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**Can Ideas be Capital:  
Can Capital be Anything Else?**

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## ***Introduction***

There is no concept in the corpus of economics, or in the realm of political economy, that is more fraught with controversy and ambiguity than the concept of “capital” (for a survey and analysis see Lewin, 2005). It seems as if each generation of economists has invented its own notion of capital and its own “capital controversy.”<sup>1</sup> The Classical economists thought of capital in the context of a surplus fund for the sustaining of labor in the process of production. Ricardo and Marx provide frameworks that encourage us to think of capital as a social class—the class of owners of productive facilities and equipment. The Austrians emphasized the role of time in the production process. In Neoclassical economic theory we think of capital as a quantifiable factor of production. In financial contexts we think of it as a sum of money.

Different views of capital have, in large part, mirrored different approaches to the study of economics. To be sure capital theory is difficult. But difficulty alone is insufficient to explain the elusive nature of its central concepts and the disagreements that have emerged from this lack of clarity. We shall argue that this ambiguity is a direct result of the chosen methods of analysis, and that these methods, because of their restrictive nature, have necessarily limited the scope of economics and, by extension, have threatened to limit the scope and insights of management theories drawing insights from economics.

A recently published article by Alison Dean and Martin Kretschmer (2007 – henceforth DK) returns to the theme of capital to provide a “review and critique.” While

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<sup>1</sup> The most famous of these controversies are those between the Austrian economist Eugene von Böhm-Bawerk and his American critics (J. B. Clark and Irving Fisher) in the 1880’s to the 1900’s; between F. A. Hayek and Frank Knight, Nicolas Kaldor and others, in the 1930’s (repeating some of the themes of the former controversy); and between “Cambridge England” (with a Marxist orientation, including Joan Robinson, Luigi Passinetti and other “Cambridge” UK theorists) and “Cambridge Massachusetts” (including Paul Samuelson, Robert Solow and a number of prominent “neoclassical economists”) in the 1960’s (see Harcourt 1969; Cohen and Harcourt, 2003).

their paper raises a number of important questions and provides some important insights, we believe it fails to capture the essential nature of capital and, as a result, sees shortcomings in the extension of the concept of capital to include social, intellectual and human capital. DK ask, “Can ideas be capital?” and answer in the negative. A reexamination of the nature of capital leads *us* to ask instead, “Can capital be anything else?”

We propose here a reexamination of the capital concept in the interest of providing a sounder and more unified basis for management studies in the post-industrial, information age. DK suggest that a static, closed-system version of capital, such as that found in the orthodox neoclassical economics literature, cannot serve as a basis for the study of management capabilities in a dynamic, ever-changing world. We agree. But as we see it, the problem is not the inappropriate use and extension of the concept of capital, it is the use of the inappropriate concept of capital found in neoclassical economics.<sup>2</sup> This is more than semantics; conceptual clarity and efficiency through shared understandings can do much to facilitate productive research – it is itself a kind of intellectual capital. We offer a unified capital-based framework for the analysis of firm management and strategy in a dynamic, changing, digitally-based world.

In the next section we review briefly the claims of DK concerning the nature of capital and its boundaries. In the third, following, section we begin our critical scrutiny of this by articulating the connection between capital and knowledge. In the fourth section

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<sup>2</sup>In other respects the closed-system neoclassical model, elegant as it is, has led management and strategy theorists astray, notably in the case of “perfect competition” as the basis for a viable and realistic model for a “resource-based” view (RBV) of firm strategy (Barney, 1986, 1991; Rumelt, 1984; Wernerfelt 1984 for a recent stocktaking see Barney, 2001). We believe the essence of the RBV is essentially correct (especially when augmented by knowledge-based considerations), but that its allegiance to the perfect-competition model has inhibited its usefulness. (For an example of the RBV with close, conscious ties to the standard of perfect competition see the seminal article by Peteraf, 1993). As we shall argue later, it is the use of the equilibrium method that is the key problem.

we explain the nature of capital as an evolving structure of heterogeneous complementary resources. In the fifth section we pull the elements together. We look more deeply at change, modularly and knowledge and consider the relationship of capital to ideas. The final section contains some concluding remarks.

### ***Can Ideas be Capital?***

DK set up a standard or “orthodox” view of capital, using Irving Fisher and some other authorities. Capital is “the durable result of past production processes, transforming future production while not being transformed itself, and part of a closed system.” (Dean and Kretschmer, 2007: 574). Jevons is seen to have extended the view of the classicals by introducing marginal evaluation, and Böhm-Bawerk expands by introducing complexity (DK quote Schumpeter on Böhm-Bawerk, rather than Böhm-Bawerk himself); but by the time we get to Fisher (1906) the idea of capital is seen (by DK) to be more or less settled (577). “[C]apital facilitates the creation of value even if it does not itself create value . . . [It is the] means by which labor effort expended in the past can be incorporated into current production, or by which current effort can be carried forward into the future” (579). Capital has come to be understood as one of the “factors of production” – a homogeneous, quantifiable (measurable), physical input into the production process. It is a produced means of production, the result of past efforts, in the service of enhancing future value.

