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Understanding and acquiring technology assets for global competition

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Abstract

Technology assets play a crucial role in enabling the competitiveness of companies in most industries. Several authors have proposed models that illustrate the role of these assets during different phases of a company's development. In this paper, we develop a model that shows the important role of technology, human expertise, organizational structure, and information assets in positioning a company for global competition. This model integrates earlier work by Christensen and Overdorf [2000. Meeting the challenge of disruptive change. Harvard Business Review], Leonard-Barton [1992. Core capabilities and core rigidities: A Paradox in new product development. Strategic Management Journal, 13, 111–126], Sharif [1995. The Evolution of technology management studies: Technoeconomics to technometrics. Technology management: Strategies and applications for practitioners, 2(3), 113–148], and Subramaniam, Youndt, [2005. The Influence of intellectual capital on the types of innovative capabilities. Academy of Management Journal, 48(3), 450–463] to show the similarities that hide behind the unique terminology presented in these earlier works.

In this paper, we attempt to clearly identify the types of technology assets that a company must acquire and apply in order to be successful in the marketplace. Numerous authors have talked about the importance of managing technologies and "weaving streams of technology" without explicitly defining these technologies. We suggest that managers must consider much more than just traditional R&D and the acquisition of new equipment that represent "hard technology". Rather, a manager must leverage the power of humanware, technoware, inforware, and orgaware. Further, we suggest that each of these plays a dominant role during a different phase of a company's lifecycle. As an asset moves from a dominant position to a supporting position, it moves from a differentiating competency, to an operational capability.

Keywords: Technology assets; Global competition; Capabilities; Competencies; Technology strategy

1. Introduction

Technology has become an integral part of nearly every business and social endeavor. However, in spite of this, each profession has different definitions for what technology is. A universally shared definition has not emerged—which indicates that the transformation of these professions by technology is still occurring faster than it can be codified.

A physical scientist might describe technology as the set of equipment and apparatus that are used for scientific experiments. A social scientist would make a more vague reference to the underlying change agent that is advancing society. An IT professional sees technology as the computer hardware and software that is used to automate internal business operations. A manufacturing plant manager might suggest that technology refers to all of the assets that enable and enhance production operations. An economist sees technology as an enabling force in society that can make significant improvements to productivity on a global scale. The diversity of these perspectives is an indication of the pervasiveness of technology, and the challenges associated with understanding how it impacts business and social activities.

Burgelman et al. (2004) define technology as,

> "the theoretical and practical knowledge, skills, and artifacts that can be used to develop products and services, as well as their production and delivery systems. Technologies can be embodied in people,

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materials, cognitive and physical processes, plant, equipment and tools. Key elements of technology may be implicit, existing only in an embedded form (like trade secrets based on know how) and may have a large tacit component." (p. 2)

Christensen and Raynor (2003) define technology as,

"the process that any company uses to convert inputs of labor, materials, capital, energy, and information into outputs of greater value. For the purposes of predictably creating growth, treating 'high tech' as different from 'low tech' is not the right way to categorize the world. Every company has technology, and each is subject to these fundamental forces." (p. 39)

Porter (1985) insists that,

"technological change is one of the principal drivers of competition. It plays a major role in industry structural change, as well as in creating new industries. It is also a great equalizer, eroding the competitive advantage of even well-entrenched firms and propelling others to the forefront. Many of today's great firms grew out of technological changes that they were able to exploit. Of all the things that can change the rules of competition, technological change is among the most prominent." (p. 164)

2. Understanding technology assets

Prahalad and Hamel (1990) emphasize the importance of integrating technology assets in order to develop the core competencies of the organization, "core competencies are the collective learning in the organization, especially how to coordinate diverse production skills and integrate multiple streams of technologies." But they do not detail what these streams of technologies are.

