The I-space as an evolutionary framework for an economics of knowledge

A comparison with generalized Darwinism

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Declaration

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Summary

The knowledge economy is regarded by many authorities and policymakers as a significant and burgeoning aspect of the global economy. Yet there is no adequate theory of the production and exchange of knowledge; there is no adequate microeconomics of knowledge. In his 1995 work, titled *Information Space*, Max Boisot responds to this theoretical challenge by undertaking a bold and insightful project to lay the groundwork for just such an economics of knowledge. Boisot's project entails two outcomes: an interwoven set of paradigmatic-ontological antecedents as a philosophical foundation; and a general theoretical framework, the Information-space (I-space), for understanding the economising principles that underlie the creation and distribution of information and knowledge. Boisot does not put forward an economics of knowledge *per se.* Rather, he sets out to lay the philosophical and general theoretical foundations for such an economic theory.

Among Boisot's paradigmatic-ontological antecedents is a commitment to evolutionary thinking. This is extended and adopted as a more specific commitment in the explication of the I-space. Thus, Boisot's commitment to evolution is not trivial, and the I-space should be evolutionary in a strict sense. This thesis focuses on the I-space as an evolutionary framework and is a conceptual assessment of the I-space in relation to generalized Darwinism as the dominant contemporary conception of what it means to be evolutionary. The I-space is taken seriously as an explanatory framework, but it is assessed on its own terms as a general theory that is not amenable to a Popperian refutationist assessment. Thus, the I-space is construed as a *putative* evolutionary explanatory framework for an economics of knowledge.

Contemporary evolutionary thinking has a long history, and is both pluralistic and polemical. However, a generalized Darwinian framework is discernable in the various applications of Darwinism in biology, evolutionary economics and evolutionary epistemology, and in the discourse of generalized Darwinism. The derivation – or extraction – of such a framework and its set of criteria is, nevertheless, a challenging task since it is not always clear what evolution and Darwinism entail conceptually, and there is no unanimity of opinion in the literature. This thesis is an attempt to identify the core logical criteria of generalized Darwinism that may be used to assess the I-space as a putative *global* evolutionary explanation.

Though it does incorporate, or satisfy, many of the criteria identified, the I-space fails to satisfy two of them, and this thesis therefore concludes that the I-space is not a global generalized Darwinian framework. Firstly, and most importantly in terms of the conceptual hierarchy of

generalized Darwinism, the I-space defines *ex ante* a finite set of attributes – degree of abstraction and degree of codification – as constitutive of global fitness. In other words, it regards the traits of abstraction and codification to be both necessary and sufficient to explain the differential diffusion of knowledge. Although evolutionary theory is of predictive value in local evolutionary situations, it is argued in this thesis that it is inadmissible in a *global* Darwinian evolutionary situation to specify *ex ante* the selection criteria in terms of a finite set of traits and to predict global evolutionary outcomes on that basis. In doing so, the I-space ignores the inherent contingency of the evolutionary process. More specifically, it ignores the contingency of knowledge creation and diffusion in a varied and changing environment, and makes exogenous to the I-space other factors that may also be of selective significance. Secondly, and closely related, is that the I-space does not define populations according to shared exposure to selection pressure; rather, knowledge is stratified according to shared attributes along the I-space dimensions of abstraction and codification. This presents a conceptual problem for the I-space, since it is conceivable that knowledge objects of the same degree of abstraction and codification may be directed at entirely different phenomenal domains and thus cannot be taken to be competing; conversely, knowledge objects of different degrees of abstraction and codification may be directed at the same phenomena and should thus be taken as competing.

The primary implication of this outcome is that, from a Darwinian point of view, the I-space, as a local evolutionary explanation, cannot serve as a general theory for an evolutionary economics of knowledge. It may give rise to other local theories, but it will not support the development of an economics of knowledge that would operate at a higher level of generality than the I-space. A second implication, also from a strict Darwinian point of view, is that evolutionary general theory may be explanatory, but it may not be predictive; evolutionary theories may indeed predict at the local level, but not at the global level. The final implication is that the search for a microeconomics of knowledge continues, and will become more urgent as the knowledge economy unfolds, and as our ability to quantify it improves.

Opsomming

Die ekonomie van kennis word deur talle outoriteite en beleidsmakers beskou as ’n betekenisvolle en steeds ontluikende aspek van die wêreldekonomie. Tog is daar geen toereikende teorie omtrent die insamel en uitruiling van kennis nie; inderdaad is daar geen toereikende mikro-ekonomie van kennis nie. Max Boisot reageer in sy boek, *Information Space*, wat in 1995 verskyn het, op hierdie teoretiese uitdaging deur ’n ambisieuse en insiggewende projek aan te pak om die grondslag te lê vir ’n ekonomie van kennis. Boisot se projek behels twee uitvloeisels: ’n verwikkelde stel uitgangspunte van ontologiese paradigmas as ’n filosofiese basis; asook ’n algemene teoretiese raamwerk, die Inligtingruimte (I-ruimte), ten einde die beginsels van diskriminasie en seleksie te verstaan wat ten grondslag lê van die skepping en verspreiding van inligting en kennis. Bosoit formuleer nie ’n ekonomie van kennis *per se* nie; hy lê eerder die filosofiese en algemene teoretiese fondament vir die teorie van so ’n ekonomie.

Een van die uitgangspunte, wat as ontologiese paradigma dien, is ’n verbintenis tot evolusionêre denke. Dit word uitgebrei en aangewend as ’n meer spesifieke verbintenis tot die uiteensetting van die I-ruimte; dus is Boisot se verbintenis tot evolusie nie gering nie, en moet die I-ruimte, in die strengste sin, evolusionêr wees. Hierdie tesis fokus op die I-ruimte as evolusionêre raamwerk. Dit is ’n konseptuele waardebepaling van die I-ruimte, met betrekking tot veralgemeende Darwinisme as die dominante kontemporêre konsep van wat presies dit beteken om evolusionêr te wees. Die I-ruimte word in ernstige lig beskou as ’n raamwerk ter verduideliking, maar word op eie terme beoordeel as ’n algemene teorie wat nie ontvanklik is vir Popper se maatstaf omtrent weerlegging nie. Dus is die I-ruimte uiteengesit as ’n *veronderstelde* raamwerk ter verduideliking van ’n ekonomie van kennis.

Kontemporêre evolusionêre denke het ’n lang geskiedenis, en is beide pluralisties en polemies, of betwisbaar. ’n Veralgemeende Darwinistiese raamwerk kan egter onderskei word in die verskillende toepassings van Darwinisme in biologie, in evolusionêre ekonomie en in evolusionêre epistomologie, of wetenskapsleer, asook in die diskoers oor dié veralgemeende Darwinisme. Die afleiding – of ekstrahering – van so ’n raamwerk en sy stel kriteria is nogtans ’n taak wat uitdagings stel. Dit is nie altyd duidelik presies wat evolusie en Darwinisme konseptueel behels nie; en daar is ook geen eenstemmigheid in die letterkunde nie. Hierdie tesis is ’n poging om logiese kernkriteria van veralgemeende Darwinisme te identifiseer, wat gebruik kan word om die I-ruimte te beoordeel as weerlegbare, globale, evolusionêre uiteensetting.

Hoewel die I-ruimte talle van die geïdentifiseerde kriteria inkorporeer, of bevredig, kan dit die kriteria in twee aspekte nié bevredig nie. Om dié rede kom hierdie tesis tot die gevolgtrekking dat die I-ruimte nie 'n globale veralgemeende Darwinistiese raamwerk is nie. Eerstens, en allerbelangriks, in terme van die konseptuele hiërargie van veralgemeende Darwinisme, definieer die I-ruimte *ex ante* 'n beperkte stel eienskappe – graad van abstraksie en graad van kodifisering – as geskik vir globale gebruik. Met ander woorde dit beskou die eienskappe van abstraksie en kodifisering as beide noodsaaklik en toereikend op sigself om die verskillende aspekte van verspreiding te verduidelik. Hoewel evolusionêre teorie voorspellende waarde het in plaaslike evolusionêre situasies, word geredeneer dat dit in 'n *globale* Darwinistiese evolusionêre situasie ontoelaatbaar is om die seleksie-kriteria *ex ante* te spesifiseer in terme van 'n beperkte stel eienskappe – en om dan globale evolusionêre resultate op daardie basis te voorspel. Deur dit te doen, ignoreer die I-ruimte die inherente toevalligheid van die evolusionêre proses. Meer spesifiek, dit ignoreer die toevalligheid in die versameling en verspreiding van kennis in 'n immer wisselende en veranderlike omgewing, en maak ander faktore, wat ook van selektiewe betekenis kan wees, eksogeen tot die I-ruimte. Tweedens, en verwant hieraan, is die feit dat die I-ruimte bevolkings nie definieer volgens soortgelyke blootstelling aan seleksie- of keusedruk nie. Kennis word eerder in strata neergelê volgens soortgelyke eienskappe wat deur die dimensies van abstraksie en kodifisering in die I-ruimte bepaal word. Dit stel 'n konseptuele probleem vir die I-ruimte, aangesien dit kan gebeur dat kennisobjekte van dieselfde graad van abstraksie en kodifisering na totaal verskillende waarneembare domeine gerig word, en dus nie kan meeding nie. Daarenteen kan kennisobjekte van verskillende grade van abstraksie en kodifisering na dieselfde fenomeen gerig word en dus as kompeterend beskou word.

Die primêre implikasie van hierdie uitkoms is dat, vanuit 'n Darwinistiese uitgangspunt, die I-ruimte, as 'n plaaslike evolusionêre verskynsel, nie kan dien as algemene teoriebasis vir 'n evolusionêre ekonomie van kennis nie. Dit kan lei tot ander plaaslike teorieë, maar kan nie die ontwikkeling rugsteun van 'n ekonomie van kennis, wat op 'n hoër vlak van algemeenheid as die I-ruimte funksioneer nie. 'n Tweede implikasie, ook vanuit 'n streng Darwinistiese uitgangspunt, is dat evolusionêre algemene teorie verduidelik word, maar dat dit nie kan voorspel nie. Evolusionêre teorieë kan inderdaad op plaaslike vlak voorspel, maar nie op globale vlak nie. Die finale implikasie is dat die soektog na 'n mikro-ekonomie van kennis voortgaan, en stellig net dringender sal word namate die ekonomie van kennis ontvou, en ons vermoë om dit te kwantifiseer verbeter.

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Chapter 1

A search for an evolutionary economics of knowledge

> *My position, very briefly, is this. I am on the side of science and rationality, but I am against those exaggerated claims for science that have sometimes been, rightly, denounced as "scientism". I am on the side of the search for truth, and of intellectual daring in the search for truth; but I am against intellectual arrogance, and especially against the misconceived claim that we have the truth in our pockets, or that we can approach certainty.*
>
> (Karl Popper, 1978, in *Dialectica* 22, 3, 339–355)

The economic phenomenon variously, and to some extent interchangeably, described as the new economy, cognitive capitalism, informationalism, the information economy and the knowledge economy, is much heralded. Interest in the knowledge economy – the broad term that will be used throughout this thesis – began in the 1960s, has intensified since the 1990s, and is the subject of a large and burgeoning body of contemporary research. In addition, policymakers worldwide regard the knowledge economy as an important aspect of national and regional economic competitiveness, and there is evidence that this phenomenon is regarded as a significant aspect of the contemporary global economy.

