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Understanding, Finding, and Conceptualizing Core Competence Depth:

A Framework, Guide, and Generalization for Corporate Managers and Research Professionals

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Introduction

The construct of the core competence—sometimes called by other names such as organizational competencies or distinctive capabilities—has been widely studied (Bogner & Thomas 1994; Fowler et al. 2000; Lei 2000; Leonard-Barton 1992; Nelson & Winter 1982; Pitt & Clarke 1999; Post 1997; Sanchez et al. 1996; Walsh & Linton 2001; Winter 2003), especially since the publication of Prahalad and Hamel's influential 1990 article, "The Core Competence of the Corporation." Since then, empirical and conceptual research on this concept has brought about many views of what these competencies are and how they can be applied to create better products and services.

In general, core competencies have been seen as capabilities held by people within a firm that, when applied through corporate operational processes to create products and services, make a critical contribution to corporate competitiveness. For a more complete discussion of core competencies, see Edgar and Lockwood (2008), which reviews the core competencies literature, describes their elements, and identifies research that remains to be done.

What has not been published, however, is a paper intended for intellectual leaders within corporations and their executives to help them understand the structure of core competencies, identify which key aspects of the competence their firms hold more deeply, and recognize concepts pertaining to competence depth that apply to all core competencies. This paper provides such direction in three ways.

First, we present a conceptual framework, drawn from previous research, for understanding the core competencies of a firm, revealing the internal dynamic of the core competence, the elements of the core competence, and the resulting competence breadth.

Second, utilizing concrete examples arising from firms' knowledge of communication networks, we present a useful methodological guide for applying this framework to discover the depth of core competencies held by a particular firm. This guide has several advantages. Primarily employing patent analysis and supplemented by interviews, it is inexpensive to do. It draws upon numerous internal and external perspectives as to the depth of a firm's core competencies. It also illuminates the complexity usually found within the depth of a core competence while making it comprehensible.

Third, we present a generalized conceptualization of core competence depth arising from the use of this methodology. This generalization addresses two important questions regarding the underlying reality about which people holding a core competence are deeply knowledgeable: 1) what does it mean to *understand* something deeply? and 2) what does it mean to be able to *perform* a skill proficiently? Answering these questions reveals that competence depth encompasses understanding things that are relatively stable, known as entities, as well as things which are inherently dynamic, known as processes. Moreover, depth includes being able to move beyond understanding entities or processes and to do things like engaging in processes by performing skills well. It also means understanding or being able to do the basic forms of entities or processes, their versions, and the variations of these basic forms and versions. As this occurs, core competence depth grows in three important ways—horizontally, vertically, and cumulatively.[1]

[1] Please note that this paper is a follow-up to Edgar and Lockwood (2011), which presented a methodology for identifying core competencies' structure through determining their breadth. In contrast, this paper presents a means for discovering the deeply held aspects within that breadth that contribute to core competencies' competitive power.

Core Competence Framework

The framework for discovering core competencies described below draws upon research that examined four corporations (Edgar & Lockwood, 2008, 2011), each with annual revenues in excess of one billion dollars. Oriented toward providing knowledge and information in different forms, the four corporations provide an array of advanced products such as switches, multiplexers, routers, transmitters, copiers, printers, scanners, and integrated circuits. They also offer complex services such as communication network planning, network design and implementation, and document management.

Across the four firms, five core competencies were identified as enabling these products and services. Three emerged from an understanding of the communication network. A fourth was based upon an understanding of both physical and digital documents. The fifth was based upon understandings of silicon and the creation of silicon-based integrated circuits.

The framework draws upon its underlying research to reveal three things:

1) How core competencies work (their internal dynamic)

2) What core competencies are made of (their elements)

3) The breadth of core competencies

How core competencies work (their internal dynamic)

The common dynamic among the above competencies was initially revealed through conceptual analysis (also known as content analysis) of corporate documents and through interviews with internal corporate professionals. The interviewees stressed the dynamic's progressive iteration. Please see Edgar and Lockwood (2011) for details of this research methodology.

The internal dynamic of a core competence can be depicted in a Core Competence Chart. Figure 1 depicts one of the three core competencies emerging from an understanding of the communication network. Here corporate understandings of the general phenomena of communication and networks converge into a thorough corporate understanding of the communication network core phenomenon. (These are shown in bold in Figure 1, as are the other examples discussed below.) Out of this emerges familiarity with specific product technologies, such as switching, and using an understanding of the general phenomenon of light, with product sub-technologies, such as optical switching. Drawing upon familiarity with the general phenomenon of computing hardware, this focused expertise brings about an understanding of the product class of optical switches.

Emerging from—and contributing back to the understandings of network technologies and product classes—are the functional skills in manufacturing optical switches to be components of communication networks, as well as the technological skill of optical switching. These skills are in turn part of a larger integrated skill set supporting the creation and management of both the elements of communication networks as well as complete networks.

As this iterative progression occurs, people holding the competence are able to use a range of technologies related to the communication network, and to provide specific products and services arising from them. The result is complex but varied competitive power to meet the networking needs of customers.

What core competencies are made of (their elements)

The progressive, iterative dynamic described above occurs through the interaction of competence elements. Conceptual analysis performed upon corporate documents like annual reports and product catalogs revealed seven major elemental categories of understandings and skills that exist within each of the five identified competencies; it also revealed numerous instances within each category. As it did so, it also revealed underlying, tangible items corresponding to the categories and instances of skills and understandings. Then, knowledge of the categories, instances, and underlying items was subsequently refined by the interviews with corporate professionals.

