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The capital-based view of the firm

Peter Lewin · Howard Baetjer

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Abstract We offer here a capital-based view (CBV) that incorporates, and goes further than related views, (like the resource- and the knowledge-based view) of the firm. This general approach uses ideas about capital and its structure to examine the nature of heterogeneous resources and their attributes and how they are organized by entrepreneurs (individually and in teams). These entrepreneurs exercise judgment in *valuing* these heterogeneous resources in productive combinations that they attempt to create. This article uses insights gained from this understanding of the nature and function of capital to draw further propositions about the role of knowledge, management, and economic organization. We survey the main components of the CBV of the firm and examine management and organizational topics looking through the lens of the CBV. The capital dimension adds new insights and provides a powerful unifying framework.

Keywords Capital-based theory · Firm boundaries · Firm governance · Uncertainty · Capital complexity · Knowledge-based view

1 Introduction

We offer here a capital-based view (CBV) of the firm that incorporates and goes further than existing approaches. This approach is in the spirit of the growing number of recent research contributions referencing the Austrian theory of capital as a foundational framework within which to consider the firm and the entrepreneurial and managerial actions associated with it. This general approach uses ideas about

P. Lewin (✉)
University of Texas at Dallas, Dallas, TX, USA
e-mail: plewin@utdallas.edu

H. Baetjer
Towson University, Baltimore, MD, USA
e-mail: hbaetjer@verizon.net

capital and its structure to examine the nature of heterogeneous resources and their attributes and how they are organized by entrepreneurs (individually and in teams). These entrepreneurs exercise judgment in *valuing* these heterogeneous resources in productive combinations that they attempt to create.[1] This article uses insights gained from this understanding of the nature and function of capital to draw further implications about the role of knowledge, management, and economic organization.

2 Alternative approaches to the firm

The CBV of the firm offered here has much in common with other approaches. In order to support the claim for its added value a brief overview of alternative views is in order.

There is no single all-encompassing theory of the firm. There are a number of different, but related, approaches, or "views" of the firm as a social institution. In some respects, these different approaches compete in offering rival explanations of the same phenomena; in others, they offer complementary explanations and predictions (Grant 1996).

In the *neoclassical economics* tradition, the firm is basically a "black box." There is no analysis of processes within the firm. The firm is synonymous with the "production function"—into which resources enter and out of which products mysteriously emerge. In fact, there is no neoclassical theory of the firm; there is only a schematic theory of "industry structure" composed of identical "representative firms." Neoclassical economics (implicitly, and sometimes, explicitly) abdicated the duty of analyzing or explaining the firm as a real-world institution (Lewin 2005). By contrast, *organizational theory* sees firms as complex organizations encompassing multiple individuals and analyzes their internal structures and the relationship between their parts (employees, departments, etc.) (Grant 1996: 109). This type of approach was joined by (until recently) isolated contributions by economists like Knight (1921), Coase (1937),[2] Cyert and March (1963), and Nelson and Winter (1982); each focusing on different aspects of the rationale and/or internal workings of the firm.

Drawing from both organizational theory and economics, the *strategic management* literature developed a much richer and varied set of approaches to understanding the firm. Its primary focus is the explanation of sustained competitive advantage, rather than economic efficiency or psychological or sociological insight per se. Thus, the Porter's Five Forces Model (Porter 1985) and later, the resource-based view (RBV) of the firm,[3] sought to explain and predict why some firms are able to establish positions of enduring competitive advantage over their rivals in the

[1] For example, Argarwal et al. (2009); Chiles et al. (2007, 2008); Foss et al. (2007a, b); Foss and Ishikawa (2007); Foss and Klein (2011); Klein (2008); Foss et al. (2008); Kor et al. (2007); Langlois (2002, 2007); Mathews (2006a, b, 2010); Sarasvathy and Dew (2008); and Sautet (2001).

[2] Coase's seminal article, after lying dormant for many years, eventually became the basis for a huge literature stream, with many tributaries, known broadly as "transactions-costs" economics associated particularly with the work of Williamson (1985), as well as Hart (1995) and others. This work continues to have enormous relevance and will occupy us at various points in what follows.

[3] For a collection of foundational and extending contributions, see Foss 1997.

form of earning superior net revenue streams over time. While Porter, drawing from neoclassical microeconomics, focuses on the structure of the industry in which the firm is situated, and its strengths and weaknesses in being able to compete for buyers of its product (good or service), the RBV focuses on the firm's productive abilities more specifically. The RBV sees the firm as a unique combination of specialized resources (which are the source of its unique capabilities). The primary task of management is to enhance the firm's value by judicious deployment and development of the resources. Clearly, the RBV comes close to an Austrian capital-theoretic approach insofar as it refers to the entrepreneurial role of creating and recreating valuable capital combinations. Yet, in many respects, the RBV contains only a superficial understanding of the nature and role of productive resources and their dynamic connection to time, value, and knowledge that is the essence of capital.

A much more promising approach, in terms of its proximity to the view offered here, is provided by the more recent knowledge-base view (KBV) of the firm.[4] Though far from monolithic, this literature stream contains in common an understanding of the importance of (different types of) knowledge in the organization of production. It draws from some of the economics literature, for example, in understanding the challenges posed by the phenomena of dispersed and tacit knowledge (Hayek 1945) and, relatedly, the challenges posed by the need to manage the connection between decision-making rights and knowledge possession (Jenson and Meckling 1992). The firm is seen as a knowledge-integrating institution; production requires the complex integration of multiple types of knowledge and this cannot be accomplished by formal, completely specified contracts, or repeated market transactions. The need to use and combine knowledge in an ongoing, creative relationship implies the need for an organization like the firm (Kogut and Zander 1992, 1996; but see Foss 1996a, b). There is also a recognition of the connection between knowledge and time ("Lachmann's axiom, Lewin 1997, 1994, 2005); "knowledge creation cannot be separated from knowledge application" (Grant 1996: 113) and of the importance of "specificity" in resource combinations.