Notwithstanding its significance, the notion of the knowledge economy is controversial in some respects. More importantly, however, in the context of this thesis, the knowledge economy remains an economic phenomenon without a cohesive economic theory; those who espouse the knowledge economy as seminal bemoan the lack of an adequate economics of knowledge. Knowledge, when it is made the focus of economic production and exchange, does not behave in the same way as physical economic goods. In crucial respects, knowledge products do not obey the laws of the dominant neoclassical microeconomic theory.

It is against this backdrop that Max Boisot's project is undertaken to lay the groundwork for a political economy of information. Thus, it is concerned with the general theory of the creation and exchange of information and knowledge *in their own right*. It undertakes to lay a foundation for an economics of knowledge. Boisot's project culminates in the formulation of the Information-space (I-space), a conceptual framework for understanding the production and exchange of information and knowledge. As a bold and insightful conjecture, the I-space is both interesting and worthy of research.

An important claim that Boisot makes for the I-space framework is that it is evolutionary. This is not a trivial commitment, nor does Boisot mean to use evolutionary concepts metaphorically. This thesis is a conceptual analysis of the I-space to assess the extent to which it is indeed an evolutionary framework in the strict generalized Darwinian sense. Such an assessment has implications for the critical treatment of the I-space and for further theoretical development in the knowledge economics sphere. There are two main research problems that need to be mitigated: (1) the approach to the identification of the logical criteria of the generalized Darwinian framework needs to be made tractable, but should also allow for a plausible assessment; (2) this is a challenging assessment of a general theory at the conceptual level, as opposed to a Popperian assessment of a scientific theory with specific testable hypotheses.

1.1 The knowledge economy and the search for an economics of knowledge

1.1.1 The significance of the knowledge economy

The Prologue to Manuel Castells's *The Rise of the Network Society* opens with the sentence: "Toward the end of the second millennium of the Christian era several events of historical significance transformed the social landscape of human life" (2002, 1). These statements, written historically, are also prophetic in that they portend the continued emergence of nothing less than a "new social structure associated with the emergence of a new mode of development, informationalism" (Castells, 2002, 14). For Castells, this revolution is of at least the same magnitude as the Industrial Revolution, and is historically specific. Its specificity is particularly evident in that "the informational mode of development is the action of knowledge upon knowledge itself as the main source of productivity" (2002, 17). Chief among the events to which this transformation is attributed is a technological revolution driven primarily by information technologies. Thus, at the heart of this rise of a new type of society is a fundamental shift towards "informationalism" as the dominant *economic* mode: a mode wherein the production and exchange of knowledge itself form a significant aspect of the economy and society.

Quah (2002) adopts the notion of the "New Economy" as a phenomenon that is historically distinctive and amounts to a social and economic transformation. However, in contrast to Castells's emphasis on the production aspect of the knowledge economy, Quah incorporates changing consumption patterns as an important aspect of what is distinctive about the knowledge economy:

> This view suggests something markedly new in the New Economy – a change in the nature of goods and services to become themselves more like knowledge. This transformation importantly distinguishes modern technical progress from earlier: The economy is now more knowledge-based, not just from knowledge being used more intensively in production, but from consumers' having increasingly direct contact with goods and services that behave like knowledge (2002, 10).

Both Castells's and Quah's accounts identify important characteristics of the knowledge economy: (1) knowledge is a significant *economic* product in its own right; (2) the economic balance has shifted from the "old economy" dominated by the production and consumption of physical products to a "New Economy" based – to a significant extent – on the production and consumption of knowledge and information; and (3) productivity growth in the "New Economy" is driven more by the creation and dissemination of knowledge and technology than by the accumulation of physical capital.

The significance of the knowledge economy is also acknowledged by policymakers. Stiglitz (1999, 16) identifies knowledge economy issues as being of great policy significance in both the developed and developing worlds:

> Throughout the world, this new perspective is having profound effects on public policy. In development work, the focus has shifted to the intangibles of knowledge, institutions, and culture…In more advanced, industrial economies, the challenge of creating and nurturing a culture of innovation and change is no less daunting.

The 2001 UN Human Development Report *Making new technologies work for human development* regards knowledge and technological change as drivers of productivity gains, economic growth and ultimately of human development (Fukuda-Parr, 2001). More recently, a World Bank report (Goldberg I et al, 2006) demonstrated a strong correlation between national GDP *per capita* and a Knowledge Economy Index constructed from variables that measure the development of the knowledge economy. Figure 1 depicts this relationship for a selection of developed and developing economies. In addition, policymakers both in the developed world and in developing countries have made clear statements about their belief in the burgeoning knowledge economy (McLeish, 1999; Dahlman, Routti and Yla-Antilla, 2005; Brinkley and Lee, 2006; Mjwara, 2007; Mbeki, 2007).

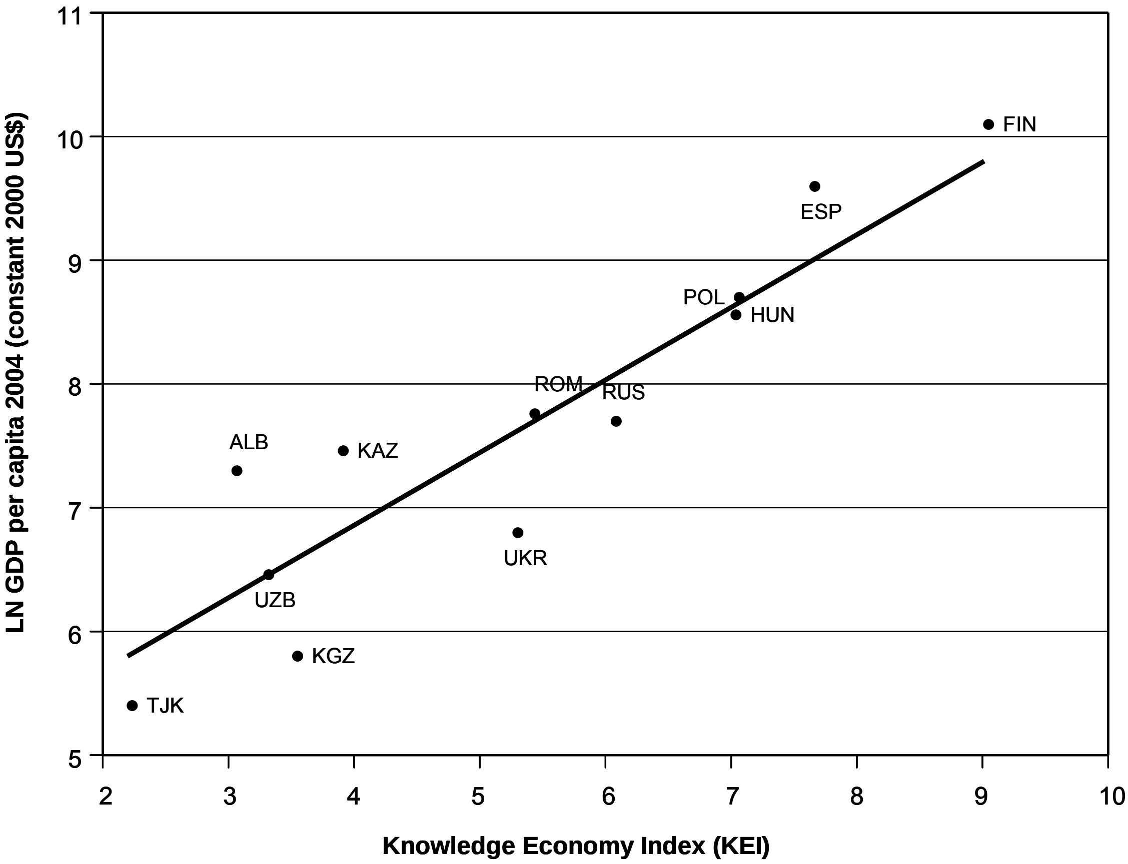

Figure 1
Relationship between GDP per capita and Knowledge Economy Index (KEI)
Goldberg I et al, 2005, 1

While it is widely accepted that information and knowledge play a significant economic role, there is disagreement about the specific nature of the phenomenon; whether or not it has brought about significant growth in productivity; about the extent to which it may be said to be something new and historically specific; and whether it is now the dominant economic mode of a magnitude that may be compared with other major historical shifts such as the Industrial Revolution (Webster, 1995). Solow's (1987) famously sceptical remark, "you can see computers everywhere but in the productivity statistics", has come to be known as Solow's productivity paradox, and is the subject of much research and controversy. The aftermath of the "dotcom" crash of the 1990s provided further evidence for scepticism of the hype around the "New Economy" (Brinkley, 2006, 4).

Claims that a "New Economy" or new information society have become predominant have drawn particularly sharp criticism. "In an extensive literature concerned with the 'information age' there is little agreement about its major characteristics and its significance other than that – minimally – 'information' has achieved a special pertinence in the contemporary world" (Webster, 1995, 2). Webster (1995) distinguishes various dimensions – technological, economic, occupational, spatial and cultural – that are used to identify what is new about "information society". In discussing the economic dimension, he (1995, 13) raises the following pertinent questions: "[A]t which point on the economic graph does one enter an information society? When 50% of GNP is dedicated to informational activities?" Gagnon (2007, 597) also questions the "newness" of the "New Economy", but approaches it from a more qualitative, Veblenian perspective: "Veblen's approach refutes the theory that knowledge is simply a new source of productivity. To the contrary, the cognitive dimension of the economy has always been the source of productivity of any material civilisation." From this perspective, all productivity is and has always been knowledge-based, and it is thus strange to categorize this as something new. Webster (1995, 12) raises the further qualitative problem of "hidden interpretation and value judgement" in the construction of categories, including what would be considered part of the information economy and what would be excluded. He makes the point that "such divisions between the 'thinking' and the 'doing' are extraordinarily hard to accept – where does one put the operation of computer numerical control systems or the line management functions which are an integral element of production?"

Various pertinent issues have been raised in the critique of the notion of the knowledge economy, especially insofar as this is put forward as a transformation of great historical and social significance. However, there are concessions made even by those who call for scepticism as an antidote to the heavily hyped claims about the "New Economy" and the information society. Webster, for instance, does not question "that information plays a critical role in the present age" (1995, 24). The position he does take is to "express suspicion as regards 'information society' scenarios and to remain sceptical of the view that information has become the major distinguishing feature of our times" (1995, 24). While Gagnon (2007, 598) questions the claims of a new economy whose defining characteristic is that productivity is now being driven by knowledge and information, he is quite emphatic that there *is* something specifically new about the knowledge-based economy as regards the nature of capital: "[T]he twilight of industrial capitalism is giving way to the dawn of a system of cognitive capitalism, under which, capital, as an earning-capacity, is no longer identified with means of production, but, instead, is identified with means to control the community's cognitive capacities" (2007, 598).

Thus, while the matter is not cut-and-dried, this brief survey confirms the academic and policy significance of knowledge and information. While specific conceptual and theoretical problems persist, it seems safe to conclude that knowledge and information are widely accepted as being of great consequence in the contemporary economic sphere. Whether the knowledge economy represents a historical transformation or simply a continuity does not negate its contemporary significance to many thinkers and policymakers, including those who tend to be sceptical of some of the more exaggerated claims that surround it.