Figure 1. Core Competence Chart

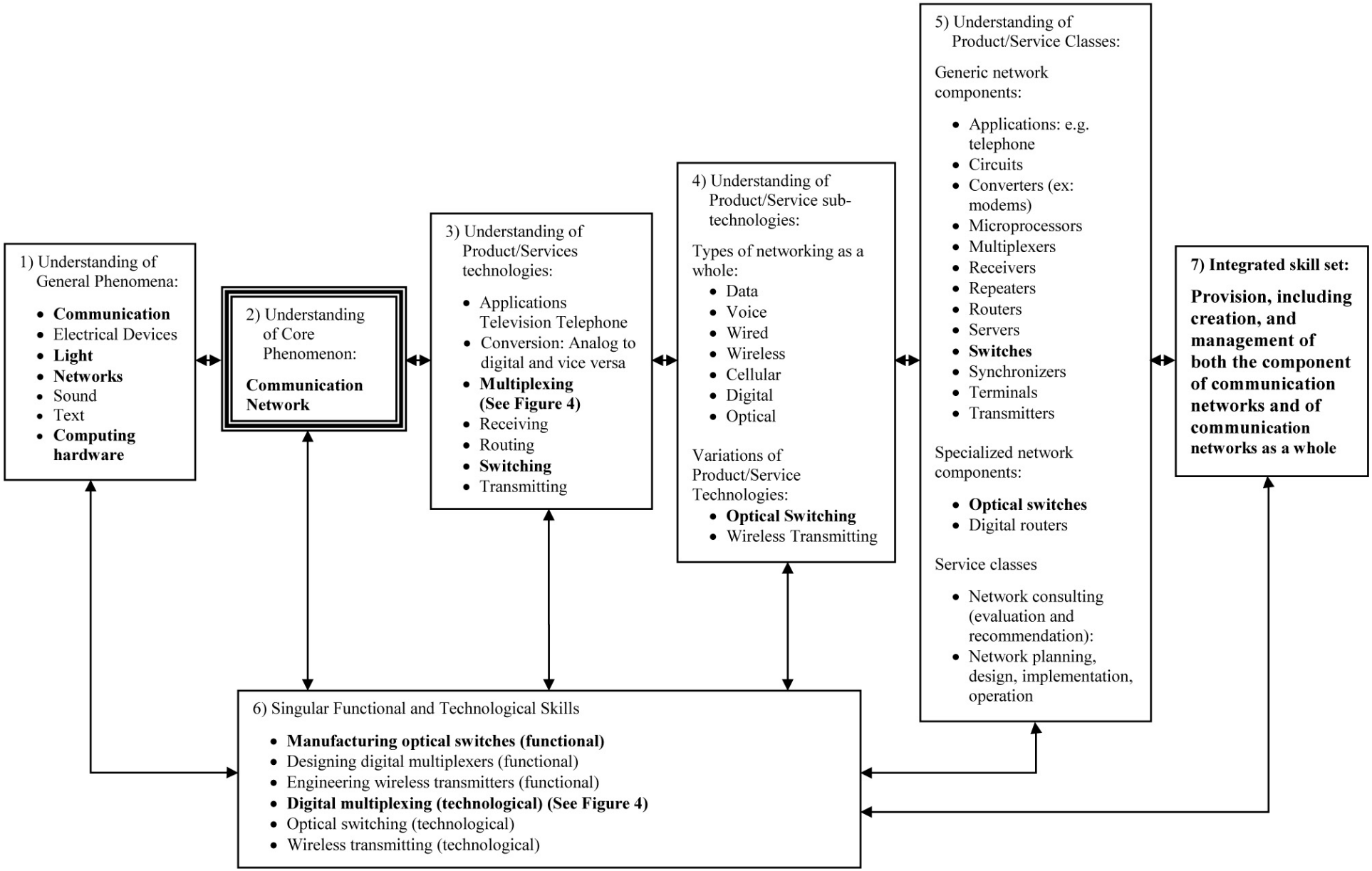


Table 1 presents the elements for three core competencies. For all three competencies, the instances, or members, within the seven elemental categories are shown as bulleted items. Only a sample of the most important instances within the categories is presented, since each competence had too many understandings and skills to present them all.

Documentary analysis and interviews of corporate professionals revealed the first five competence elemental categories to include complex understandings of different phenomena, technologies, and types of products or services (Table 1, left two columns). Similarly, they showed the last two categories to involve singular and integrated skills.

Table 1: Core Competence Comparison Table

Type of Knowledge	Competence Elemental Categories			
		Competence One	**Competence Two**	**Competence Three**
Understandings	1) Core Phenomenon	• Communication Network	• Document	• Silicon • Design integrated circuits • Manufacture integrated circuits
	2) General Phenomena	• Communication • Electrical devices • Networks • Light	• Text • Paper • Color • Electricity • Digital format for content	• Electrical systems • Materials
	3) Product/ Service Technologies	• Switching • **Multiplexing (see Figure 4)** • Routing • Transmission	• Imaging • Marking	• Controlling content • Storing content
	4) Product/ Service Sub-technologies	• Optical Networking • Optical Switching • Optical Transmission	• Color Digital Imaging • Color Copying • Digital Printing	• Personal computing • Server computing
	5) Product/ Service Classes	• Optical switches • Optical Transmitters	• Color copiers • Digital printers	• Micro-processors • Routers
Skills	6) Singular Functional and Technological Skills	• Manufacturing optical switches • Manufacturing optical transmitters • Optical switching • Optical transmitting • **Digital multiplexing (see Figure 4)**	• Installing color copiers • Repairing digital printers • Creating color Images • Performing digital marking	• Designing microprocessors • Manufacturing routers • Microprocessing • Data routing
	7) Integrated Skills	• Provision, and management of communication networks and their components	• Provision of document management equipment, software, and services	• Provision, including creation, of computers and their components.

1) Understandings of core phenomenon and related disciplines (Table 1; Row 1). A core phenomenon, the foundation of a core competence, is the thing or activity which people holding a core competence *understand* most thoroughly. Understandings of general phenomena, discussed below, converge into the thorough understanding of this phenomenon, and it is out of this thorough understanding that the other understandings and skills comprising the rest of a firm's core competence emerge. These understandings are often enriched by corporate employees' knowledge of related disciplines. Analysis revealed four variations of core phenomena. They include

1. Something created by the company holding the competence.
2. Something the company's customers create.
3. Something that exists naturally.
4. Something that people within the firm do (an activity).

An example of the first variation occurs in Competence One (Table 1), since its core phenomenon is the communication network, which the host firm provides to customers. Related disciplines for it include computer science and mathematics. Competence Two (Table 1) is an example of the second variation, since its core phenomenon is the customer documents the host firm manages. Related disciplines supporting it include linguistics and psychology. Competence Three is an example of the third variation, since one of its core phenomena is the element silicon. Related disciplines supporting it include materials science and engineering. Competence Three is also an example of the fourth variation, since its other core phenomena are activities: the design and manufacture of silicon circuits.

2) Understandings of general phenomena (Table 1; Row 2). General phenomena are ones that can be used in many areas of life, not just with regard to the core competence. However, they often combine to form a core phenomenon, as occurs in Competence One, where the two general phenomena of communication and networks combine to create the core phenomenon of the communication network. This also happens in Competence Two, where the general phenomena of text and paper are combined to create the core phenomenon of the document.

3) Understandings of product/service technologies (Table 1; Row 3). Product/service technologies emerge directly from the core phenomenon. Sometimes they are activities that create it. An example occurs in Competence One, where the product/service technologies of switching and transmission act together to form the communication network core phenomenon.

A second variation occurs when the product/service technologies are the activities that can be done to the core phenomenon. Competence Two is an example. In this, product/service technologies are actions such as imaging and marking that can be performed upon the document core phenomenon.

A third variation happens when product/service technologies are the activities that arise from understanding of a core phenomenon that exists naturally. Competence Three is an example. In this case, the functions of computing, e.g., controlling content (data) or storing it in memory, are made possible by a thorough understanding of the natural element of silicon.

A fourth variation develops when product/service technologies arise from skills necessary to do the core phenomenon. This occurs in Competence Three. Here, the functions of computing, such as controlling content, are made possible by the activities of designing and manufacturing integrated circuits.

4) Understandings of product/service sub-technologies (Table 1; Row 4). Product/Service sub-technologies emerge from product/service technologies, usually in combination with general phenomena. Essentially, they are more specialized versions of product/service technologies. Several variations exist.

First, product/service sub-technologies can arise from the application of one general phenomenon to one product/service technology. This occurs in Competence One with optical transmission, which is performed when the general phenomenon of light is applied to the product/service technology of transmission.

Second, they can emerge through the application of one general phenomenon to multiple product/service technologies. This also occurs in Competence One, where the general phenomenon of light is applied to all the functions within a network, such as switching and multiplexing, to create optical networking. In Competence Two, this happens in the application of the general phenomenon of color to the product/service technologies of imaging and marking to create color copying.

Third, product/service sub-technologies can arise through the application of multiple general phenomena to one product/service technology. This occurs in Competence Two, where the general phenomena of color and electricity are applied to the product/service technology of imaging to create color digital imaging.

Fourth, they can arise through the application of multiple general phenomena to multiple product/service technologies. One example occurs in Competence Three. In this, the general phenomena of electrical systems and materials are applied to the product/service technologies of controlling and storing intellectual content such as data to support personal computing.

5) Understandings of product/service classes (Table 1; Row 5). Product/service classes are types of products and services made possible by product/service technologies and sub-technologies, often in combination with an understanding of a general phenomenon. An example occurs in Competence One. Here the product technology of switching, the sub-technology of optical switching, and the general phenomenon of light enable the production of optical switches.