We believe, however, that a more satisfactory treatment of knowledge is offered by the CBV. The KBV sometimes characterizes knowledge as a "resource," as the most important of the firm's resources, along with labor and physical capital. In this work, the connection between knowledge and human capital is fuzzy. By contrast, in the CBV knowledge is *not* a resource; rather it is a "dimension" of *all* resources, be they physical capital or human capital. Indeed, all resources are rightly conceived of as a form of capital. This means seeing resources in terms of *the value they add over time* to the productive venture. And knowledge is not human capital; it is part of all capital, without which resources would have no value, as we show below.

In particular, we shall argue that the crucial difference between physical and human capital (and any other kind of capital, like social and intellectual capital) lies not in the fact that the latter involves knowledge. All capital is intricately involved with knowledge—is a form of "embodied knowledge". The crucial difference lies rather in the alienability of physical capital (together with its embodied knowledge) and the inalienability of human capital. This means that the management–

[4] See, for example, the special 1996 winter issue of the *Strategic Management Journal*.

organization of physical and human capital present different challenges and opportunities. Management–organization skills and abilities (a type of human capital) must evolve in a world in which the capital structure at all levels is evolving and becoming more complex. The increasing complexity of the capital structure is an implication of the increasing heterogeneity of capital, which itself is a result of an increasing complexity of the division of labor and knowledge that comes with economic development over time. In a dynamic economy, design and production are inextricably linked as they coevolve. Finally, it is becoming increasingly clear that the only way to cope with this increasing complexity (and the *uncertainty* it implies) is by implementing, consciously and unconsciously, the principle of modularity. The modular nature of the capital structure is mirrored by the modular nature of the organizational structure which is really, in essence, a matter of knowledge management.

So, while the RBV and the KBV of the firm provide useful and, in many ways, complementary views of the firm, we believe that the CBV subsumes them both. Also, a full appreciation of the profound connection between capital and knowledge is not found anywhere in the management literature[5] and is the central contribution of the paper. Its significantly extends recent contributions (for example in entrepreneurial studies) in exciting ways—for example, by providing a bridge to the traditional management concerns of internal governance and firm boundaries.

The CBV of the firm, examined in detail below, draws heavily on the most well-known contribution of the Austrian school of economics, the theory of capital, and spells out new implications of applying this theory to the context of the firm as a social organization. It also contains the natural extension of Austrian capital theory to human capital. But, in many ways, recent work in the management literature has extended, improved, and gone beyond received Austrian capital theory, particularly in the field of entrepreneurial studies[6] and drawing on concepts from computer science. The theory that began with Menger, was elaborated by Böhm-Bawerk, and modified by Lachmann, can be seen to have been unconsciously used (rediscovered) and extended by theorists working in the areas of product design theory (notably, Baldwin and Clark 2000; Baldwin Baldwin 2008).[7] We attempt to take account of these developments in what follows.

The next section surveys the main components of the CBV of the firm. Subsequent sections examine management and organizational topics looking through

[5] Note however the recognition by Grant that "all human productivity is knowledge dependent and machines are simply *embodiments* of knowledge" (italics added). The lead-in to this is, however, disconcerting: "Indeed, if we were to resurrect a single-factor theory of value in the tradition of the classical economists' labor theory of value or the French Physiocrats land-based theory of value, then the only defensible approach would be a knowledge based theory of value, on the grounds that all human productivity is knowledge dependent and…" (Grant 1996: 112). The classical economists and the Physiocrats were not wrong because they picked the wrong factor of production for their single-factor theory of value. They were wrong because *any*, single or otherwise, factor theory of value is wrong. The value of outputs is not determined by the value of the inputs. Rather the value of any input is determined by (imputed from) the value of the output which is the result of acts of consumer evaluation. The importance of knowledge, we shall show, is that it is a (technologically) necessary dimension (component) of all factor inputs.

[6] See the references cited at note 1 above.

[7] See Tulloh and Miller (2006) for a conscious, subtle work along these lines—combining Lachmanian insights with recent insights in the theory of product design and development.

the lens of the CBV. We begin by noting the importance of uncertainty in order to establish the basic framework of analysis.

3 The capital-based view of the firm: the basic framework

3.1 Capital and production in an uncertain world

Consider the essential nature of production and its relationship to time, knowledge, uncertainty, and value. The production[8] of every valuable good or service entails the performance of certain necessary (and jointly sufficient) tasks or activities over time. This is an essentially human phenomenon. These activities do not occur automatically, they are the expression of human action and decision and at some level they need to be organized. This need for organization is not a simple matter. Organization is as crucial to successful production as is production technology. All production occurs within a social context in real time and depends in a crucial way on the knowledge that human participants bring to it.