1.1.2 Notions of the knowledge economy

What is meant by the term "knowledge economy"? Webster (1995) points out that there is fuzziness evident in the various definitions that researchers use. To begin with, he takes issue with how the proponents of the information age define the important constituent term "information": "The definitions of the 'information society' we have reviewed perceive information in non-meaningful ways. That is, searching for quantitative evidence of the growth of information, a wide range of thinkers have conceived it in the classic terms of Claude Shannon and Warren Weaver's (1964) information theory. Here a distinctive definition is used, one which sharply distinguished from the semantic concept in common parlance" (1995, 27). And further: "'Valuing the invaluable', to adopt Fritz Machlup's terminology, means substituting information content with the measuring rod of money. We are then able to produce impressive statistics, but in the process we have lost the notion that information is *about* something" (1995, 28).

In considering what "knowledge" means, Boulding (1966) wishes to avoid the danger of the "philosophical morass" around knowledge; by "knowledge" he does not mean something approaching "Truth", but rather the cognitive contents of minds, which he also terms "images". Marschak (1968) refers to "symbols" and "symbol manipulators". In similar vein, Mokyr (2002) avoids the epistemological aspect and opts for "a simple and straightforward approach"; he is concerned with "useful knowledge" that is confined to "knowledge of natural phenomena that exclude the human mind and social institutions"; his distinction between "what" (propositional or Ω-knowledge = "*episteme*") and "how" (prescriptive or λ-knowledge = "*techne*") knowledge is important in his conception of knowledge. According to this view, "technology is knowledge, even if all knowledge is not technology" (2002, 2). From the preceding, it is clear that there are many differing conceptions of information and knowledge. The above sampling demonstrates

Webster's (1995) point that extant conceptions of information and knowledge are many and varied.

Brinkley (2006, 29) concludes that "defining the knowledge economy is challenging precisely because the commodity it rests on – knowledge – is itself hard to pin down with any precision. Perhaps for this reason there are few definitions that go much beyond the general and hardly any that describe the knowledge economy in ways that might allow it to be measured and quantified." Yet much research into the knowledge economy has been undertaken over the last six decades. The discussion below deals with some of the ways in which the knowledge economy has been conceptualized, particularly by those researchers who pursued the quantification of this aspect of the economy.

1.1.2.1 The production/distribution view

Machlup (1962), in one of the earliest attempts to quantify knowledge production in an economy, is concerned to avoid the epistemological notion of knowledge and all the difficulties that go with such an emphasis. "For the purposes of our study there is no need to enter deeply into epistemological discussions. Sermons and Sunday-school classes have to be included in our study no matter what one holds concerning the truth value of the contents taught" (1962, 22). Thus, in Machlup's conception, the qualitative issue of truth-value is avoided; he is concerned with the quantity and economic value of knowledge production in which knowledge is broadly defined and more akin to cognitive production than to knowledge in the epistemological or semantic sense. Machlup (1962, 28) adopts a broad conception of knowledge in another respect as well: in drawing a distinction between "subjectively new knowledge" and "socially new knowledge", he regards knowledge production as inclusive of both the creation of new knowledge and the diffusion of existing knowledge. He adopts a pragmatic and subjective view of knowledge: "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*" (1962, 21).

> My concepts of knowledge and knowledge-production are unusually wide, particularly because I recognize, and work with, both meanings of knowledge: as *that which is known*, and as the *state of knowing*. Hence, to "produce knowledge" is not only to add to the stock of what is known but also to create a state of knowing in anybody's mind. Producers of knowledge may, however, work on very different levels: they may be

> transporters, transformers, processors, interpreters, or analyzers of messages as well as original creators" (1962, 25).

Machlup (1962) disaggregates the knowledge economy into sub-sectors: education, R&D, communication media, information machines and information services. He further classifies knowledge on economic principles "either as a final product or as a necessary requirement – cost element – in the production of other goods and services." The class "knowledge as a final product" is divided into two subclasses, consumption and investment. Education and research are given as examples of investment, and burlesque shows as an example of consumption.

Porat identifies the indirect input of knowledge in the production of physical products as an element missing in Machlup's study. According to Webster (1995, 11), Porat (1977b) identified a weakness in Machlup's analysis "which failed to account for information activities that were disguised from initial examination, for example because they are an in-house element of other industries." Thus, according to Porat, Machlup's quantification would underestimate knowledge production. Porat's study identified a "secondary information sector" to include such activities.

1.1.2.2 The economic policy view

The growing sense of the significance of the knowledge economy among policymakers has influenced how it is characterized. The characterizations from a policy point of view differ from those that proceed from a theoretical point of view in that they tend to emphasize areas of action rather than areas requiring explanation. Thus, the emphasis tends to be on breaking down the problem and identifying key areas in which resource allocations are likely to yield the best results.

> With sustained use and creation of knowledge at the center of the economic development process, an economy essentially becomes a Knowledge Economy. A Knowledge Economy (KE) is one that utilizes knowledge as the key engine of economic growth. It is an economy where knowledge is acquired, created, disseminated and used effectively to enhance economic development…It has been found that the successful transition to the Knowledge Economy typically involves elements such as long-term investments in education, developing innovation capability, modernizing the information infrastructure, and having an economic environment that is conducive to market transactions. These elements have been termed by the World Bank as the pillars of the Knowledge

Economy and together they constitute the Knowledge Economy framework (Chen and Dahlman, 2005, 4).

Policy-driven notions of the knowledge economy are often developed in the context of the nation-state and have national economic competitiveness as a major underlying concern. A prominent example is the case of Finland, which, through a conscious strategy, was able to transform its predominantly agrarian economy into one of the world's leading knowledge economies. This was achieved primarily through a government-driven policy that directed significant investment to specific areas of the knowledge economy. Figure 2 depicts the historical development of the Finnish economy and the associated increase in the significance of knowledge in the process.

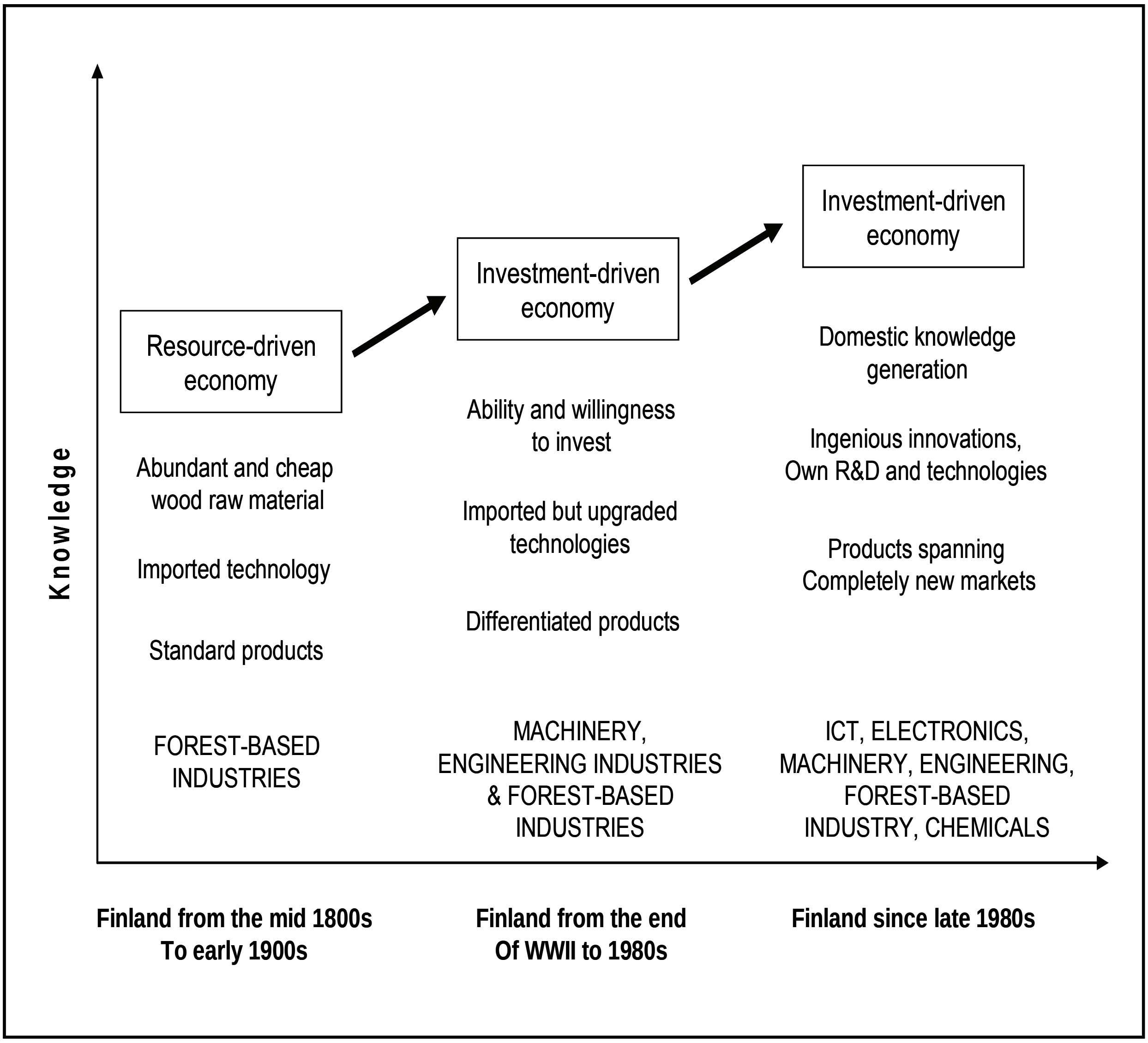

Figure 2

Finland's stages of industrial and economic development

Dahlman, 2005, 5

The 2001 UN Human Development Report *Making new technologies work for human development* regards knowledge and technological change as drivers of productivity gains, economic growth and ultimately of human development (Fukuda-Parr, 2001, 36). Thus, the policy concern with the economic effects of knowledge goes beyond national competitiveness and has become a broader matter of human development. Figure 3 sets out the inter-relationships between knowledge, technological change, economic growth and human development.