6) Functional and Technological Skills (Table 1; Row 6). A core competence's skills—the ability to do something—can exist in functional or technological forms. Functional skills are made possible by understandings of classes of products and services (Table 1, Row 5). Examples of functional skills include manufacturing optical switches (Competence One) and designing microprocessors (Competence Three).

Technological skills, in contrast, are made possible by understandings of technologies related to specific products or services. Differing from the technological understandings shown in Rows 3-4 of Table 1, these skills are the capability of people to use the technology itself. For instance, in one of the firms, the people contributing to Competence Two have an understanding of the product/service technology of imaging (Row 3), but they also can *apply* this to the next step and actually create color images (Row 6).

7) Integrated skills (Table 1; Row 7). This is the ability to do an activity caused by the functional *and* technological skills discussed above. This integrated skill consists of the individual skills and the relationships between them. An example is the ability to provide entire communication networks (Competence One). These networks arise from the integration of functional skills in manufacturing optical network components (switches and transmitters); however, they also emerge from the integration of technological skills in optical switching and transmission.

Within the above structure of seven competence elemental categories, note that general phenomena (Category 2) can take two forms. Sometimes they are relatively unchanging, stable objects, such as the general phenomenon of paper is for the core competence based upon the document. Other times, however, they involve relatively dynamic, changing things that occur repetitively, such as the general phenomenon of light is for the core phenomenon based upon the communication network. Either way, general phenomena can be considered the "raw materials" of core competencies because understandings of them are repeatedly incorporated into understandings of core phenomena, product/service technologies and their variations, and classes of products and services.

Core Competence Breadth

Based upon the core competence structure revealed by content analysis, interviews of corporate professionals, and an analysis of corporate patents, Edgar (2000; Edgar & Lockwood, 2010) found that one particularly strategically relevant attribute of the core competence can be described precisely: its

breadth. Competence breadth is the *number of members* across seven competence elemental categories. For example, in Table 1 the breadth of Competence One is illustrated by the number of bulleted members within the entire Competence One column. Thus, the breadth of Competence One includes 20 understandings and skills.

Therefore, whenever a company adds members to any of these seven categories, the breadth of the company's core competence increases. If a firm has a core competence based upon the core phenomenon of the communication network and it adds an understanding of the product/service technology of switching or the skill of manufacturing optical switches, then it has increased the breadth of its core competence. Conversely, if it loses an understanding or skill, it has decreased the breadth of its core competence. Breadth is depicted in the Core Competence Chart in Figure 1 with each understanding or skill a bulleted member. Adding a new member would represent broadening the competence and vice versa.

Framework Summary

Employees' competence-related understandings include ones of general and core phenomena; supporting product or service specific technologies; and classes of products and services arising from the understood technologies. The skills within a competence can be specific ones, as well as integrated ones encompassing multiple functional or technological skills. Functional skills emerge from understandings of types of products or services, while technological skills arise from understandings of technologies. Adding further understandings and skills to a competence increases its breadth and vice versa. Utilized together, the different understandings enable the competence's specific and integrated skills, and the skills in turn reinforce the corporate understandings of phenomena, disciplines, general or product/service specific technologies, as well as of types of services and products.

Represented by a Core Competence Chart (Figure 1), this core competence framework identifies how core competencies work and what they are made of. It shows that core competencies are a set of progressive, iterative understandings and skills held by corporate employees that collectively operate at the core level, providing the intellectual foundation for corporate competitiveness.

Depth Analysis Methodology

This framework's contribution is to describe the elements, dynamic, and intellectual breadth of a core competence. However, much of the competitive power of a core competence arises from understandings and skills within the competence's breadth that are deeply held by employees of a firm.[2]

Core competence depth can also be represented in a Core Competence Chart (Figure 1) if one imagines that the Figure had a third, underlying dimension and that one could "drill" down into the understandings of and abilities in all of the individual bulleted technologies, general or core phenomena, product/service classes, or skills. Having greater competence depth means knowing more about one or more particular bulleted category members and vice versa. This can also apply to the bulleted members in Table 1. The difference between the two is that the Chart depicts in depth the understandings and skills of one competence. In contrast, the Table supports comparisons of diverse competencies within a firm or across them by presenting only their key understandings and skills.

What is needed, therefore, is a methodology for explicating these deeply held aspects of a core competence. Ideally, the method should be thorough, relatively inexpensive to do, and draw upon experts on the competence's underlying phenomena, technologies, product/service classes, and skills.

The methodology presented here meets these criteria by utilizing an analysis of the firm's patents, supplemented by interviews with its key executives and research professionals. Patents are especially

[2] Core Competence depth can increase as an individual employee enhances his or her individual competence understandings and skills. It can also increase as the number of employees holding competence understandings and skills grows. The latter case is what is known by practitioners of the Malcolm Baldridge National Quality Award as increased deployment—increasing the percentage of employees that know or practice an approach to work.

useful for competence depth analysis because the United States patent database has a subject classification system which displays an item's components, capabilities, and any objects upon which it frequently acts, along with their sub—components, sub-capabilities, and sub-objects down through several intellectual layers. It also provides standardized descriptions of the subject categories, called patent classes, in the classification system. Please see http://www.uspto.gov/web/patents/classification/index.htm for access to this classification system. Visitors can use this internet site to find patent classes by patent number (from 002, apparel, to 987, organic compounds); they can also search the classification description for each patent number.

To determine Core Competence depth, the methodology described here and presented in Table 2 first discovers the breadth of a core competence and depicts this in a Core Competence Chart (See Table 2, Step A). Figure 1 is an example of such a chart. The methodology next links patent classes to key understandings of or skills in the individual general phenomena, technologies, and product or service classes underlying the core competence, e.g. the bulleted members of the seven elemental categories in Figure 1 (Table 2, Steps B-E). It explicates the depth of competence knowledge regarding these key individual bulleted understandings and skills in some detail in depth statements (Table 2, Step F). Then it depicts the total depth of the competence across these statements in a depth summary (Table 2, Step G). Next, it uses interviews of key corporate personnel to verify and refine the depictions of competence depth presented in the depth statements and depth summary (Table 2, Step H). Finally, completing the "loop" begun in Step A, it inserts these results into the Core Competence Chart (Table 2, Step I), providing an extensive overview of the competence's breadth and depth.

Generalization of Core Competence Depth

Utilizing the core competence framework indicates the need to apply a generalized, systematic understanding of competence depth to the details of the reality underlying a core competence. Such a generalized conceptualization can also be applied to determine the details of the depth of individual competence understandings and skills (Table 2, Step F), which in turn supports depiction of depth across the competence (Steps G-I).

The investigators found that the generic depth of a core competence consists of the extent to which people within a company have understandings of its related, underlying core phenomena, general phenomena, product/service technologies, or product classes and the extent to which they can perform the competence's individual skills and integrated skills. This section discusses how people holding a core competence can understand these things deeply or be able to do them more proficiently.

Previous research (Edgar 2000; Edgar & Lockwood, 2008, 2010, 2011) revealed five core competencies held across four firms, and approximately 7,000 patents spanning the five competencies were examined using this depth analysis methodology. One of these five competences, reflected in approximately 2,000 patents held by is host firm, is used here as an example.

Entity and Process

We found that these general phenomena, technologies, product/service classes, and skills underlying core competencies can be classified as either entities or processes. An entity can be thought of as a relatively stable thing containing component parts and relationships among them. It has capabilities to perform activities but may remain inactive for sustained periods of time. Processes, in contrast, can be thought of as a set of repetitive, dynamic component activities and objects acted upon by them. The activities of some processes are performed by people as skills, either directly by hand or indirectly through technology while other processes occur in nature.