In their 1994 book, *Competing for the Future*, these same authors state that, "a core competence is a tapestry, woven from the threads of distinct skills and technologies. … Many companies have had difficulty blending the multiple streams of science or technology that comprise their heritage into new, higher-order competencies" (Hamel and Prahalad, 1994, p. 214). Again they identify the importance of technologies, but assume that the manager will be able to identify all of the streams of technology that are important to his business.

Sharif (1995, 1999) suggests that the streams of technology referred to by Prahalad and Hamel fall into four major categories and that mastering these technological assets is essential for competitively positioning a company (Fig. 1). These comprise the "THIO Framework":

- Technoware—object-embodied physical facilities

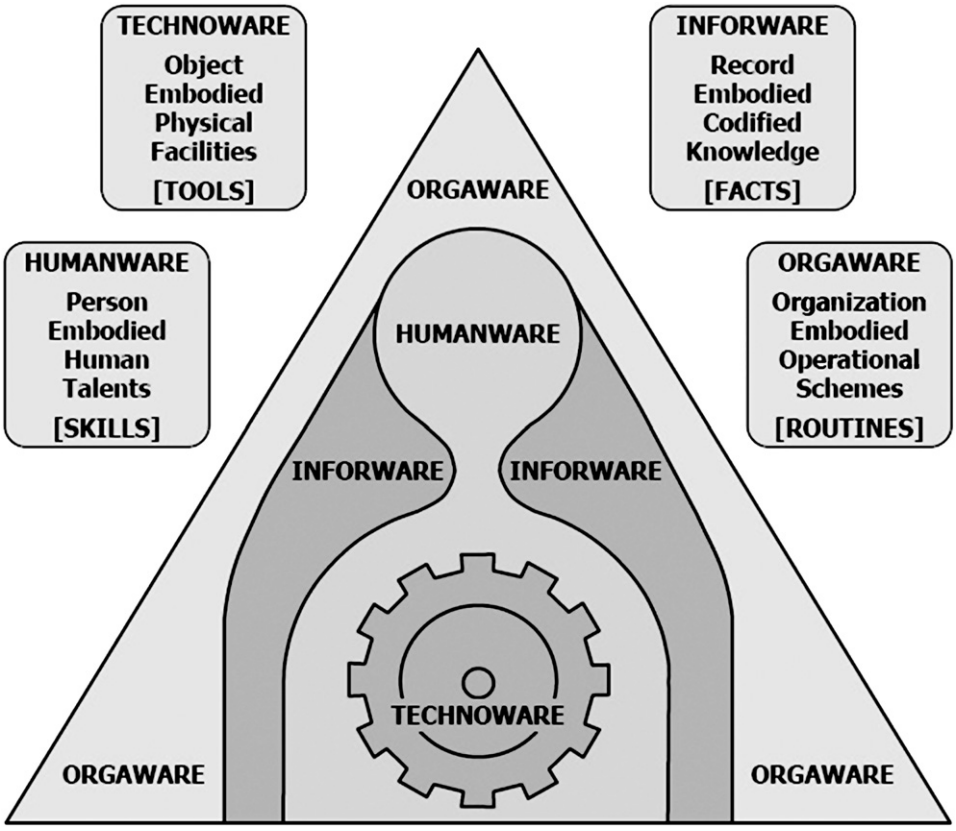

Fig. 1. There are four technological components that play an essential role in creating and establishing a competitive position for a company. *Source*: Sharif (1995).

- Humanware—person-embodied human talents
- Inforware—record-embodied codified knowledge
- Orgaware—organization-embodied operational schemes

Technoware refers to equipment, laboratories, and other assets that a company can acquire or create to assist in creating a product or offering a service. Humanware refers to the capabilities of the people in the organization and their ability to apply those capabilities in a productive manner. Inforware is the knowledge that is encoded in documents and processes and that are accessible to the organization. Finally, orgaware describes the capabilities of the organization that are derived from its structure and the processes that determine how it operates.

