The Commercialization of Nanotechnology

Executive Summary:

Nanotechnology has the potential to revolutionize product development across all industries. Nanotechnology is a collaboration between scientific disciplines and commercial products, and requires the utilization of collaborative communication technology. The greatest downside to any organization looking to develop products using nanotechnology is the high cost involved in the acquisition or use of the required equipment. Nanotechnology also poses potentially significant security and health concerns. Organizational changes may also be needed in order to facilitate a culture of communication, collaboration, and innovation. Ultimately, an organization needs to examine traditional product markets and ask what unfilled needs might be addressed by nanotechnology in order to decide whether or not nanotechnology should be incorporated in its IR strategy.

1) Nanotechnology – What it is and current products:

Nanotechnology is science, engineering, and technology conducted at the nanoscale, which is in the range of 1 to100 nanometers (1 nm = 1 billionth of a meter). On a comparative scale, if a marble were a nanometer, then one meter would be the size of the Earth.[1] Nanotechnology is more than just mixing nanoscale materials together, it is "creating, using and manipulating structures, devices, and systems that have unique properties and functions because of their nanometer-scale dimensions."[2] Therefore, an understanding of how to manipulate and control these materials in a useful way is essential.

Nanoscience and nanotechnology can be used across all scientific as well as commercial industries such as chemistry, biology, physics, manufacturing, engineering, and healthcare. An increasing number of nanotechnology products and materials are becoming commercially

available. These include nanoscale powders, solutions, and suspensions of nanoscale materials as well as composite materials and devices having a nanostructure. An inventory of such products was compiled by the Woodrow Wilson Center's Project on Emerging Nanotechnologies.[3] Modern computer processor chips, such as Intel and AMD, are examples of current applications of nanotechnology as the chip sizes are in the range of 30 nanometers or less. Other applications of nanotechnology include nanofoods, nanotools, textiles, catalytic converters, computer storage drives, and surgical masks.

2) Implications of Adding Nanotechnology to IR Strategy:

Opportunity Analysis: Due to the relative infancy in the nanotechnology field, and the high costs associated with an emerging field, organizations can take advantage of governmental subsidies designed to improve the commercialization of nanotechnology.[4] In addition, an organization can capture a high market share in niche markets in emerging nanoproduct fields, as well as leverage the knowledge of a worldwide scientific community.

Strength Analysis: Because nanotechnology is a collaboration between several scientific fields, an organization with superior communication and a collaborative organizational structure will be able to utilize these strengths to a greater extent. In addition, a highly innovative organization will be empowered to utilize this new field to expand and diversify the organization's product offerings, knowledge base, and can increase the differentiation of their products from their competitors.

Threat Analysis: Due to the emerging state of nanotechnology, there is a high cost of entry and this cost can be mitigated through collaboration with other organizations, as well as possible government subsidies. However, this collaboration results in the sharing of profits from the new product. In addition, because the characteristics of nanomaterials may be different from

those of larger materials with the same chemical composition, and because the effects of these characteristics are not completely known, nanomaterials are considered to represent a potential risk to health and safety.[5,6,7,8] This side-effect uncertainty, consumer lack of knowledge about nanotechnology, market uncertainty, and long-term time commitment to product development (three years or more) make risk management and benefit analysis difficult or even impossible.

Weakness Analysis: An organization that is in a highly mature market can use nanotechnology to change the industry by looking at what products are available and then viewing nanotechnology as a tool to create new products. In addition, an organization that wants to become more innovative could use nanotechnology as a means of empowering its employees and expanding its knowledge base. However, the uncertainty surrounding nanotechnology may require more public relations work and transparency of the organization's operations.

3) Existing IR Setup Conditions Necessary for Nanotechnology to be Beneficial:

Nanotechnology R&D and the eventual nanomanufacturing of products require advanced and often very expensive equipment, such as various electron microscopes, which are needed to both see and manipulate nanomaterials in order to take advantage of their special properties.[9] Working at the nanoscale also requires an understanding of the various types and dimensions of nanoscale materials.[10] Therefore, nanotechnology is strongly science-based wherein 'technological success' increasingly depends on strong scientific capabilities and the ability to interact with scientists and scientific institutions.[11]

Collaboration, communication, and the sharing of information are critical in nanotechnology. "Participants of modern technology development oriented networks (consortia, alliances) contribute tangible and intangible assets; manage research and commercialization initiatives in hope of sharing future rewards. Modern networks are not bounded by geographic

distance. They require advanced information and communication technology to communicate and store ideas and knowledge."[12] Thus, IT should provide systems, such as internal social networks, email, collaboration systems, and file-sharing systems that facilitate collaboration and communication as well as establish policies that do likewise.

Ernie Cleveland, IT Coordinator of the University of Maryland (UMD) Nanocenter, says that security is a very important issue in nanotechnology because the information often is patented or patentable, and unauthorized access to or misappropriation of this information can be costly. For these reasons, many of their nanotechnology devices are not connected to the network. This makes collaboration and information sharing more difficult. Users often need to share information and images from different nanotechnology devices. Users currently use thumb-drives to share this information, however this presents another security risk. Also, the Nanocenter is a member of a consortium of facilities involved in a particular area of nanotechnology research. Because these facilities are located throughout the country, and because they need to share information, they store files to be shared on the consortium website.[13] These personal, online, and email information sharing techniques pose security risks that IT departments must address sufficiently.

