

Analogous Models of Complexity:

The Austrian Theory of Capital and
Hayek's Theory of Cognition as Adaptive Classifying Systems

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The last decade has seen a number of books looking at F. A. Hayek's contributions to economics and social theory and attempting to draw both connections between them and large lessons from them. In the most recent, and best, of these books, Bruce Caldwell (2004) argues that one central moment in the development of Hayek's thought is a shift in his methodological perspective from one that emphasized the dualism of the social and natural sciences to one that explored the distinction between "simple" phenomena and "complex" phenomena.¹ Caldwell points to the period of the 1940s as the time when Hayek began to undergo this shift. Hayek's decision to revisit theoretical psychology and publish *The Sensory Order* (1952) brings together both this emphasis on complex phenomena and Hayek's attempts to provide a scientific underpinning for traditional Austrian subjectivism.

At the most general level, Hayek was seeing this new framework of emergence, complexity, evolution, and spontaneous order in a variety of places. After quoting a passage from Hayek's "Notes on the Evolution of Rules of Conduct" from 1967 that reflects Hayek's move toward these other explanatory strategies, Caldwell (2004: 285) captures the breadth of this change in Hayek's thought:

Hayek included a note in the article containing the passage just cited that summarizes the point well: "We shall occasionally use the pair of concepts 'order and its elements' and 'groups and individuals' interchangeably, although the former is of course the more general term of which the relation between group and individual is a particular instance" (1967: 66 n. 1). This is just what one should expect from someone who was identifying analogous explanations in a variety of fields.

To the extent that Hayek began to see, in the 1940s, a new framework for conceptualizing the relationship between the natural and social world, and to offer explanations for phenomena in each area, it is not surprising that there would be analogous explanatory strategies at work in diverse areas of his thought. McQuade and Butos (2005) argue that this shift in Hayek's thought can best be understood as his having implicitly laid out in *The Sensory Order* the fundamentals of a class of phenomena that they christen "adaptive classifying systems." They offer an abstract discussion of how such systems operate and then offer several examples of such systems, focusing on the market and the scientific process.

However one chooses to characterize it, the question of what might have prompted Hayek's shift to these ideas remains an interesting one. A number of hypotheses have been advanced, but what I wish to argue here is that one possible source of Hayek's thinking about complexity and adaptive systems, particularly as it appears in *The Sensory Order* and then later in a series of essays in the 1960s, was his work on capital theory in the late 30s that culminated in 1941's *The Pure Theory of Capital*, along with the similar contributions and extensions by Ludwig Lachmann in the 1940s and 50s. It is striking how similar the Austrian theory of capital is to Hayek's work on cognition. Many of the same underlying ideas of function, complementarity, and structure are present in both. They are, I will argue, analogous models of complexity and capital can fruitfully be understood as an example of the "adaptive classifying systems" identified by McQuade and Butos. And there is, in fact, one piece of evidence in the secondary literature that Hayek saw a direct connection between the two areas, and it is certainly possible that additional evidence exists in correspondence and other places that confirms

that his work on capital got him thinking about ideas and approaches that led to his later work on the mind and complexity more generally. After exploring both Austrian capital theory and Hayek's theory of mind, I discuss the ways in which capital is an instance of an adaptive classifying system and how capital and mind are analogous models of complexity. I conclude with brief discussions of some theoretical and methodological implications.

The Austrian theory of capital

Austrian capital theory begins where so much of Austrian economics begins, with Menger's (1981 [1871]) *Principles of Economics*. Specifically, it is Menger who delineated the difference between goods of the "first order" and goods of the "higher orders." First-order goods are those devoted to the direct satisfaction of consumer wants. Goods of the higher orders are those that contribute to the making of first-order goods. The piece of bread I eat for breakfast is a first-order good, while the flour, eggs, milk, etc. that went into making it are second-order goods. The inputs that went into making the flour or the milk (e.g., the milking machines at the dairy where the milk was produced) are third-order goods, and so on. For Austrians, capital can be understood generally as any input that contributes to the production of a first-order good, either directly or indirectly. That is, capital is all of the goods of higher orders.

Implicit in this definition is the idea that capital is "forward-looking." What makes something capital is not where it came from but what it is doing in forwarding the production plans of its owner. Older definitions, such as Bohm-Bawerk's, that referred to capital as "produced means of production" or the like were focused on the *origins* of a

good rather than its *function* in determining whether or not it was capital. Even Hayek was somewhat guilty of this as he defined capital as “the total stock of the non-permanent factors of production” (Hayek 1941: 9). As Lachmann (1956:12) rightly responds, “we cannot adopt this definition as we cannot ignore the uses to which permanent resources are put.” More generally, Lachmann (1956: 11, emphasis added) defines capital as “the stock of material resources” and adds, in response to Bohm-Bawerk, that “the question which matters is not which resources are man-*made* but which are man-*used*.” Lachmann focuses attention more sharply than Hayek on the uses to which resources are put rather than their physical nature or origin.