Our research revealed that product or service classes underlying core competencies are usually entities. In contrast the skills underlying them are usually processes. The general phenomena, core,

Table 2: Depth Analysis Methodology

A: Determine Core Competence Structure Using the Framework presented in the first section of this paper, the core competence's structure—its elements, dynamic, and breadth—are determined, since competence depth exists only in relation to these. This can be done using a methodology we have described previously (Edgar & Lockwood 2011) that uses the analysis of corporate documents and interviews with key corporate managers and research professionals. Document analysis preliminarily identifies the instances of the seven elemental cat-egories, depicted as bulleted items in Figure 1. The interviews verify and refine these results. The result is a Core Competence Chart as depicted in Figure 1.
B Identify Firm's Patents. The set of patents issued to the firm for a relatively recent period (e.g. the past 10 years) is identified.
C. Identify Patent Classes with Patents. The firm's patent set is examined to identify associated patent classes in the U.S. patent classification system.(In the patent system, each subject class has sub-classes documenting the sub-components, capabilities, and objects of the subject class, often down to several intellectual layers.)
D. Isolate Patents Classes with Numerous Patents The numbers of patents assigned to each isolated subject class and its sub-classes are determined, and the classes and sub-classes having a large number of patents (e.g. more than 20) are isolated.
E. Link Key Core Competence Skills and Understandings to Patent Classes with Numerous Patents. *For each core competence, the different underlying general and core phenomena, technologies, product/service classes, and skills corresponding to each isolated patent subject class, and, if needed, sub-classes, are determined. This "linking" step highlights the depth of some of the understandings and skills comprising the breadth of each core competence, as revealed by Step A. It can be helped greatly by using the U.S. patent system descriptions provided for each patent class or even by examining firm's patents themselves.*
F. Prepare Depth Statements of Individual Competence Understandings and Skills. *The information gathered in Steps B through E is compiled into a depth statement for each key competence understanding or skill in which the firm holds numerous patents, represented by individual bulleted category members in a Core Competence Chart (Figure 1). For an example of a depth statement, see Figure 4 below. Each depth statement defines the item underlying an understanding or a skill, identifies it to be an entity and/or a process, highlights the versions and variations the item covers, and provides details concerning the patents held by the firm concerning the item. During this step, conceptual tools such as Entity and Process charts (Figures 2-3) and Depth Structure Charts (Figures 5-8) can help elucidate the underlying item's components, capabilities, and objects, and their resulting basic form, versions and variations. It is in preparing depth statements that a generalized conceptualization, discussed in the next section of this paper, is applied to reveal the details of competence depth for specific, "local" understandings and skills, represented by particular bullets in Figure 1. To balance the subjective views of researchers, we recommend that Steps A through F be done by a team of at least two investigators.*
G. Compile Depth Statements into Depth Summary for Entire Competence. *For each competence, these statements are compiled into a depth summary describing cumulative, "global" depth across many of the core competence's understanding and skills, represented by multiple bullets in Figure 1. An example of such a depth summary is presented in Appendix 1.*
H. Corporate Managers and Researchers Review and Revise Competence Chart, Depth Statements, and Depth Summary. *The core competence chart, depth statements, and depth summary for the competence are then reviewed by key corporate managers and research professionals during semi-structured interviews. Following a "tree and branch" approach (Rubin & Rubin, p. 159), these interviews ask a series of diverse but related questions (the "branches") arising from the underlying topic (the "trunk") of competence depth. See Appendix 2 for a sample instrument to use for these interviews. This review of patent analysis' results is important for revealing several aspects of core competence depth: nuances of the depth of specific competence understandings and skills represented by patents; specific deeply held competence understanding and skills not represented by patents; and a competence-wide, cumulative depth of the competence.*
I. Describe Core Competence Breadth and Depth in Core Competence Chart Using Results of Previous Steps. *The findings and responses of Steps F-H's depth summaries, depth statements, and interviews can be inserted into a Core Competence Chart. This is shown in Appendix 3. Numbers of patents can be displayed in parenthesis next to their corresponding bulleted understanding or skill, with a higher number of patents indicating greater competence depth and vice versa. Also, deeply held competence skills and understandings not represented by patents but revealed by interviews can be depicted in bold. The result can be to "close the loop" begun in Step A and provide a nuanced portrait of a core competence's elements, dynamic, breadth, and depth.*

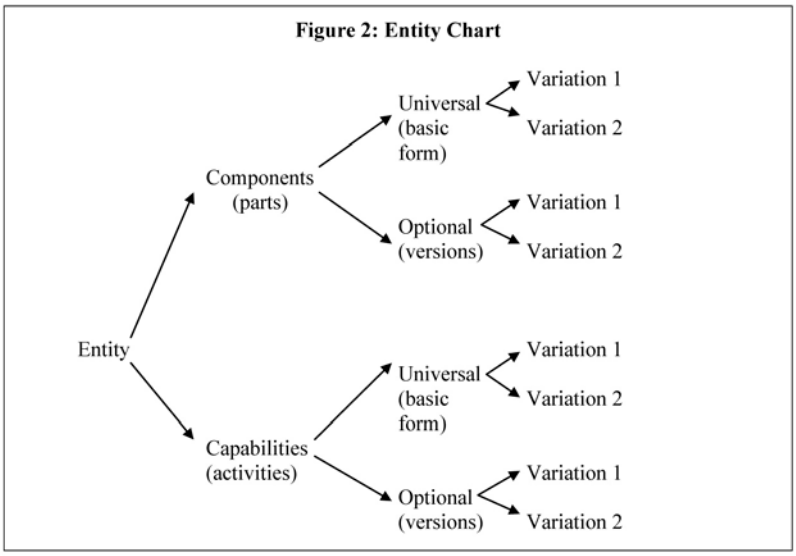
phenomena, and technologies related to them can often be either entities or processes. Consequently, three important questions emerge:

1) What does it mean to understand an entity, regardless of the elemental category the understanding occupies within the competence?
2) What does it mean to understand a process?
3) What does it mean to engage in a process proficiently if that process is a skill?

Question 1: Understanding an Entity

Entities contain components and have capabilities which the components, working together, can perform. Components mean the parts of the entity while its capabilities mean the activities the entity can be used to do. Some of these components and capabilities exist in all occurrences of the entity, in which case they can be said to be universal. Some of these, in contrast, exist in only some occurrences of the entity, in which case they can be said to be optional. The presence of only universal components creates the *basic form* of the entity itself, and the presence of only basic sub-capabilities creates the basic form of the entity capability. In addition, the presence of optional components and optional sub-capabilities creates *versions* of the corresponding entity itself or entity capabilities. Moreover, the basic form or versions of an entity's component or capability can have multiple *variations*. This can be depicted graphically in an Entity Chart, as in Figure 2.

Figure 2: Entity Chart



For instance, one competence involved deeply held expertise in electrical devices necessary to operate communication networks, represented as Competence One in Table 1. The entity of an electrical device has the basic component parts of circuits and connectors, which have the basic capabilities of moving and directing electrical current. But it can also have optional components, such as a power regulator (conditioner) with the capability of controlling current levels. Each optional component part and capability can be thought of as a version of an electrical device. Moreover, the entity of an electrical device in its basic form can vary by having more or less powerful circuits and connectors that send or direct current. Similarly, in its version form, an electrical device can vary having a conditioner that regulates extremely high or low levels of current.