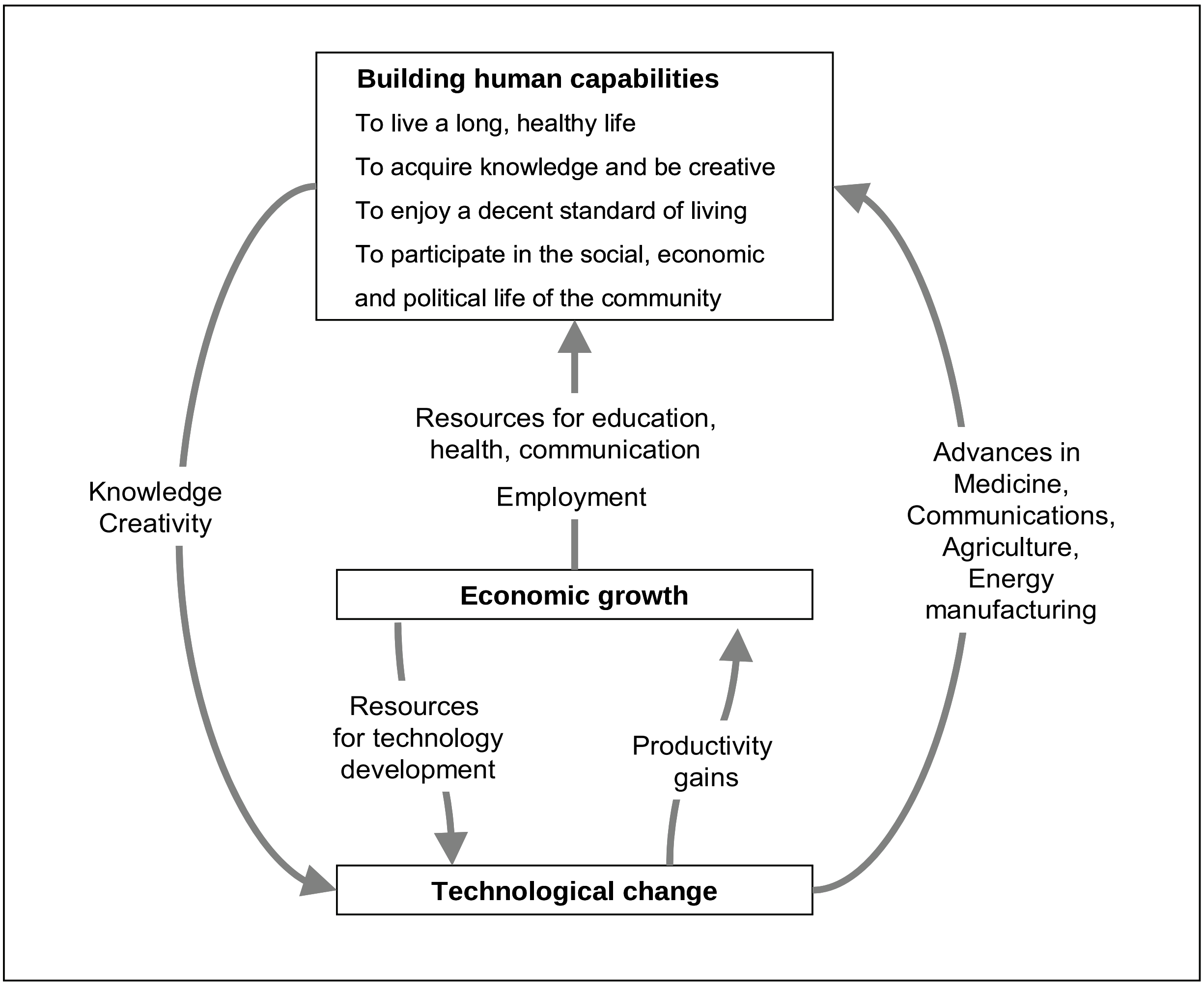

Figure 3
Links Between Technology and Human Development
UNDP – Human Development Report 2001, 45

1.1.2.3 The technology/innovation view

In *Guide to Measuring the Information Society*, OECD (2005, 15) takes a decidedly ICT view of the information society: "That we live in a period of unprecedented technological change, both in terms of the extent and speed of change, has been discussed extensively. Many of the underlying transformations are undoubtedly associated with the set of interrelated and, more recently, converging technologies that have come to be known as ICT. They permeate every aspect of life − economic, social, political, cultural and otherwise − and have created great interest regarding their actual and potential impact". The OECD (2005, 15) acknowledges that "there is no agreed comprehensive statistical framework of the information society" and, taking an economic view, develops a conceptual model for measuring the production of and demand for "ICT products" which may be "ICT goods and ICT services."

The latest OECD measurement trends entail a broadening of definitions from the purely technological view to include innovation. Dryden (2007) says that this view "explores the growing interaction between knowledge and globalization at the centre of the ongoing transformation of OECD economies." The OECD scorecard for 2007 measurement purposes is expected to cover the following categories, which go beyond ICTs and include many categories in the area of innovation:

A. R&D and Investment in knowledge (e.g., Health-related R&D)
B. Human resources in Science & Technology (Earnings by level of skills)
C. Innovation Policy (Tax treatment of R&D)
D. Innovation Performance (Economic Performance due to innovation)
E. ICTs (Broadband and security)
F. Specific Technologies (Biotechnology, Nanotechnology, Environmental Technologies)
G. Internationalisation of S&T (R&D sources from abroad)
H. Global Economic Flows (International outsourcing in intermediary inputs)
I. Productivity and Trade (Technology- and knowledge-intensive industries) (Dryden, 2007).

1.1.2.4 The employment pattern view

Brinkley (2006) argues for a view of the knowledge economy that is based on employment patterns, as well as the changes in those patterns in the "knowledge-based industries" as defined by Eurostat. These would include: high to medium technology manufacturing, communications, financial and business services, health and education; and also recreational, cultural and sporting services and some travel services (sea and air) that the OECD excludes. It should be noted that Brinkley's motivation is to find credible and tractable means of measuring the knowledge economy and its significance. As an example of this type of representation of the knowledge economy, consider Table 1, which sets out the proportions of employment that are accounted for by the knowledge-based industries in the EU15 group of countries.

	Manufacturing	Services	Total
Sweden	6.5%	47.8%	54.3%
Denmark	6.3%	42.8%	49.1%
UK	5.6%	42.4%	48.0%
Finland	6.8%	40.5%	47.3%
Netherlands	3.3%	41.9%	45.2%
Belgium	6.5%	38.3%	44.8%
Germany	10.4%	33.4%	43.8%
France	6.3%	36.3%	42.6%
Ireland	6.0%	33.9%	39.9%
Austria	6.5%	31.0%	37.5%
Italy	7.4%	29.8%	37.2%
Spain	4.7%	27.0%	31.7%
Greece	2.1%	24.5%	26.6%
Portugal	3.3%	22.7%	26.0%
EU15	6.7	34.7%	41.4%

Table 1
2005 EU15 employment in knowledge based industries
Brinkley and Lee, 2006, 6

1.1.3 The knowledge economy without an economics of knowledge

The views of the knowledge economy discussed above in Section 1.1.2 vary in many respects. However, the important characteristic they share is that they all are macroeconomic in perspective. They are concerned with aggregations such as knowledge production and consumption, sector definitions, industry production, employment patterns and national economic performance. These views or approaches are not theoretical; while they involve conceptualizations, these are not intended to be explanatory or to be predictive of events or behaviour in the knowledge economy. They are concerned primarily with measurement of the knowledge economy at the aggregated level. There is nothing inherently wrong with this approach, but it does not offer any economic *theory* of knowledge as such.

The knowledge economy is regarded by many (Castells, 2002; Quah, 2002; Mokyr, 2002; Machlup, 1962; Lamberton, 1971; Boulding, 1966; Stiglitz, 1999, Dahlmann et al, 2005) as a significant and burgeoning aspect of especially, but not exclusively, developed economies. Machlup (1962), for example, estimated that up to 29% of production in the United States in 1958 could be accounted for by the knowledge sector. Information and knowledge are even regarded as central to all economic processes (Gagnon, 2007). Why then has the discipline of economics not yet provided an adequate theoretical treatment of information and knowledge? According to Stigler, "One should hardly have to tell academicians that information is a valuable resource: knowledge is power. And yet it occupies a slum dwelling in the town of economics" (1968, 171 in Lamberton [1971, 8]). While Mokyr (2005, 202) notes the attempts to provide such theories being made by economists Gary Becker and Kevin Murphy (1992), philosophers such as Philip Kitcher (1993) and the evolutionary epistemologists Donald Campbell (1960) and David Hull (1988), he points out that an economics of knowledge "is a difficult theoretical problem". In discussing the economics of information and knowledge, Stiglitz (1999, 165) says: "We are all in uncharted territories, and we will have much to learn from the experiments of each other."

Accepting the difficulties involved, and that no adequate theoretical framework for an economics of knowledge has emerged, we may still ask: What would constitute an adequate economic theory of knowledge? For Lamberton (1971, 7), "the economics of information and knowledge...analyses the processes by which information and knowledge is produced, diffused, stored, and used." Thus, information and knowledge entities or objects would be the focus of such an analysis. This would be the case whether such objects are used to support transactions in markets, in the production of physical products, or to produce other knowledge. The point is that an economics of knowledge must focus on knowledge and explain how it is "produced, diffused, stored, and used." Boulding (1966, 22) begins by first defining economics as "the study of the 'econosphere'...as that subset of the sociosphere, or the sphere of all human activity, relationships, institutions, which is particularly characterised by the phenomenon of exchange." Going further, he (1966, 23) says "as it is exchange or potentiality of exchange or relevance to exchange that makes things commodities, one would think that economists would be interested in knowledge itself as a commodity." While Lamberton emphasizes knowledge and its creation and dissemination as the focus of an economics of knowledge, Boulding goes further in saying that it is the exchange of knowledge as a commodity that an economics of knowledge must explain.

Attempts to construct an economics of knowledge have to deal with conceptual difficulties that bring to light the specific ways in which the dominant neoclassical economic paradigm is ill-suited to such an exercise. "The production of knowledge is, for the greater part, not guided by the market mechanism. Most of the knowledge produced is not purchased by the consumer at a price but is offered to him free of charge" (Machlup, 1962, 28). Lamberton (1971, 12) says that "the conclusion might be drawn that the traditional equilibrium mode of thought is not well-suited to the analysis of the processes by which information and knowledge are created, diffused, stored and used." Lamberton's anthology, *Economics of Information and Knowledge: Selected Readings*, is of particular relevance to this research because it is concerned with the microeconomic aspects of information and knowledge and the "selection of papers and the structuring of the volume reflect an attempt to explore the extent to which the customary conceptual framework of economics permits an adequate treatment of the role of information and knowledge in economic activity" (1971, 12). In short, traditional economics cannot comfortably and fruitfully accommodate information and knowledge *as products or commodities*. Boulding (1966, 23) identifies several characteristics of knowledge that make a knowledge economics difficult to achieve:

> [T]he absence of a unit of knowledge itself, however, and perhaps the intrinsic heterogeneity of its substance, makes it very difficult to think of a price of knowledge as such, and indeed has probably contributed to a certain resistance which we feel to thinking of knowledge as a commodity…Another difficulty is that only things which are clearly capable of being appropriated are subject to being exchanged, and if a thing cannot be property, it obviously cannot be a commodity. While knowledge has many of the aspects of property, its capacity for reproduction in many minds and its accessibility in the form of the published word make it a very peculiar form of property.

Stiglitz (1999, 1) argues "that there are some fundamental ways in which knowledge is different from ordinary commodities, differences which have fundamental implications for the way a knowledge economy must be organized, and accordingly, fundamental implications for public policy." He goes on to (1999) identify the following peculiar characteristics of knowledge: it is non-rivalrous, meaning that its consumption by one economic agent does not exclude its consumption by other agents; the economic effect, and the externalities, that result from new knowledge may be of an order of magnitude greater than is typically the case for new physical products; and knowledge is less subject to competition because it gives rise to increasing returns to scale.

Theorizing the knowledge economy, therefore, is challenging precisely because the neoclassical economic paradigm is fundamentally ill-suited to explaining the creation and distribution of knowledge. As Boulding (1966, 26) points out: "It is only information and knowledge processes which in any sense get out from under the iron laws of conservation and decay, though they only do this, as it were, by operating at another level." The knowledge economy has developed without an economics of knowledge; knowledge is being produced and exchanged in apparently large quantities *sans* an economic theory. While this is a striking confirmation that history and praxis do not wait for theory, it is troubling that we do not have an adequate theory for such a significant phenomenon. In this regard, Boisot's project is a valuable set of conjectures and worthy of research.