Christensen and Overdorf (2000) wrestle with this same issue of defining the valuable assets of an organization when they discuss its resources, processes, and values. They emphasize that the capabilities of new companies are often concentrated in their people (i.e. humanware) because operational processes and organizational values have not had time to form yet. The resources of a start-up company may also include technoware in the form of unique equipment or patent protection on a new technology. Christensen and Overdorf's "processes" are an expression of Sharif's orgaware in that they refer to the valuable capabilities of the organization as unique from both individual people and specific equipment. Their "values" capture the organization's analysis of the industry and market (i.e. inforware) to determine what they will specialize in. Subramaniam and Youndt (2005) also recognize the importance of humanware and emphasize that it is one of the essential ingredients for enabling radical innovation in an organization. They go to state that the social relationships between people are an equally important ingredient for innovation—a.k.a. orgaware or social capital. Finally, their research indicates that patents and historical knowledge/information within the organization create organizational capital (i.e. inforware) that is an essential ingredient for enabling incremental innovation of existing products and services. The technology start-ups in Silicon Valley are classic examples of the importance of humanware at the beginning of a venture. The algorithms that established Google as the leading search engine in the world were created and implemented by its two founders, Larry Page and Sergey Brin. In the beginning, their expertise was the most important ingredient in making the company successful. However, over time, that skill and knowledge is not sufficient to grow and operate the business. The company must add organizational capabilities, supporting technologies, and protection of their proprietary information.

In their report on the need for innovation in America, the Council on Competitiveness (2004) emphasized the differences between small start-up and large established companies, specifically that small companies rely on the depth of expertise of individuals (humanware) while larger companies rely on the capabilities of the organization (orgaware) and often lack the ability to access unique individual expertise.

Sharif also accepts that there are financial and natural resources available which are not necessarily related to technology. The importance of natural and financial resources was also emphasized by Daniel Bell in describing the evolution of society from its agricultural roots, through its 19th century manufacturing foundation, to the more recent post-industrial or information economy (Bell, 1973). The pattern of this evolution is shown in Fig. 2.

Leonard-Barton (1992) suggests that there are four dimensions (or assets) that make up the knowledge-set that enables technological innovation (Fig. 3). These are:

- Skills and Knowledge Base—knowledge and skill embedded in employees (i.e. Humanware)

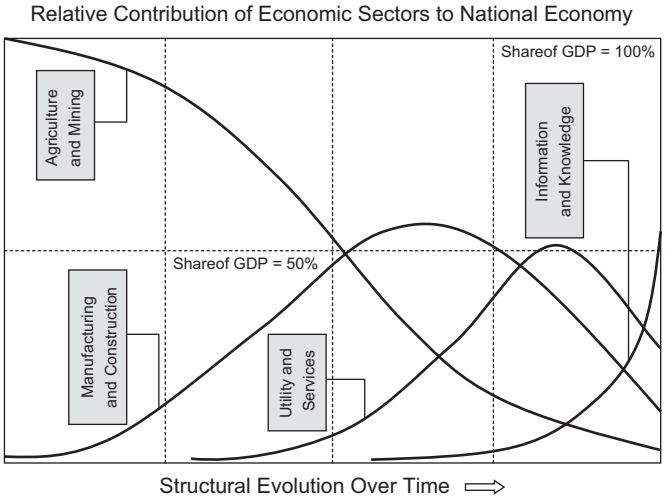

Fig. 2. The contribution of specific resources and industries to the social economy has evolved over time.

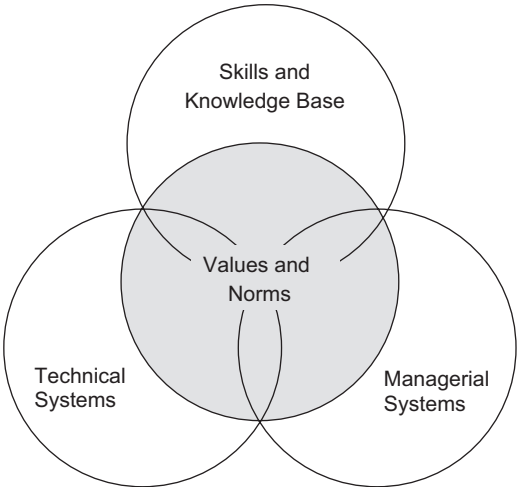

Fig. 3. Leonard-Barton presents four dimensions of knowledge that contribute to organizational capabilities. *Source*: Leonard-Barton (1992).