But even Lachmann does not quite go far enough. Where his definition falls short is its focus on the “material” nature of capital resources. We can generalize Lachmann’s emphasis on capital being “man-used” by arguing that capital resources need not be material. To see this, we can look at Kirzner’s extension of Lachmann’s emphasis on “the plan” as central to his theory of capital. In addressing the question of how we are to understand how capital gets used and what explains the “structure” that emerges economy-wide, Lachmann (1956: 8) argues that “Capital uses must ‘fit into each other.’ Each capital good has a function which forms part of a plan.” Kirzner (1966) picks up on this idea by defining capital more generally as “unfinished plans.” Seen this way, capital is any input into a plan. If I wish to produce running shoes, all of the elements that must be combined to execute that plan are thus capital. Seen in the context of my overall plan, each input and each intermediate good produced along the way is an “unfinished plan.” Under this Kirznerian view, the materiality of resources is not relevant to their capital status; any good that is part of the plan is capital. For example, human capital or things

such as reputation and goodwill should be counted as capital because they are aspects of the production plan need to create the final good in question. In their role in the context of that larger plan, they themselves are “unfinished plans.”

Another way of viewing the question of what makes something capital is to see it as a matter of function. Capital is what capital does: contribute to the plans of entrepreneurs. This observation’s importance is that the same good can be capital in one situation and not another. The identical ham sandwich would be a consumer good and not capital if I have prepared it at home for the purpose of direct consumption. However, if I had taken that exact same sandwich and put it in a picnic basket and then sold it in my store, it is now a capital good as it is an “unfinished” element of my plan to sell complete picnic lunches. What makes the sandwich capital or not is its relationship to other goods and services and the plans of actors. It is *context* or, better yet, the place a good sits in the structure or network of production that determines its capital quality. The Austrian theory of capital denies that one can look at a good or service, or even a non-material asset, standing alone and determine whether or it is capital. It is not the physical qualities of the good that make that determination but where it sits in the network of plans of actors. This is why Lachmann (1956: 4) continually refers to the *structure* of capital:

It will be our main task in this book to study the changes which this network of capital relationships, within firms and between firms, undergoes as the result of unexpected change. To this end we must regard the ‘stock of capital’ not as a homogenous aggregate but as a structural pattern. The Theory of Capital is, in the last resort, the morphology of the forms which this pattern assumes in a changing world.

This emphasis on relationships and unexpected change also highlight the dynamic nature of the theory.

Because being capital depends upon a good's location within a plan, it is possible, and quite likely, that the same good can serve as capital in more than one imaginable plan. Any single good has what Lachmann (1956: 2) calls "multiple specificity," which is the quality of being used in more than one, but yet a still limited, number of uses.

What is central for the Austrian theory is that capital is not homogenous; capital goods are not perfect substitutes for one another. Any given good can only serve in a limited number of production plans, and it is not possible to create any given production plan out of any capital goods. Goods are not infinitely substitutable, and not all goods have the requisite complementarity necessary to be part of any particular production plan. This emphasis on the "heterogeneity" of capital distinguishes Austrian capital theory from many of its predecessors, especially those, most obviously Knight's "Crusonia plant" or Solow's "shmoo," that viewed capital as a homogenous fund of resources from which equally useful "ladles" could be applied to any production process.

Recognizing that capital is heterogenous in this way suggests the importance of the complementarity and substitutability of capital. When viewed as part of a production plan, the various capital inputs must "fit together" in order for that plan to be executed. How well various capital inputs can be fit together in this fashion is their degree of complementarity. What entrepreneurs do in constructing their plans is to integrate complementary capital inputs. In the mind of the entrepreneur at the moment the plan is put in motion, the various capital inputs are all in a complementary relationship to one another. Substitution, by contrast, is a feature of capital goods when we consider

dynamic change. The plans of entrepreneurs are always constructed in a world of uncertainty and may fail to play out as intended. When plans fail to one degree or another, entrepreneurs may choose to reshuffle their capital inputs and formulate a new plan. At this point, the central question is the degree to which one capital good can substitute for another in the plan. The substitutability of capital is what matters when change is necessary. The process of entrepreneurship and monetary calculation is one of constant plan creation, execution, and revision, with the corresponding consideration of the complementarity and substitutability of the capital inputs into those plans. The result of this ongoing process is the production of a capital structure that is an unintended consequence of the various decisions being made by entrepreneurs. Although each individual entrepreneur is consciously and intentionally fitting together complementary capital items into production plans, the degree of integration and complementarity in the capital structure of the economy as a whole is an emergent outcome of the interplay between intra-plan complementarity and inter-plan substitution.

One final aspect of Austrian capital theory that should be noted is that capital is understood in a “forward-looking” manner. As noted earlier, capital is defined not by how it was produced but by how it contributes to the production of future output in the plans of entrepreneurs. Capital’s value is derived from the value of the output it helps to produce. In this way, capital is a good with a potential to contribute to the creation of further value. That potential, like economic value in general, is due to the expectations and perceptions of entrepreneurs about its contributions to the production process and nothing inherent in the good itself. When we consider the importance of complementarity in the production process, it also becomes clear that the value-potential

of any particular item of capital is bound up with context in which it is placed at any point in time. Capital's value depends on its place in a production plan and the perceptions of its contributions to the final good that plan will produce. Capital value is both forward-looking and contextual.