1.2 Boisot's project

It is necessary at this stage to discuss by way of introduction what is referred to in this thesis as 'Boisot's project'; later sections delve more deeply into all of the issues presented in this section. Boisot's project refers here to the pursuit of an intellectual aim which is inter-disciplinary, operates at distinct conceptual levels (the paradigmatic-ontological, the general theoretical, and the theoretical), and culminates in a compound conceptual framework rather than any kind of specific research outcome, such as a specific new theory or a conclusion about some existing specific theory. To refer to such a pursuit as 'Boisot's theory' would fall short of what Boisot has put forward; and to refer to it as 'Boisot's research programme' would be to claim too much for it given that other authors operate in the same domain, and a few, including Machlup (1962), Boulding (1966) and Marschak (1968), articulated similar concerns before Boisot did (1995).

Boisot's project, first set out in his 1995 text titled *Information Space – A Framework for Learning in Organisations and Culture*, is ambitious (Walsham, 1998, 613); and has been well received (Hovenden, 1998, 227). Ashford's (1997, 353) review noted it as "a path-breaking text which lays the foundations of a new political economy of information…[it] addresses issues that are at the heart of information science." It is indeed a bold project, which in Boisot's (1995) words, sets out to "delineate the contours of a political economy of information"; to make sense of the "weightless economy". While the project does go beyond economics, also dealing with culture, for example, its economic aspect is central.

The "political economy of information" is defined by Boisot as "the theory of its production and exchange" (1995, 6). Boisot's "political economy of information" is thus fully inclusive of Boulding's (1966) and Lamberton's notion of an "economics of knowledge" as discussed in Section 1.1 above: "...[O]ur task in this book: a study of the production and exchange of information as a phenomenon subject to economizing..." (Boisot, 1995, 36). Stiglitz (2001, 522) uses the phrase "political economy of information" in a different sense, in that he regards it as being related more specifically to "the ways in which information affects political processes"; for Stiglitz, "information imperfections, and asymmetries of information, are pervasive in every aspect of life and society" and would thus have an effect on political processes and institutions. Mokyr (2002, 282) also uses the term "political economy of knowledge"; however, his conception is more akin to Boisot's, in that he regards it as crucially about both the diffusion of existing knowledge and the growth of new knowledge.

Boisot (1995, 1999) is unequivocal about the significance of information and knowledge in the contemporary world, and the resulting historical transformation: "The second half of the twentieth century will be remembered as the period in which information came to replace energy as the central fact of life in post-industrial societies" (1995, 10). For Boisot, information is central to the new "techno-economic paradigm" that drives productivity, and is evidenced particularly by the massive growth in employment in the services sector since the 1950s. "If we take information to be the dominant form of wealth in most post-industrial societies – that is to say, if we treat it as an object of, as much as a support for, economic exchange – we can view our mission...as preparing the ground for a political economy of information" (1995, 94). Boisot is thus by no means an information society naysayer.

Boisot (1995, 5) is motivated by the view that the economic production and exchange of ideas "in the knowledge-intensive society" is fraught with complications to the extent that properly functioning markets and trading are unlikely to occur. "We have an economic theory that can help us to understand and hence to manage the production and exchange of tangible objects like cornflakes and houses, but, as yet, no satisfactory economic theory to help us manage the production and exchange of intangible objects like knowledge." Thus, Boisot proceeds from the view that knowledge cannot be "subjected to the same laws of production and exchange" as tangible products, since knowledge is fundamentally different. A "Newtonian economics" – the neoclassical, competitive, energy-based paradigm – will not do for Boisot's purpose; a new paradigm or "Gestalt switch" is necessary for *any* economics of knowledge to emerge (1995, 21). It is for this reason that Boisot must attempt his project from the ground up, so to speak; in rejecting "Newtonian economics", the paradigmatic and theoretical slate of neoclassical economics is wiped clean, with Boisot setting out to provide a new paradigm as the foundation for an economics of knowledge. Here again is evidence of Boisot's intellectual daring, as the neoclassical economic paradigm is not easily ignored. "There is fermentation, there is interest, but a paradigm, in the sense of a conceptually articulate framework that can compete with the neoclassical one in explanatory scope, there is not" (1995, 13). Ultimately, Boisot's project is directed at the problem of an inadequate economics of knowledge.

Boisot's project offers two important outcomes: (1) a paradigmatic-ontological synthesis; and (2) the Information space (I-space) – a "hypothesis" or "general theory" (Boisot, 1995, 167). A key feature of the paradigm is the "evolutionary production function", which posits the substitutability of data and matter. In constructing a new paradigm, Boisot's project proceeds philosophically – as it must in Kuhn's conception of "paradigm"; and it entails numerous philosophical and theoretical antecedents that, while they are not originally conceived by Boisot, are woven together in an impressive and original paradigmatic-ontological synthesis. These antecedents are drawn from a broad, multi-disciplinary literature, with Boisot's synthesis incorporating various extant streams of thought: Maupertius's theory of "Least Action" as a universal organizing principle and "the physical basis" of information are explored and adopted as ontological commitments; systems and complexity theories are chosen in opposition to the Newtonian scheme of mechanism and linear, closed systems; and, most importantly in the context of this research, *there is a firm and general commitment to evolutionary thinking and evolutionary change* as opposed to mechanical change.

Boisot (1995, 37) claims much for the I-space, his general theory: "[I]t offers *greater generality*"; it is "more *realistic*" and "promises *greater explanatory power*"; and it "offers the advantage of *relevance*". The I-space theoretical framework is the culmination of Boisot's project and his most original contribution. He describes it as follows:

> In this book we present a conceptual tool, the Information Space or I-space, that can be used to study the codification, abstraction, and diffusion of knowledge – i.e., its production and exchange – in a social system. The I-space allows us to study how knowledge and information flow through the system and how they evolve as they do so (1995, 23).

The I-space is a conceptual framework for an economics of knowledge as conceived by Boulding (1996). Boisot does not avoid the difficulty of approaching knowledge epistemologically. Indeed, Boisot *begins* philosophically, and his project includes a treatment of the epistemological aspects of data, information and the creation of knowledge. In this sense, the I-space has one foot in economics and the other firmly planted in epistemology. The I-space is *an epistemological framework both in terms of Boisot's in-depth treatment of data, information and knowledge, but also because the primary concern of the I-space is the growth of knowledge.*

While both the paradigm and the I-space "general theory" may not be assessed in the strict Popperian sense, they are approached in this research with due Popperian respect for bold conjecture. Thus, the I-space is taken seriously as an *explanatory framework* rather than being regarded merely as a visualization device or a convenient representation of conceptual broad strokes. As an explanatory framework, the I-space explains *and* is predictive, although not in the strict deductive scientific sense.

Apart from the general commitment to evolutionary thinking that Boisot makes in the formulation of his paradigm, he also makes a clearly stated specific commitment to evolutionary thinking in his formulation of the I-space. Thus, the I-space is characterized in this thesis *as an explanatory, evolutionary, epistemological framework for an economics of knowledge.* In the context of this research, it is best to say that the I-space is *putatively* evolutionary.

1.3 Research problem and approach

The knowledge economy is by many accounts a burgeoning mega-trend without an adequate economic theory, and I concur wholeheartedly with Boisot (1995, 9) that "what is now needed is a far-from-equilibrium information economics which allows for innovation, evolution, and learning." The I-space is Boisot's bold and valuable conceptual framework for just such an economics of information and knowledge. This thesis focuses on the evolutionary nature of the I-space. It is a comparative conceptual assessment that tests whether the I-space framework, as set out in Boisot's 1995 *Information Space*, is indeed evolutionary in a strict, generalized Darwinian sense. It is a contention of this thesis that the claim that the I-space is evolutionary constitutes a core commitment that, apart from Boisot's stated commitment to evolutionary thinking, needs to be tested in the paradigmatic context of Boisot's project.

The hypothesis is that the I-space is not evolutionary in the contemporary generalized Darwinian sense. The extent to which this assessment succeeds or fails in its hypothesis – or is even indeterminate – has implications for the critical treatment of the I-space, and will hopefully contribute in some way to theoretical development in the sphere of the economics of knowledge. A failure to satisfy the generalized Darwinian evolutionary criteria identified in this research calls into question whether the I-space is evolutionary at all; *but it does not, and indeed cannot, prove it as a fact*, since the Darwinian evolutionary framework is not the only extant conception of evolution, nor is it the only logically possible conception of evolution. However, since it is the dominant contemporary conception of evolution, it makes sense to begin with Darwinism.

This research does not test any of Boisot's specific hypotheses nor does it test the veracity of the I-space in describing things as they actually are. As pointed out in Section 1.2, this assessment is not approached as a Popperian refutation, as, according to Boisot himself, no specific, testable hypotheses are put forward. Similarly, this research does not assess Darwinian evolutionary thinking or any of its theories *per se*. Rather, it assesses the claim that the I-space is evolutionary; it is a comparative assessment of conceptual isomorphism between a derived generalized Darwinian evolutionary framework on the one hand, and the I-space as a general theoretical framework on the other.

1.3.1 Generalized Darwinism as the conception of what it means to be evolutionary

The "generalized Darwinian" construct is explored to identify a set of *general*, core criteria that may be applied to any conceptual framework that is putatively evolutionary. Locating the conception of what it means to be evolutionary in this Darwinian construct, instead of some other extant conception of evolution, is a conscious choice; however, this research does not set out to demonstrate that the Darwinian version is the only, or the best, available conception of what it means to be evolutionary. Thus, this research is concerned with the evolutionary/non-evolutionary demarcation problem from a generalized Darwinian perspective. This choice is not arbitrary. Chapter 4 provides support for contemporary Darwinism as the dominant conception of evolution. Developing such a conception is an important aspect of this research, and is thus dealt with in detail; the "contemporary generalized Darwinian' construct and its criteria are focused on in Chapter 5; and Chapter 6 deals with the assessment of each of these criteria in relation to the I-space.

The assessment undertaken in this research depends primarily on discerning general Darwinian evolutionary criteria. The challenge is to do so in a pluralistic field of thought. Darwin himself was a pluralist (Mayr, 1988, 197). Nordgren (1995) also deals with what he calls the "pluralism in evolutionary theory". Sober (1993) discusses "the threat from without" – that is, the creationist threat – and the "turmoil within" – that is, the various theoretical controversies in evolutionary theory.

Apart from the pluralism of evolutionary theory, Darwinism itself has changed over time. It has been 150 years since Darwin and Wallace (1858) published their joint statement, and since Darwin published *The Origin of Species* (1859). Over this period, the Darwinian evolutionary model has been the subject of much research and debate. As a theory, it has enjoyed sometimes broad acceptance, sometimes broad rejection, and at other times, qualified acceptance of certain of its aspects while other aspects have been rejected. Thus, what might constitute contemporary Darwinism cannot be taken for granted.