All production activities take place in real time. The production of valuable goods and services over time implies the economic concept known as "capital." Capital essentially involves the relationship between value and time (Lewin 2005). Productive resources are valuable because (and only because) they are capable, in combination with other physical and human resources, of adding value over time. Capital value is the conceptualization of this value. The resources involved in any production process are *capital assets*; they form a *capital structure*—a structure or ordered set of items that yield services over time resulting (if successful) in the production of products (goods and services) that consumers value. To repeat, these capital resources derive their value from the value of the products their services help to produce, in the absence of which they would have no value. Capital value is, thus, the result of *forward-looking* processes undertaken by the entrepreneurs who plan them. There *must* be a production plan if the activities of these resources are to have any meaning to anyone. These production plans reflect the knowledge and the expectations of the planners and of the human resources employed by the planners. Thus, *knowledge is an important and complex dimension of every production plan*. The knowledge dimension is always there. Further, capital accumulation, adding value to the capital structure, involves learning—it involves change—as the knowledge-base of workers and planners is enhanced. Time and knowledge are inextricably connected. One cannot conceive of the lapse of time in real-world situations without a change in knowledge (Lachmann 1956), though, of course, some changes have more economic significance than others. Changes in knowledge often become incorporated in additions to the capital structure. Capital accumulation and technological change are thus intertwined (Menger 1871: Böhm-Bawerk 1889; Lachmann 1956: Lewin 1999; Baetjer 1998, 2000).[9]

[8] Here we understand "production" very broadly to include all activities from the initiation of the production process to the final delivery to the consumer—including, that is, manufacture, transportation, distribution, marketing, etc.—all the stages in the supply chain.

[9] This contrasts with economic approaches that imagine a world in which additions to capital occur without changes in technology like standard neoclassical growth models deriving from Solow (1956).

Let us now consider production in a world without radical uncertainty (real uncertainty (Knight 1921) as distinct from probabilistically known risks). In such a world of complete (or probabilistic) certainty, the necessary complementary productive activities of any production process would be relatively easy to organize and evaluate. Knowledge about how they fit together to produce the desired good or service would be generally available. Teamwork could be directed by any team member. It is a world of shared mental models of the production process—there is no cognitive heterogeneity. In such a world, values could be fairly easily imputed to the heterogeneous resource inputs that combine to produce the valuable product, on the basis of their known "contribution" to the value of the output (the values of all outputs being equally certain). Such values would become the basis for the prices (values) of the resource inputs (and the services they provide).

Expanding on this, *stocks* of resources yield *flows* of productive services. These services of resources are either purchased in the resource market from their owners by *renting* the resources—the rental rate being the price of the service provided; or they are available inside the firm from resources that the firm owns. In the latter case, we may conceive of the firm renting the resource to itself and paying itself the rental rate which is the "price" of the service provided by the owned resource. This implicit price is the internal cost of using the resource. If correctly set, it will incorporate the cost of maintaining the resource, that is, the cost of depreciation.

In a world without uncertainty, payments to resource owners would exhaust the value of the product produced and there would be no surplus value, no profit. The *rental* payments to resource owners would leave no room for earnings in excess of the market value (the opportunity cost) of the productive resources. In order to explain profits, entrepreneurship, and sustained competitive advantage, one must therefore take account of the fact that the real world is an uncertain world (a disequilibrium world) in which change is endemic (Lewin 2008; see also Bromiley and Papenhausen (2003) for a recognition of the limiting role of equilibrium).

To be sure, the world as we know and experience it could be no other way. It is a world characterized by necessary economic and cognitive heterogeneity. Productive resources are heterogeneous because they are constructed for specific purposes—they have a limited range of applications.[10] Heterogeneity is to be understood essentially in terms of function rather than form. As Ludwig Lachmann maintains, something is a capital good not because of its physical form, but rather because of its economic function (Lachmann 1956).[11] This is not to say that physical form is irrelevant. But it is the economic function for which such form is appropriate that is the essential aspect of a capital good. It may happen that two capital goods with different physical forms could perform identical tasks in a given production process,

[10] Close your eyes and imagine the hundreds of millions of different things that are involved in production activities in the American economy; the buildings that contain untold varieties of complex, specialized physical equipment, producing billions of different goods and services, using diverse raw materials, under the direction of highly trained and finely specialized human beings. Many of the specialized resources, human and physical, have limited adaptability to alternative activities and purposes.

[11] Lachmann: "The generic concept of capital without which economists cannot do their work has no measurable counterpart among material objects. Beer barrels and blast furnaces, harbor installations and hotel-room furniture are capital not by virtue of their physical properties but by virtue of their economic functions. Something is capital because the market, the consensus of entrepreneurial minds regards it as capable of yielding an income (1956: xv)."

and equally well. They would then possess no essential economic heterogeneity. By the same token, two capital goods of identical form may be deployed in different capital combinations with other complementary goods, and perform very different and differentially valued tasks. Thus, the heterogeneity of capital goods refers to their economic functions.

Each capital good may be said to possess a set of attributes that are (potentially) useful in the production process (Barzel 1997). These attributes determine the services that the capital good can yield. Sometimes they are deliberately constructed with these attributes in mind. Other times, these attributes may be fully revealed only after being used in combination with other resources. In either event, the entire set of valuable attributes of capital goods, and especially *combinations* of capital goods, is not likely to be obvious to every observer. Different evaluators see them differently. Capital goods combinations have to be subjectively appraised according to the value of the product they are expected to yield, that is, according to the revenue streams they are expected to generate in changing circumstances (Mises 1949; Kor et al. 2007; Mathews 2010: 227). Account must be taken of the future actions of both competitors and producers of complementary products (Richardson 1960) as these will affect the value of the product produced. *Different appraisers will thus have different expectations*. Their cognitive models will be heterogeneous (Klein 2008). In forming specific capital combinations, it is the role of the entrepreneur to bring to the production process her particular appraisal—her vision (Penrose 1959; Lachmann 1956). It is unavoidable, therefore, that in many spheres of human action, notably in the sphere of economic competition, *expectations will be mutually inconsistent*. Rival economic models are the essence of the competitive process—for example, in predicting standards, fashions, brand appeal, price–quality trade-offs, etc. And where expectations are mutually inconsistent, at most one person can be right (Lachmann 1956, Lewin 1997, 1999). *Disparate expectations* mean inevitable errors.[12] They are a normal part of the experimental nature of the market process. Entrepreneurs pit their judgments against each other. Such judgment is necessary in a world where product values are uncertain. The more successful the judgment, the appraisal, the more surplus value will be earned by the entrepreneur—revenue minus the payments (or opportunity costs, implicit prices) of the services of the employed resources. In a world of uncertainly, of heterogeneous capital resources and heterogeneous cognitive models, profit (and competitive advantage) is not difficult to explain (Knight 1921; Mathews 2006b: 102, 2010: 225–226).