Hayek's theory of mind

Hayek's theory of mind and cognition is largely laid out in his 1952 book *The Sensory Order*. The task he sets for himself in that book is to explain how it can be that the world we understand to exist through the methods of science presents itself to us in the mind as a different sort of world. For example, we may know that what we see is but a jumble of waves, particles and the like, but our minds somehow translate those raw physical inputs into the orderly picture of the world we associate with mind and consciousness. Hayek (1952: 7) wants "to know the kind of process by which a given physical situation is transformed into a certain phenomenal picture." Hayek frames his investigation in terms of the "physical" and "mental" orders. He (1952: 14) wants to understand the relationship between the two and how mind renders the world orderly in a way that is different from the order we know exists in the physical world:

There exists, therefore, no one-to-one correspondence between the kinds (or the physical properties) of the different physical stimuli and the dimensions in which they can vary, on the one hand, and the different kinds of sensory qualities which they produce and their various dimensions on the other. The manner in which the different physical stimuli can vary and the different physical dimensions in which they can be arranged have no exact counterpart in the manner in which the

sensory qualities caused by them will differ from each other, or in the dimensions in which these sensory qualities can be arranged. This is the central fact to which we have referred when we insisted that the two orders, the physical order of the stimuli and the phenomenal or mental order of the sensory qualities, are different. Mind is “thus a particular order of a set of events taking place in some organism and in some manner related to but not identical with, the physical order of events in the environment” (Hayek 1952: 16).

More specifically, Hayek argues that mind is a “relational” order. What makes any given situation “orderly” is not just that there is a certain set of events occurring together, but that there are “certain relations between them” (Hayek 1952: 47). It is in this sense that the whole (the order) is greater than the sum of its parts. One has to understand the relationships among the various elements in order to understand how their arrangement in particular ways can lead to an order that is something distinct from the sum of the elements. It is not just the presence of certain elements that generates an order, but how those elements are arranged. In the case of the mind, it is certain relationships among physical stimuli that produce the orderliness in the world that we associate with consciousness. Furthermore, because we know that there are times when physically different stimuli present themselves identically to our senses and other times when physically identical stimuli can appear different, we know that the mental order depends on the context in which particular stimuli appear. There is no simple one-to-one correspondence between physical stimuli and the mental order. The role that a particular physical stimulus plays in producing the mental order (what Hayek calls the sensory qualities of that stimulus) will depend on the relational context in which it appears.

These relationships and the order they facilitate is made possible because mind is, in the core of Hayek's theory, a classification system. The mental order is the result of the mind classifying physical stimuli as they arrive. Hayek is careful to argue that the mind does not just take "pre-sorted" stimuli and then "put" them in the right place. Rather, the mind is the way in which stimuli are classified in the first place. The world presents itself to us as orderly because the mind "pre-classifies" stimuli based on networks of neural connections that have been built up through our history of interaction with the external world. The complex part of this process is that what is normally happening is a process of "multiple classification." The category to which particular inputs get assigned may differ depending on the other inputs that accompany it. Hayek (1952: 50) explains another sense of "multiple:"

The classification may thus be "multiple" in more than one respect. Not only may each individual event belong to more than one class, but it may also contribute to produce different responses ... if and only if it occurs in combination with certain other events.

An example of the first sort of multiple classification would be the fact that an orange can be classified as "round", "orange," and/or "fruit." The particular response we have to an orange in front of us might well depend on what else it appears with. For example, on a tray with a strawberry and a watermelon, it would likely evoke "fruit," but with a carrot and a basketball, it would evoke the color orange (Feser 1999). Furthermore, it is possible that it could generate a unique response if it occurs with a particular combination of other objects. Individual events often have multiple ways in which they could be classified and

the particular response they generate will often depend upon the other events with which they present themselves.

As organisms learn through time, these connections and systems of multiple classification become progressively more sophisticated. Hayek (1952: 109ff) uses the metaphors of “map” and “model” to explore the way in which the mental order is structured. The map and the model generally reflect the more static and more dynamic aspects of cognition. The map refers to the relationship between the “network of connections” among stimuli acting upon the organism and the “structure of external events which it can be said to reproduce” (Hayek 1952: 109). These are the established connections that have been built up in the mind over the lifetime of learning. They reflect the “lay of the land” in terms of the learned associations that the mind has made through time. They are neural and physical phenomena. Hayek is careful to say that this is a “very imperfect map, but also a map which is subject to continuous although very gradual change” (110). It is a record of past relationships. He continues:

The model, by contrast, refers to the pattern of impulses which is traced at any moment within the given network of semi-permanent channels [and] may be regarded as a kind of model of the particular environment in which the organism finds itself at the moment and which will enable it to take account of that environment in all its movements (Hayek 1952: 114-15).

The map is a reflection of the past, but the model is what the organism uses to “represent” the present. The semi-permanent nature of the map restricts the kinds of things that the organism can model at any point in time; we understand our present environment on the basis of the experiences we have accumulated through time. However, the model is

dynamic in the sense that it guides behavior in the particular context the organism finds itself. It reflects the set of current impulses that are taking place in the brain, as opposed to the channels for directing those impulses that are captured by the “map.” How the behavior resulting from that set of current impulses plays out in that particular instances may feed back over time to gradually adjust the map by restructuring the underlying physical relationships, but in the short run, the model is bounded by the map. This dynamic feedback process is the “adaptive” part of the “adaptive classifying system” framework of McQuade and Butos.