- Technical systems—knowledge embedded in technical systems (i.e. Technoware)
- Managerial systems—formal and informal ways of creating knowledge (i.e. Orgaware)
- Values and Norms—traditions from the founders (i.e. Inforware)

Each of the above models of technological assets presents them as interlocking or interdependent. The authors emphasize that an organization needs all of them if it is to be successful. Different types of industries and competitors may need them in different proportions, but few if any industries totally omit any one category. The balance between these assets also varies over time as a company or industry matures or is transformed by changes in its social or technical environments.

3. Acquiring technology assets

"For the past 25 years, we have optimized our organizations for efficiency and quality. Over the next quarter century, we must optimize our entire society for innovation" (Council on Competitiveness, 2004).

As industry and business have evolved, so have the means of acquiring technology to improve the effectiveness and productivity of human economic endeavors. Chandler (2001) identified the essential role of an "integrated learning base" in supporting the long-term success of a company's innovation programs. He studied the emergence of the consumer electronics and computer industries to determine why some companies were extremely successful in the short term, but completely lost their position over time. The learning base to which he refers is synonymous with the acquisition of new technologies and internal human expertise in applying these technologies. The ability to apply these within a company was one significant differentiator between those companies that survived as producers of electronics and those that have failed because they had no internal, integrated competitive advantage. Chandler offers RCA as a classic example of this pattern of growth and decline. RCA held patents for a number of important electronic components and manufacturing methods. However, instead of developing internal capabilities to turn these into products, the company chose to make its money by licensing these patents to other manufacturers. As a result, RCA never developed their own internal expertise with the technology and when advances came they came from other companies, leaving RCA holding the rights to outdated technology. It was primarily the Japanese companies that had licensed RCA IP who developed the next generation of technologies and methods and used them to pull the entire electronics industry away from American companies and into Japanese companies (Chandler, 2001).

In a knowledge economy, the ability to acquire, organize, and apply new knowledge is an essential ingredient in effective innovation. Christensen and Raynor (2003) state that, "corporate IT systems and the CIOs who administer them figure among the most important contributors to failure in innovation" (p.89). They emphasize that ready access to useful and customized information is a prerequisite for growing and changing the organization. Inforware is not just a controlled body of knowledge that enters with a new employee or is created through internal activities. Rather it is a global environment that extends far beyond the boundaries of the organization. Ingesting and managing as much inforware and technoware as possible is an important part of stimulating the innovation process. This occurs by sending employees to trade shows, industry trade publications, experimenting with competitors' products, looking for inspiration in other industries, and a number of similar approaches to information acquisition.

Technoware is often seen as being the most sophisticated because it has the power to do more work. Its efficiency in reducing materials and energy, its ability to contain self-guidance and control, and its ease of use and reduced impact on the environment place it in the limelight of executive attention. But without humanware, this technoware is nonfunctional and useless. Though technoware often contains encoded humanware, it still requires human control and application, which requires human knowledge and skill. Additionally, Orgaware is the structure that is able to bring together the right technology and human skills with a market opportunity. Shifting IBM from a company primarily focused on computer hardware to one centered on services required pulling together all four of the resources we have identified. They had to master the technology of the new open systems environment, which required applying their humanware expertise, technoware capabilities, and inforware licenses. They also had to recreate the organization so that it could operate effectively around services.

