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Typologies of knowledge: a reexamination from the perspective of cognitive materialism

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ABSTRACT

The aim of this paper is to reexamine some typologies of knowledge as a means of framing the presentation of our own typology, which arises from a particular theoretical framework – cognitive materialism. In a somewhat arbitrary route through the economics of innovation, organizational and management studies, the typologies of Lundvall, Machlup, Mokyr, Spender, Blackler and Chartrand are reviewed and criticized. Then, picking up on some elements which arise from the previous analysis, the proposal of a cognitive materialist typology is introduced, based on distinguishing types of knowledge on the basis of the material medium or bearer in which they exist. A division into four types is suggested: knowledge with a biological, subjective, inter-subjective and objective bearer, each with its own respective sub-types.

Introduction

It is necessary to begin with an introduction to the Introduction. This paper has its origins in a communicative difficulty – the difficulty of presenting a theory to the social sciences academic community. Not a concept or an interpretation, but a theory which is expressed in a three-volume work. The simplest path would seem to be to publish these volumes. However, the most prestigious publishing houses aspire, quite rightly, to having some sort of guarantee regarding the acceptance that a project of such scope will receive, if not from the general public, at least from scientific institutions.[1] Before being published in book form, the ideas in question must take the form of papers in order to be scrutinized by the reviewers of prestigious journals, and only after having passed this test, do they earn the right to book format. Of course, this move implies the need to dismember, to a greater or lesser extent, the integral body of work. This body consists of at least three organs working in conjunction: the review and critique of the previous literature, the specific presentation of the original theory, and the application of the theory to empirical material of some sort.

However, beyond personal tastes and philosophical perspectives about the relationship between the particular and the universal, a series of very simple difficulties emerges. If a paper expounding an original theoretical proposal is presented (something that in and

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of itself implies a considerable effort of conciseness), its referees will, quite fairly, make two severe criticisms: on the one hand, it will be argued that because there is no review of existing literature, it is not clear what vacancy the theoretical proposal is meant to fill. On the other hand, it will be argued that because there is no application of theory to empirical material, the practical utility of the formulation is unclear. If, contrastingly, the empirical work utilizing the theory in question is presented (offering a brief conceptual summary in the notes and a theoretical section), the referees will point out, reasonably enough, that the definitions of the concepts utilized are insufficient and their relationship with previous academic work is unclear. For this reason, the best way to begin the presentation of a theory seems to be to review, systematize and demarcate the limitations of the existing literature, this through the lens of situating and justifying the theoretical proposal we seek to make in appropriate fashion.[2]

The theory that we wish to present is cognitive materialism, which studies flows and stocks of knowledge based on their material bearer. Four of these material bearers are identified (objective, biological, subjective and inter-subjective, each with its own subtypes) and the translations among them are analyzed. This perspective is oriented towards the analysis of processes of production and appropriation of knowledge in relation to the dynamics of capitalism.

The literature related to this perspective is of four sorts. The first is the most general and abstract and involves the comparison of cognitive materialism with two important traditions. On the one hand, epistemology; on the other, sociology (which ranges from Marxism, through the sociology of knowledge, to some social studies of science and technology). A second, more delimited, group of literature originates in economics and relates to the characterization of knowledge in relation to two variables: exclusion and rivalry. This refers to the debate about public goods and club goods; that is, the concepts of exclusion and rivalry applied to knowledge (Ostrom and Ostrom, 1977; Cornes and Sandler, 1996; Giuliani, 2002; Ostrom and Hess, 2006). Thirdly, the study of knowledge in the social sciences should enter into dialogue with the extensive literature dealing with the opposition between tacit and codified knowledge, starting from Michael Polanyi but influencing numerous authors from the fields of sociology and economics (see Nonaka and Takeuchi, 1995; Cowan *et al.*, 2000; Collins, 2010).

The fourth group includes the various typologies of knowledge that serve as counterpoint to the typology which cognitive materialism puts forward. This paper is concerned only with this last group of antecedents, while the previous three groups are the object of other papers. In this way, the paper reexamines some typologies of knowledge as a means of reviewing the antecedents of each of the types of knowledge proposed in our typology. But why is discussing typologies an important task? What are typologies useful for? Is every kind of knowledge typology relevant here? And how should the effectiveness of a typology be evaluated?[3] Let us discuss some answers to these important questions.

First, typologies are important because they show that knowledge is an entity with certain properties while at the same time its manifestations can be ontologically and economically very different. Knowledge has been treated, for a long time and in different fields, as an entity with unique properties. However, in recent decades, along with a growing interest in considering the relationship between knowledge and productive processes, empirical studies have demonstrated that there are different types of knowledge. For example, in some economic texts knowledge has been considered a pure public good. In other words,

its consumption is understood as non-rival and non-excludable. However, many authors have found that while knowledge can indeed adopt these properties, it can adopt others as well (Romer, 1993).

More generally, a consensus recognizing that different forms of knowledge are characterized by very diverse economic properties has long been approaching. For example, while some forms of knowledge have marginal costs close to zero, others present very elevated costs. It was the confirmation which led to the necessity of drawing up typologies of knowledge, typologies that allow us to understand which types of knowledge match up with which ontological and economic properties. Secondly, typologies are useful for devising an extensional definition of knowledge. Defining knowledge through an intensional definition (Lyons, 1977) is a quite complex task, especially if the concept of knowledge is to be removed from the truth-falsehood axis and placed on a very different axis based on material, ontological and economic properties. As in other cases, when defining the essence of a term (an intensional definition) is a difficult or purely abstract endeavor, listing its varieties (an extensional definition) turns out to be extremely helpful. Thus, typologies are useful because they allow us to map different knowledge regions.

Thirdly, typologies are also useful for grasping empirical material and going beyond the speculative. Classifications of knowledge are needed to cope with the amount of knowledge that a firm or a national system of innovation has. This is why the typologies in which we are interested have flourished in such fields as management and the economics of organization rather than in social theory. Summing up the second and third points, it could be said that knowledge typologies are powerful – and maybe unavoidable – tools in the process of operationalizing the concept of knowledge. Fourthly, not all knowledge typologies are relevant for the purposes of this paper: there are, indeed, several kinds (for instance, those related to the social actors that produce and use that knowledge). In this sense, not only does scientific knowledge exist, but also traditional, religious knowledge. Thus, we will not concern ourselves with taxonomies of knowledge related to this axis (the truth regime that underpins them and the social groups that wield them). Instead, we are interested in another axis, one completely independent of the last, but which also points to diversity in the variety of ontological and economic properties that different forms of knowledge assume.