More interestingly, Hayek (1952: 120) argues that the model “will thus continually tend to run ahead of the actual situation.” Because the model frames the current situation in which the organism finds itself, based on the historical relationships embedded in the map, the model is essentially “predictive” in that it can be used to anticipate the result of various actions the organism might take.² The classification process that is the mind is largely one that classifies by *function* in the sense that it classifies by the likely consequences that any set of stimuli will jointly produce. As a result, mental processes are very much processes of expectation:

The representation of the existing situation in fact cannot be separated from, and has no significance apart from, the representation of the consequences to which it is likely to lead. Even on a pre-conscious level the organism must live as much in a world of expectation as in a world of “fact,” and most responses to a given stimulus are probably determined only via fairly complex processes of “trying out” on the model the effects to be expected from alternative courses of action.

The reaction to a stimulus thus frequently implies an anticipation of the consequences to be expected from it (Hayek 1952: 121).

In summary, Hayek's theory of mind suggests two important implications for our analogy to capital. First, mind is a structure where the importance of any element of that structure can only be understood in terms of its relationships to other elements of the structure, and where the said structure can only emerge if the said elements have particular sorts of relationships. The mind is a network of such connections. Second, those more or less static networks of neural relationships enable the organism to create a more dynamic model of its environment, where that model is constrained by the semi-permanent network (what Hayek calls the map) but is essentially expectational in that its representation of the current environment is the result of having "tried out" various possible action-consequence combinations. Consciousness of the moment, for Hayek, is therefore a world of expectations not a world of "experienced facts."

This brief summary of Hayek's theory cannot do it real justice. The purpose was to highlight those parts that seem most relevant to the analogy to capital theory.

Is capital an adaptive classifying system?

McQuade and Butos (2005: 338-340) identify three elements necessary to be able to identify a phenomenon as an "adaptive classifying system." These elements are generalizations of features of Hayek's description of the mind found in *The Sensory Order*. After summarizing these, I will identify their analogues in the capital structure and then explore some further analogies between mind and capital.

The first element McQuade and Butos identify is that the structured of any adaptive classifying system “must implement an adaptive map.” The generalized conception of the map is as a semi-permanent set of features that provide the system with “general integrity” and order as well as “conforming it to the external environment.” At the same time, it must also be “adaptive” in the sense of having “reactive components” that accept external stimuli and are connected to other components of the map such that the map can change as a result of this in-system activity: “The structure of the system is, therefore, mutable, and is conditioned by its experience” (McQuade and Butos 2005: 339).

Secondly, the activity defined by the map “must implement an expectational model.” In abstract terms, the model must derive from the way in which ongoing stimuli affect the map and must also be “capable of inducing responses on the environment consistent with the current map, responses which may, in some cases, anticipate events” (2005: 339). The model is the “forward-looking” component of the adaptive classifying system in that the model, at any point in time, might lead the system to react to current stimuli by anticipating further stimuli based on a past connection between the current stimuli and the anticipated ones. The model is the way in which the semi-permanent features of the map enable the system to interact with the external world.

Finally, McQuade and Butos posit that “the reactive components of the system must be sufficiently interconnected to support the ability of the system as a whole to classify stimuli” (2005: 339). How any given external stimulus changes the patterns of transmission across the system is both “what is being classified and the results of the classification process” (2005: 339). Changes in the external environment that impact the

system at any point can only be classified if the point of impact is “sufficiently interconnected” with the rest of the system such that system-wide classificatory processes can be invoked. Classification is a property of the system as a whole, thus the system must be sufficiently “tight” in order for external stimuli that impact it at any point to be classified effectively. They also note that the very interconnectedness of the system ensures that if one part of the system is damaged, it will lead to the system relearning in ways that enable it to continue classifying but “that work around the injury” (2005: 340).

The capital structure, as described by Hayek and the Austrians, has the necessary elements to be seen as an adaptive classifying system. The “map” aspect of the capital structure can be seen as actual capital goods and the physical production possibilities frontier they represent. In the easier case of machinery, this would be the physical, engineering capabilities of a particular machine. For human capital, it would be the capabilities represented by the skills, experience, and knowledge of the person in question. For more abstract notions of capital, other notions of the “limits of its capabilities” could be articulated. Clearly the array of “physical possibilities” of capital represent a kind of “semi-permanent” set of features that both relate to the external environment of the capital structure and provide it with general integrity. These possibilities represent the contours of the possible. They are also, however, mutable in response to changes from incoming stimuli. A historical inventory of the capital structure of the US economy would illustrate the slow but steady changes that have occurred. Those changes result from the impact of external stimuli, in the form of market signals such as prices, profits, and losses, that feed back to entrepreneurs who then make decisions about what sorts of items will comprise their own capital stock, and, through

emergent processes, that of the economy as a whole. Again, the analogy to the map here is set of things we call capital as understood as a set of physical, biological, or mental capacities with objective limits. Changes in the physical stock of capital represent changes in the “map.”