DK see these characteristics as necessary criteria for calling something capital, and therefore object to the inclusion of intellectual capital (and similar “hybrids”) in the category of capital proper.

We argue that the explanatory value of the term *intellectual capital* in an analysis of post industrial social and economic relations may be limited by the (perhaps unconscious) ties to the traditional, economic concepts of capital. . .

[incorporating as they do] static notions of factors of production. . . We conclude, therefore, that It is inappropriate to label intellectual resources as *capital* in the economic sense, both because they do not resemble capital closely enough and because referring back to an analysis based on a static closed system of tightly defined, mutually exclusive factors of production does not further our understanding of production and competitive advantage in a postindustrial age. . . If *intellectual capital* terminology is to be retained, then the fundamental differences from the traditional concept of capital should be made explicit (574). Other “hybrid” forms of capital are similarly tainted according to DK. Intellectual, human and social capital have an essential mental or human aspect – they refer to ideas.

For ideas to be conceived of as capital in the traditional economic sense, they must be durable, measurable and ownership-exclusive. . . Ideas should enable production to take place and magnify value created through production. Ideas as capital should embody a notion of depreciation over time and replacement. . . [Capital] should embody past labor, and be a store of labor for the future . . . [Also] the stock of ideas cannot be measured (585).

[These hybrid forms of capital imply] a fundamentally different conceptualization of what is capital: the older, traditional economic concept in which capital is an immutable measurable stock versus the new extended concepts in which “hybrid” forms of capital embody processes and are dynamic (581).<sup>3</sup>

We offer a different approach. We contend that the concept of capital extends naturally to *all* productive<sup>4</sup> resources. It is the traditional, static concept of capital devoid of dynamic

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<sup>3</sup> DK refer a few times to the notion of “capital as a catalyst” in production, suggesting (or suggesting that the economics tradition suggests) that capital itself does not create value, that its presence allows the other resources (labor and land) to create value. This conception is inherently problematic and of dubious exegetical validity. And it is not economically sound. From an economic point of view capital creates value in combination with other inputs. This “jointness” or complementarity creates the problem of imputing to the joint inputs their individual contributions to the jointly-produced output. Within the confines of the neoclassical competitive factor model the problem is easily solved by measuring the value-marginal-product of each input, but in reality, in a dynamic disequilibrium world there is no easy solution and, indeed, the imputation problem is of the essence of management in the context of team production. (Klein, Crawford and Alchian, 1978)

<sup>4</sup> Here “production” ought to be understood broadly to encompass all aspects of the transformation of resources into useful goods and services – including manufacturing, marketing, distributing, and any and all activities in the so-called “supply chain.”

processes that is flawed. A proper understanding of “capital” removes any mystery in its definition. The key to this understanding is the connection between knowledge and capital.

### ***Capital as Knowledge***

Can ideas be capital? If ideas are considered knowledge (or vice versa) then there is a sense in which capital cannot be correctly understood as anything else. There is a fundamental relationship between knowledge and capital. Indeed, capital *is* embodied knowledge of productive processes and how they may be carried out. Different varieties of knowledge are involved, as well as different kinds of embodiment (see Baetjer 1998 and 2000).

### **Embodied Knowledge**

To explore this we need to draw on an alternative tradition of economics, one that derives not from David Ricardo and the Classical economists, but rather from Carl Menger of Austria, who drew much of his inspiration (though not altogether uncritically) directly from Adam Smith. Carl Menger writes, “The quantities of consumption goods at human disposal are limited only by the extent of human knowledge of the causal connections between things, and by the extent of human control over these things” (1981/1841: 74). This statement comes in a passage contrasting simply collecting first-order goods (consumption goods like fruits and berries bequeathed to us by nature) with employing goods of higher-order—capital goods—in production processes. It is clear that we are to take the use of higher-order goods as the application of the knowledge Menger speaks of. When we know how to produce in a “roundabout” indirect way, we can employ capital goods for the purpose to great advantage. In practice, much of our knowledge is to be found not in our heads, but in the capital goods we employ. Capital is fundamentally

embodied knowledge.<sup>5</sup> In particular, capital equipment—tools—embodies knowledge of how to accomplish some purpose.<sup>6</sup> Much of our knowledge of the causal relationships between things, and of how to achieve the changes we desire, is not articulate but tacit knowledge. Adam Smith speaks of the “skill, dexterity, and judgment” of workers (1976/1776: 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.