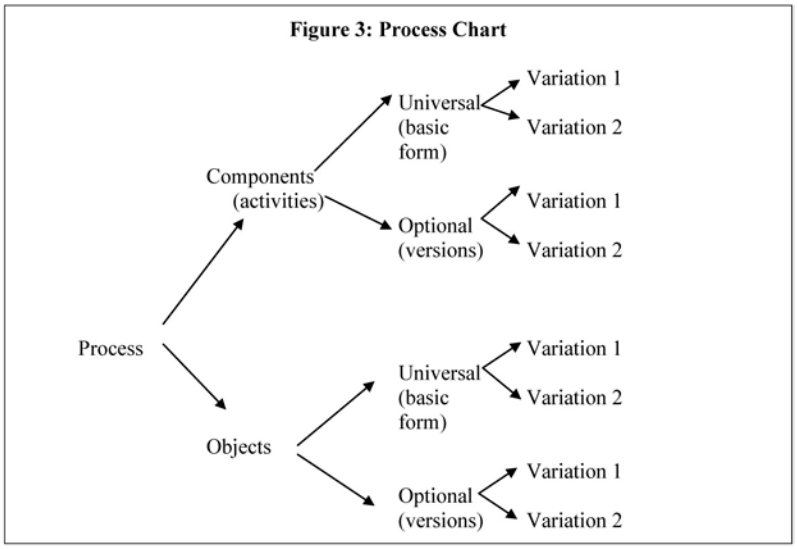
Therefore, to answer the first question posed above, having an understanding of some entity like an electrical device means being thoroughly *aware* of any of its basic or optional components (e.g. circuits or conditioners) and capabilities (power transmission and regulation) as well as the relationships among them—its basic form and versions. Understanding an entity also means having an extensive

awareness of any variations (e.g. transmitting or regulating lower or higher amounts of power) existing across the basic form or versions of the entity's components and capabilities.

Question 2: Understanding a Process

As is true with entities, processes contain components, but in contrast to entities, they also contain objects. Rather than being parts or elements of the whole, however, components here are the activities that occur within the process because as they occur together, the process operates to accomplish work upon the objects. Some of these component activities and objects exist in all instances of the process, in which case they can be said to be universal. Some of these, in contrast, exist in only some instances of the process, in which case they can be said to be optional. As with entities, the presence of only universal component activities and objects creates the basic form of the process. Conversely, the presence of optional component activities and objects creates *versions* of the process. The basic form or the versions can in turn exhibit variations. This can be depicted graphically in a Process Chart, as in Figure 3.

Figure 3: Process Chart



For example, the competence based upon the communication network involved deeply held expertise in the process of multiplexing. This involves the activities combining separate object data signals into one, transmitting them to a destination, and then disassembling them for use there. Multiplexing is used in many instances of communication networking, such as when residential telephone signals from one city are consolidated and sent simultaneously to another city along high capacity transmission lines.

In its basic form, the process of multiplexing includes the activities of combining and routing different object data. But it can also have optional component activities, such as diagnostic testing of data streams, and optional objects, such as different forms of data like electricity or light. Each optional combination can be thought of as a version of multiplexing. Moreover, in either its basic form or a version, multiplexing can exhibit variations such as routing or testing more or less complex digital or optical data.

Therefore, to answer the second question posed above, having an understanding of some process means being aware of any of its basic or optional component activities and objects, meaning its basic form and versions, as well as the relationships among them. It also means having an awareness of any variations existing across the basic form or versions of the process' activities and objects.

Question 3: Engaging in a Process (Performing a Skill)

To answer the third question posed above, proficiently engaging in a process as a skill involves not only awareness of the component activities of the process, but also the ability to *do* the activities making up the process effectively. It means being able to go beyond understanding them to performing well the activities inherent to the basic form, versions, and variations of the process. Effectiveness might mean performing the skill quickly but if often means performing the skill with few or no mistakes.

This distinction related to effective action—doing—is a vital one because people in corporations can understand many processes without being able to do the activities within these processes directly. For example, people within a firm making communication devices like telephones will likely have an awareness of the activities within the process of multiplexing, but they might not directly engage in its activities.

In contrast, employees within a firm that manufactures multiplexing equipment (e.g. switches) have this awareness and do engage in the activities themselves, albeit indirectly through technology, as they perform quality tests on the equipment.

Depth Statement Example: The Process of Multiplexing

These concepts regarding basic forms, versions, and variations underlying individual competence understandings and skills—represented in the individual bulleted category members of both Figure 1 and Table 1—can be operationalized using the United States patent classification system. Utilizing this generalization of core competence depth, Figure 4 presents an example depth statement of patents—drawn from Table 2, Step F in the methodology described above—depicting the realities underlying the understanding of and skill in multiplexing embedded in one firm's core competence.

One way to understand Figure 4 is that it presents what one would find by "drilling" down into two of the bulleted members related to multiplexing in the Core Competence Chart of Figure 1. The first can be found Box 3 of Figure 1 depicting an understanding of various versions of multiplexing, and in Box 6 depicting skill in its digital version. They can also be found in Table 1 (Competence One, Rows 3 and 6).

In Figure 4, the depth statement's first two paragraphs provide a narrative overview of the item underlying the competence's corresponding understanding or skill. After indicating its appropriate Patent Class (Number 370, Multiplex Communications) in the first paragraph, the depth statement defines the patent class as a process or entity: multiplexing is a process of consolidating an object—data in different forms—transmitting it, and reversing the consolidation once the transmission is complete. Next the depth statement—drawing upon the patent subject class description and even the patents themselves—indicates the purpose of the patent's sub-classes, especially with regard to the processes' versions and variations. The patent sub-classes cover the basic form, and all versions or variations of the multiplexing process by representing all of its universal and/or optional component activities and objects upon which it performs. Such a statement places the depth of a competence's knowledge into a larger context as to whether the depth covers all or only some of what is known about the topic.

In the second paragraph of the depth statement (Figure 4), the core competence's patents related to the patent class, multiplexing, are specifically described. The patents protect the firm's expertise in multiplexing's component activities of controlling data flow, diagnostic testing, fault recovery, and data routing. Then the statement indicates whether the core competence includes only an understanding of a process by people within a firm or a skill in engaging in the process as well. For multiplexing, this firm has both: its people are aware of how to do multiplexing and they can also engage in multiplexing. Finally, the statement indicates the larger systematic, thorough understanding which is supported by the more focused expertise described in the depth statement. In this case, this understanding of multiplexing supports a core competence based upon the thorough understanding of the communication network core phenomenon.

Figure 4: Example of Core Competence Depth Statement (Process of Multiplexing)

Multiplexing (Patent Class 370)

Multiplexing is the process of consolidating two or more information signals into one transmission medium and then transmitting them simultaneously so that the distinct signals which have been combined can be recovered at the receiving place of the transmission. As such, the patent class' sub-divisions represent the basic form and all versions or variations of the processes' component activities and objects.

The competence's patents are concentrated in multiplexing's a component activities of controlling data flow, diagnostic testing, fault recovery, and data routing. The patents represent the firm's expertise in both understanding the process of multiplexing as well in practicing the skill of multiplexing by engaging in the process. This supports a core competence based upon an understanding of the communication network core competence.