So what do the terms "evolution", "Darwinism" and "generalized Darwinism" mean in *contemporary* discourse? There are no uncontested, concise answers to these questions. Moreover, these terms have meanings that have changed in the course of their long histories, with different authors describing them in different ways. Writing about the term "Darwinism", Mayr (1988, 196) says: "This term has numerous meanings, depending on who has used the term and at what period." A further difficulty, and one that explains the lack of concise definitions of the terms "evolution" and "Darwinism", is that they refer to compound theories. "Darwin's theory of evolution was a whole bundle of theories, and it is impossible to discuss Darwin's evolutionary thought constructively if one does not distinguish its various components" (Mayr, 1988, 198). And the various components simply do not fit neatly into a nutshell. Mayr himself had to write a entire book titled *What Evolution Is* (2002) simply to describe contemporary Darwinian evolutionary thinking in biology. Nevertheless, this research must arrive at some conception of what "contemporary generalized Darwinism" entails before proceeding to assess anything against the yardstick of "contemporary generalized Darwinism".

On what basis does this research arrive at a *contemporary* conception of Darwinism? One aspect of the approach used here is described by Hodgson and Knudsen (2006, 2): that there is little value to be had in "starting from the vague and fruitlessly contested word evolution" and that a more useful approach would be to consider what it is, in general, that evolutionary thinking aims to explain. To this end, Chapter 3 considers Darwinism from a number of contemporary perspectives: in biology, evolutionary economics, evolutionary epistemology and generalized Darwinism. In considering these multiple applications of evolutionary thinking, the task of identifying the logical criteria of the contemporary generalized Darwinian model is made tractable; a generalized Darwinian framework is discernable in the various "applications" of Darwinism and in the discourse of generalized Darwinism.

A second aspect of the approach used in this research to mitigate the definitional difficulty is that espoused by Nelson (2007, 91): that while Darwinism is broadly applicable to evolutionary processes in disciplines outside of biology, "hunting for or constructing analogies [of biological concepts] on the presumption that they ought to be there" should be avoided Thus, beginning with Darwinism in its contemporary biological conception is simply a matter of logical convenience and historical accuracy, given that Darwin first developed his evolutionary framework, concepts and language in that discipline. But this should not be construed as biological reductionism or biological imperialism. That this chapter considers Darwinian evolutionary thinking in other disciplines attests to this. The assessment of isomorphism between generalized Darwinism and the I-space is highly conceptual rather than an assessment of one-to-one, literal correspondence between Darwinian organic evolution and the I-space, in which the organic conception is taken to be the template.

1.3.2 The conceptual assessment of general theory

Boisot's stated objective is not to formulate specific theories in the scientific sense, but rather to put forward a general theory or framework. In addition, occasionally he uses concepts and theories as expository devices without necessarily claiming them as firm commitments. This makes it challenging to identify those commitments that may be subjected to a Popperian refutation or indeed to any kind of assessment. Boisot sets out his intention as follows:

> The book sets out a broad conceptual scheme that indicates the kind of thinking about information that economists and those in related social science disciplines will have to undertake if information is to be credibly incorporated into their theorizing. The scheme explores the conditions in which information is produced and exchanged in human affairs and, using broad qualitative strokes, it brushes the outlines of what could be called a political economy of information (Boisot, 1995, 22).

In this way, the I-space, as a "general theory" is insulated from a strict Popperian refutation. In reference to the I-space, Boisot notes: "The hypothesis, as developed here, receives only a general formulation and is therefore not cast in a form that would make it easily refutable" (1995, 167). He reiterates this point: "This book does not offer an economic theory of information as such. Rather, it maps out the contours of the territory that such a theory would have to cover" (1995); and further, "What we offer here is not an articulate and refutable theory but a rough conceptual guide to further thought and action in this area, a framework based on a heuristic principle in Simon's sense of the term" (1995, 37).

What, then, would constitute an admissible assessment of such a "general theory"? The research approach adopted here proceeds from the principle that the I-space should be assessed on its own terms; and following from this, that the I-space should be approached as a conceptual framework rather than attempting to squeeze out firm theoretical hypotheses or predictions that may then be assessed against things as they are. The strategy in this analysis is to unearth the paradigmatic and conceptual commitments inherent in the I-space. Thus, this thesis identifies the claimed evolutionary nature of the I-space as a core commitment and assesses the broad "sketch" put forward by Boisot on this front.

The Darwinian theories of evolution are also not regarded by some authors as testable scientific theories in the Popperian sense. "Newton formulated a set of universal laws intended to describe the interaction, and consequent behaviour, of the physical universe. Darwin's theory of evolution proposed no such universal laws. There are no Darwinian laws of evolution" (Popper, 1978, 267). "The principle of natural selection is more comprehensive than a specific theory, and it has therefore been referred to as a generic theory or basic general principle (Tuomi and Haukoja 1979; Tuomi 1981; Beatty 1981; Brandon 1981), which as such can neither be refuted nor does it have predictive powers. It becomes a genuine theory, called by Tuomi a theoretical model, only when enriched with specific ancillary assumptions…" (Mayr, 1988, 97). Thus, in testing Boisot's "general theory" against the generalized evolutionary framework, we are testing "apples against apples", so to speak; we are not demanding more from the I-space than what its author is prepared to claim for it.

1.3.3 Thesis flow

The thesis proceeds as follows: Chapter 1 explores the significance of the knowledge economy as the context and impetus for Boisot's project and the notion of both the "knowledge economy" and an "economics of knowledge"; Chapter 2 provides an analysis of the I-space that explores its underlying concepts and dimensions; Chapter 3 explores Boisot's inherent commitment to evolutionary thinking at the paradigmatic level, and his specific commitment to evolutionary thinking in the formulation of the I-space itself; Chapter 4 discusses Darwinism at the core of the contemporary evolutionary concept by providing an overview of evolutionary thinking, a discussion of Darwinism in contemporary biological evolutionary theory, Darwinism in evolutionary epistemology, Darwinism in evolutionary economics, and the discourse in generalized evolutionary thinking; Chapter 5 discusses the contemporary Darwinian evolutionary construct and its criteria; Chapter 6 contains an assessment of the I-space in terms of the minimum criteria; and Chapter 7 sums up the thesis, discusses its implications, and raises and discusses related areas for further research.

Chapter 2

Conceptual analysis of the I-Space

> *I can therefore gladly admit that falsificationists like myself much prefer an attempt to solve an interesting problem by a bold conjecture, even (and especially) if it soon turns out to be false, to any recital of a sequence of irrelevant truisms.*
>
> Karl Popper, 1989, *Conjectures and Refutations*

The Information Space (I-space) is a bold conjecture directed at the interesting problem of an economics of knowledge, and Boisot's most original contribution. The I-space is not just a descriptive device, although it may serve such a purpose as an aid to visualization. It is a compound conceptual framework for understanding the creation and diffusion of knowledge. It is in the formulation of the I-space that Boisot's project to delineate the "outlines of what may be called a political economy of information" (1995, 22) reaches a culmination; and, it is the I-space, according to Boisot's definition thereof, that constitutes the groundwork for an economics of knowledge in Boulding's (1966) conception.

> In this book we present a conceptual tool, the Information Space or I-space, that can be used to study the codification, abstraction, and diffusion of knowledge – i.e., its production and exchange – in a social system. The I-space allows us to study how knowledge and information flow through the system and how they evolve as they do so (Boisot, 1995, 5).

The I-space has remained conceptually unchanged since its first and most detailed formulation in 1995, and this reflects a steadfast commitment. Within the I-space, the foundational concepts of data, information and knowledge have also remained unchanged in Boisot's work between 1995 and 2004 – further evidence that the I-space as a whole has remained stable. The following quotations bear this out:

> Our basic proposition is that the way that useful knowledge is produced – essentially, as we shall see, through a process of codification and abstraction – facilitates its subsequent diffusion, and hence the terms on which it can be exchanged (Boisot, 1995, 26).

> …The I-Space is a framework for the dynamic analysis of knowledge flows which takes the structuring and sharing of information to be positively related (Boisot, 1999, 525).
>
> …The I-space builds on the proposition that the structuring of data facilitates its diffusion. The structuring of data, the process through which information is extracted from data, achieved through acts of codification and abstraction (Boisot, 2004, 6).

While the I-space has remained stable over numerous publications, as discussed in Chapter 1, it receives its most detailed explication in Boisot's 1995 work *Information Space*. Thus, it is the 1995 work that is most heavily relied on in this thesis as the definitive explication of the I-space.

2.1 Foundational concepts of the I-space

2.1.1 Data

For Boisot, data is a cognitive relation between a data-processor and discernable differences in physical states. Thus data, in the first instance, has a physical basis, but is restricted by the observer's ability to discern differences in physical states. This is an important epistemological statement, since Boisot defines data relationally – not as physical states of the world in themselves – but as states that are *discernable* by an agent. "Data" then is an act and an ability rather than being purely a state or an energy difference.

> Data itself can then be thought of as an energetic phenomenon that links us in our capacity as knowing subjects to an external physical world. Data in its most basic formulation is a discernable difference in energy states of phenomena as they occur and propagate in space-time, whether as matter or electromagnetically…Any state, to qualify as such, must have spatiotemporal extension, however brief, and be potentially discernible to an "observer"; that is, it must register as data with some entity that can process it as such as well as being a purely energetic phenomenon (Boisot, 1995, 22).

2.1.2 Information

In Boisot's conception, information is extracted from data in the form of regularities: "Information constitutes an *extraction* from data that acts upon our probability distribution and either modifies or reinforces them…" (1995, 22); "Information constitutes those significant regularities residing in the data that agents attempt to extract from it" (Boisot and Canals, 2004, 6). However, Boisot (1995, 47) also says: "Information is about originality. It is the unexpected, that which causes surprise. Some experiences, however, are so original as to become well-nigh unintelligible; nothing can be made of them at all." Information that does not change the agent's expectations is non-informational; a peculiar event does not provide sufficient data from which a regularity may be extracted, and is thus also non-informational, but in a different sense. Boisot's notion of information is closely related to that of knowledge. Information extracted from data acts on the knowledge already held by the agent by either modifying it or adding to the stock of their knowledge.

2.1.3 Knowledge

An understanding of Boisot's concept of knowledge is crucial to understanding the I-space, given that the I-space is primarily concerned with knowledge: its creation, its form, its value, and the way in which it becomes distributed.

> As Popper has stressed, knowledge is dispositional, a readiness to act on the basis of beliefs, more or less firmly held, concerning the world or some part thereof (Boisot, 1995, 22).
>
> ...knowledge is a set of expectations held by agents and modified by the arrival of information (Arrow, 1984) (Boisot and Canals, 2004, 6).
>
> …Like the pragmatists and the evolutionary epistemologists, we are inclined to associate knowledge more with a disposition to action than with the disinterested pursuit of truth, that is, we are more aligned with Peirce, James, and Campbell, than with Plato (Peirce, 1868; James, 2000; Campbell, 1974). Although these two views of knowledge are not actually incompatible, the focus here is thus on the value of knowledge to an action system such as a living organism rather than on abstract truth conditions that need to be met in order to achieve a given level of certainty (Boisot, 2004, 2).

Thus, Boisot's "knowledge" is, in the first instance, conceived subjectively; it is the "set of expectations" held by an agent; in other words, that agent's disposition to act on the basis of internally held, tentative sets of beliefs. This view is associated with Popper's rejection of the notion that we are able to achieve certainty as an epistemic outcome. Boisot's notions of data, information and knowledge are related, forming a chain from sense data to the creation and modification of knowledge.

> To summarise, we might say that information is an extraction from data that, by modifying the relevant probability distributions, has a capacity to perform useful work on an agent's knowledge base (Boisot and Canals, 2004, 7).