Adam Smith gives a clear example of the embodiment of knowledge in capital equipment in his account of the development of early steam engines, on which

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<sup>5</sup> 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 are embodied knowledge also: they embody knowledge of what will directly satisfy our wants.

<sup>6</sup> In a wonderful passage Friederich Hayek writes:

Take the concept of a ‘tool’ or ‘instrument,’ or of any particular tool such as a hammer or a barometer. It is easily seen that these concepts cannot be interpreted to refer to ‘objective facts,’ that is, to things irrespective of what people think about them. Careful logical analysis of these concepts will show that they all express relationships between several (at least three) terms, of which one is the acting or thinking person, the second some desired or imagined effect, and the third a thing in the ordinary sense. If the reader will attempt a definition he will soon find that he cannot give one without using some term such as ‘suitable for’ or ‘intended for’ or some other expression referring to the use for which it is designed by somebody. And a definition which is to comprise all instances of the class will not contain any reference to its substance, or shape, or other physical attribute. An ordinary hammer and a steam-hammer, or an aneroid barometer and a mercury barometer, have nothing in common except the purpose for which men think they can be used (1979:44).

Similarly Ludwig Lachmann writes:

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 (1978/1956: xv).

a boy was constantly employed to open and shut alternately the communication between the boiler and the cylinder, according as the piston either ascended or descended. One of those boys, who loved to play with his companions, observed that, by tying a string from the handle of the valve which opened this communication to another part of the machine, the valve would open and shut without his assistance, and leave him at liberty to divert himself with his playfellows (Smith, 1976/1776: 14).

The tying of the string, and the addition of the metal rod which was built onto subsequent steam engines to accomplish the same purpose, is an archetypal case of the embodiment of knowledge in a tool. The boy's observation and insight were built into the machine for use indefinitely into the future.

### **Knowledge is of the Essence**

The point here is more radical than simply that capital goods have knowledge in them. It is rather that capital goods *are knowledge*<sup>7</sup>, knowledge in the peculiar state of being embodied in a form ready-to-hand for use in production. 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 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.

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<sup>7</sup> Albeit "knowledge" of a particular kind (embodied-knowledge) that substitutes for the original knowledge that it embodies. We clarify this later.



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 diskette, 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 (Bennet 1985). 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.

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 (of which more below), 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 (CAD) 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 hammer-head; 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 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:

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 (1959/1889: 7).

Mankind did not develop its fabulous stock of capital equipment by acquiring new quantities of iron and wood and copper and silicon. These have always been here. Mankind became wealthy through developing the knowledge of what might be done with these substances, and building that knowledge into them. 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. As Carl 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.

### **Varieties of Knowledge are Embodied in Capital**

The knowledge to which Menger refers in the above passage is heterogeneous; it is not all of a kind (Polanyi 1958, Hayek 1945, Lachmann 1986 also Teece 2001: 13-14). There are important differences among different kinds of knowledge. (We beg the readers indulgence for those for whom this discussion is very familiar.)

Some of our knowledge we can articulate: we can say what we know, and thereby convey it to others (assuming they know how to interpret what is said; see below for further discussion). But much of our knowledge is inarticulate: we cannot say what we know or how we know it. Hence we cannot explicitly convey that knowledge to others, at least not in words. The experienced personnel officer cannot tell us how she knows that a certain applicant is unfit for a certain job; she has “a feel for it.” The skilled pianist cannot possibly tell us how to play with deep expressiveness, although he clearly knows how. A child cannot learn to hit a baseball from reading about it in a book, although the book might help. Furthermore, much of what we know we are not aware that we know. In such cases we do not become consciously aware of our knowledge until it is somehow brought to our attention, perhaps by our being asked to behave in a way that conflicts with that knowledge.

This distinction applies to the knowledge embodied in capital as well. 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. This fact has important implications for how we treat capital in our theories and our actions.

### **Capital Goods and the Division of Knowledge Across Time and Space**

The previous section stressed that capital embodies knowledge. We need to note the *social* character of that knowledge. The knowledge of *lots of people* is combined in capital goods; hence capital 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 almost 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.” 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.

The division of labor (Smith 1976/1776) 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. There is a deep, rich social interaction represented in the capital goods with which any individual works. The crucial “labor” is the creative effort of learning how, and the embodying of that learning in the design of a tool that can be used by others, who themselves lack the knowledge in any other form. We really do better to speak of the *division of knowledge* (Hayek 1945) rather than the division of labor.