The analogue to the model is the current array of *uses to which those capital goods are being put*, i.e., from among all the possible things the stock of capital *could* be producing, to what uses are capital goods being put at the moment? As noted above, the plans of entrepreneurs are “forward-looking” in that the combinations of complementary capital that they construct are based on their expectation that the particular combination will be the most profitable from among those that are objectively possible based on the capabilities of the capital items. The value of capital goods is derived from expectations about the value of the output they will produce. In this way, the capital stock at any point in time is an “expectational model” that is based on “the effects of current stimuli on the map.” As market signals impinge on the current plans of entrepreneurs, they are led to reshuffle their capital combinations in response to those “stimuli.” Like the generalized notion of model outlined above, current stimuli may lead to anticipatory reactions based on past connections between those stimuli and the anticipated ones. Owners of capital make use of historical and time-slice information to assist in their adjustments. Routinized behavior has become part and parcel of recent work on the firm.³

McQuade and Butos (2005: 339) also note that the “overall pattern induced by a particular and concurrent stimuli is characteristic not only of itself, but of what else is sensed by the system at the same time.” This is true of the current uses to which capital is being put. If the owner of a capital combination is suffering losses, it will suggest the

need for reshuffling the combination. In deciding what new combination to make use of (and will thus determine the “overall pattern”), the owner must pay attention not only to the signals directly affecting his capital goods but those affecting others as well (“what is sensed by the system at the same time”). The eventual pattern of capital uses that emerges from this decision-making process will reflect the owner having scanned the whole system for the effects of other stimuli. Thus the pattern of capital uses at any moment is the result of the way in which specific stimuli (price changes) are related to other similar stimuli being sensed by the system at the same time. The model/pattern of capital uses at any one point in time is a consequence of decisions that are based on the ability of the capital stock as a whole to register and classify the effects of stimuli at any point in the structure in a way that is usable system-wide. Entrepreneurial reshuffling, and the “substitutability” of capital, represent the “activity within the system” that lead to a new set of capital combinations which is the “model” of the adaptive classifying system known as the capital structure.

It should be clear from this discussion that the third element of an adaptive classifying system is present here as well. The “reactive components” of the capital structure are tightly interconnected in ways that allow “the system as a whole to classify stimuli.” The reactive components in the case of the capital structure are the owners of capital and the interconnections among them are the price signals provided by the external context of “the market.” Movements in prices induce reshuffling of the current uses of capital in the short run (the model) and in the long run those changes will affect the kinds of items that comprise the capital stock (the map). As noted in the previous paragraph, movements in price at any one part of the capital structure will be transmitted

system-wide, which allows the system as a whole to classify those new stimuli, leading in turn to a new pattern of responses. The classification of these stimuli in the form of changes in the uses of capital (or the stock of capital in the long run) are indeed reflections of the “system’s knowledge of its environment” (2005: 340). Finally, damage to one part of the capital structure will certainly reduce the system’s ability to classify and generate better response patterns to price inputs in the immediate run, but the signals generated by the damage and the attempts to work around it in the short run will lead to “relearning” and reconstruction of the map (i.e., the creation of new capital). For example, in the immediate aftermath of the capital destruction of Hurricane Katrina on the US Gulf Coast, existing capital was repurposed for new uses (i.e., adjustments in the model) and new, often lower quality, capital was brought into being (i.e., adjustments in the map).⁴ As the capital structure as a system operates in the external environment of the market, the key interconnectedness within that structure are the prices of capital goods and the profit and loss signals they produce. The interconnectedness of those signals ensure effective classification and reactivity.

The capital structure would therefore appear to qualify as a “adaptive classification system” by the criteria laid out by McQuade and Butos. It is important, if obvious, to note that their generalization of the argument of *The Sensory Order* offers no insight into whether Hayek himself saw these connections explicitly. However, the fact that the insights of *The Sensory Order* can be generalized and then reapplied in ways consistent with Hayek’s thinking is certainly suggestive that he was “on to something.” In a later section, I offer some textual evidence to support that he did indeed see the analogies we have been exploring.

Further analogies between mind and capital

Seeing capital as an instance of an adaptive classifying system as generalized from Hayek's theory of mind enables us to explore a few other analogies between mind and capital.

Multiple classification and multiple specificity

One such analogy is found in the concepts of "multiple classification" and "multiple specificity." In the same way that multiple specificity describes the ability of any given piece of capital to be used to produce a variety (although less than an infinite variety) of outputs, Hayek's description of the multiple classification process of the mental order refers to the ways in which any given stimulus can lead to a variety of possible responses. In both cases, the relationship between the capital/stimulus and the output/response is not a linear one. That relationship depends on the other capital/stimuli that work/appear jointly with the good/stimulus in question. Hayek's description of the "model" as "trying out" various possible responses and selecting the one that is best can be seen as the mind sorting out how the particular combination of stimuli it is processing are best understood. As with Feser's orange example, the same stimulus can fall into various categories, and trying to determine which categories which stimuli fit into and how best to classify the particular combination of stimuli that appear at any given time is the sort of multiple classification that Hayek is referring to.

In his discussion of capital mobility, Hayek (1941: 328) writes in a way that suggests the parallel to the mind:

The problem of mobility becomes, however, still more complex by the fact that, in view of the extremely intricate relationships of complementarity between different capital goods, it is practically impossible to speak of the mobility of a particular capital good in isolation. What effect any particular sort of change will have on its value will always depend not only on the alternative uses to which it can be turned, but also on the degree of mobility of the other resources with which it might co-operate in its former and in its alternative uses.