Vertical Depth: 4 Layers:
1) 15 (7.50%)
2) 67 (33.50%)
3) 64 (32.00%)
4) 54 (27.00%)
Total: 200 (100%)

Horizontal Depth: 25 subdivisions (patent sub-classes), 12 of them with competence patents

1. 1 (under 1%)	2. 10 (5.00%)	3. 10 (5.00%)	4. 10 (5.00%%)	5. 10 (5.00%%)
6. 3 (1.50%)	7. 6 (3.00%)	8. 15 (7.50%)	9. 40 (20.00%)	10. 65 (32.50%)
11. 10 (5.00%)	12. 20 (10.00%)			

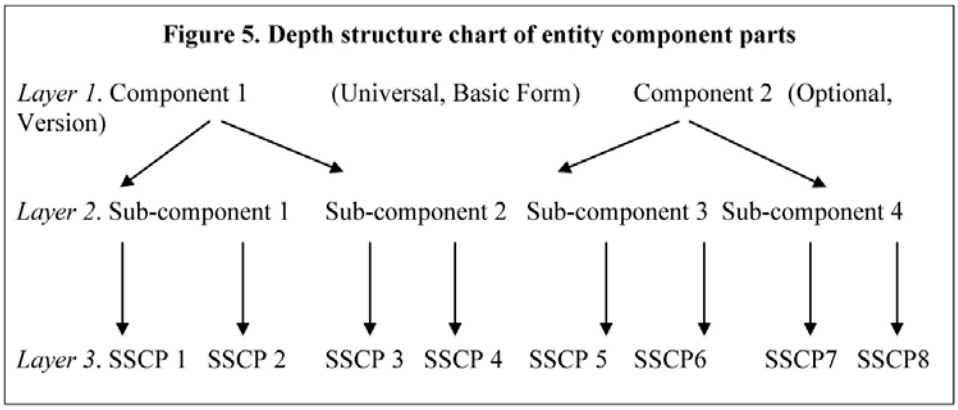
Total: 200 (100%)

The firm's expertise is rather vertically deep, with about 92.5% of its patents at the second intellectual layer or below. However, its expertise is quite horizontally narrow, with nearly three-fourths of its patents in only 4 of 25 available sub-divisions.

Dimensions of Competence Depth

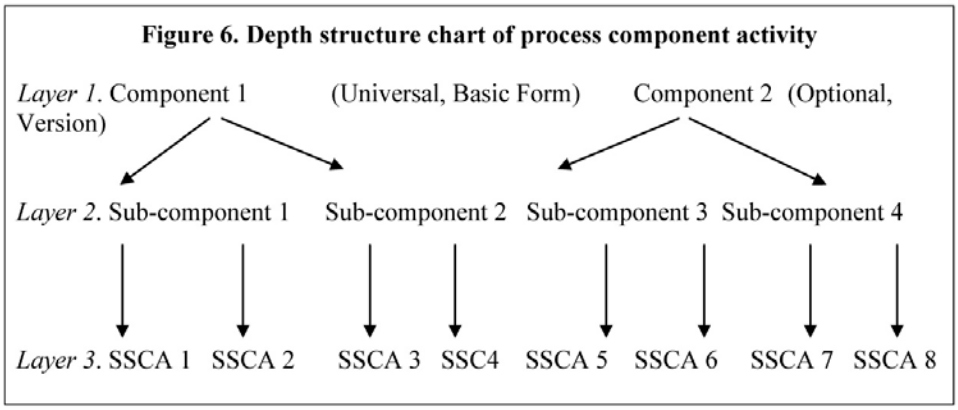
To summarize, the deepening of a core competence's knowledge of an *individual* process or entity brings a thorough understanding of or ability to do more of the variations within the basic form or versions of the process or entity. As depicted next in the depth statement of Figure 4, this increase in localized knowledge depth with respect to a single competence understanding or skill can occur in two ways—vertically and horizontally.

Core competence depth is based upon the reality that understood entities will have their own component parts and their corresponding capabilities, and processes—either understood or engaged in—will have their own component activities and their corresponding objects. Each of these components may in turn have its own respective sub-components, potentially leading to an internal structure of great complexity. Any of these might be universal or included in an option and so create basic forms, versions, and variations of the entity or process. This structure of components as parts for entities can be shown in a Depth Structure Chart, such as in Figure 5:



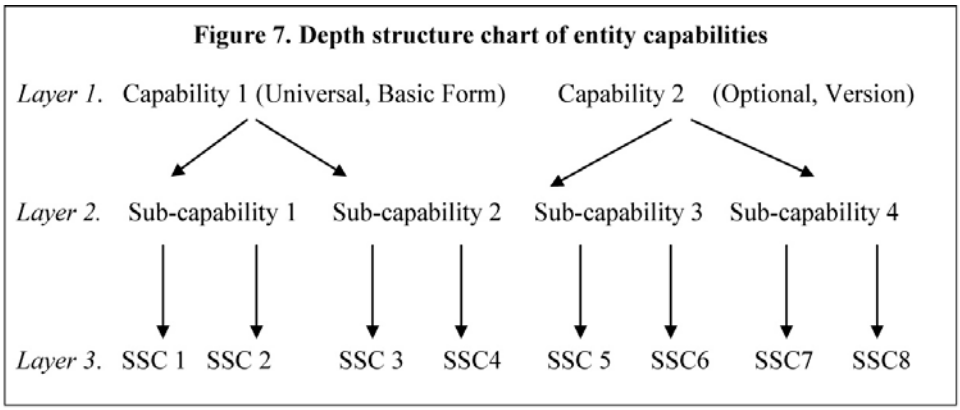
Note: SSCP =Sub-Sub-Component-Part

This same layered structure also applies to the component activities of processes, which are what accomplish work, as shown in Figure 6.



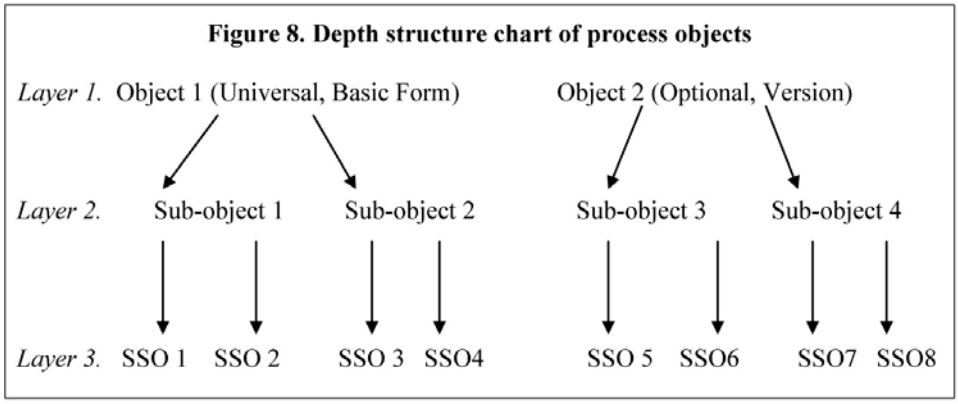
Note: SSC =Sub-Sub-Component-Activity

The structure applies to the capabilities of entities, which are what enable entities to act in accomplishing work, as shown in Figure 7.



Note: SSC=Sub-Sub Capability

This layered structure can even apply to the objects of processes, which have the processes' work performed upon them, as shown in Figure 8.



Note: SSO=Sub-Sub Object

The layered structural approach shown in each of Figures 5-8 contains three intellectual layers of aggregation and eight vertical chains of composition, revealing two different kinds of competence depth. For instance, as depicted generically in Figure 5, employees of a firm might have an understanding of the entity of electrical devices, which have universal component parts of circuits (Layer 1, Component 1) and optional component parts of power regulators (Layer 1, Component 2). The circuits and regulators have sub-components (Layer 2), which also have their own respective components (Layer 3). The employees could have understandings and sub-understandings that encompass items at Layer 1, 2, or 3 of circuits or power regulators. The more items they understand at Layers 2 or even Layer 3, regardless of the vertical chains the items occupy, the more what we term to be *vertical depth* of the competence increases.