The ongoing development of advanced capital goods is an intensely social activity. As Thomas Sowell has observed, “the intellectual advantage of civilization ... is not necessarily that each civilized man has more knowledge [than primitive savages], but

that he *requires* far less” (1980:7, emphasis in original). 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. The structure becomes increasingly complex over time, as the pattern of complementary relationships extends.

In capital-intensive, modern 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 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. The little boy is there in a modern steam engine, his knowledge embodied in the valve-control rod. The farmer at his plow is empowered by the knowledge and labor of hundreds of others, who designed his plow and hardened its steel, who developed his tractor, who learned how to refine its fuel, etc.

### ***Capital Structure***

Understanding of the nature of capital and of capital development requires a clear appreciation that capital goods work and have value in particular relationships with one another—in the capital structure (Lachmann 1978/1956, Hayek 1941). New tools contribute to the economy not by being thrown, as it were, into a bubbling economic pot, where one ingredient adds as much to the amorphous stew as another. Rather they each must fit into a structure, or, more aptly, they must play a particular role in a particular niche in a kind of economic “ecosystem.” If they are ill adapted to their niches, they make no contribution, fail to sustain themselves, and are selected out.

Capital exists and works within a structure. It is *an ever-evolving structure* to be sure—it is *never static*—but throughout its evolution the relationships among capital goods, and among capital goods and human capital, are essential. Contra the picture painted by orthodox neoclassical economics, capital is neither static nor homogeneous. In its aggregate manifestation it is best understood as a *structure* rather than as a *stock*. A structural approach to capital is one better suited to an understanding of business institutions than is a stock-based approach (Lewin 2005).

Of the various perspectives we might take on the capital structure, two will be important to us. One looks at the relationships of complementarity between capital goods used jointly in a production process; another looks at relationships of dependency between capital goods, one or more of which are used in producing another.

### **Complementarity and Capital Maintenance**

According to Ludwig Lachmann:

It is hard to imagine any capital resource which by itself, operated by human labor but without the use of other capital resources, could turn out any output at all. For most purposes capital goods have to be used jointly. *Complementarity* is of the essence of capital use. But the heterogeneous capital resources do not lend themselves to combination in any arbitrary fashion. For any given number of them only certain modes of complementarity are technically possible, and only a few of these are economically significant (Lachmann 1978/1956: 3) emphasis in original).

Most programming languages run only on certain kinds of computers. Many require further that the computer be equipped with a mouse, a high-resolution display, certain minima of RAM and disk space, and perhaps a math co-processor. Various graphical user interface builders run only on certain specific versions of particular programming environments. These are very powerful tools, but usable only if the

necessary complementary goods are present. None of them, of course works at all with such other capital goods as, say, tractors, diesel fuel, and plows, which have their own complementarities.

The challenge of capital *maintenance* (the prevention/preemption of depreciation or obsolescence) has fundamentally to do with complementarity. Capital exists and functions in a capital structure that *evolves over time* as old tools and processes are supplanted by new. Consequently, for any particular (kind of) capital good, maintenance is very much a matter of maintaining its complementarity to the rest of the changing capital structure. Hence maintenance may have to do not so much with preventing any change through deterioration, as with actually changing that (kind of) good directly, in a manner that adapts it to the changing capital structure around it, and thereby delays obsolescence.

Because change is pervasive, how a particular (kind of) capital good is used will inevitably change. As Hayek has pointed out (1935), capital maintenance is often more a matter of maintaining the value of capital than merely preventing decay. But because value depends on position in a changing capital structure, maintaining value may mean changing the good more than preserving it as is. Software, of course, does not deteriorate. (A CD may, but a CD is software's storage medium, not software itself.) Yet programmers speak of "bit rot," that creeping incompatibility that erodes software's usefulness as the environment changes—with new computers, peripherals, operating systems, etc.—and the code does not. This is purely a matter of complementarity. To maintain the value of a piece of software, even when what it does stays exactly the same, requires changing that software to keep it complementary to the changing capital goods with which it must work.

## **Orders of Capital Goods**

Another important aspect of the capital structure is “orders” of goods, consumer goods being goods of the first order, and capital goods being goods of higher orders as distinguished by their “distance” from the final (first order) consumer goods or services they are engaged in producing. As the capital structure lengthens, we develop tools for producing tools for producing tools and so on. The better the tools at each stage, the better and more cheaply we may produce the goods at the next lower stage. Menger and Böhm-Bawerk stressed the importance of lengthening the capital structure. Improvements in tools (and related processes) of high order are very important to economic development because those improvements can be leveraged throughout the production process. Frequently, there is a kind of recursion involved, in that developments at one stage make possible developments at another stage, which can in turn improve processes at the first stage. Better steel, for example, the product of a steel mill, makes possible the construction of better steel mills. The availability of the programming language Smalltalk made possible the user interface builder WindowBuilder, which was itself an improvement to the Smalltalk programming environment.