Finally, there are three criteria to which we will have recourse in the evaluation of knowledge typologies. The first arises from our perspective: to what extent is the typology in question, or a certain type of knowledge within it, approached from a materialist perspective (one that departs from its ontological and economic properties)? The second and third are the usual requisites for every kind of typology in the scientific realm – exhaustiveness and the types being mutually exclusive (Koren and Eisikovits, 2014).

Is the typology exhaustive? Is it capable of subsuming every form of what could be labeled 'knowledge'? Are there forms of knowledge the typology is not prepared to deal with? Are the types mutually exclusive, or do the categories overlap? Is there, for any particular form of knowledge, one and only one category into which it fits? These requisites are certainly quite simple. However, they are not easy to meet.

Leaving to one side ancient philosophical proposals,[4] the first mentioned must be the trio of pairs of related concepts: knowledge of acquaintance and knowledge-about from William James (2007/1890); knowing-how and knowing-that from Gilbert Ryle (1949) and Polanyi's division between tacit and explicit knowledge (1958, 1967) that subsumes and improves upon the previous two. Half way between philosophy and sociology is Max

Scheler's classification[5] which has had an impact on the sociology of knowledge. But it is in the fields of economics that the antecedents of our proposal are located. Now, instead of organizing the presentation in chronological order, it is more useful for our objectives to discuss these antecedents in order of increasing proximity to our typology.

Further sections deal with the pioneering taxonomy in the field of the knowledge economy by Machlup (1962). Joel Mokyr works with a dichotomous division that reassembles the distinctions made by James, Ryle and Polanyi, except that he adds to them, as Machlup does, historical and empirical data. Spender (1996) offers a typology that, combining two variables, describes four types of knowledge. Blackler (1995) suggests five types of knowledge, and Harry Hilman Chartrand (2007) offers a taxonomy closer to that of cognitive materialism. The paper briefly presents the proposal of a typology based on cognitive materialism, picking up the elements suggested during the course of the argument. Finally, conclusions are presented.

Lundvall and the OECD's questions

We start with one of the most frequently used, and certainly one of the simplest, typologies. First published by Lundvall and Johnson (1994), it rose to fame in a chapter of a book published by the OECD (Organization for Economic Co-operation and Development) (Foray and Lundvall, 1996). Its reformulation in later articles has hardly varied much. This typology distinguishes among four types of knowledge.

- *Know-what* refers to knowledge about 'facts'. Here, knowledge is close to what is normally called information – it can be broken down into bits and communicated as data.
- *Know-why* refers to knowledge about principles and laws of motion in nature, in the human mind and in society.
- *Know-how* refers to skills, the ability to do something. It may be related to the skills of artisans and production workers, but it actually plays a key role in all-important economic activities. As the complexity of the knowledge base increases, however, co-operation among organizations tends to develop. One of the most important reasons for industrial networks is the need for firms to be able to share and combine elements of know-how.
- *Know-who* involves information about who knows what and who knows what to do. But it also involves the social ability to co-operate and communicate with different kinds of people and experts (Lundvall, 2000, pp.4–5).

The first problem with this typology is that it does not fulfill the requirement that its categories be exhaustive, meaning that they embrace the totality of the universe. Where are technologies located? Or are these not considered forms of objectified knowledge? Richard Nelson, in two articles (Nelson and Nelson, 2002; Nelson, 2003) astutely points out that one form of *know-how* is objectification in artifacts, but this seems to have been overlooked by Lundvall. Of course, it could be established that knowledge exists only in human beings, but it is difficult, if not impossible, to carry out an economic analysis of knowledge while disregarding its existence in technological artifacts.

A second, more serious, problem is that a determined form of knowledge can be ambiguous. For example, let us suppose that we wished to classify a certain piece of digital information, a certain quantity of bits. For Lundvall, but above all for those who use his *schema*,

the information is understood as know-what. However, different types of digital information can occupy all the categories of such a scheme. A software program acts as a know-how, a treatise on physics is bursting with know-why, and a telephone directory, a search engine, or – even better – a database from a social networking site from web 2.0, is a form of know-who. This ambiguity is not least because Lundvall intended to show the differences between information (with its marginal costs tending towards zero, etc.) and other forms of knowledge (embodied, costly to reproduce, etc.).

A third limitation lies in the failure to distinguish between individual and social knowledge or, in our terms, knowledge with a subjective or inter-subjective bearer. However, as some of the authors we look at below point out, individual know-how has economic properties that differ from those of a team or a company, which is collective know-how. Reproduction costs and mechanisms of appropriation, for example, differ. Other difficulties with this typology could be enumerated, but they would not greatly add to what has already been argued, and they would converge with the aforementioned weaknesses in the final analysis – the failure to include the material bearer when typologizing knowledge.

Machlup's pioneering study

Various types of classification are offered in the beautiful and pioneering book by Fritz Machlup (1962). It represents the first systematic attempt to measure the stocks of knowledge in the US economy. Over and above the formidable empirical work that he carried out, Machlup demonstrates the economic uselessness of definitions of knowledge that deny the status of knowledge to some of its forms, according to the particular tastes of each author. He suggests, in contrast, that the typologies could prove much more productive for the measurement of knowledge (Machlup, 1962, pp.15–16). Next he reviews and criticizes, from an economist's standpoint, some of the usual distinctions. Here we endorse the limitations that Machlup notes regarding the distinctions between scientific and historical knowledge; between basic and applied knowledge; between general/abstract and particular/concrete knowledge; between durable and transitory knowledge, among other differentiations (Machlup, 1962, pp.16–21). In addition to the importance of typologies, Machlup insists that the categories utilized within them be mutually exclusive and that they cover the totality of the universe (see, for example, Machlup, 1962, footnote 4). Lastly, Machlup offers his own abstract *schema*. In it he distinguishes:

(i) Practical knowledge – a category including the strictly instrumental, abstract knowledge (the knowledge of the professional) and everyday knowledge (of the housewife).
(ii) Intellectual knowledge – knowledge that satisfies an intellectual curiosity, that refers to the incorporation of cultural values.
(iii) Small talk and pastime knowledge – alluding to entertainment, news and other ephemeral knowledge.
(iv) Spiritual knowledge – related to metaphysical beliefs.
(v) Unwanted knowledge – acquired and kept in an accidental and involuntary way (Machlup, 1962, pp.21–2).