For entrepreneurial judgment to be effective, it must be exercised within a framework in which the entrepreneur has property rights (use and residual claimant rights) to the capital goods necessary to fulfill his vision (Barzel 1997). In this sense, entrepreneurship implies ownership (Foss and Klein 2011; Foss et al. 2007b). It is the entrepreneur's judgment that is implemented by him or his delegates (in which case the judgment of the delegate is "derived" from him).

In sum, *production occurs through the formation of capital structures in which heterogeneous capital goods are combined in real time by ambitious entrepreneurs in an uncertain world in the hope of earning a profit as a result of the superior*

[12] See Arend (2007: 5) for a discussion of the role of heterogeneity and uncertainty in understanding entrepreneurship.

judgment of the value of those combinations—or, equivalently the value of the produced product.

The above discussion briefly encapsulates many of the recent insights presented in (what we are calling) the CBV approach. It provides the basis for a closer examination of the nature of capital and capital goods in the hope of extending these insights. What kinds of things qualify as capital goods? Should we consider knowledge to be a capital good? And what exactly is the role of knowledge in the production process?

3.2 Knowledge about the knowledge in capital

In order to use capital goods, we have to know what they can do. The attributes that a capital good possesses (referred to above) can be thought of as useful (productive) knowledge. *Different capital goods "know"*[13] *how to do different things*. Capital heterogeneity (of economic function) is a reflection of the division of labor—we might say it is a "division of capital." This division of labor, whereby different parts of the production structure are devoted to specialized activities, is an organizing principle (Loasby 2007) based on what Hayek called a "division of knowledge" (Hayek 1945; Tsoukas 1996). In order to understand this principle, one needs to take account of the various ways in which knowledge enters the production process. This is the knowledge dimension of production.

There is a fundamental relationship between knowledge and capital. Indeed, capital goods are useful because they *embody* knowledge about productive processes and how they may be carried out (see Baetjer (1998, 2000) for a fuller exposition). In practice, much of our knowledge is to be "found" not in our heads, but in the capital goods we employ.[14] In particular, capital equipment (tools) embodies knowledge of how to accomplish some purpose or function, as explained above. Of course, much of our knowledge of the causal relationships between things, and of how to achieve the changes we desire, is tacit knowledge. Adam Smith speaks of the "skill, dexterity, and judgment" of workers (Smith 1776: 7); these attributes are a kind of knowledge, a kinesthetic "knowledge" located in the hands rather than in the head. The improvements these skilled workers make in their tools are embodiments of that knowledge. The very design of the tool passes on to a less-skilled or less-dexterous worker the ability to accomplish good results. Consider how the safety razor enables those of us unskilled in the barber's craft to shave with the blade always at the correct angle, rarely nicking ourselves. The skilled barber's dexterity has been passed on to us, as it were, embodied in the design of the safety razor.

To emphasize, the knowledge aspect of capital goods is the fundamental aspect. Any physical aspect is incidental. A hammer, for instance, is physical wood (the handle) and minerals (the head). But a piece of oak and a chunk of iron do not make

[13] The scare quotes indicate that we understand that this is knowledge without awareness or cognition, discussed further below.

[14] Consumption goods also have a knowledge aspect, of course. Indeed, knowledge is a necessary aspect of any economic good; if by economic good we mean something people value. It is only because of our knowledge that something will satisfy some purpose—in either consumption or production—that we consider it a good. Hence, we may reasonably say that consumption goods embody knowledge of what will directly satisfy our wants.

a hammer. The hammer is those raw materials infused with the knowledge embodied in the precise shape of the head and handle, the curvature of the striking surface, the proportion of head weight to handle length, and so on. (We leave aside, for now, all the additional knowledge required to shape the oak into a handle and the iron into a steel head.) Even with a tool as bluntly physical as a hammer, the knowledge component is of overwhelming importance. With precision tools such as microscopes and calibration instruments, the knowledge aspect of the tool becomes more dominant still. We might say, imprecisely but helpfully, that there is a greater proportion of knowledge to physical stuff in a microscope than in a hammer.

The case of computer software provides both a compelling analogy for general understanding and a particular case of the nature of capital. Software is less tied to any physical medium than most tools. Because we may with equal comfort think of a given program *as* a program, whether it is printed out on paper, stored on a hard drive, or loaded into the circuits of a computer, we have no difficulty distinguishing the knowledge aspect from the physical aspect with a software tool. Of course, to *function* as a tool, the software must be loaded and running in the physical medium of the computer, and there are definite physical limits to computation. Nevertheless, it is in the nature of computers and software to separate clearly the *knowledge* of how to accomplish a certain function from the *physical embodiment* of that knowledge.[15]