This is interesting in that, in terms of the above definition, extractions from data that *do not* modify an agent's probability distributions are *not* construed as information. In this sense, that which is merely confirmatory is not information, as it does not change the agent's expectations.

Boisot acknowledges that the chain – data→information→knowledge – is not the only route to knowledge creation:

> Where an adequate repertoire is not available, however, cognitive innovation becomes necessary. Langley and his co-workers term such innovation "data driven" when it originates with percepts, and "theory driven" when it emerges from purely conceptual deliberations (Boisot, 1995, 65).

Thus an important concession is being made in regard to knowledge creation: new concepts may be formed without direct reference to data. In such a process, knowledge is the result of "conceptual deliberations"; the agent's expectations may be altered through reflection rather than purely through direct experience of data. Boisot's distinction between "concept" and "percept" is akin to Whitehead's (1945) distinction between "prehension" – which is the act of perception or percept formation – and "apprehension" – which includes the act of concept formation and which in Boisot's terms may be represented as follows: apprehension = percept + concept formation.

> Only to unreconstructed empiricists are perceptions always immediately given; to those who accept the research findings of modern physiology, sensation can never be totally naïve but is always to some extent "theory laden" (Boisot, 1995, 56).

But there is a difference between "theory laden" and "theory driven". "Theory laden" refers to the observer's conceptual filter as it operates in the relational act of data or sense perception (what Whitehead [1945] calls "prehension" and what Boisot calls "percepts"). On the other hand, "theory driven" refers to *acts of concept formation* that are not directly based on or prompted directly by "data" (Whitehead's "apprehension" and Boisot's "concepts"). This distinction is important, since it would entail a qualification of what "discernable" means in Boisot's "data". In addition to referring to the physical limits of our senses both as a species and as individual agents, what is discernable may also be constrained and influenced by the agent's conceptual repertoire. Moreover, the distinction brings into view an aspect of knowledge creation that Boisot's "structuration" chain – data→information→knowledge – does not explore in detail; that is, the aspect of conceptual knowledge creation which at times entails very high-level conceptual constructs that are often far removed from the world of data as observable energy differences.

2.1.4 Codification

A discussion of the difference between coding and codification assists in understanding these concepts in Boisot's conceptual scheme. Coding refers to "the act of assigning phenomena to categories" (Boisot, 1999, 42) and suggests "a completely autonomous process carried out by unique individuals" (Boisot, 1995, 111). Codification, meanwhile,"creates perceptual and conceptual categories" (Boisot, 1999, 42) and suggests that the process is "at least in part socially structured" (Boisot, 1995, 111). Coding is highly subjective, with Boisot (1995, 41) noting that: "Perception can then be thought of as a coding activity in which subtle and elaborate inferences are drawn from neural signals that bear some homomorphic relationship to incoming energy patterns. Such inferential activity is the very process through which information is extracted from data." Coding, therefore, is described as a necessary coping mechanism in the face of the sheer quantity of data (Boisot, 1995, 47).

Codification economizes on the quantity of information to be processed by reducing the number of attributes that have to be dealt in sense data (Boisot, 1995, 57). "The higher the degree of coding, the less the amount of data [needed] to describe the object" (Boisot, 1995, 51); "The degree of codification of a unit of length of that message, is defined as the reciprocal of the number of bits of information required to transmit it" (Boisot, 1995, 143). Thus, where the degree of codification approaches zero – that is, the number of bits required to represent the object approaches infinity – then we approach the ineffable. At the other end of the scale, the highest degree of codification is reached when only one bit is required to represent the object.

> Codification draws distinctions and articulates boundaries between states or around objects. Codification is a precondition for the creation of objects and categories (Boisot, 2004, 6).

Boisot's distinction between uncodified and codified knowledge is also instructive in understanding his concept of codification and its role as a dimension of the I-space:

> Uncodified knowledge: knowledge that cannot be captured in writing or stored without losing the essentials of the experience it relates to – i.e., of the smile on your child's face; of a sunrise on Mount Taishan; of riding a

> bicycle; of playing a guitar; of a headache…Codified knowledge: knowledge that can be stored or put down in writing without incurring undue losses of information – i.e., stock market prices; the Tudor Constitution; the chemical formula for benzene; a postal address (1995, 145).

2.1.5 Abstraction

Abstraction is the process of categorization that entails "generalization…on the basis of a few stimuli, to recognize and respond to a much larger and possibly more varied class of stimuli" (Boisot, 1995, 54). Such categories, which may be conceptual or perceptual in nature, "share a common aim: complexity reduction – making sense of the world with a minimum consumption of the organism's scarce data processing resources" (Boisot, 1995, 56).

> Abstraction treats things that are different as if they were the same (Dretske, 1981). It either associates or – if they are recurrent – correlates the objects or categories discerned or created by codification and allows one object or category to stand in for another…" (Boisot, 2004, 6).

Codification is closely related to abstraction, but they are not equivalent concepts. In explaining the difference, Boisot (1995, 56) describes the function of codification as economizing on the quantity of data to be processed, while abstraction reduces the number of categories used in filtering sense data. Codification selects, and thus reduces, the "attributes to be attended to", while "abstraction economizes on categories" (Boisot, 1995, 58–59).

> A well-chosen coding strategy...cannot fully function unless it is accompanied by insights into the structure of phenomena that give codes their initial purchase. Insight calls for a skill which is quite distinct from coding. It is called *abstraction* (Boisot, 1995, 54).

> …Abstraction, then, can be thought of as a choice among competing hypotheses concerning which categories better capture a perceptual attribute. In contrast to the computation paradigm, the categories are not given *a priori*; they have to be discovered through a process of hypothesis creation and testing that make them emergent properties of the microstructure of cognitive process (Boisot, 1995, 59).

Boisot acknowledges that perceptual detail is lost in the process of abstraction. A further crucial qualification is that "coding and abstraction, then, may help to make experiences more communicable…but they do not thereby convert them into valid knowledge (1995, 66).

Nevertheless, the contention is that abstraction as "symbolic coding" lies at the heart of the notion of the economic value of information:

> In sum, abstraction might be described as a move away from a process of manipulating images or other objects of experience that have been given form – call this iconic coding – and towards operating with symbols that are more easily manipulated, stored, and retained in memory because they have been largely drained of perceptual content…If information is then taken as having value – this, after all, is one of the basic themes of this book – then symbols act as a measure of information, as a store of information, and as a means of information exchange (Boisot, 1995, 60).

Boisot's notion of abstraction is subtly different from the traditional concept of abstraction as generalization. Boisot splits the traditional notion into abstraction and codification. Both are forms of generalization; however, in the I-space, codification generalizes attributes while abstraction generalizes categories; abstraction operates on codifications and is therefore a higher level of generalization (and of a higher level of abstraction in the traditional sense). Codification does not operate on the singular phenomenon, since one can only discern regularities on the basis of multiple data instances. Abstraction cannot operate on simple, single-attribute codifications. Consider an example. There is a set of five things before me. I codify this set using the following attributes: they all have an "outer sheath of wood", with a "graphite centre", and are "used for writing". I abstract from these attributes: these things are all of the category "pencils". In this example, "pencils" is an abstraction as it groups attributes into a category. Clearly there are higher degrees of abstraction, since "pencils", "pens", "quills", "crayons" and "chalk" may be captured by the category "writing instruments" at a higher level of abstraction; a similar example may be constructed for "stationery". Thus, abstraction is based not only on perceptual categories, but also economizes on conceptual categories. An important feature of codification and abstraction is that they are matters of degree. Figure 3 sets out the relationship between the degree of coding and abstraction, on the one hand, and number of attributes and categories on the other. The smaller the number of attributes and categories required to describe an abstraction, the greater the degree and economy of that abstraction.

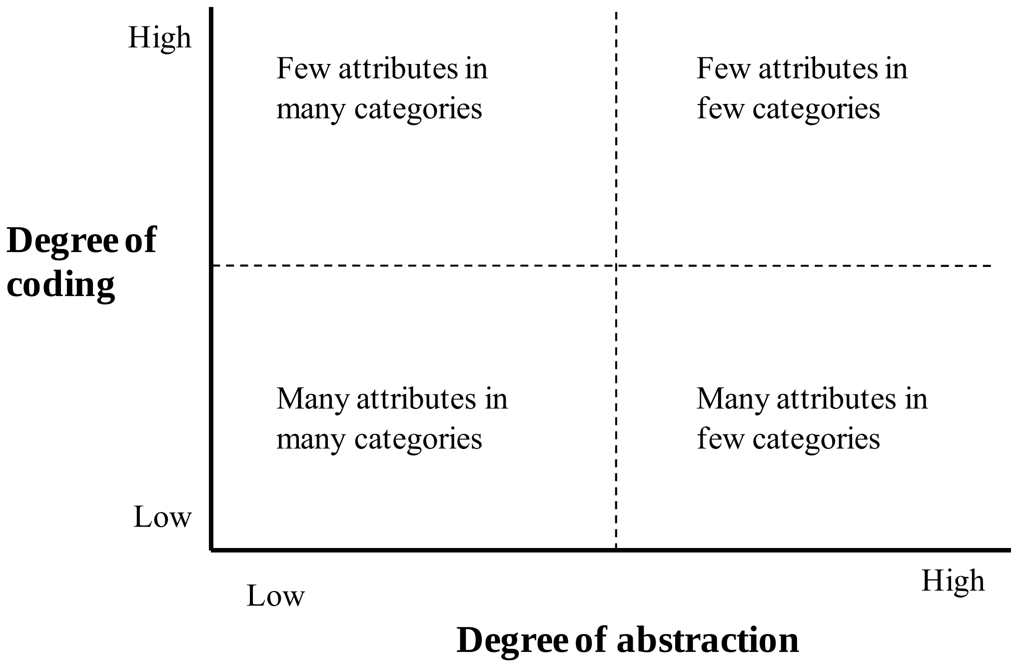

Figure 4

Degrees of coding and abstraction

Boisot (1995, 57)

2.1.6 Diffusion

Boisot (1995) describes diffusion as a process of imitation in which communication is the most important factor at play in cultural evolution. Following Tarde's conception, Boisot regards the diffusion process as "…essentially Darwinian. All repetitive imitation [or diffusion] originates in an individual invention that survives a process of competitive selection, criticism, modification, and further invention. Invention, then, forms a bridge between individual and social processes" (Boisot, 1995, 109). Furthermore,"Codification and abstraction work in tandem and, over time, selectively shift limited quantities of embodied knowledge into a narrative mode" (Boisot, 2004b, 8). And it is in the narrative mode that information and knowledge becomes amenable to diffusion.

In simple terms, diffusion "is the percentage of a given population of data processors that can be reached in a given unit of time with a particular message..." (Boisot, 1995, 143). This definition makes it clear that what is actually being referred to is "*diffusability"*; that is, the *propensity* for diffusion rather than actual diffusion; it is about who *can* be reached rather than who is *actually* reached. Conceived in this way, the population of agents to which a knowledge item is diffusible is restricted in two ways: (1) it will be restricted to those who want the knowledge; and (2) it will be restricted to those who can make sense of the knowledge. Thus, knowledge that is highly abstract and codified is like "treacle"; in other words, it diffuses very slowly (Boisot, 1999).