## **Capital Development as a Social Learning Process – the Production of Designs**

We are now in a position to draw some conclusions about the nature of capital development—the process by which people, over time, develop better, faster, cheaper tools with which to provide themselves with “the necessaries and conveniences of life.”

(Smith, 1976/1776: 1).

As our attention is on developing new and better tools, we must focus on how people develop new *designs* for goods, as distinguished from how they produce individual instances—real cases—of those designs. The production processes are very



different. Living as we do in a physical world, where physical instances catch our eye, it is easy to overlook the production of designs, and see only the production of instances. Economics, certainly, has overlooked the production of designs, by and large assuming it away: standard models assume “given technology” or use of the “best available technology.” But for our purposes—investigating how the capital structure develops and improves—it is essential to focus on production of designs as an activity different from production of particular goods embodying those designs.

Contrast our common conceptions of producing cars, on the one hand, and of producing software, on the other. When we think of GM producing cars, we think of their work creating new *instances* of extant designs. True, GM employs many designers, who *design* new cars, but we don’t think of that; we think of the assembly line, spot welding, riveting, bolting, etc. We think of the *physical* work of *realizing* these designs—imprinting a design on metal and rubber and glass so that a new instance of the design—a new car—comes to be. When we think of Microsoft’s work producing software, by contrast, we think of programmers writing code—creating new designs (or enhancing older designs). True, Microsoft employs people who store the programs onto diskettes, thus in a sense creating instances of the extant designs; but we don’t think of that; we think of the late nights at the terminal designing, coding, revising, running, debugging, etc. We think of the *mental* work of creating new software—new *designs*, specific instances of which will eventually be copied in mass onto CDs or distributed over the internet.

The point here is not that design is unimportant in heavy industries such as automobile manufacturing. Not at all. (Indeed, product design in manufacturing industries is receiving a lot of attention. See Wheelwright and Clark (1992), and Womack

et. al. (1990)). In fact, we hold that design is just as important in heavy industries as in software. By way of example, the design process for the GM-10 line of cars at General Motors was allocated \$7 billion and five years. The point is simply that design of capital goods and what we will call their *instantiation*—the creation of actual instances of those designs—are fundamentally different. Instantiation is concerned with the known, design with the unknown. Instantiation is a matter of imprinting a design onto a different medium; design is a matter of bringing together knowledge of how to accomplish productive purposes that has not yet been brought together in that manner. What then, can we say about the nature of capital good development, given what we know of capital goods as such?

First, because capital is embodied knowledge, capital development is a matter of learning, through which the knowledge gets embodied in the new good. Again, we must think of the design of the new good—the model of tractor or version of a software application—rather than any particular instance. Second, because the necessary knowledge is *dispersed* among many different people who must interact to communicate their particular and often tacit knowledge, capital development is a matter of *social interaction*. Third, because this interaction takes time and because the capital structure changes as learning occurs, capital development is an on-going *process*. In brief, because capital is embodied knowledge, capital development is a *social learning process*.

### ***So What is Capital? - Complementarity and Heterogeneity***<sup>8</sup>

We are now in a position to address some of the key characteristics of capital as it functions in the real world economy. We must distinguish between capital in the abstract and specific capital goods. The capital of an economy is composed of the capital goods

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<sup>8</sup> This section draws heavily on Lachmann 1956/1978 and Lewin 1999; see also Lewin 2005.

used in its production processes. These capital goods are part of its capital structure. The capital structure is characterized by *capital complementarity*. Capital goods are productive inputs that when successfully used in combination, are capable of producing valuable outputs. They are often, but not always, physically durable in nature – raw materials and intermediate goods such as seed and construction materials are non-durable capital goods that are transformed into consumption goods in the production process. Capital goods are physically *heterogeneous* – there is no way to simply quantify them. They can be and are routinely valued according to the discounted value of the output they are expected to yield. Since they are used in combination it is often difficult to impute to individual capital items their “accurate” contribution to the value produced by the capital combination. Nevertheless, to value a capital item there is no alternative to estimating the value of the output expected to flow from it over its lifetime. The capital combinations that make up the capital structure of an economy are the results of the production plans of the producers (entrepreneurs) who have originated them. Firms are essentially combinations of physical and other capital, which themselves combine with other capital combinations beyond firm boundaries. The capital structure entails a plan structure.