Just as the value that capital goods will produce will depend upon the relationship between their alternative uses and those of the capital goods complementary to them, so does the way in which any sensory stimulus is classified depend on the context of other stimuli it comes with. Similarly, Lachmann (1956: 58) writes of capital as “nodal points” in the move from inputs to outputs and points out that the same capital good can generate very different flows of value in different situations.

The capital-theoretic ideas of complementarity and capital combinations appear to translate fairly straight-forwardly to Hayek’s work on the mind. The vision of capital that emerges from the Austrian approach is one that emphasizes the way in which heterogeneous resources are combined into production plans by entrepreneurs. These plans are integrated by the very complementarity of the elements envisioned by the entrepreneur, and the importance of any one element of that plan depends upon its place within the entire structure. The very same input will take on a different importance in different contexts. The multiple specificity of inputs means that owners of capital often engage in multiple classification as they respond to market signals by considering

alternative uses of specific capital and alternative combinations of capital that might generate profits.

Structure

The most obvious way in which Hayek's view of mind as the way in which an organism orders the external world bears a resemblance to capital theory is its similarity to Lachmann's insistence on viewing capital as a structure. The opening chapter of his 1956 book is titled "The Order of Capital." Early on in the argument, he rejects the notion of capital as either a flow of income or as a "stock" of material goods. Much as Hayek argues that minds "order" the physical world for organisms, the order of capital is part of "the complex interaction of economic forces from which the entrepreneur takes his orientation" (Lachmann 1956: 4). More specifically, as I noted at the outset, Lachmann (4) argues that the purpose of the book is to

study the changes which this network of capital relationships, within firms and between firms, undergoes as the result of unexpected change. To this end we must regard the "stock of capital" not as a homogenous aggregate but as a structural pattern. The Theory of Capital is, in the last resort, the morphology of the forms which this pattern assumes in a changing world.

In the same way that Hayek's definition of an "order" included not just the presence of various elements, but that those elements have certain relationships with each other, so does Lachmann's use of "morphology" in describing the order of capital suggest that it is not just the "counting" of inputs that makes a capital structure, but that those inputs stand in particular relationships to each other, i.e. they comprise a "structural pattern."

Lachmann (1956: 59), in fact, defines structure precisely this way: “A structure is a complex of relationships which exhibit a coherent pattern. The relationships exist between *entities*. It is probable that when these entities undergo change, so will the relationship between them: probable but not necessary.”

Though he places less emphasis on it than Lachmann did later, this notion of capital as a structure is also present in Hayek’s *The Pure Theory of Capital*. The second paragraph of the book claims that “the central aim of this study is to make a systematic survey of the interrelations between the different parts of the material structure of the process of production, and the way it will adapt itself to changing conditions” (Hayek 1941: 3). He elaborates a few pages later (6):

The problems that are raised by any attempt to analyze the dynamics of production are mainly problems connected with the interrelationships between the different parts of the elaborate structure of productive equipment which man has built to serve his needs....The fact that this stock of capital is not an amorphous mass but possesses a definite structure, that it is organised in a definite way, and that its composition of essentially different items is much more important than its aggregate “quantity,” was systematically disregarded....[S]uch hints [about the integration of capital] were not followed up by a careful analysis of the way in which the different parts were made to fit together.

Capital for Hayek, like his later theory of mind, was a matter of explaining a structure or an orderly pattern of events, where the individual events stood in particular relationships to each other such that the combination of events and their relationships produced the observed pattern. The recurrence of the words “structure,” “order,” “relationships”, and

“complexity” in Hayek’s work on both capital and on mind is highly suggestive of some linkage between them.

Relational Orders

Deepening that suggestiveness is the idea that these are “relational orders.” In the structures of both mind and capital, the importance of any of the elements of the order depends upon the relationship between that element and the other elements. We have seen this in the case of the mental order where the particular response from the organism will depend upon the whole set of stimuli that impinge on it. Any given stimulus might produce very different results if it is accompanied by different other stimuli. Hayek’s whole discussion of multiple classification explores these issues. In the theory of capital, this point is one of the most central Austrian contributions. Both Hayek and Lachmann stress the idea that capital must be understood as part of an entrepreneurial plan in which the complementarity of those capital inputs is what defines that set of inputs as a “plan.” In this way, the term “plan” serves the same purpose for the Austrian theory of capital as the word “order” does for Hayek’s theory of mind: each captures the coherent and complementary interrelationships of the various elements of the capital structure and brain respectively.

Within Austrian capital theory, there is almost no way to talk about the importance of any single capital good without seeing it in the context of the complementary inputs that comprise the plan of which it is a part. Although we can, analytically, attempt to talk about the marginal product of a particular capital good, even

the good's marginal product will depend upon the complementary contributions of the other inputs in the process. Lachmann (1956: 3, emphasis in original) argues that:

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.

Hayek (1941: 328-9) makes a very similar argument about the "mobility" of capital, where he notes that you cannot assess the value or mobility of a good based on its physical attributes such as its individual durability, rather you have to understand "the position of the good in the whole process."

Did Hayek recognize the analogy?