The first comment to make is that Machlup's *schema* is based on Scheler's (mentioned above), adding categories iii and v in order to fulfill the requirement that any form of knowledge can be located under one of the types proposed. It is interesting that in both

schemas the limitations of epistemology and certain forms of Marxism, consisting of situating knowledge somewhere along the truth-falsity axis, are avoided. Here, in contrast, we are not interested in whether knowledge is true or false, but simply in whether it exists and in what bearer this existence occurs. In turn, Machlup's *schema* has a certain similarity to Gilbert Ryle's distinction. The first category appears akin to knowing-how and the rest to knowing-that. In a more profound manner, Machlup's, and also Scheler's, distinction, is linked to classical sociology's division between the instrumental and the consummatory (or non-instrumental).[6] The simplest criticism of Machlup's typology is that it opts for a completely subjective focus, leaving to one side the material elements of knowledge which are necessary for an economic analysis. Identifying individual human subjects as the only location for knowledge for classification is a conscious decision on Machlup's part:

> With regard to all schemes of classification of knowledge I believe that an objective interpretation according to *what* is known will be less satisfactory than a subjective interpretation according to the meaning which the knower attaches to the known, that is, *who* knows and *why* and *what for* … Using the subjective meaning of the known for the knower as the criterion, I propose to distinguish five types of knowledge… (Machlup, 1962, p.21, original emphasis)

The problem of adopting a non-materialist perspective towards knowledge is not philosophical, but strictly empirical. Indeed, if the *schema* proposed by Machlup is exhaustive, where is the knowledge objectified in artifacts classified? Where are computers? Where are newspapers, books, all codified knowledge to be located?

One option would be to demonstrate that in those entities there is no knowledge, but only information, in the last case, and something else in the first. But Machlup understands perfectly well that when the time comes to study knowledge materially, it is necessary to integrate these objective forms of knowledge *as such*. To achieve this, without alerting us to the contradiction in his typology, he recognizes that music and works of art are 'objects of knowledge' (Machlup, 1962, p.25) and that technology is a type of knowledge (Machlup, 1962, p.9).[7] Furthermore, and this is the decisive element, when he moves on to concrete analysis of the production and distribution of knowledge, his previous categories turn out to be insufficient and he includes a chapter dedicated to the media (to the transmission of codified knowledge or information) and another to what today we call 'information technologies' (Machlup, 1962, chapters 6 and 7, respectively). Thus, the author is faced with the materiality of (some) of the forms in which knowledge exists, and part of the theoretical *schema* is overwhelmed by the empirical evidence and needs to be adapted. This is why Machlup inserts, before his typology, an idea that is completely contrary to its emphasis on subjectivity and that agrees with our perspective:

> Again we conclude that all information in the ordinary sense of the word is knowledge, though not all knowledge may be called information. (Machlup, 1962, p.15)

Despite his typology sharing many features with the sociology of knowledge, the empirical work that Machlup undertook has a certain materialist character, given that he analyzes knowledge, at least partially, on the basis of its material contexts and that, in turn, he understands information as a form of knowledge.

Mokyr and dichotomic classifications

The economic historian Joel Mokyr focuses on the analysis of knowledge related to economic growth. This is what he calls 'useful knowledge' (whose original formulation comes from Kuznets, 1965, pp.85–7). The author recognizes that it is difficult to define precisely what is understood by 'useful' and remarks:

> I confine myself to knowledge of natural phenomena *that exclude the human mind and social institutions.* … Hence useful knowledge throughout this book deals with natural phenomena that potentially lend themselves to manipulation, such as artifacts, materials, energy and living beings. (Mokyr, 2002, p.3, emphasis added)

This useful knowledge is related to physical objects and is presented as being opposed to knowledge about humans and our institutions, regardless of whether either of these represents scientific or common sense. In turn, recognizing that a large part of the recent economic debate has focused on the problem of diffusion of knowledge, in the sense of the integration of useful knowledge in the productive processes of firms, Mokyr decides to concentrate on the contexts of generation and circulation, which can be far removed from labor processes. Following this, Mokyr introduces his simple typology distinguishing two types of useful knowledge:

> One is knowledge 'what' or propositional knowledge (that is to say, beliefs) about natural phenomena and regularities. Such knowledge can then be applied to create knowledge 'how' that is, instructional or prescriptive knowledge, which we may call techniques. (Mokyr, 2002, p.4)

So, there is practical, or prescriptive knowledge (a set of techniques, of forms of know-how skills), and there is propositional knowledge (which Mokyr refuses to relate only with theory). Mokyr, as with Machlup and the sociology of knowledge, includes as propositional knowledge that which has impact on society, regardless of whether it is correct (Mokyr, 2002, p.6).

So, Mokyr's *schema* also owes a considerable debt to Ryle's dichotomies (particularly), and to James and to Polanyi (to a lesser extent). Additionally, there is a strong similarity with Bateson's types of learning (type I and type II) (Bateson, 1972). Lastly, it bears similarity to the distinction in neurosciences between explicit (or declarative) and implicit (or procedural) memory (e.g. Kandel, 2006). Thus, when discussing Mokyr's dichotomy, we are giving an account, broadly speaking, of these other five dichotomic typologies. But why should we focus on Mokyr's *schema*? Fundamentally, because his *schema* introduces a significant novelty with regard to his predecessors, who concentrate purely on the subjective level of knowledge: Mokyr recognizes, without Machlup's ambiguities, that knowledge also exists in objective bearers, in texts and technologies.

> Knowledge resides either in people's minds or in storage devices (external memory) from which it can be retrieved. (Mokyr, 2002, p.4)

In fact, Mokyr deals with knowledge flows in economic history. He analyzes the circulation of diverse types of knowledge and how they are translated from one form to another. 'What I propose here', says Mokyr (2002, p.4), 'is to look at technology in its intellectual context.'

Nevertheless, Mokyr's theoretical *schema* proves insufficient. A common sin of economists (and Lundvall is no exception) is to neglect the difference of level between the social and the individual, or more precisely, between subjective and inter-subjective bearers of knowledge. Society appears as a sum of individuals and social knowledge as the mere adding

up of individual brains. Even more notable for its absence here is the biological level in which flows of information circulate. So, even with recognition that knowledge exists in human and objective form, there is no distinction elaborated between the different levels in which knowledge lives within women and men – biological, subjective and inter-subjective.