Because the knowledge aspect of software tools is so clearly distinguishable from their physical embodiment, in investigating software capital we may distinguish clearly the knowledge aspects of capital in general. While software may seem very different from other capital goods in this respect, when we think in terms of the capital structure, we find no fundamental difference between software tools and conventional tools. What is true of software is true of capital goods in general. What a person actually uses is not software alone, but software loaded into a physical system—a computer with a monitor, or printer, or plotter, or space shuttle, or whatever. The computer is the multi-purpose, tangible complement to the special purpose, intangible knowledge that is software. When the word processor or computer-assisted design package is loaded in, the whole system becomes a dedicated writing or drawing tool. But there is no important difference in this respect between a word processor and, say, a hammer. The oaken dowel and molten steel are the multi-purpose, tangible complements to the special purpose, intangible knowledge of what a hammer is. When that knowledge is imprinted on the oak in the shape of a smooth, well-proportioned handle, and on the steel in the shape, weight, and hardness of a hammerhead; and when the two are joined together properly, then the whole system—raw oak, raw steel, and knowledge—becomes a dedicated nail-driving tool.

All tools are thus a combination of knowledge and matter. They are knowledge imprinted on or embodied in matter. Software is to the computer into which it is loaded as the knowledge of traditional tools is to the matter of which those tools are composed. If this is true, then knowledge is the key aspect of all capital goods, because the matter is, and always has been, "there." As Böhm-Bawerk says in discussing what it means to produce:

[15] More accurately, the software is a symbolic representation of the knowledge; in this way it *embodies* the knowledge. When loaded in a computer, the computer then embodies the software that embodies the knowledge. Skirting this distinction helps make the point about the relationship between knowledge and "stuff" discussed in the text.

> To create goods is of course not to bring into being materials that never existed before, and it is therefore not creation in the true sense of the word. It is only a conversion of indestructible matter into more advantageous forms, and it can never be anything else (1889:7).

The value of our tools is not in their weight of substances, however finely alloyed or refined. It is in the quality and quantity of knowledge imprinted on them. Menger notes:

> Increasing understanding of the causal connections between things and human welfare, and increasing control of the less proximate conditions responsible for human welfare, have led mankind, therefore, from a state of barbarism and the deepest misery to its present stage of civilization and well-being. Nothing is more certain than that the degree of economic progress of mankind will still, in future epochs, be commensurate with the degree of progress of human knowledge (1871: 74).

In sum: a significant proportion of the knowledge we use in production is not in any person or even group, but in the tools we use. I who use the hammer know nothing of ergonomics, and have not the slightest idea what the "correct" ratio of head weight to handle length is. Nevertheless, when I drive a nail, I can tell if the hammer feels right. Thus I use that knowledge. The knowledge is "built into" my hammer. *Capital goods, then, are embodied knowledge of how to accomplish productive purposes*.

3.3 The social character of the valuable knowledge in capital

The knowledge of *many people* is combined in capital goods; product development is a process of *social* interaction, not a matter of individuals working autonomously. Most individual capital goods are manifestations of a far-flung division of knowledge, an incomprehensibly extensive sharing of the knowledge and talents of thousands of people across time and space. *The ever-changing pattern of relationships among these capital goods*—the capital structure as a whole—is an essential aspect of what Hayek called "the extended order of human cooperation" (Hayek 1973). Capital goods and the capital structure at any time result from a tremendously rich social interaction through which the knowledge of many has been combined. One type of social interaction occurs in the social construct that we refer to as the firm (and the teams within and between firms that work on particular projects).

The division of labor is best understood as the whole pattern of cooperation in production, direct and indirect. The indirect contributions—in the form of tools and processes developed elsewhere—are, in an advanced economy, the most significant. The crucial "labor" is the creative effort of learning how to do things, and the embodying of that learning in the *design*[16] of a tool that can be used by others, who

[16] The concept of embodied knowledge is closely related to the concept of product design and the latter term may have expositional advantages. Product design is more concrete than embodied knowledge and builds a bridge to the emerging literature on the science of design (related to the modularity literature considered below) that uses the term precisely in this way. We owe this observation to Bill Tulloh. For the purposes of this article, however, retaining the embodied knowledge concept may better serve the purpose of explicating a CBV of the firm, especially for an audience interested in Austrian economics.

themselves lack the knowledge in any other form. Through the embodiment of knowledge into an extending capital structure, each of us is able to take advantage of the specialized knowledge of untold others who have contributed to that structure. *Thus, this structure becomes increasingly more complex over time*, *as the pattern of complementary relationships extends*.[17]

In modern, capital-intensive production processes, the division of knowledge and labor is to be found not in the large number of people at work in a particular production process, but in the tools (including scripted techniques and instructions) used by a relatively few people who carry out that process. The knowledge contribution of multitudes is embodied in those tools, which give remarkable productive powers to the individual workers on the spot, though, as explained above, these productive powers have to be organized by the discerning judgment of the entrepreneur. In a fundamental sense, all economies are "knowledge economies" and all firms are "knowledge-based" and this is because they are "capital-based."

To be perfectly clear, when we say that a capital good "knows" how to accomplish a certain set of activities, what we mean is that, when used by someone who *knows* what he is doing, these activities can be successfully accomplished because at some earlier time someone else *knew* how to design this capital good to perform the way it does when used properly. The latter knowledge is obviously more comprehensive in that the designer of the equipment, in addition to possessing the knowledge of how to use it, also has an understanding, at a more fundamental level, of the workings of the designed equipment. This deeper knowledge has to be retained by someone if such expertise in design is to be retained in the economy at all, and if progress in design is to occur, but it can be dramatically economized on to the extent that it is unnecessary for the routine operation of the capital good. Most of the *users* do not have and do not need to have that knowledge.