So far, I have avoided the question of whether this analogy is one that Hayek himself recognized. Though published after *The Pure Theory of Capital*, the essential argument of *The Sensory Order* was laid out in a student paper of Hayek's in 1920. So the question of whether Hayek recognized the analogy is also bound up in the interesting question of which set of ideas might have been the inspiration for the other, as it seems possible it could go either or both ways. Although I have not had time to explore the archives, there is only one mention of this relationship in Hayek's published work. In an essay he wrote on the occasion of the 25th anniversary of the publication of *The Sensory*

Order, he (1982: 291, emphasis added) notes the essentials of his theory of mind and what might have inspired the framework he brought to it:

Mind thus becomes to me a continuous stream of impulses, the significance of each and every contribution of which is determined by the place in the pattern of channels through which they flow within the pattern of all available channels – with newly arriving afferent impulses, set up by external or internal stimuli, merely diverting this flow into whatever direction the whole flow is disposed to move. Stimuli and responses thus become merely input and output of an ongoing process in which the state of the organism constantly changes from one set of dispositions to interpret and respond to what is acting upon it and in it, to another set of such dispositions. *In my own mind – perhaps naturally, since not long before I wrote ‘The Sensory Order (1952), I published the results of many years’ work on ‘The Pure Theory of Capital (1941) – I liked to compare this flow of “representative” neural impulses, largely reflecting the structure of the world in which the central nervous system lives, to a stock of capital being nourished by inputs and giving a continuous stream of outputs – only fortunately, the stock of this capital cannot be used up.*

So this is some evidence that the mind-capital analogy is not coincidental, but very much a part of Hayek’s thinking.

Implications for the theory of the firm

Does viewing the capital structure as an analogy to the mind and as an instance of an adaptive classifying system have any payoff in terms of understanding the social

world? I will offer some brief and tentative thoughts on some implications it might have for the theory of the firm. In general terms, much of the literature in that area in the last few decades has focused on the firm as a site of organizational learning. In addition, several important contributors to that line of thought have linked their work to the Austrian theory of capital.⁵ If the analogy explored in this paper deepens our understanding of Austrian capital theory, it may well have some implications for how we understand firms. I will suggest two possibilities below.

Adaptive classifying systems are organized learning structures. Clearly this is true of the mind, and it is true of the capital structure in the sense that it responds to external stimuli in ways that cause it to adapt and better come to “know” its environment as the capital structure is responsive to changes in human wants and the objective facts of the world. Thinking of the capital structure in this way might help us to deepen our understanding of firms as sites of organized learning. First, it is worth asking whether firms are instances of adaptive classifying systems. If that answer is yes, then we have a fruitful line of inquiry. But even if it is no, there may still be interesting analogies between the ways in which the brain “learns” and the capital structure “learns” and firms “learn.” The focus on “routines” in the firm has echoes of these other learning systems.

The second possibility is to see within the firm analogies to the ideas behind the map and the model. Firms need both a map, in the sense of a longer-term, more permanent picture of its overall learning and a model, in the sense of something that provides more immediate and “anticipatory” kinds of feedback as to its relationship to its environment. One might see the balance sheet and the budget as analogies to the map and model in this way. The balance sheet provides a more stock-oriented sense of the

“semi-permanent” state of the firm. It represents the firm’s assets and liabilities and in that sense provides the contours of what is possible. The budget is analogous to the “model” as it provides a way of “trying out” various options for the use of capital and making a decision about which direction to pursue.⁶ It is “anticipatory” as it is based on the firm’s expectations about its actions over the next period of time. Budget models are also a key tool through which managers attempt to make decisions about the allocation of capital within the firm. Over the shorter run, changes to the budget register interactions with the external environment and those “stimuli” may well affect the balance sheet over time, in much the same way as the model-map relationship in adaptive classifying systems. As the predictive accuracy of the budget model is born out by market responses, there will be feedback to the firm’s balance sheet as it may need to recalculate the value of various assets in light of these market results. If the budget model was accurate, then the balance sheet may need little reworking as current estimates of the value of capital remain largely valid. However, if the market results differ significantly from what was anticipated, then revaluation of the balance sheet and, by implication, capital, may be necessary.

These implications for the theory of the firm are, again, very speculative, but might well prove to be fruitful lines of inquiry.

Conclusion: Mind, capital, and methodological dualism

One crucial difference between the structure of capital and the structure of the mental order is that the former, at least to some degree, is the result of human intentionality, while the latter, being the very source of human intentionality, is not.

Clearly, each individual entrepreneurial combination of capital is the product of human design. The entrepreneur must consciously and intentionally create a plan for the use of resources that integrates complementary capital goods. This is what Lachmann (1956: 54) calls the “plan complementarity” of capital. It is both subjective (i.e., the complementarity is in the eye of the entrepreneur) and the result of intentional human action. He distinguishes this from “structural complementarity,” which refers to the way in which the various plan-embedded capital goods fit together across the whole economy. Structural complementarity is not subjective in the same sense, and it is an emergent phenomenon. It is “objective,” or perhaps “inter-subjective,” in that it is a feature of the structure itself, not the subjectively-perceived plan of the entrepreneur. Structural complementarity emerges because it is the task of the market to ensure that the whole variety of complementary capital combinations embedded in entrepreneurial plans are themselves integrated into an overall capital structure that is highly complementary. That integrated structure of complementarity comes about “indirectly” through the market rather than directly by the entrepreneur.