### **Capital in a Dynamic World**

It is important to realize that since capital values are *always forward looking*, that is they involve the estimation of future output values<sup>9</sup>, they and the plans of which they are part almost always entail *error*. Error is a crucial part of the dynamic market process in which

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<sup>9</sup> Consequently, the incorporation of past labor efforts into current productive items is neither a sufficient nor a necessary condition for something to be capital. A new resource might suddenly be discovered – a gift of nature. What matters to make it capital or not is whether it can be expected to yield an income stream in the future. *As a practical matter* it is almost always necessary to invest in capital in order to acquire it. Societies that have insufficient savings for the creation of a productive capital structure cannot prosper. Human and intellectual capital (and sometimes social capital) share this characteristic.

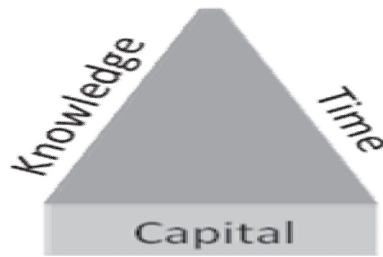
capital plays its part. In attempts to correct error (plan failure, in whole or in part), managers revise capital values (upward or downward) and constantly recombine their capital items. Some capital goods lose their value entirely – become economically obsolete – while others are redeployed to second-best uses. Others may have their value enhanced. Much depends on the *degree of specificity* in production that individual capital goods possess. A high degree of specificity makes a good less adaptable and more vulnerable to loss of value over time. Only in a hypothetical sustained and ubiquitous equilibrium in which no errors occur, in which all production plans are successful and mutually consistent (see Hayek 1937; Lewin 1997), would capital combinations achieve a long term optimality, for example, in the model of perfect competition. Thus, only in a hypothetical equilibrium can the capital of an economy be unambiguously valued – only when all agree on the values of the individual capital items. In equilibrium capital heterogeneity has no operational implications. But this idealized<sup>10</sup> situation is one in which no actions are called for either. It is a clockwork economy in which everything is predetermined. There is no error and no place for the entrepreneur. “Perfect competition” is actually no competition at all (Hayek 1978).

In the real economy, by contrast, entrepreneurial plans frequently conflict with one another – this is the essence of competition. Different visions compete for the future. Among any group of inconsistent plans, expectations, or visions at most one can be right, so error is inevitable. The passage of time brings new knowledge. And entrepreneurial managers build this knowledge into new capital combinations of new and existing capital items. Time, knowledge and capital belong together – they form an inseparable triangle of interacting relationships. Capital reflects what has been successfully learnt in the past –

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<sup>10</sup>But by no means ideal. After all, equilibrium means no change and hence no improvement, no “creative destruction.”

it embodies past knowledge. Over time as new knowledge appears, entrepreneurs revalue individual capital items and rework capital combinations. The capital structure is in a state of ceaseless evolution.



### **Capital Structure and Modularity**

Recognizing the importance of structure as a phenomenon to be investigated in and of itself, the question of interactions at various levels within structures comes into focus. If interaction patterns are such that they occur more at some levels than at others, we may make use of the phenomenon known as *modularity* to gain a better understanding of the structure—its behavior and development (Baetjer 1998; Langlois 2002; see Garud, Kumaraswamy and Langlois 2003 for a collection of articles on modularity). Modularity is a ubiquitous property of many types of structures such software programs, electronic systems, biological systems, social systems (like firm hierarchies) and more traditional capital structures; and examining modules and their relationships may be a fruitful direction along which to develop a structural-capital approach.

Modularity is crucially related to the knowledge-based firm, to the learning company. In a sense capital-embodied knowledge, in capital goods or combinations of capital goods (production “teams”) are knowledge modules. Understanding and using certain principles of modularity may enhance value-adding performance and the

attainment of competitive advantages. In particular modularity serves to insulate disturbances, foster problem-solving and facilitate adaptation. It does this by *knowledge specialization*. One might speak of how individual modules “hide” their knowledge from other modules, exercise a sort of “property right” in that knowledge. The analogy of property rights is meant to convey an understanding of how such knowledge-hiding facilitates innovation and adaptation. Since production occurs in an uncertain, evolving environment, modular designs are not about momentary *optimization*. Rather they are about organizational and production designs that anticipate the need to adapt to unexpected (frequently unimagined, or only dimly imagined) changes – changes like upgrades, recalibrations, and changes in product specifications. When changes occur, the impact on the capital structure can be isolated to affected modules and only those modules need to be replaced, repaired or updated. And this applies whatever the source of the change (be it a business cycle or the persistent march of technology). Firms use modularity, consciously and unconsciously, in production structures and in organizational structures that often mirror each other.