Furthermore, and importantly, *the design process* itself is subject to knowledge and time-saving design, in that the various design components, or modules, are highly specialized (Baldwin and Clark 2000). This obviates the need for very costly and time-consuming iteration when setting design parameters of different components of the capital good. In fact, in modern production processes, in the current information age, the line between production and design is often blurred. Products evolve rapidly through various versions as specialized producers implement incremental improvements. The rapidly growing literature on the science of product design (see Baldwin and Clark (2000) for an extensive treatment) unconsciously echoes in a very concrete way the more abstract Austrian capital theory with its examination of, what Austrians would call, the inseparable connections between capital accumulation and technological change (Lachmann 1956; Lewin 1999), as well as the phenomenon of the enhanced productivity of wisely chosen roundabout methods of production (Böhm-Bawerk 1889) or, more recently, the increasing complexity of the capital structure (Lachmann 1956). These enhancements and complementarities offer opportunities for further research along these lines.

[17] We use the term complexity in this article in its intuitive, common sense meaning. A system (structure) becomes more complex as the number of components it contains increases *and* the number of types of interface (interconnections) increases with it. Its increased complexity means that it is more difficult to figure out, to comprehend, though it is clear there is a coherent structure to it.

In summary, we have established that underlying the physical form of machine and human, there lies an intricate structure of knowledge embodied in capital goods and complemented by the knowledge of how to use such goods in the minds of workers. The development of capital goods brings to bear increasing amounts of knowledge to the productive process over time. *Economic growth and development entails the increasing complexity of knowledge, one aspect of which is the increasing ratio of knowledge to "stuff" embodied in capital structures.* We may refer to this as the *complexification* of production. It is this complexification that has given rise to the challenges of managing in the so-called "knowledge economy." It is, therefore, to an examination of some of the prominent management issues that we now turn.

4 Managing in the complexified knowledge-intensive economy

4.1 Agency and hold-up problems

Understanding that below the surface of the physical phenomena of production lies the knowledge necessary to accomplish planned activities (embodied in physical capital assets and the human capital of the team members) leads to the realization that management is always "knowledge-management." The crucial difference between physical and human capital is not that the latter is about knowledge and the former is not. Both are about knowledge, albeit in different forms. The crucial difference is that human capital is *not alienable*. Human capital ownership cannot be alienated from its original owner. Its services can be rented, but the capital itself always remains the "property" of the original "owner."[18] This means that use and development of human capital by firms is necessarily governed by human relationships. And human relationships are characterized by numerous agency-type problems.

Williamson's "hold-up" problem (for example Williamson 1985) occurs because expected performance (the making of an investment in firm-specific human and physical capital) is "relationship"-specific—it depends on the motivations of human capital owners who become tied in to an economic relationship by its specific nature. Hold up is thus a possibility on both sides. This is similar to the making of an investment by a firm in the human capital of one of its employees who may quit and take the human capital with her.

Similarly, managing knowledge-rich human assets *inside* the firm has to take account of agency problems—trying to get the worker to use her knowledge as you, the principle, would use it if you were as knowledgeable as she. Since you do not have the knowledge necessary to fully judge the performance of activities, you have to resort to attempts at incentive alignment to safeguard against moral hazard on the job. This monitoring problem is greater the greater the knowledge intensity (or complexity—of which more below) of the job. Complexity is thus another dimension governing agency problems.

[18] Even in a slave economy, where the human embodiment of the human capital (say acquired skills) could be sold, the slave would still be in crucial control over the use of his brain in a way that a machine is not, thus posing very different management problems.

Providing knowledgeable employees with decision rights optimal to the performance of required activities and the development of necessary future knowledge that is needed to remain competitive, is at the heart of the management dilemma (Jenson and Meckling 1992). Finding the right combination of "high-powered" incentives (associated with ownership and market) and centralized direction is an ongoing challenge that determines both the boundaries of the firm and its internal organization (Williamson 1985). This is further elucidated by an examination of the role of knowledge in the production process.

4.1.1 Knowledge problems apply as much to capital as to labor

Much of the difficulty of managing (whether to accomplish routine activities or to plan and implement activities directed to growth and innovation) relates to the very nature of knowledge as a phenomenon. Knowledge is peculiar in that "having it" means "knowing." To have knowledge, one has to learn, one cannot simply buy it as one buys an automobile. Knowledge of knowledge is not the same thing as having the knowledge in the first place. And, as is well-known, the knowledge transfer problem is exacerbated by the fact that tacit knowledge is particularly difficult to transfer (for example Grant 1996: 114). Thus Hayek's (1945) *knowledge problem*, the problem of planning in a world in which the planner has to deploy and make use of knowledge which he himself does not (and cannot) have, so that he cannot form an opinion as to the value of knowledge assets in various production combinations, *exists as much in regard to physical as human capital assets*. Also, the *manner of interaction* of capital assets is crucial to the outcome, much of which is not predictable, and is subject to learning, that is, the accumulation of new knowledge. Insofar as capital assets are embodied knowledge (indeed we might say they are types of "knowledge modules") and insofar as that knowledge is brought to bear in combination with other capital assets (physical and human) the central planner of the firm faces a Hayekian knowledge problem in regard to the successful coordination of *all* of the firm's assets.