In contrast, the employees could have understandings that encompass items within some to all of the eight vertical chains. For instance they might have understandings of circuits (Vertical Chains 1-4) but not regulators (Chains 5-8). The more items they understand across the vertical chains, regardless of the intellectual layers the items occupy, the more what we term to be *horizontal depth* increases.[3]

Why might a competence's knowledge encompass Layers 1 and 2 but not Layer 3 or include some of the eight vertical chains (e.g. Chains 1-4, encompassing the basic components like circuits) but not all of them? It could be because a firm's vendors provide parts, e.g. components and subcomponents, to items in this vertical or horizontal intellectual structure. When this occurs, a firm's own deep knowledge might end and instead the firm could rely upon the vendor's knowledge.

Therefore, as depicted in Figure 5, a deep core competence with regard to a particular understanding of electrical devices would be one in which employees of a firm have understandings concerning items in all three of the components' horizontal layers (vertical depth) as well as in all eight of the sub-sub-components' vertical chains (horizontal depth). In this example the competence includes knowledge of the basic form of an entity like an electrical device, and it has knowledge of one its versions.

Moreover, these dimensions—vertical and horizontal core competence depth—apply not only with regard to entities' component parts—the example just presented—but also with regard to processes' component activities (Figure 6), entities' capabilities (Figure 7), and processes' objects (Figure 8). When applied to the entity's capabilities (Figure 7) and processes' objects (Figure 8), core competence depth

[3] Perhaps counter-intuitively, in Figures 5-8 the number of horizontal layers, taken together, indicates potential vertical depth within the competence, and the number of vertical chains, also taken together, indicates potential horizontal depth. In each of these examples there are three horizontal layers and eight vertical chains. Moreover, remember that most entities and processes will be much more complex than ones depicted in Figures 5-8 because their sub-components, capabilities, and objects will be far more numerous, resulting in many more versions and variations.

represents employees' understandings (and sub-understandings) of the capability (e.g. an electrical device's ability to direct electrical current) or of the processes' object (e.g. data manipulated by multiplexing).

However, as discussed earlier in the multiplexing example, when applied to processes' activities (Figure 6), competence depth could represent employees' understandings of the activities without the ability to do them, or depth could represent their skills (and sub-skills) to do—engage in—the activities. As discussed earlier, a firm that makes only telephones might understand the activities of the multiplexing process without doing them directly. In contrast, a firm that manufactures switching equipment will engage in multiplexing directly.

Depth Statement Example: Horizontal and Vertical Depth

The remainder of the depth statement presented in Figure 4 applies these concepts. Just below its two opening paragraphs, it provides a numerical description of vertical and horizontal depth of a core competence's patents supporting the process of multiplexing. The numerical data on approximately 200 patents held by the firm in Patent Class 370 reveal this competence's knowledge of the process's component activities (diagnostic testing, data routing) and objects (electricity and light) of multiplexing. The competence's vertical depth of knowledge extends down to four intellectual layers of components, sub-components, etc. of multiplexing. The competence's horizontal depth of knowledge extends across 12 sub-divisions, representing 12 vertical chains of knowledge.

Finally, in the depth statement (Figure 4) there are important points about the firm's vertical and horizontal depth of knowledge concerning the instance of the core competence category. This firm's competence depth in multiplexing is vertically deep, with 92.5% of its patents at the second intellectual layer or below. In contrast, the competence's multiplexing expertise is horizontally narrow, with 70% of its patents in only 4 of 25 available sub-divisions. Therefore, the firm's overall knowledge of multiplexing—embedded in its core competence based upon an understanding of communication networks—is vertically deep but horizontally narrow: people within the firm have deep but very focused knowledge about certain aspects of multiplexing.

Cumulative Depth: Depth Summary

Completed during Step F in the depth analysis methodology presented above in Table 2, the preparation of depth statements, such as Figure 4, reveals depth of knowledge with regard to particular key competence understandings and skills for which a firm holds patents, represented by *individual* bulleted category members in a Core Competence Chart (Figure 1) or a Core Competence Comparison Table (Table 1).

As such, depth summaries depict "local" depth of specific aspects of a competence in vertical and horizontal forms.

Next, in step G (Table 2) of this methodology, these statements are compiled into a depth summary depicting cumulative horizontal and vertical depth of patented knowledge across all the seven elemental categories of an entire core competence, represented by *multiple* bulleted members in the Core Competence Chart (Figure 1). As such, a depth summary depicts more accurately the "global" depth of a core competence. Appendix 1 shows a generic example of such a depth summary. Each row in the Appendix summarizes a depth statement covering an individual competence understanding or skill bulleted in Figure 1. Collectively the rows depict the cumulative depth of the competence across its understandings and skills.

Core Competence Depth: Interviews

Moreover, once complete, the core competence charts, depth summaries, and depth statement can be reviewed through interviews of key corporate managers and professionals to stimulate thought, debate, and conclusions about the depth of a core competence (Table 2, Step H). The interviews can help reveal deeply held competence understandings and skills that are not represented by patents, and they can

provide a global perspective of the depth across the competence. See Appendix 2 for a sample interview instrument for these interviews.

Core Competence Overview: Chart

Then, in the conclusion (Table 2, Step I) of the depth analysis methodology, the findings as to a core competence's depth arising from the previous steps can then be inserted into a Core Competence Chart like the one in Appendix 3. Here horizontal and vertical depth is summarized "locally" by the numbers of patents indicated next to individual understandings and skills in one or more elemental category (specific bulleted items in one or more boxes) and by placing deeply held individual bulleted understandings and skills in bold. It is summarized "globally" by the numbers of patents across bulleted items and by the overall set of bolded, bulleted items. The result can be a powerful portrait of core competence depth, along with its underlying competence dynamics, elements, and breadth.

Discussion

Methodological Advantages

Using patents to isolate the depth of a firm's core competence has several major methodological advantages. Two have to do with its intellectual validity. First, a firm's patent is a good indication of the existence of a competence's depth because it reports knowledge which a company has formally developed and legally protected as important to its future. Second, patent analysis ensures that the knowledge and skills isolated for inclusion in the core competence are not in fact ones held by the firm's vendors. For instance, one way to determine competence depth is to perform an analysis of products or services and then infer from this the depth of knowledge the firm must have to provide them. However, it may be extremely difficult or even impossible for a researcher to determine which components of a product or service are based upon the knowledge held by people within a firm and which are based upon knowledge held by people within its vendors.

Patent analysis also makes use of the latent content analysis of patent application documents done by expert patent subject classifiers. Researchers need not rely only upon their own ability to analyze how all the concepts and skills of each technology, product class, or skill within a core competence relate to one another. They can also utilize the perspectives of independent experts outside of the firm being studied. Patent analysis is inexpensive to do. Information on a firm's patents, and the patent office's conceptual classification system, can be gained through government resources available at fairly low cost. Finally, using patents for core competence depth analysis enables a researcher to use publicly available information. This avoids inadvertently disclosing the firm's confidential information or depending upon information the firm will not reveal in order to describe its core competencies.

Methodological Limitations

However, there are important limitations to using patents to indicate core competence depth. One is that that some firms primarily use other companies' technologies to provide solutions to its customers rather than having their own huge patent portfolio. More generally, firms often will have unpatented but deeply held understandings and skills within a competence, which can be revealed through interviews of key managers and research professionals once patent analysis is complete.

Another limitation is that it is sometimes difficult to link specific patents to only one instance of a technology, product/service class, or skill. This is because the patent classes sometimes do not correspond exactly to these entities or processes underlying a core competence. To account for this, the same patents can be counted twice, with each count indicating depth in a different element of the core competence. This occurs with the multiplexing example discussed in Figure 4, since depth for it represents both an understanding of the process of multiplexing as well as the skill in performing the process.