Secondly, and returning to the definition of 'useful knowledge', it is clear that this is problematic. Indeed, it denies the status of knowledge to certain forms of knowledge on the grounds of content – the social sciences, religions, philosophy and all other non-natural knowledge about humans and society. This is inconsistent with the proper criteria of rejecting the separation between the correct and incorrect in order to decide if a form of knowledge affects economic activity. In fact, it is not clear why knowledge about humans would be alien to economic activities.[8] Once again, a delimitation based on the content of knowledge and not on its material existence implies practical drawbacks. As a consequence, upon confronting the historical narrative about flows of knowledge (which occupies the bulk of the author's production), Mokyr's *schema* obliges him to leave out, for example, the influences of contractualism or political economy in the hotbed of instrumental rationalism gestating in the eighteenth and nineteenth centuries. On the contrary, for any other narrative it is clear that the ideas of the natural and social sciences are integral (e.g. Foucault, 1989). We have, then, a case in which the incompatibility between the proposed typology and the empirical material is resolved in a less felicitous way than in Machlup's case: in order to satisfy the theoretical prescription, certain elements that are blatantly relevant are excluded. It should be stressed, however, that this is no more than a detail in Mokyr's monumental work, whose historical references are of a value which is hard to overestimate.

Spender and other typologies based on two variables

Another kind of typology arises from derivations of the ideas of tacit and explicit knowledge. We are not referring to the typologies that only separate between these two forms, which would hardly be very distinct from the dichotomies we have just analyzed, with Mokyr's proposal at the center. Now we are interested in the proposals that add a second variable. The pioneer of these is Nonaka and Takeuchi (1995). The authors analyze the interaction between two dimensions of the production of knowledge. One, to which they pay the closest attention, is the relationship between tacit and codified knowledge. But they also add another, related to the subjects that produce the knowledge, and they consider four levels: individual, group, organizational and inter-organizational. In an immediately subsequent re-elaboration, Spender (1996) proposes four types of knowledge, combining the two variables (Table 1). In this approach, *explicit* knowledge refers to that which can be articulated verbally, while *implicit* refers to what can be performed but not communicated linguistically.[9] For Spender, the distinction between individual and social levels refers to the contrast between psychological and sociological levels respectively.

Table 1. John Spender's typology of knowledge.

Knowledge	Individual	Social
Explicit	Conscious	Objectified
Implicit	Automatic	Collective

Source: Spender, 1996.

It is interesting that Spender's paper, published in *Strategic Management Journal*, situates the origin of his two variables in references that have nothing to do with the world of economy and management. Even the distinction between explicit and implicit does not refer to Polanyi, but rather to James. And the distinction between the individual and the social is inspired by Durkheim (Spender, 1996, pp.51–2). This type of *schema* represents, in our point of view, a noteworthy advance, especially because Spender notes that the individual implicit and the inter-subjective implicit (social) have different economic properties.

> … the different types of knowledge lead to different types of economic rents, and that firms' strategies, as the pursuit of these economic rents, will also differ. While an individual's knowledge is inherently transferable, moving with the person, giving rise to Pareto rents and the resultant agency problems, the social types of knowledge are either publicly available or collective and embedded in the firm's routines, norms and culture. (Spender, 1996, p.52)

So, there are at least two aspects that are worth highlighting and retrieving from this work. The first is the hierarchical structuring of collective knowledge as a level in its own right and not detached from the sum of subjectivities. It is interesting that Durkheim appears for the first time in these debates. Forgotten by the postmodern boom, discredited by his association with functionalism, this author contributes concepts such as 'collective consciousness' (Durkheim, 1993/1893) and 'social fact' (Durkheim, 1986/1895), which are inseparable from the existence of what we will call 'knowledge in an inter-subjective bearer'. Unfortunately, the numerous approaches that dissolve the collective into the individual, that reduce the inter-subjective to the subjective, do not contribute refutations of Durkheim and other thinkers. In fact, the problem of the relationship between the individual and the social is not dealt with beyond a few texts concerned with knowledge (e.g. Ancori *et al.*, 2000). Even eliminating Durkheim, Levi Strauss, Vygotsky, Marx, and other approaches akin to sociology, anthropology and linguistics, the existence of an inter-subjective level of knowledge with properties that cannot be reduced to the other levels can be borrowed from systems theory, the science of complexity, and even from a rarely-cited chapter from Polanyi, 1967, (Capítulo 2). In summary, what concerns us here is the idea that there is a collective, social or inter-subjective level where knowledge lies, a level that possesses emergent properties which cannot be reduced to those of individual subjectivities.

The second significant aspect is that Spender notes that there is a form of knowledge which is 'objectified'. This term, which we will maintain, clearly refers to something that has been announced in other analyses, although without giving it this material character: forms of knowledge exist which are fixed outside human subjects. However, once again, it is necessary to specify certain limitations of the *schema* under analysis:

(a) The first is that it confines all the forms of knowledge to four pigeonholes that determine the two variables utilized. This hinders the clarification, for example, that objectified knowledge can exist in contexts that bestow very diverse properties. It is one thing to categorize objectification in a text as explicit, as Spender does. But the objectification of a technological device, awkward to locate on the implicit-explicit axis, is quite another. Clearly, texts and artifacts have very diverse economic properties.
(b) The biological levels on which information circulates are not taken into consideration. Even though the distinction between the individual and the social represents an advance, it is insufficient. For example, advances in the neurosciences demonstrate

that there is solid scientific evidence to support the usefulness of the relationship between biological processes and cognition in the study of these phenomena from the social sciences (Kandel, 2006).

(c) A last, and less important, question (which requires only development rather than great change) is that varieties within knowledge called 'collective' are not differentiated. Languages, norms, beliefs, organizational modalities and networks of recognition are not separated, but are nonetheless part of extremely heterogeneous collective knowledge.

Blackler and Chartrand: close to cognitive materialism

The fifth variety of typologies is closely related to cognitive materialism. Here we have, first, Blackler's well-informed elaboration, which shares aspects of Spender's. It is differentiated by leaving the set of two variables to one side and proposing five categories. Although the author does not actually point this out, the axis of division seems to be largely similar to the material bearer of knowledge. The categories, based on the author's own words, are the following:

> *Embrained knowledge* – knowledge that is dependent on conceptual skills and cognitive abilities (what Ryle (1949) called 'knowledge that' and James (2007/1890) termed 'knowledge about'). Within Western culture, abstract knowledge has enjoyed a privileged status, and in the organizational learning literature a number of commentators have emphasized its importance.
>
> *Embodied knowledge* – action oriented and likely to be only partly explicit (what Ryle (1949) calls 'knowledge how', and James (2007/1890) 'knowledge of acquaintance'). A contemporary account of embodied knowledge is included in Zuboff (1988). Such knowledge, she says, depends on peoples' physical presence, on sentient and sensory information, physical cues and face-to-face discussions. It is acquired by doing, and is rooted in specific contexts.
>
> *Encultured knowledge* – the process of achieving shared understandings. Cultural meaning systems are intimately related to the processes of socialization and acculturation. Such understandings are likely to depend heavily on language, and hence to be socially constructed and open to negotiation.
>
> *Embedded knowledge* – knowledge which resides in systemic routines. This is how, for example, Nelson and Winter (1982) analyze an organization's capabilities. In addition to the physical and mental factors that comprise individual skills however, organizational skills are made up of a complex mix of interpersonal, technological and socio-structural factors.
>
> *Encoded knowledge* – information conveyed by signs and symbols. To the traditional forms of encoded knowledge (such as books, manuals and codes of practice) has been added information encoded and transmitted electronically. (from Blackler, 1995, pp.1023–5)