Fig. 4 brings together the concepts presented by multiple authors to illustrate how each of them describes a similar phenomenon. These assets are aligned with the business growth phase, showing which asset is dominant during each phase of the company's lifecycle. During the start-up phase of a company, the humanware assets are the most important ("skills and knowledge" in Leonard-Barton and "human resources" in Christensen and Overdorf). The unique skills of individuals are usually the foundations of the company's ability to compete in an industry. As the company expands, it uses its financial capital to purchase technoware that will allow it to extend the productivity of is humanware and reach a larger market ("technical systems" in Leonard-Barton and "technical resources" in Christensen and Overdorf). As it runs into stiff competition and its expansion caries it into areas that it cannot excel at, the organization realizes the need to consolidate. It must apply inforware about the market, customers, suppliers, and competitors to determine what its unique place should be. This selection leads to a definition of its values and norms, the definition of what it will pursue and what its measures of success will be. If the company survives it can potentially enter the market leadership phase of its

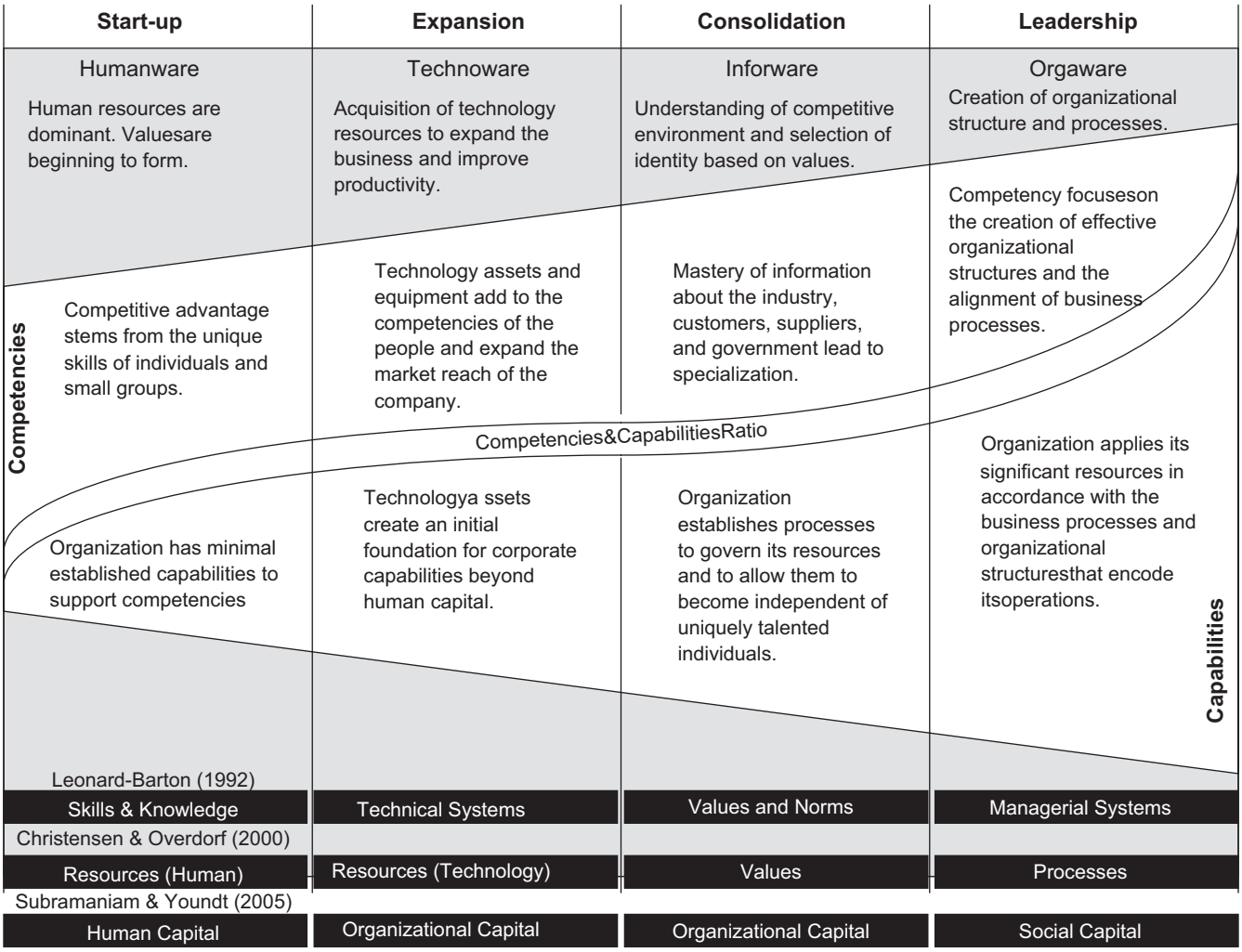

Fig. 4. Different technology assets make different types of contributions to the growth and competitiveness of a company as it moves through its lifecycle.

lifecycle. In this phase, its orgaware is most important. The creation of an organizational structure that can operate the business independent of the individual humanware and technoware assets that were the foundations of the company is essential (“managerial systems” in Leonard-Barton and “processes” in Christensen and Overdorf).

Throughout this evolution, as a category of technological assets moves from a dominant position to a supporting position, it also moves from being a competitive competency of the organization to being an operational capability. These assets are always important, but they become woven into the fabric of the company, to use Prahalad’s analogy, and are part of the stable foundation of capabilities rather than the front-end transformative force of the organization.

4. Application to global competition

The four categories of technology assets are essential resources both in defending current market positions and in usurping those positions from competitors. Burgelman asserts that, “From a competitive strategy point of view, technology can be used defensively to sustain achieved advantage in product differentiation or cost, or offensively as an instrument to create new advantage in established lines of business or to develop new products and markets” (Burgelman et al., 2004, p. 143). Having achieved an advantage, technology assets are one essential ingredient in defending that position. Operational efficiencies are necessary, but these can be copied. The earlier quote from the US Council on Competitiveness emphasized the need for innovation to remain competitive, and their report focused on the application of new technology and investment in R&D as a key part of innovativeness.