A third limitation of patent analysis for determining core competence depth can be that the firms' patents might tend to support some competence elements over others. For instance they might represent the firm's expertise in product or service technologies rather than general phenomena. Therefore, it

should be kept in mind that this kind of patent analysis is approximate because it reveals depth across only some parts of the competence—not all of it.

More generally, as is true with competence breadth (Edgar & Lockwood 2011), determining a core competence's depth using the methodology presented here is a subjective, demanding task—potentially as intellectually valuable to a firm as finding the competence itself. It requires balancing specialized knowledge of the competence's underlying phenomena, technologies, products, and skills with a generalized, abstract conceptualization of these as entities and processes about which people hold horizontally, vertically, and cumulatively deep knowledge. It requires balancing input from investigators, patent examiners, corporate executives, and research professions. The result can be multiple, accurate views of the horizontal and vertical depth within an individual competence understanding or skill—like ones related to the product/service technology of multiplexing. It can also be multiple, valid views of cumulative depth across a entire core competence.

Conclusion

This paper presents a framework describing core competencies, a method involving patent analysis and interviews for discovering some aspects of their depth, and a generalization of depth that can apply to all core competencies. The framework reveals competence breadth to be complex, encompassing seven elemental categories of phenomena (Edgar & Lockwood 2008). Usually reflecting an intricate, underlying reality of entities and processes, these include diverse understandings and skills containing sub-understandings and sub-skills, which affect each other iteratively, creating a complicated internal dynamic within a competence.

The depth analysis methodology and generalization reveal a core competence's depth to be as complex as its breadth. A core competence's depth arises from its breadth as people within a firm more thoroughly understand or can do the components, capabilities, and objects of entities or processes related to a competence's underlying core phenomena—whether the processes or entities are general phenomena; product/service technologies; product/service classes; or functional and technological skills. When competence depth increases, the employees' individual understandings and skills grow horizontally and vertically across the basic forms, versions and variations of individual "local" processes and entities. As this occurs, a core competence grows cumulatively deeper in its understanding of and ability to do more of its underlying entities and processes. Such "global" depth across the competence in turn accelerates its competitive power, enabling the competence to generate corporate wealth by providing products and services to economic sectors, industries, and customer segments (Edgar & Lockwood 2010, 2011).

We hope the paper proves to be useful to corporate managers and professionals interested in more clearly identifying, understanding, and strengthening their core competencies' depth as well as in applying them more effectively. We welcome questions on and suggested revisions to the core competence framework, the methodological guide to discovering aspects of competence depth, and the conceptualization of it presented here. Collectively, we believe it is possible to understand and identify these knowledge resources so vital to competitive success.

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Appendix 1

Competence Depth Summary (Cumulative Depth)

Elemental Category Underlying Competence	Category Item	Type of Underlying Item	Type of Knowledge Regarding Underlying Item	Horizontal and Vertical Depth Knowledge Patterns	Number of Patents for Element Instance	Relative Percentage of Patents for Element Instance
General Phenomenon	Electrical Devices	Entity	Understanding	Horizontally Narrow; Vertically Deep	52	2%
Product/Service Technology	Multiplexing (see Figure 4 for Depth Statement)	Process	Understanding	Horizontally Narrow; Vertically Deep	200	10%
Skill (Technological)	Multiplexing (see Figure 4 for Depth Statement)	Process	Skill	Horizontally Narrow; Vertically Deep	200	10%
Total Patents for Core Competence Based Upon Communication Network Core Phenomenon: 2000						

Notes:

1. Each row can be depicted in a Depth Statement, and further rows can be added to describe other items identified in the Core Competence Framework, such as understandings of product classes or functional skills. Each row represents a bulleted item in a Core Competence Chart (Figure 1).
2. The row for electrical devices is given as an additional example to multiplexing.
3. The 200 patents for multiplexing are counted twice because they support both an understanding of the product/service technology of multiplexing and the competence's technological skill in this process

Appendix 2

Sample Interview Instrument for Verifying Core Competence Depth[4]

From our study of the literature on core competencies, the intellectual strengths of companies, as well as annual reports, and product overviews and catalogs your company provides describing its activities, we have divided a firm's core competencies into seven elements. Five of them involve an intellectual understanding of different topics and two of them involve actual skills, the ability to do something, based upon the understandings of the first five elements. The basic idea is that understanding of some general technologies leads a firm to a thorough understanding of a core phenomenon, which leads to the firm's understanding of product or service technologies and sub-technologies, which leads to the firm's understanding of classes of products and services. This understanding of classes of products and services in turn leads to certain skills and these skills are ultimately integrated into a combined skill. More specifically:

- General technologies: capabilities that can be used across many products and services and even many areas of life. Examples: communication, networks.
- Core phenomenon: the thing which a company understands most thoroughly and out of which emerges the rest of its core competency. Example: the communication network.
- Product/services technologies: basic capabilities upon which classes of products and services are based. These emerge from the core phenomenon. Examples: circuiting, routing, switching.
- Product/services sub-technologies: specific variations of product/service technologies, such as specific types, components, or capabilities of them. Examples: wireless networks, conferencing (voice and video), paging, T-1 circuits
- Product/Service classes: types of products and services made possible by a firm's understanding of its product/service technologies (and with that, of its product/service sub-technologies). Examples: routers, switches
- Skills: abilities to do activities caused by an understanding of types of products and services. Examples: research, market, manufacture and install communication networks.
- Integration of skills: a combined skill, one the firm has because it has two or more skills. Example: the skill above, when combined with others, leads to the integrated skill of the provision, including creation, of communication networks as whole entities.

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[4] This is a generic example of the questionnaire used in interviews with corporate managers and research professionals. Pages 3-6 are referred to but omitted and reference a Core Competence Chart, two Depth Statements and a Depth Summary.

Please see the Core Competence Chart on page 3 (to follow) representing what seems to be your firm's core competence in the provision including creation of communication networks as whole entities.

Once you have reviewed this, please see the depth statements on Pages 4-5 of this Interview Instrument. These use the analysis of your firm's patents underlying the competence to depict in some detail horizontal and vertical depth of key individual understandings and skills within the competence. These are represented by bulleted items in the Core Competence Chart. Where applicable, the number of patents held by the firm is displayed in parenthesis next to the item, with a larger number of patents representing greater depth and vice versa.

Next, please review the depth summary for the competence located on Page 6 of this instrument. It provides an overview of the depth statements. Each row in this summary corresponds to one depth statement and one or two bulleted items of the Core Competence Chart. The depth summary reveals the patterns of horizontal and vertical depth across the competence's understandings and skills. It also reveals the cumulative depth of the competence, represented by the total number of patents supporting the competence (bottom row), and the relative contribution of each understanding and skill to that total (far right column).

Based upon your examination of the Core Competence Chart, individual Depth Statements, and Depth Summary, please consider your answers to following questions. We will contact you soon for your responses:

1. To what extent do you agree or disagree that these seven categories are the elements of your firm's core competence, as depicted in the Core Competence Chart? Would you add or remove any? Particularly, to what extent do you agree or disagree concerning the specific core phenomenon, product/service technologies and sub-technologies, product/service classes, and skills? Would you add any or remove any?
2. To what extent do you agree or disagree with the results of the individual depth statements? How would you refine them based upon your expertise within the firm?
3. To what extent do you agree or disagree with the results of the Core Competence Depth Summary? How would you refine it based upon your expertise within the firm?
4. What elements, if any, of this core competence are held deeply by people within the firm even though these are not represented by patents?
5. What other thoughts on the overall depth of this competence do you have?

Appendix 3. Core Competence Chart: Elements, Dynamic, Breadth, and Depth

Relatively High Depth Indicated in Bold and by NP Next to Understanding or Skill