So, we have knowledge carried by 'brains', by 'bodies', by 'culture', 'embedded' in a productive organization and 'encoded' as information. Beyond the suitability of the terms used, the first argument in favor of this typology is that it revolves around *where* knowledge is situated, on its material bearer. In turn, this typology recovers the triple distinction made by James, Ryle and Polanyi (with the categories 'embrained' and 'embodied') while transcending it. In addition, it includes the collective contexts of knowledge and does not pigeonhole them into explicit and implicit forms as Spender does. Another advance in relation to Spender arises when Blackler starts to overcome criticism that the collective (meaning inter-subjective) knowledge has varied forms that Spender does not contemplate. Blackler

proposes two. One (embedded knowledge) explicitly picks up the gauntlet thrown down by Nelson and Winter (1982) with their concept of routines. The other sub-type of inter-subjective knowledge is that of culture. Notably, this returns to both Machlup's categories ii to v and the idea of 'forms of life' from Wittgenstein (Blackler, 1995, p.1023). Lastly, it is noteworthy that codified knowledge is integrated as information not because of its articulated nature, but rather because of the materiality of the bearer in which it exists. It does not matter if the information exists as words or images; it is enough that it exists as a materialized code outside the human body.

Despite these important contributions, the typology presents some limitations:

(1) The simplest limitation is that the typology does not consider objectified knowledge that is not information, though this was part of Spender's *schema* (for example, the knowledge carried by technological devices). Even if the encoded knowledge is one of the forms in which knowledge is fixed outside the human body, it is certainly not the only one.
(2) The same occurs with biological information. Strikingly, despite the terms used, it is not noted that embrained and embodied knowledge enter into dialogue with data flows that correspond to a biological being.
(3) Although it may be a minor detail, the notion of encultured knowledge is left broad and imprecise, as often occurs when the term 'culture' is used. Cultural inter-subjective knowledge deserves a greater degree of disaggregation.

Finally, we turn to Harry Hillman Chartrand's little-known typology. Although it does have a certain complexity, the following offers a reasonable summary:

> Knowledge takes three forms – personal & tacit, codified and tooled. Knowledge is fixed in a person as neuronal bundles of memories and as the trained reflexes of nerves and muscles. As code it is fixed in a medium of communication or matrix that allows knowledge to cross Time and Space until another person reads or decodes it and thereby adds it to his or her personal & tacit knowledge. Knowledge is tooled into a functioning physical matrix as an instrument such as a sensor, tool or toy or, more generally, as a work of technological intelligence. (Chartrand, 2007, p.95)

The axis of the distinction among forms of knowledge is decidedly materialist. It depends on the material bearer in which each form of knowledge exists. We are presented with a clear separation of knowledge residing in a 'human' bearer, knowledge objectified as technologies and objectified as information. At the same time, various forms of knowledge proposed by previously described typologies are also integrated.

A detailed critique of Chartrand's *schema* would oblige us to clarify each of his categories. Here it is sufficient to make the following remarks:

(a) The difference between the two levels of subjective knowledge is not recognized. Chartrand follows Polanyi in the idea of the complementarity of explicit/focal and tacit/subsidiary knowledge (Polanyi, 1967), but he does not comment on the distinction developed in neuroscience between an implicit memory circuit and an explicit one. This means that he does not consider that there are two sub-types of subjective knowledge with relative autonomy: explicit and implicit.
(b) The idea that ultimately all knowledge is 'personal and tacit' (Chartrand, 2007, p.96) does not take into account that this type of knowledge also comes from somewhere. Thus, he ignores flows of encoded biological data. Is there no relationship

between genetic, endocrine and nervous (system) information, on the one hand, and conscious and unconscious knowledge on the other? Is there not a bidirectional relationship between the biological and subjective levels? Actually, Chartrand considers the biological level in the quote, but he makes it coincide, without any great distinction, with the subjective level. However, some knowledge that is 'fixed in a person as neuronal bundles of memories and as the trained reflexes of nerves and muscles' can be divided into two types: while the latter have a biological character, the former exist at the implicit subjective level. Naturally, and related to point a, both should be distinguished from explicit subjective knowledge.

(c) More importantly, the fact that subjective knowledge originates from social or inter-subjective flows is ignored. Chartrand, in a text replete with many erudite quotes, totally overlooks the traditions of anthropology, sociology, linguistics and a broad range of philosophical tendencies. All these schools agree that inter-subjective flows precede any particular individual. Languages, norms, beliefs are pre-individual or super-individual. The root of this oversight is that Chartrand completely dodges any social (inter-subjective) dimension of the existence of knowledge.

(d) It cannot be deduced from the quotation reproduced above, but in other sections of his text, Chartrand considers software as a 'tooled' form of knowledge, meaning that he treats it as a tool and not as a codified form of knowledge. Here he departs from a materialist perspective, given that if we observe a software program, an image or a text in this way, we find the same bearer (bits, electrical on-off signals). All these are forms of codified knowledge and it makes no sense to split them up by virtue of whether they are de-codified by humans or non-humans. Once again, this materialist approach is not a question of theoretical affectation – it is decisive to understanding how capitalist norms regulate software. Indeed, its protection under copyright law, much like texts and audiovisual products, is ineffably linked to this materiality, consisting of digital information.[10]

Anyway, Chartrand's typology is to a large degree materialist, taking elements from various disciplines, and it is a useful basis for what we put forward. However, it fails to distinguish biological and inter-subjective levels (which are much more important). As a consequence, it does not appreciate the varieties of these latter forms of knowledge. Finally, in spite of introducing the distinction between tooled and codified knowledge (that is, two modalities of objective knowledge), the conceptualization displays chinks in its armor when we give an account of some key goods (typically, of software).