The mental order is, as noted above, more akin to structural complementarity as it emerges in an unplanned way through the physical processes of the brain. The brain, like the market, contains feedback processes that *indirectly* turn individual events into a more or less integrated structure. Much as the biological processes of the brain lead to the emergent phenomena of the mind and consciousness, so do the individual capital-using plans of entrepreneurs get translated via the market into the emergent phenomenon of a more or less integrated capital structure.⁷ What drives the analogy between the mental and capital structures is the notion of spontaneous order (and, as argued here, the idea

that both are adaptive classifying systems). Both structures are complex, emergent phenomena. In the case of capital, the spontaneous order is a human one, emerging from human action but not human design. With the mind, it is a spontaneous order in nature, akin to the structuring of crystals that Polanyi (1958: 43ff) discusses. In both cases, however, there are feedback processes that enable the interaction of individual elements to produce complexity that is of an order of magnitude greater than could be produced by any individual element.

Recalling that capital is a social phenomenon while mind is, ultimately, a natural one returns us to Caldwell's interpretation of Hayek's "shift" from the dualist conception of the social and natural sciences to the continuum of simple and complex phenomena. It is worth noting, as Koppl (this volume) argues, that this shift need not imply a rejection of the methodological dualism that underlies the social/natural science distinction. One can, conceivably, make important distinctions between simple and complex phenomena and how to study them while still believing that natural and social phenomena, whether simple or complex, should be approached very differently. Rather than one distinction replacing the other, we might have a 2x2 matrix of different possibilities, with natural-social along one axis and simple-complex along the other (Koppl, this volume).

The case at hand illustrates the need for these sorts of distinctions. Capital is a social phenomenon and needs to be studied using the methods appropriate to the study of human phenomena. The whole subjectivist approach associated with Austrian economics is appropriate for such study. The mind, by contrast, being rooted in, but not reducible to, the physical processes of the brain is, ultimately, a product of nature and should be studied as such. The methods appropriate to the natural sciences are those required to

understand the emergence of the mind. Recognizing that both capital and mind are adaptive classifying systems *only means that we must treat them as complex phenomena; it, by itself, says nothing about where each sits on the natural-social continuum.*

Approaching capital and mind using different methodologies is appropriate even though both are complex phenomena in Hayek's sense of the term. The fact that both are complex phenomena does suggest that we might wish to bring similar analytical frameworks for studying both (e.g., viewing them as adaptive classifying systems), but it does not replace or override the natural/social distinction in guiding us how to proceed in doing the actual work. Recognizing that human intentionality undergirds the emergence of the structure of capital implies the appropriateness of the use of subjectivist methodologies that can start explanations with those intentions, while the physical interactions that comprise the mental order of necessity eliminate references to human intentionality. So, as Koppl argues, rather than *replacing* the natural-social distinction, the simple-complex continuum *overlays* it in important ways.

The argument I have presented is largely, though not completely, an argument by "suggestion." The analogy between Hayek's theory of mind and the Austrian theory of capital is, I believe, a very strong one, especially when both are viewed as examples of adaptive classifying systems. My claim has been only that such an analogy exists and that it is fruitful enough to explore in more detail. The suggestiveness of the mind-capital analogy fits in with broader interpretations of Hayek's work. The most fundamental characteristic shared by the mental order and the capital structure is that they are complex phenomena in the way Hayek uses that phrase. It is not surprising that these analogous modes of thought would be seen in Hayek's work in the 1940s and 50s, because, as

Caldwell (2004) argues, he was beginning to distinguish between simple and complex phenomena rather than focusing on the natural/social distinction. And the one piece of textual evidence we have suggests that the parallels between mind and capital were not accidental. However, the analogies between capital and mind end, as all analogies must at some point, when we recognize that one is a social phenomenon and one is a natural phenomenon and that, despite their similarities, they would appear to call for differing methodological approaches in attempting to study them. Thus, this specific analogy not only allows us to see how Hayek's shift in emphasis toward complex phenomena was put into motion, it also reminds us that such a shift does not obliterate the distinction between social scientific and natural scientific phenomena.

Notes

¹ As Koppl (this volume) argues, the switch to the simple/complex continuum need not substitute for the natural/social science continuum, but might well complement or supplement it. I shall return to these issues later in the paper.

² Rather than “re-present” it might be more accurate to say that the model “*pre-presents*” the current environment.

³ See Nelson and Winter (1982) for the origins of this work.

⁴ Examples of the former include the ways in which existing buildings that had little or no damage were used for new purposes and examples of the latter would include the construction of tents or other temporary structures to replace damaged buildings.

⁵ See the pioneering contributions of Penrose (1959) and Richardson (1972). On the links to Austrian capital theory, see Lewin (1999), Sautet (2000), and Foss and Ishikawa (2007).

⁶ See Lewin (1998) for more on the firm, budgets, and the discovery process of the market.

⁷ The philosopher John Searle (1998: 112ff) makes a parallel argument about “social meaning” as an emergent phenomenon. Like the complementarity seen in the capital structure as a whole, the meanings that institutions or objects take on in a society are not the results of anyone’s intention. They are emergent. Individuals can engage in acts of “intentionality” but social meaning is trans-individual.

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