or organizational challenge, under what conditions should action be taken; when should it be delayed?" Follow up questions are: "Who should initiate action — your boss, you, or your subordinates? Why?"

Interpersonal skills & Emotional Intelligence

Does the candidate have interpersonal skills and emotional intelligence? Emotional intelligence has two components. The first element of emotional maturity is the understanding of self. Does the candidate understand his or her unique strengths and weaknesses? Can the candidate make the tough calls when the business situation necessitates emotional toughness? The second element of emotional maturity is the understanding of and the ability to empathize with others. Does the candidate have the emotional maturity to deal effectively with people who are different from himself/herself? A high emotional intelligence enables the executive to deal effectively with the high touch human issues in today's high-tech world.

Does the candidate have the emotional maturity and interpersonal skills to deal with a wide variety of personalities and cultures? Can the candidate deal effectively with the introverted techie as well as the extroverted sales rep? Does the candidate have the emotional intelligence to recognize the cultural differences among his or her staff as well as global cultural differences? An interpersonal approach of what is acceptable in Finland may crash in France.

You might ask the candidate, "Please describe your emotional strengths and weaknesses." Or, "Please give me an example of how you deal with people who are very different from you." Or, "What and how do you think individuals contribute to the organization's scientific and commercial successes?"

Integrity

Integrity is the ability to apply intelligence, imagination, initiative, and interpersonal skills to do the right thing for both the individual and the organization. Integrity is grounded in the individual's character.

Honesty and integrity have special significance for scientists and engineers. Honesty is being truthful and principled. R&D is ultimately based on scientific integrity. Integrity is correspondence between knowledge, word, and deed. Kirkpatrick and Kelly (1991) underscore in their seminal article, "Leadership: Do traits matter?" that honesty and integrity are the foundation of a trusting relationship between leaders and followers.

Members of a technical team must trust their leader to follow. The team will not follow an individual lacking in integrity. Where there is a lack of trust, there may be a semblance of following but it will fall apart when the going gets tough such as approaching technical program deadlines. Individuals are amazingly accurate in assessing their team leader's integrity. Team members assess their team leader by whether he or she values others by just watching what the leader does and the impact on both the team and it's tasks (Kotter, 1990).

A scientist or engineer with integrity generates trust and respect but also acts as the role model for his or her team. The executive with integrity sets the tone for those led.

You might probe the finalist candidates by asking; "Tell me about the most difficult situation you faced that challenged your personal integrity; how did you handled it, and why did you handle it as you did?"

Discussion

Worldwide R&D accounts for slightly more than 2% of the world economy. The positive impact of economic value creation worldwide by R&D is disproportionate to its size.

In the US there are nearly 7 million scientists and engineers are engaged in research and development in businesses, government institutes, and universities. The scientists and engineers are paid nearly twice as much as the average US worker. The high salaries paid to scientists and engineers are justified by their contribution to the tech organizations' profitability.

The recruiting and staffing of research and development organizations is the key to technical success. Recruiting is a multi-step process. It is relatively easy to evaluate a candidate's technical knowledge. However, assessing the candidate's socio-personal fit for a team and an organization is challenging as is deciding among similarly qualified the candidates. The "5I formula" suggests questions and probes on intelligence, imagination, initiative, interpersonal skills, and integrity to assess a candidate's non-technical strengths. One emerging area for future research is the use of algorithms and artificial intelligence to assess a candidates human characteristics by measuring a candidate's response to the 5I questions and then, comparing the candidates responses to highly successful scientists and engineers in similar positions.

The "5I formula" probes personal traits that matter most for candidates who met the technical benchmark, Candidates' responses to the probes will help organizations determine the best scientist or engineer to hire.

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