Cognitive materialism in a nutshell

Our theoretical perspective, cognitive materialism, starts from recognizing two ontological entities, matter/energy and knowledge, which are combined in goods, services and living beings in variable ratios (see Zukerfeld, 2017). Whereas we adopt the mainstream concepts and typologies of matter/energy, we understand the concept of knowledge in a very different and much broader sense than usual.

But, what do we understand by 'knowledge'? Knowledge is an emergent form of matter/energy. That is to say, it exists only upon some material bearer in which it is based. Likewise, knowledge represents negative entropy. Matter/energy is finite and limited, it

is not created, nor can it be destroyed, but only transformed (as the laws of conservation indicate). Knowledge is born and expands, but it can also die. Thus, with a certain license, it could be said that matter/energy has an immanent existence while knowledge is transcendent. Knowledge is that which is always more than it is. In economic terms, knowledge is that whose consumption does not run out (it is non-rival, infinitely expandable or has zero subtractability). The human individual, the human collective, the biological human and the non-human, and the inorganic that has been shaped by flows of social knowledge – all are forms of knowledge.

Thus, there is no knowledge that is an independent entity, only an emergent property of matter/energy. This, from the point of view of knowledge, becomes a bearer. It is evident that the bearer of any knowledge conditions several of the properties that such knowledge assumes. For example, the idea that a wheel (knowledge) exists as an individual mental representation, as a reification in a determinate object, or as a codification in a text (three different bearers) conveys varied possibilities to this knowledge. It may be that its being transmitted widely, being considered useful, or falling into oblivion. For this reason, we have tried to use the bearers as a dividing line in order to conform to a typology of materialist knowledge. This perspective, which views knowledge from the material bearers through which it exists, we call 'cognitive materialism'.

The idea of knowledge as an ontological entity implies a crucial assumption: knowledge is not something situated on the truth-falsehood axis. From a materialist point of view, knowledge has nothing to do with epistemological debates. Several theories discussed here (and others coming from economics and sociology) implicitly share this standpoint: from an epistemological, idealistic perspective, they focused on the material properties of different kinds of knowledge. Thus, what matters here is the material existence of, say, an idea, and not if that idea is true, false or unclassifiable. More specifically, the purpose of this perspective is to distinguish different kinds of knowledge with respect to their material bearers.

But, what are the types of knowledge based on their bearers? We propose four types of knowledge:

(1) biological bearer of knowledge (BK)
(2) subjective bearer of knowledge (SK)
(3) inter-subjective bearer of knowledge (IK)
(4) objective bearer of knowledge (OK).

The biological bearer of knowledge consists of the flows of codified data in terms of genetics, endocrine or nervous systems in all living beings. We distinguish between natural or organic and post-organic flows. This type of knowledge arises from the aforementioned gap in the literature (with the partial exception of Chartrand, 2007) and from the fact that neuroscience draws on similar notions.[11] The subjective bearer of knowledge refers to the knowledge for which the bearer is the individual mind. We give the name 'memories', as neuroscience does, to stocks of subjective knowledge. The most significant distinction between types of SK is between the implicit (activated unconsciously and not intentionally), and the explicit (which we can access by means of a conscious recollection of memories). The former is akin to tacit knowing (Polanyi, 1967) know-how (Lundvall, 2000), embodied and embrained (Blackler, 1995), and automatic (Spender, 1996). The latter is analogous to explicit knowing (Polanyi, 1967), know-what and know-why (Lundvall, 2000). A particular

sub-type is the *technique* defined as a form of subjective procedural knowledge acquired in an instrumental fashion and performed in an implicit way (see Mokyr, 2002).[12]

The inter-subjective bearer of knowledge lies in collective, inter-subjective or (to use the common and imprecise term) 'social' aspects of humanity. It relies on the pre-existing bonds between the human subjects and has a life which is autonomous from any particular individual. As we mentioned above, several typologies fall short of distinguishing this human-beyond-individuals level (Collins, 2010). There are types of inter-subjective knowledge, each of which presents diverse properties. It is necessary to differentiate among five kinds: linguistic, recognition, organizational, axiological and normative (or regulatory). The linguistic IK is not only based on the collective human ability to encode and decode knowledge, but above all on the ability to create new inter-subjective codes. This type was not considered in the typologies discussed, but is related to debates on articulable and non-articulable knowledge (Cowan *et al.*, 2000).

The recognition IK refers to the forms the social bonds assume, through which subjects integrate themselves into groups or human collectives and are recognized by other subjects, and through which they recognize themselves. Recognition refers, therefore, to the triple operation of recognizing others, being recognized and self-recognition in a series of bonds or links. Lundvall's (2000) know-who, for instance, points to this kind of knowledge.

The organizational IK is the form of knowledge expressed in the division of labor in productive processes, and external to each subject that participates in it, constituting a collective knowledge that usually maintains itself even when the performers of the productive process change. Concepts such as embedded knowledge (Blackler, 1995) and routines (Nelson and Winter, 1982) describe this type of knowledge.

The axiological IK corresponds to all forms of inter-subjective belief, usually internalized values. Knowledge described as spiritual (Machlup, 1962), encultured (Blackler, 1995), collective (Spender, 1996) and collective tacit (Collins, 2010) pertains to this type. The normative or regulatory IK refer to the inter-subjective internalization of certain models of behavior that are supported by various sanctions. It encompasses different kinds of norms (laws, decrees, acts, ordinances, treatises, etc.), judicial rulings, and institutions, to the extent that they are embodied in a collective framework.[13] Despite normative knowledge not being explicitly tackled by the authors discussed, it is a key concept for sociological approaches from Durkheim onwards.[14]

The objective bearer of knowledge is found crystallized outside living beings, materialized in a variety of goods. It is of two kinds. On the one hand, we have knowledge in the form that a determined good assumes with an instrumental purpose – technologies, analogous to objectified knowledge (Spender, 1996) and tooled knowledge (Chartrand, 2007). Within technologies, in turn, we can differentiate between those that manipulate, process, accumulate or convert material/energy and those that do all this with information. A specific sub-group of the latter is digital technologies. The other type of knowledge with an objective bearer is codified. We use the term 'information' for codified knowledge materialized in symbolic content with an objective bearer, similar to encoded knowledge (Blackler, 1995) and codified knowledge (Chartrand, 2007). One particular type of information is digital information (DI), which is defined as any form of binary codified knowledge using electrical on-off signals. Among other properties, DI is replicable; in other words, it can be cloned with marginal costs close to zero.

Finally, the picture of the flows and stocks of different types of knowledge and matter/energy for a certain time and place results in a Cognitive Materialist Configuration (CMC). This can be very useful to characterize very diverse productive processes: a company, a science laboratory, a situation from daily life, an epoch. Of course, knowledge is translated all the time from one type to another, gaining and losing something in each translation. And certainly, different kinds of knowledge are always producing excesses and contradictions. Inevitably, a CMC is always unstable, forever 'becoming' (*werden* in German).