The severity of that problem is related not to the distinction between human and non-human assets, but rather to the *knowledge intensity* of the assets, whatever their form. And, as explained, above, since knowledge intensity is related to capital accumulation and capital accumulation implies the complexification of the (physical and human) capital structure, it is the *complexity* of capital broadly understood that intensifies the Hayekian knowledge problem.[19]

Thus, the perception that the "information-age" economy is one that requires different types of economic organizations—smaller, flatter, more democratic, etc.—can be understood in terms of the increased complexity of knowledge rather than of the existence of "knowledge-workers" as such. Both physical and human assets become more complex with economic growth and capital accumulation, increasing the severity of Hayekian knowledge problems and encouraging greater use of market decentralization where the market is thick enough to possess the necessary specialized and complex capital assets (Langlois and Robertson 1995). This

[19] This is an implication of Lachmann's (1956) reconstitution of Böhm-Bawerk's famous assertion that chosen "roundabout" methods of production are more productive. In effect, Lachmann replaced "increased roundaboutness" with "increased complexity."

becomes more likely with economic growth. Where activities are relatively simple, are of low knowledge intensity, vertical integration is easier to manage, such as in assembly line manufacturing.

Table 1 indicates the relationship between the dimensions of complexity and alienability and the two commonly mentioned types of management problems—incentive problems and knowledge problems. The cell entries indicate whether the problem (knowledge or incentive) is affected by the dimension of alienability and/or complexity.

Incentive problems apply only to human (non-alienable) capital, and complexity makes it worse. But knowledge problems apply to all assets, whether alienable or not, and are also exacerbated by the degree of complexity. The cells in which a "Yes" appears are thus affected by the degree of complexity.

4.2 Firm boundaries

A perennial problem in economics is the question of the size of the firm; the question of where to draw the firm boundaries. One way to understand the firm boundary decision is in these terms. Integrating the capital assets of independent firms removes the incentive (hold-up type) problems associated with cooperation between separate owners of (physical and human) capital, though it may also dilute incentives if ownership is more dispersed. At the same time, however, it exacerbates the knowledge problem by increasing the extent of centralization and the distance of the decision maker from the knowledge, and imports incentive (agency type) problems associated with the new human capital acquired. In other words, the boundary decision, associated with any set of activities (or, thinking about it another way, market or internal *transactions* for those activities) depends on three complex considerations:

1. $\mathbf{V_1}$—the increase in value from *removing the incentive problem* associated with organizing separate (physical) capital owners. Each capital owner has his own personal agenda and the problem is to fashion a (formal or informal) contract adequate to the harmonization (coordination) of separate agendas toward a common aim; and to adequately monitor the fulfillment of the contract at various stages and of avoiding hold-ups.
2. $\mathbf{C_1}$—the loss of value associated with *diluting the incentives* of previously separated capital owners. If the separate capital owners are integrated into a common firm, the market–contract–coordination problem (associated with $\mathbf{V_1}$) disappears but is traded for the costs associated with diluting (spreading out) capital ownership of the combined firm. This dilution effect will exist if the perceived capital value of the part ownership of the combined firm by key decision-makers goes down.[20]

[20] It may not. The integrated firm may keep the ownership value of all the parties unaffected or some may increase. When one firm acquires another, the principals of the acquired firm (it could be a sole proprietorship) often experience a dilution of their capital. Depending on how the deal is structured, they may become shareholders of a larger combined entity, or they may be diluted shareholders of a newly incorporated subsidiary. In the later case, though their percentage ownership may have gone down, the value of their capital may have increased—which is the point of the merger. To that extent (the extent to which the merger is successful), the dilution effect may be mitigated or erased—$\mathbf{C_1}$ may be negative. The value of the merger is, however, at least partly endogenous—it depends, in part, on the behavior of the newly-incorporated owners.

Table 1 The Dimensions of Management Problems

	Human capital (not alienable)	Physical capital (alienable)
Knowledge problems	Yes	Yes
Incentive problems (hold-up and agency)	Yes	No

3. $\mathbf{C_2}$—the loss of value from the *knowledge problem* associated with *increased centralization* of decisions as discussed above. This is a governance problem. The more complex the knowledge of the acquired human and physical capital, the more difficult it is. So even if there is no dilution of incentives, the knowledge structure of the new entity is more complex and therefore more difficult (costly) to manage.

So, any set of activities (or transactions associated with them)[21] should be internalized if the estimated capital value of $\mathbf{V_1}$—$\mathbf{[C_1+C_2]}$ is positive.[22]

By thinking about it in this way, in terms of capita-based components, one may be able to put some flesh on the bones of the problem as originally outlined by Coase and developed by many other theorists. This is both a prescription and a potential tool for empirical investigation of historical decisions associated with firm boundaries. If one could get a handle on the estimated and realized values of these three components one may be able to produce interesting case studies of real-world events in these terms.

5 The organization of production

5.1 The task of organizing in a growing complexifying economy

The framework of the CBV may be used to analyze the difficulties of organizing in a rapidly changing, complexifying world. Thinking of production and organization in terms of capital structures brings up the relationship of increasing heterogeneity to knowledge complexity. We offer some brief remarks indicating how the CBV perspective unifies these disparate themes.

In a nutshell, the CBV of the firm considers the problem of organizing (and managing) production to be the formation, maintenance, and adaptation of profitable capital combinations. The ingredients of any production project are the (human and physical) capital assets in capital combinations, characterized by their economic heterogeneity and complementarity and also by their substitutability/specificity/adaptability in the face of change. Though capital goods are heterogeneous, they do

[21] Baldwin (2008) considers this problem in the framework of transactions which she defines and the transfer of (any of) information, material and energy for compensation. Thus, a firm is considered as a kind of "transactions free zone" (there are other kinds), in which ongoing transactions are replaced by relational contracts or close cooperation. Transaction-free zones are semi-isolated modules of resources and economic activity; specialized production units. This is examined further below. The discussion in the text can be formulated in terms of her framework as well.