### **The Nature of Knowledge**

Conceiving of capital as embodied knowledge raises important and fundamental questions relating to the nature of knowledge that are central to our main thesis. Specifically, how does this concept of capital, in which the ideas of humans become embodied in the design and production of capital goods and in ceaselessly changing capital combinations, affect our conception of the nature of the ideas that exist in human minds, or in organizational routines, or in social institutions? In other words, how does the above discussion bear upon the concepts of human capital, intellectual capital

(property) and social capital? Before we can answer these questions, we need to probe a bit more deeply. We begin with a consideration of the *location* of knowledge.

### **The Location of Knowledge**

Earlier we stated: “In practice, much of our knowledge is to be found not in our heads, but in the capital goods we employ. Capital is fundamentally embodied knowledge.” This revealing way of thinking about capital raises questions concerning the meaning of “knowledge” in the embodied knowledge that is capital.

The concept “knowledge” comes from the verb “to know.” Knowledge requires consciousness and awareness, phenomena that are manifestly absent in the case of inanimate physical capital. Strictly speaking, knowledge can only be located in someone’s mind. Hence all social phenomena involving knowledge in some way, such as institutions and organizational routines, as well as physical capital, ought to refer back to the mental location of that knowledge if one is seeking a complete and valid understanding of them. (One could imagine reducing matters further to examine the biological processes that give rise to ideas – assuming this were possible, but for most social scientists the logical stopping point seems to be the smallest social unit, the individual.)

This, of course, is pertinent to the vast body of work developing under the rubric of the *knowledge based view* (KBV) of the firm, where often the underlying methodology is collectivist (holistic) rather than individualistic in nature. Firm heterogeneity (differences in firm profitability) are attributed to heterogeneous resources, like routines or team capabilities, or to different organizational types, *without reference to the genesis of these phenomena in the minds of particular individuals*. Often these “social” phenomena are seen as “emergent” outcomes from individual actions in the sense that the

firm ends up “knowing” more than the individuals that compose it (see for example, Spender, 1994, Liebeskind 1996; but contrast Grant 1996). A recent article by Felin and Hesterly (2007) surveys and examines many aspects of the individualistic-collectivistic methodological divide to great effect. Felin and Hesterly point out that if, as much evidence suggests, individuals possess essentially (fundamentally) heterogeneous abilities, knowledge and capacities for learning, then firm differences may be traced ultimately to such individual differences rather than to the more proximate causes manifesting in the firm structure. In a dynamic setting, in which selection processes tend to favor certain kinds of individual characteristics, the routines and organization types we observe may be the creations of the individuals involved. To attribute firm-level performance differences to organization and routines implies what may be an unrealistic underlying homogeneity across individuals. In this view it is the routines that matter and not the characteristics of the individuals involved. Are we to see the direction of causation proceeding from individuals up to the firm and the market or going in the opposite direction (Felin and Hesterly, 2007: 200)? If we changed the human composition of the firm and left its structure intact could we imagine routines unaffected? Would firm performance not be affected? This difference in outlook obviously matters for an accurate picture of value-creation and competitive advantage. We favor a methodological-individualist approach.<sup>11</sup> How, then, do we see capital equipment, which we have identified as embodied knowledge – not to mention intellectual and social capital? We offer the following elaboration by way of resolution. Again semantics is relevant.

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<sup>11</sup> For an in-depth justification see Felin and Hesterly 2007.



Though they are often used interchangeably, we suggest that we ought to understand the terms “data,” “information,” and “knowledge” differently.<sup>12</sup> Data and information refer to tangible, “external” phenomena. They refer to lists, software files, music, and video recordings, etc. The difference between data and information is that the latter is a subset of the former, a subset that has the potential for “meaning,” for “significance.” A collection of figures or words is data; it may be information too if it can be *interpreted* by an active human mind and “transformed” into knowledge. Information plus meaning becomes knowledge. Knowledge is an “internal” phenomenon, it is “subjective.” So strictly speaking, knowledge cannot be shared.<sup>13</sup> Of course, information can be shared, almost costlessly, but there is no direct connection between information and knowledge – and some people are more capable of turning information into knowledge than others. We call this “learning.” Learning-abilities are heterogeneous and, no doubt, affected by learning environments. The important point is that we cannot dispense with the interpretative step – the human element.