Conclusions

We have analyzed various typologies of knowledge. The analysis has been neither exhaustive nor systematic, but rather designed merely to gather contributions from these typologies for the cognitive materialist perspective, and especially for a typology of knowledge based on its material bearers. Some contributions from the economics of knowledge and management literature were reviewed. We discussed taxonomies by Lundvall, Machlup, Mokyr, Spender, Blackler and Chartrand. Some of these are well-known; others completely unrecognized. Some deal with empirical studies, others do not. This is an important clarification because, although some of the first *schemas* (Machlup and Mokyr) are easy to criticize theoretically, they have accepted the challenge of empirical work. In contrast, the typologies of the fourth group (Chartrand and Blackler), which are closer to the one we have tried to put forward, have not gone through a practical, historical or systematic application. Some of these typologies are based on categories originating from other disciplines, others offer original formulations. Finally, some have a markedly materialist character, something that others clearly lack. In any case, the aim of this discussion is to show origins, milestones or indices of different types of matrices that we integrate into our own typology.

Of course, we have been unable to review all the antecedents of each of the categories that we propose in our cognitive materialist typology. For example, the idea of a biological bearer does not emerge in any of the typologies analyzed here. In the same way, the sub-division of knowledge with an inter-subjective bearer into five kinds also exceeds the taxonomies reviewed here. This arises because we have included only some partial antecedents and not all that are necessary to explain the origin of each category in our typology. As we remarked at the beginning of this paper, this is a necessary evil. Only a much more extensive study, taking into account the whole corpus of literature, could justify each category in detail.

The simplest conclusion of this review and our proposal is the suitability of using the material bearers in which knowledge actually exists as tools to generate a typology of knowledge. This includes two aspects. On the one hand, a non-anthropocentric materialist intention: knowledge must be analyzed as it actually exists, in its flows and material stocks. This must lead us to study the translations between the human and non-human bearers in which knowledge exists. On the other hand, the emergent levels must be respected. In contrast to fashionable traditions in the sociology of science and technology (and the social sciences and humanities in general), here we defend the idea that the biological, subjective and inter-subjective levels present unique characteristics that are not reducible to other levels. The translation of cognitive flows between these levels does not in any way mean that their relative autonomy can be disregarded.

A further conclusion is that our proposal of a typology is justified. This opens up two invitations for future research. The first is to compare the exhaustivity and coherence of

this proposal with other theoretical sources. The second, and more important, is to submit the proposal to empirical material. Does our cognitive materialist typology prove to be of use in giving an account of flows and stocks of knowledge within capitalist productive processes? Our readers will have to answer this question.

Notes

1. A fortunate update: thanks to Christian Fuchs and the University of Westminster Press, a theoretical book on cognitive materialism will be published in early 2017 (Zukerfeld, 2017). The book and this paper are complementary.
2. This option is not without risks. One is that literature reviews can be, as in our case, much more extensive than one or even two papers can cover. The other is that the analysis of texts can seem to be an end *per se* rather than a means to demarcate the new approach.
3. I am grateful to an anonymous reviewer for this point.
4. Leaving to one side Plato's division between *doxa* and *episteme* (which makes a separation only between knowledge and that which is not knowledge) and his tangential remarks about *techne*, one of the first significant typologies is from Aristotle, between *episteme*, *techne* and *phronesis* in *Nicomachean Ethics*. While the first refers to abstract knowledge, located along the truth-falsity axis and with a universal character, the second is associated with skills, to know-how in the productive processes (both those that today we call economic and those we call artistic). *Phronesis* marries knowledge with practical abilities and with axiological beliefs. While the first is not relevant to our *schema*, we will return to the second as knowledge with an implicit subjective bearer, and to the third as inter-subjective axiological knowledge.
5. Scheler distinguishes among (i) inductive and instrumental knowledge, 'knowledge for the sake of action or control' of an object (herrschaftswissen); (ii) cultural knowledge, understood as intellectual formation (bildungswissen); and (iii) metaphysical, spiritual knowledge, for the sake of salvation (erlösungswissen) (Scheler, 1980/1926, p.250). While the first form includes instrumental knowledge, the other two exceed it. This aspect represented an advance for Scheler over philosophical distinctions based only on scientific knowledge. Here culture in general and metaphysical sentiments are considered legitimate forms of knowledge. However, it is clear that the distinction lacks any consideration of material bearers of knowledge.
6. Further, it is coupled to the question about types of action. The first category is consonant with knowledge that serves Weber's instrumentally rational action and the rest is connected in an imperfect way with value rational action, traditional and affective action.
7. In an enumeration of reasons for his curiosity being stirred to study the production and distribution of knowledge in terms of economics, Machlup includes with numbers 6 and 7 the following motives:

   > (6)The production of one type of knowledge –*namely, technology* – results in continuing changes in the conditions of production of many goods and services. (7) One may advance the hypothesis that new *technological knowledge* tends to result in shifts from physical labor to 'brain workers' (Machlup, 1962, p.9, emphasis added).

8. Facing this difficulty, Mokyr recognizes the impact of some disciplines; for example, economics (Mokyr, 2002, p.6). However, once this is done, it is difficult to decide which social knowledge to include.
9. This distinction follows the usual interpretation of Polanyi (1967) in the field of social studies of science, technology and innovation.
10. On the other hand, the prototypical protection for tooled knowledge is patents.
11. With regards to intellectual property rights, organic biological knowledge can be partially protected by plant breeders' rights. Post-organic knowledge can be protected in many countries by biotechnology patents. The ethnobotanic knowledge of diverse communities can be protected by a new collective right called 'traditional knowledge'.