Christensen and Raynor (2003) attempt to identify actions that senior executives must take to lead this innovation. These actions align very well with the THIO framework that is at the center of this paper. First, executives should stand astride of the interface between sustaining and disruptive innovation for their organization. They should examine the threats of new technology (study and apply technoware) and the need to maintain the capabilities of the current organization (foster humanware). Second, they should champion new processes for

generating disruptive growth (advancing orgaware). Third, they should sense when circumstances are changing and teach others to recognize these signs as well (monitoring inforware and mentoring humanware).

von Hippel (2002, 2005) and Chesbrough (2003) both point to an additional dimension of this model for managing innovation, one that extends beyond the boundaries of the company. von Hippel points out that there are ''leading-edge users'' of every product. These people and organizations press the product to its limit and often end up inventing modifications that are beyond what is delivered in the original product. As the broader consumer base for these products evolves, it will also discover a need for the modifications pioneered by leading-edge users. Therefore, a company needs to tap into these leading-edge users, create partnerships with them, and bring their modifications into the product research and design process. Chesbrough's ideas concerning ''open innovation'' talk to the need to leverage the capabilities of multiple organizations to create new products. He has observed that no company possesses the expertise necessary to innovate in all of the domains that apply to its products. Therefore, partnerships are necessary to maintain a lead over more insular competitors. These ideas extend the management and optimization of the THIO framework beyond the boundaries of a single company.

4.1. Early starter advantage

Technological advancements form S-curves in which early applications provide small, incremental improvements, but these soon lead to significant or exponential improvements. During this exponential phase, it is tempting to believe that the technology will continue to improve business operations, productivity, efficiency, and cost savings at this rate. But as the potential within each improvement is realized, its contributions taper off significantly to an incremental tail. When an industry is in a stagnant phase, it will remain in the incremental improvement tail for a significant period. Luckily, complex organizations have a number of opportunities to apply new technology assets and to jump onto the early phases of a new S-curve (Moore, 2005).