### **The Capital in “Hybrid” (Human, Intellectual or Social) Capital**

So, a hammer *is* embodied knowledge in the sense that someone who *knows* what it is for, and how to use it, can leverage the knowledge of the many people who conceived and designed and built it. Some people usefully refer to knowledge as “wetware” – software in the brain. This wetware, or human capital, is crucially *complementary* to any physical capital in the creation of value. This is similar to, but does not exactly mirror, the software-hardware complementarity. Computer software is

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<sup>12</sup> We do not claim any originality for this distinction or for the discussion that follows (see Foss, 2005: 7; Nonaka and Takeuchi 1995; Spender 1996; and Teece 2001 and many others).

<sup>13</sup> This after-all is a recurrent human dilemma, the stuff of romantic literature and philosophical rumination, is it not? Each of us remains frustratingly imprisoned within our own minds as we strive for greater intimacy and understanding. We cannot directly transfer what we feel we know to be true or false or important, we can only try imperfectly to communicate information that we hope the other will interpret in a way that brings them to that state of knowledge.

information, not knowledge; it is potential knowledge. It has to be loaded into the hardware before the combination can project further knowledge-objects—reports, pictures, etc.—to be interpreted<sup>14</sup> to create knowledge, or create physical things (as does manufacturing software) to be consumed or used to create consumption goods. Similarly, any physical capital must combine with human capital before it can create value. In the capital structure overall, therefore, software is more akin to physical capital than to intellectual capital. It embodies knowledge in the same way a hammer does.

Still, in the final analysis, no great inaccuracy is done by thinking of organizational routines, procedures, or rules of operation as social capital; or of software, patents, or trademarks and copyrights as intellectual capital – and these terms are certainly descriptively helpful. Our main point is that these intangible chunks of know-how fulfill the characteristics of capital properly understood. They are part of the capital structure of the economy insofar as they add value to the productive process.

Similarly, we should have no difficulty in thinking of human capital as part of the capital structure. In some ways the term “human capital” is unfortunate. It originates probably from the fact that, as we have seen, knowledge must originate in the human mind. There is no human knowledge without a human knower. This aspect of knowledge suggests that it must be thought of as “subjective,” although information from which it derives is “objective.” But as we have stressed, capital is embodied knowledge and, in fact, *all capital* has a knowledge dimension. In this sense, all capital is “human.” Capital is resources (information, wood, steel, etc.) plus meaning, the meaning that humans, by virtue of their purposes, impose on the resources at their disposal. When the knowledge in human minds is applied to physical resources in the production process, the source of

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<sup>14</sup> Or loaded into the mind, as it were.

the enhancement in value that it occasions is naturally referred to as human capital (Lewin 1999: 175).

And social capital, in the form of routines, conventions, standards, networks, languages, laws, markets, etc., also add value to production. To be sure they exist because of the complementary ideas in people’s minds as to what they are and how they ought to be used (much of which may be tacit in nature). And they are often the unconscious result of human interaction – the result of human action but not human design. Nevertheless, it appears to us appropriate to call them a kind of capital – social capital, the “social” indicating their collective nature.

To extend the concept of capital to all productive resources in this way is not to empty the concept of meaning. Capital is an umbrella term that should motivate the analysis of its disparate and varied components. This is not the capital of the neoclassical tradition, but it is the capital of Adam Smith and his continental disciples and it deserves a more prominent place in the studies of modern business activities and institutions.

**Table 1: Market Process and DK Views of Capital**

Aspect of Capital	DK	Market Process Economics
The whole is	a measurable quantity – values in perfect competition are “objective”	composed of components in structured relationships – values in a changing world are “subjective”
Depreciation is the result of	physical deterioration	economic devaluation - as the capital structure evolves and the components no longer fit as well
Past effort is	necessary and sufficient	neither necessary nor sufficient (but is the usual case)
Change is	incidental	central
Durability	is relevant: Capital is not “used up” in the production process	is irrelevant to whether or not something is capital
Comprehensiveness: Capital	refers strictly to physical items	includes all productive resources
Ideas are	a different type of capital	a central part of <i>all</i> capital

### **Conclusion**

Social scientists have always struggled to find the best way to conceive of the process by which value creation occurs in *capitalist* societies. What is the “capital” to which

“capitalist” refers? We claim that capital is naturally, and at least since Adam Smith has been, conceived of as part of a dynamic value creating process, in which individual capital items are heterogeneous, complementary components of an extensive, but ever-changing, structure of production. In such a conception capital is not a quantifiable aggregate of durable things that have been constructed by past labor, subject to physical deterioration. Rather capital refers to the ability of combinations of things and ideas to produce value over time, whether or not they are the result of past construction and whether or not they are subject to physical deterioration. Value is necessarily forward looking; it relates to aims or purposes yet to be carried out, and capital *value* is a necessary aspect of capital. There is an indispensable knowledge component to all productive resources—all capital—physical, human or social. Physical things are not capital. Without ideas capital does not exist.

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