12. Capitalist regulations protect knowledge with a subjective bearer through trade secrets, confidentiality agreements, aspects of certain laws that deem an industrial invention to be a possession of the employer, and other related mechanisms. In some cases, subjective knowledge can be protected by patents, and in others as traditional knowledge. Likewise, professional qualifications (awarded by labor unions, the state, companies or other organizations) are highly relevant to the regulation of subjective knowledge. Of course, this subjective knowledge may also be in the public domain.
13. There are some norms particularly relevant to our approach. These are the norms that provide the backbone for the functioning of capitalism, that regulate different types of access (private, public) and resources (material/energy and knowledge). They are the norms related to different kinds of property.
14. Inter-subjective knowledge has a complex relationship with regulations. Take just two examples: linguistic and recognition inter-subjective knowledge. Under capitalism, linguistic knowledge is not directly protected by intellectual property rights. As with the majority of inter-subjective knowledge, this is explained by Metcalfe's Law: in general, dissemination benefits those who possess the knowledge, including in economic terms. Thus, natural languages have no owner. However, there are two kinds of regulation that should be mentioned. On the one hand, the regulation of what is permitted or prohibited in each language, the linguistic rules and corresponding accreditations. For example, in Spanish, the *Real Academia Española* determining which terms are permissible is inseparable from the forces wielding power over other aspects of the Spanish language. Likewise, the regulation of English language by various institutions (for example, Cambridge University or TOEFL) intervenes decisively in the capitalist dynamic. On the other hand, in computing, the coded version of some languages (not linguistic IKs, but a derivative of them) is subject to copyright, recognition of the inter-subjective knowledge most susceptible to capitalist regulation. One of the forms through which this occurs is the right to trademarks. This is nothing less than a crystallization of the recognition that a company or a subject has achieved. Some associated rights are geographical indication and appellation certification that, above all, protect reputation. In a complementary, and increasing, fashion (particularly associated with celebrities), rights and contracts arise which are related to public image.

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References

Ancori, B., Bureth, A. and Cohendet, P. (2000) 'The economics of knowledge: the debate about codification and tacit knowledge', *Industrial and Corporate Change*, 9, 2, pp.255–87.

Bateson, G. (1972) *Steps to an Ecology of Mind*, Ballantine Books, New York.

Blackler, F. (1995) 'Knowledge, knowledge work and organizations: an overview and interpretation', *Organization Studies*, 16, 6, pp.1021–46.

Chartrand, H. (2007) *The Competitiveness of Nations in a Global Knowledge-Based Economy, Ideological Evolution*, VDM Verlag Dr, Mulle, La Vergne.

Collins, H. (2010) *Tacit and Explicit Knowledge*, University of Chicago Press, Chicago.

Cornes, R. and Sandler, T. (1996) *The Theory of Externalities, Public Goods, and Club Goods*, Cambridge University Press, Cambridge.

Cowan, R., David, P. and Foray, D. (2000) 'The explicit economics of knowledge codification and tacitness', *Industrial and Corporate Change*, 9, 2, pp.211–253.

Durkheim, E. (1986/1895) *Las Reglas del Método Sociológico* [The Rules of Sociological Method], Hispamérica, Buenos Aires.

Durkheim, E. (1993/1893) *La División del Trabajo Social* [The Division of Labour in Society], Planeta Agostini, Buenos Aires.

Foray, D. and Lundvall, B. (1996) 'The knowledge-based economy: From the economics of knowledge to the learning economy' in Foray, D. and Lundvall, B. (eds.) *Employment and Growth in the Knowledge-based Economy*, OECD, París, pp.11–32.
Foucault, M. (1989) *Las Palabras y las Cosas* [The order of things], Siglo XXI, México DF.
Giuliani, E. (2002) 'Cluster absorptive capability: an evolutionary approach for industrial clusters in developing countries' in DRUID (ed.), *Industrial Dynamics of the New and Old Economy - Who is Embracing Whom?*, DRUID, Copenhagen/Elsinore, June, pp.6–8.
James, W. (2007/1890) *The Principles of Psychology*, Cossimo Classics, New York.
Kandel, E. (2006) *In Search of Memory: The Emergence of a New Science of Mind*, W. W. Norton, New York.
Koren, C. and Eisikovits, Z. (2014) 'Mutually exclusive and collectively exhaustive: typology construction in qualitative research', paper presented at the Tenth Annual Congress of Qualitative Inquiry, University of Illinois at Urbana-Champaign, 21 May.
Kuznets, S. (1965) *Economic Growth and Structure*, Norton, New York.
Lundvall, B. (2000) 'From the economics of knowledge to the learning economy' in *Knowledge Management in the Learning Society*, OECD, Paris, pp.11–36.
Lundvall, B. and Johnson, B. (1994) 'The learning economy', *Journal of Industry Studies*, 1, 2, pp.23–42.
Lyons, J. (1977) *Semantics*, Cambridge University Press, Cambridge.
Machlup, F. (1962) *The Production and Distribution of Knowledge in the United States*, Princeton University Press, Princeton, NJ.
Mokyr, J. (2002) *The Gifts of Athena: Historical Origins of the Knowledge Economy*, Princeton University Press, Princeton NJ.
Nelson, R. (2003) *On the Uneven Evolution of Human Know-How*, LEM Papers Series 2003/25, Laboratory of Economics and Management (LEM), Sant' Anna School of Advanced Studies, Pisa, Italy.
Nelson, Katherine and Nelson, Richard R. (2002) 'On the nature and evolution of human know-how', *Research Policy*, 31, pp.719–33.
Nelson, R. and Winter, S. (1982) *An Evolutionary Theory of Economic Change*, Harvard University Press, Cambridge, MA.
Nonaka, I. and Takeuchi, H. (1995) *The Knowledge Creating Company: How Japanese Companies Create the Dynamics of Innovation*, Oxford University Press, Oxford.
Ostrom, E. and Hess, Ch (2006) 'Introduction: an overview of the knowledge commons' in Ostrom, E. and Hess, C. (eds) *Understanding Knowledge as a Commons: From Theory to Practice*, MIT Press, Cambridge, MA, pp.3–26.
Ostrom, V. and Ostrom, E. (1977) 'Public goods and public choices' in Savas, E. (ed.) *Alternatives for Delivering Public Services: Toward Improved Performance*, Westview Press, Boulder, CO, pp.7–49.
Polanyi, M. (1958) *Personal Knowledge: Towards a Post-Critical Philosophy*, University of Chicago Press, Chicago.
Polanyi, M. (1967) *The Tacit Dimension*, Doubleday, New York.
Romer, P. (1993) 'Two strategies for economic development: using ideas and producing ideas' in *Proceedings of the World Bank: Annual Conference on Development Economies*, World Bank, Washington, DC, pp.63–92.
Ryle, G. (1949) *The Concept of Mind*, University of Chicago Press, Chicago.
Scheler, M. (1926/1980). *Problems of a Sociology of Knowledge*, Routledge and Kegan Paul, London.
Spender, J. (1996) 'Making knowledge the basis of a dynamic theory of the firm', *Strategic Management Journal*, 17, pp.45–62.
Zukerfeld, M. (2017) *Knowledge in the Age of Digital Capitalism: An Introduction to Cognitive Materialism*, University of Westminster Press, London.