This makes it very important for a company or a country to adopt and apply new technologies early enough that the explosive financial benefits are still available to pay for start-up costs, which may be significant. If a company or country waits too long to apply a new technology, then it may find itself in a position where the profits available cannot overcome the start-up costs.

Once a company is established in an industry, it can benefit from multiple waves of technological improvement. Moore (2005) points to the importance of applying innovative technologies throughout the lifecycle of the company. During some phases it is possible to innovate in the technoware components of the product. During others it is possible to innovate in the orgaware/production processes. At other times it may be necessary to innovate in the humanware domain.

Innovation may emerge in many different parts of the organization, but it is unlikely that transformative changes will be continuous in any one area. Instead, disruptions in one area will be followed by stability and standardization to make those changes into a repeatable part of the organization's operations. While this standardization is occurring, disruptive innovation may emerge in one of the other domains that drive productivity and competitiveness (Christensen, 1999). Microsoft has experienced the early starter advantage and has had to wrestle with the disruptions that have occurred within and around its operating system business. Having successfully captured the desktop operating system market, Microsoft still had no control over the evolution of the definition of the operating system from the customer's perspective. Companies like Qualcomm and Netscape extracted the email client and the web browser from university labs and introduced them to Windows customs. Microsoft missed the opportunity to introduce these tools themselves and had to catch-up to the idea that they should reside side-by-side with every copy of the operating system. More recently, this early starter is facing the same challenges from search engines, media management programs, media editing suites, blogging tools, and a growing list of contenders who hope to create the next ubiquitous tool for the Windows environment.

4.2. Late starter advantage

Not all industries require a major investment to enter—i.e. they do not have a significant barrier to competitive entry (Porter, 1985). When this is the case, it is possible for a late starter in the field to have an advantage over early starters. Early starters typically pay a premium price for equipment that is just being created to take advantage of technological advancements. Early starters also take the largest risks in predicting market demand and experimenting with new production processes. Since technoware changes so rapidly, it is possible that the early starter will spend significant money and time pursuing failed products and markets. This may make it possible, even advantageous, for another company to start later, but hit the right market with the right product the first time out. Under these conditions, the late starter may outperform the early starter and capture a dominant position in the market (Markides and Geroski, 2005). Apple's iPod is a fantastic example of this approach. They entered the MP3 player market 5 years after many of the early starters. They had the advantage of understanding the approaches of dozens of existing competitors and most of the necessary technology had already been created. Apple brought two new ingredients to the MP3 device—a massive internal hard drive that could store thousands of songs and a superior user interface that appealed to a larger portion of

the consumer market. These two advantages allowed them to consolidate a fractured market, capture 70% of the business, and redefine what an MP3 player should be.

5. Conclusion

In this paper we have attempted to clearly identify the types of technology assets that a company must acquire and apply in order to be successful in the marketplace. Numerous authors have talked about the importance of managing technologies and "weaving streams of technology" without explicitly defining these technologies. Referring back to Christensen's definition of technology as "the process that any company uses to convert inputs of labor, materials, capital, energy, and information into outputs of greater value" (Christensen and Raynor, 2003), we suggest that managers must consider much more than just traditional R&D and the acquisition of new equipment that represent "hard technology". Rather, a manager must leverage the power of humanware, technoware, inforware, and orgaware as described in this paper. Further, we believe that each of these plays a dominant role during a different phase of a company's lifecycle. As an asset moves from a dominant position to a supporting position, it moves from a differentiating competency to an operational capability. A company cannot survive without creating a strong foundation of capabilities. But capabilities can often be duplicated by competitors, so it is difficult for them to continue to provide a competitive advantage. Therefore, a company must continue to innovate with new technology assets.

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