[22] All values are in discounted present-value terms.

not come together in an "amorphous heap" rather they are ordered in a coherent structure (Schumpeter 1954). The capital goods of an economy compose a structure within which exist a multitude of substructures. At each level, these structures are the result of planning and exogenous change. At the level of the economy, the capital structure is a result of the spontaneous workings of the market and inter-firm contracts. Firm-level structures have to be carefully planned and maintained, though their adaptive mutations are governed by unpredictable, emergent knowledge phenomena.

As discussed earlier, recapping briefly, heterogeneity of capital resources is a reflection of the division of labor and knowledge—of the specialization of knowledge and function. As emphasized, different capital goods "know" how to do different and complementary things. Thus, *the greater the degree of specialization the more heterogeneous the capital structure.* Furthermore, heterogeneous capital implies *heterogeneous knowledge*. And since the extent of the market and of economic growth is crucially related to the degree of specialization, heterogeneity will increase with economic growth and development—as will complexity. *The greater the heterogeneity of resources the greater the complexity of the organizational task.* Organization of heterogeneous knowledge assets into productive combinations requires *organizing ability* and an *organizational structure*. The organizational structure of the firm can be thought of as an aspect of the firm's general capital structure. The firm has "social capital" in the useful (knowledge economizing) rules, customs, norms, etc. that it develops. The value of its leadership lies in the ability of the leaders to organize complementary activities "through the creation of belief conditions that (at least) approximate common [homogeneous] knowledge" (Foss 2001: 357). So, homogenization of the knowledge of both the "rules of the game" and "the aim of the game," is necessary for the efficient coordination of heterogeneous production knowledge. This homogenization provides the "constitution" within which the complex activities of the firm are carried out (Vanberg 1994). The organizational efficiency of the firm thus depends crucially on the functionality of this constitution and the value of its leadership depends on the extent to which such a constitution can be successfully developed and accepted.[23]

5.2 Modularity as structure

As knowledge becomes more complex (heterogeneous), advanced knowledge management strategies can be expected to develop. Successful business ventures, involving more complex knowledge, can only occur if the complexities can be successfully handled. So, the observation of such successes is a clear indication of the development of practical advanced knowledge management strategies. One of the most ubiquitous development strategies is increased modularization (Garud et al. 2003; Langlois 2002).

As indicated above, resource management requires structure. A structure can be described by a list of items that stand in a certain *orientation* to one another.

[23] The counterparts to this at the economy level are social *institutions*—law, language, custom, etc.—the social capital of the economy. These homogenize expectations across individuals concerning the general rules of the social game thus enhancing social coordination. Disequilibrium in some spheres of human action is only possible against a backdrop of equilibrium of other (enclosing) spheres (Lewin 1999, chapter 3; Lachmann 1971).

Complex structures are composed of many items with many orientations, interactions. A structure, as opposed to a simple list of the structure's elements, is distinguished by the fact that one can infer properties about the whole list from a description or observation of just a few component (or typical) parts together with an articulation of the principles of interaction, in other words by abstraction (Tulloh and Miller 2006). *It is an important strategy for economizing on knowledge about knowledge*. Modules are self-contained substructures, whose inner workings are hidden from the high-level observer (manager).[24]

It can be readily seen that the modular design of knowledge structures is an organizational design. Organizations (and their design and production activities) must be organized by deciding what managers need to know and need not know. They do need some knowledge of the knowledge of others. But, what do we really know when we have knowledge about knowledge? We move to successive levels of abstraction (modularization) in order to economize on what we need to know. Yet the nature of knowledge as a phenomenon makes this very difficult. Knowledge of what we need to know about the knowledge of others is most complete when we share their knowledge, but this is precisely what we wish to avoid having to do. *Successful management thus depends on finding the right level of abstraction—that is, knowing enough to make correct judgments about the deployment of assets (human and physical) that know more (about their specialized activities) than the managers do; but not seeking to know so much as to tie up managers' time and energies in the process of learning and understanding.*

The managers' "big picture" must be accurate yet not too detailed. Easier said than done, yet this is a key element of successful organizational design.[25]

6 Conclusion

The CBV of the firm sees the firm as a capital structure composed of ordered physical and human capital assets. Capital value relates to time. It is an assessment of the *prospective* services of productive assets at a single point in time looking forward.[26] Capital combinations can be understood (derive their meaning) from the production plan of which they are/were a part. Capital implies planning. The task of the planning entrepreneur is the formation of productive capital combinations taking as full account as possible of the knowledge and incentive problems intrinsic to all human cooperative ventures. These transaction and governance costs are "real" production costs that affect the (capital) value of firm—they are not merely incidental to the

[24] The M-form corporation is a particular form of modularization, in which the divisions form large modules (Sautet 2001).

[25] Of course there are other aspects of modularity, like adaptability and resilience in the face of change, that are not examined here. See Lewin 2008 for example.

[26] Erroneous views of capital have led to an under-appreciation of the centrality of the concept for understanding production, the firm, entrepreneurship, and the like (see Dean and Kretschmer 2007 for an example and Baetjer and Lewin 2008 for a critique). Perhaps the most egregious mistake is to think of capital as necessarily physical in nature and to exclude human, social and intellectual capital from the category of capital—confining them to a special and very different category. In this article we argue, to the contrary, that these are all part of capital generically speaking, part of the capital structure, though the non-alienability of human capital does imply specific management issues.

physical production aspects. All aspects of the firm, its boundaries, its organizational structure, its growth and management can be fruitfully analyzed from this central capital-based perspective. The CBV focuses on organizing (deliberately or spontaneously through the market process) the knowledge embodied in human and physical capital resources so as to accomplish necessary productive tasks; firms, rules, routines, and similar social artifacts and institutions aid in this process.

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