4) Implementation Challenges to Including Nanotechnology in IR Strategy:

An example of an industry where nanotechnology can be used in commercial enterprises is storage batteries, particularly for electric and hybrid vehicles. Currently, most of the batteries for these vehicles are made using lithium-ion technology.[14] Nanotechnology offers several potential advantages for these batteries. Improved electrolytes using nanoparticles and nanocomposite materials have been shown to considerably enhance specific attributes of lithium batteries, as well as other, more novel battery technologies.[15] Tesla Motors is an example

company currently using nanotechnology batteries. These batteries offer increased power, storage capacity, reduced overall weight and size, faster recharge times, longer product life, improved performance, as well as being more environmentally friendly.[16]

Despite these benefits, there are numerous challenges to developing vehicle batteries using nanotechnology. One of these challenges is the high R&D costs of these batteries. As stated above, nanotechnology equipment can cost hundreds of thousands of dollars. Renting this equipment is an option, but this is expensive as well. Ernie Cleveland cited the UMD Nanocenter charges about $200/hour to rent some of its expensive equipment.[13] Another challenge is the uncertainty of which technology will prove to be the most efficient. There are many different nanotechnologies being used or considered to make batteries (e.g., zinc, silicon, or magnesium-ion as opposed to lithium-ion), and it is unclear which of these will become the industry standard. Also, there are other new technologies besides nanotechnology, such as new screen-printing technologies, that are being used to produce more efficient batteries.[17] Therefore, a company could invest hundreds of thousands of dollars in a particular technology only to find out years later that it doesn't work well in the real world or that it has already become obsolete.

5) Cost/Benefit Analysis of Nanotechnology:

The United States invests more money in nanotechnology R&D than any other country, and is the world leader in the absolute number of nanotechnology patents issued. In addition, U.S. public and private investments in nanotechnology grew at 18 percent annually.[11] The President's 2013 Budget provides nearly $1.8 billion for the NNI, with a cumulative total of almost $18 billion since the inception of the NNI in 2001.[18] As a result of this funding, there are several federal, state, and local funding opportunities available to assist organizations in the continued commercialization of nanotechnology.[19]

As mentioned previously, nanotechnology equipment can be very expensive. The UMD Nanocenter has several electron microscopes that cost tens or hundreds of thousands of dollars, and the cost of one of these devices (Electron Beam Writer) was over $700,000.[13] Furthermore, companies most likely will not have the necessary skills to perform their own maintenance on these elaborate machines, so they must purchase annual maintenance agreements which can cost tens or hundreds of thousands of dollars. Ernie Cleveland indicated that the annual maintenance cost of their Electron Beam Writer is about $100,000.[13] So, if a company wants to have its own nanotechnology equipment, the initial and recurring costs alone can be crippling. However, by making this investment, an organization is able to tap a previously unused source of revenue by renting their equipment to outside users. Using another facility's equipment is less expensive, but is inconvenient and reduces the amount of control exercised by the organization.

Another major cost is the R&D time for products, which Ernie Cleveland stated typically ranges between three to four years with some projects taking six years or more.[13] In addition, it can be very uncertain whether a particular nanotechnology product will be cost-effective enough to produce profits, and even if it is cost-effective, other nanotechnologies may ultimately prove to be more successful. These uncertainties could mean that all the time and expense a company expended on producing nanotechnology products was wasted. Furthermore, there is at least some evidence that exposure to some types of carbon nanotubes (nanometer-sized carbon-walled cylinders that possess properties, particularly great strength and electrical conductivity, that have great technological potential) pose a cancer risk for humans, so if a company is contemplating manufacturing or having close physical contact with these nanotubes, this is another concern.

6) Criteria for Including Nanotechnology in IR Strategy:

To identify opportunities for investing, companies should examine traditional product markets and ask what unfilled needs might be addressed by nanotechnology. Eric Levenson, President and CEO of high-tech consultancy MP Systems of Los Altos, California, advises that the best way of identifying opportunities for nanotechnology "seems to be to first step back from the technology question and ask what markets have large, unfilled needs".[20] If cost is not a factor (either because of the scale of the organization or because of external funding), then use of nanotechnology would be a way for an organization to differentiate their product. In an industry where differentiation can mean the difference between first and last place, this use of nanotechnology would enable the organization to better compete in the industry.

However, if an organization does not have a compete strategy, or if the organization is risk averse, then use of nanotechnology in the organization's IR strategy is not advised. If cost and risk are factors, then a strategy of being a commercialization organization for the mature nanoproduct could be considered; thus, making the organization a platform for the commoditization of intellectual property. Ultimately, "the well-learned rule still holds: look for a market need and apply the appropriate technology, whether that be nano or conventional technology."

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