2.2 Dimensions of the I-space framework

2.2.1 The epistemological space (E-space)

The E-space represents the *subjective* "structuring of information" along the two dimensions of abstraction and codification. "The E-space is a personal space, being confined to what is going on inside one individual's head" (Boisot, 1995, 69). Boisot's notion of knowledge, therefore, is not justified true belief and validity, but rather refers to the individual agent's set of expectations. It is in the E-space that the "production of knowledge" (Boisot, 1995, 93) occurs in the individual.

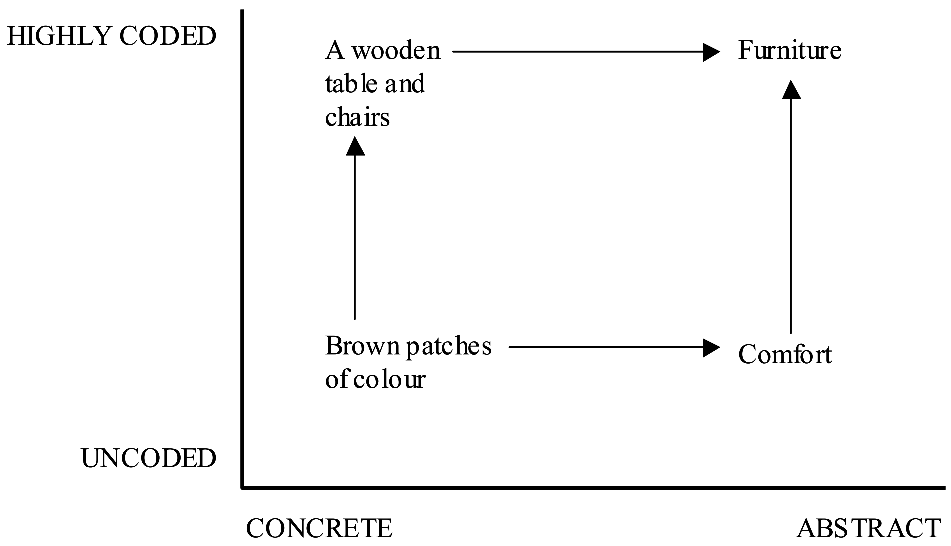

Figure 5
The Epistemological space (E-space)
Boisot (1995, 69)

2.2.2 The Utility Space (U-space)

While the E-space is concerned with the production of knowledge by individual agents, the U-space is concerned with the distribution of knowledge in a population. It thus accounts for the dimensions of abstraction and diffusion. The U-space and the Culture space (or C-space, discussed in Section 2.2.3) deal with "social knowing, moving from personal knowledge individually held to personal knowledge collectively held" (Boisot, 1995, 95).

The U-space is crucial in this thesis since it deals with the notion of value in the I-space; it "explicitly links the diffusability of a message to its degree of abstraction" (Boisot, 1995, 93). Thus, diffusability is the measure of value, and abstraction increases the value of knowledge because it enhances diffusability. "Utility can be increased...by a move towards great abstraction and generality..." (Boisot, 1995, 123). Potential utility refers to knowledge with a high degree of abstraction, but which is monopolistically held by a group or an individual. Such knowledge is both scarce and useful, and thus valuable. Figure 6 represents a typology of knowledge according to the degree of abstraction and diffusion in the U-space.

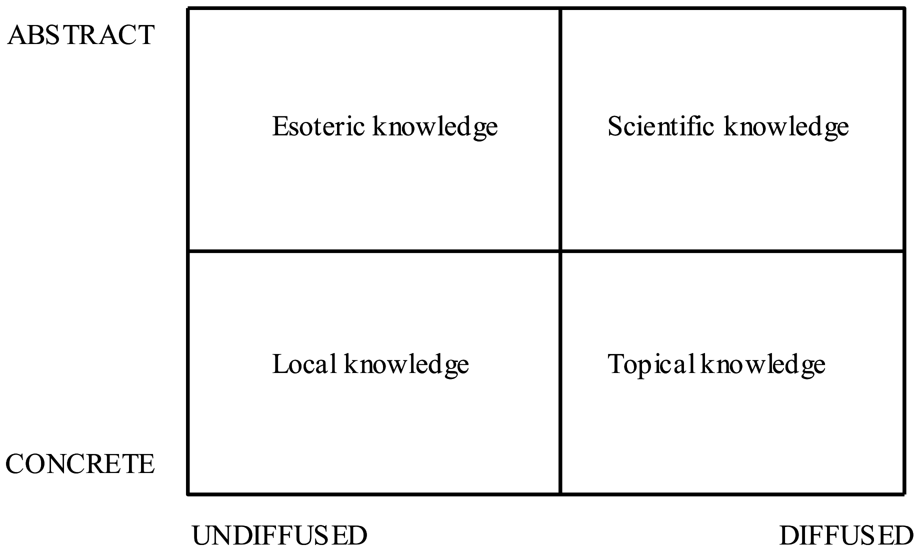

Figure 6
The Utility space (U-space)
Boisot (1995, 122)

2.2.3 The culture space (C-space)

The C-space considers knowledge located along the dimensions of codification and diffusion. The C-space further clarifies Boisot's notion of value in the I-space, since codification aids diffusion and increases diffusability. As with abstraction, "codification and diffusability of information are systematically related" (Boisot, 1995, 143).

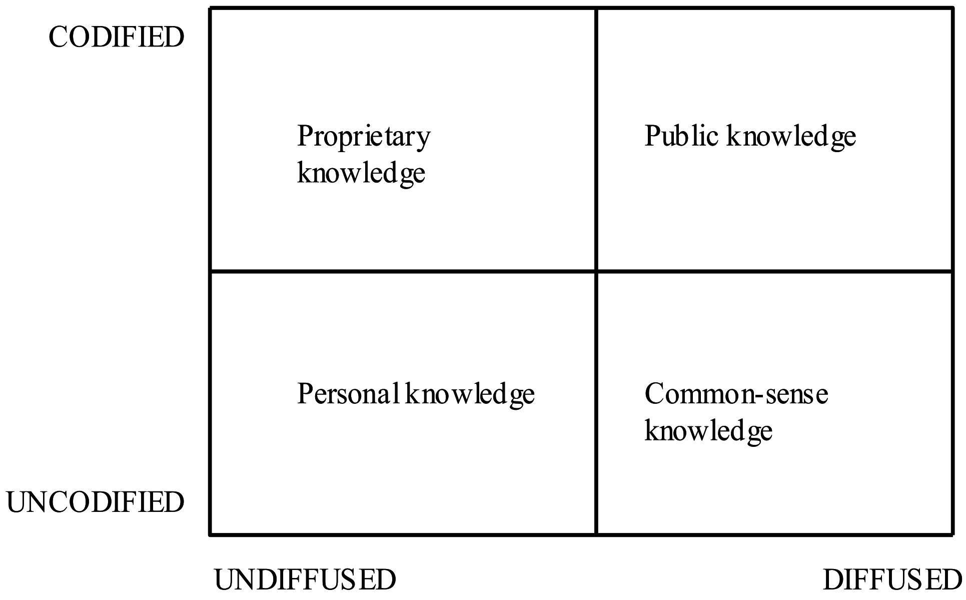

Figure 7

The Culture space (C-space)

Boisot, 1995, 146

2.3 The I-Space as a whole

It is significant that Boisot, unlike other more pragmatic authors (Machlup, 1962; Boulding, 1966; Castells, 2002, Stiglitz, 1999) who advocate the need for an economics of knowledge, does not shy away from the "philosophical morass" of approaching knowledge epistemologically. Indeed, Boisot *begins* philosophically, and his project includes a treatment of the epistemological aspects of data and the structuring of information and knowledge (1995, 39–92). In this sense, the I-space has one foot in economics and the other firmly planted in epistemology. "The central problem of epistemology has always been and still is the problem of the growth of knowledge" (Campbell, 1987, 51). From this perspective, the I-space is an epistemological framework, as its central concern is to explain the creation of knowledge. According to Boisot (1995, 167), "we shall be concerned solely with those movements in the data field that lead to the emergence of new knowledge, and we shall use the I-space for the identification and analysis of such movements". Furthermore, Boisot explicitly incorporates the notion of "epistemological status", but only as an outcome of the I-space as whole:

> No point along the codification dimension, however, enjoys a privileged epistemological status by virtue of its degree of codification alone. Only when evolving knowledge has met other conditions, set by its parallel trajectories in the E- and C-spaces, will movement along the codification

dimension towards greater codification be acknowledged as contributing to epistemological status (1995, 169).

The I-space is a three-dimensional field that is a synthesis of the C, U and E-spaces.

> Our newly created data field is structured by forces traceable in E-, U-, and C-spaces – let us for the sake of convenience bring them together and treat them as a single three-dimensional entity that we can label the Information Space or I-space – forces that channel the flow of knowledge and its distribution in the field; forces, then, which by implication give the field its evolutionary orientation over time (Boisot, 1995, 166).
>
> …The I-Space is a framework for the dynamic analysis of knowledge flows which takes the structuring and sharing of information to be positively related – i.e., the more you can structure information, the faster and more extensively you can share it. Structuring is represented by the two dimensions of codification and abstraction. Sharing is represented by the diffusion dimension (Boisot and Cox, 1999, 528).

The "contours" of the I-space are abstraction, codification and diffusion. As a "data field", the I-space framework constitutes the environment in which "movements" of various entities occur. (Figure 8 depicts the I-space in three-dimensional space.)

> To be sure, our whole theoretical edifice rests, in the final analysis, on the physical flow of data within the field, but that is not what we aim to represent in the I-space. As the term implies, we are concerned with information, that extraction from the data the processing of which is characteristic of intelligent behaviour – i.e., it modifies those prior probability distributions that pass for expectations and accumulated knowledge among data processors. If we were accountants we would think of knowledge as a stock of usable assets distributed in the data field, and information as a flow of data that modifies the size and distribution of the stock (Boisot, 1995, 186).

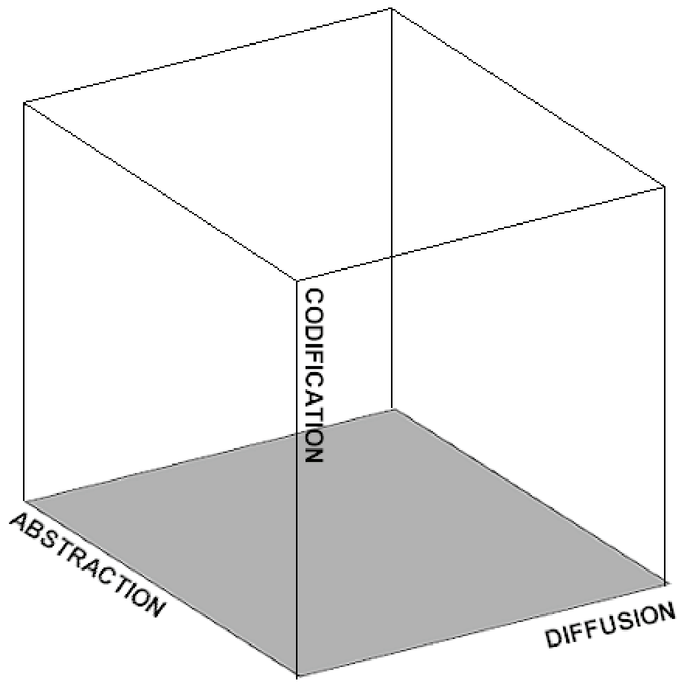

Figure 8
The Information space (I-space)
Boisot (1995)

The notion of economic value in the I-space rests on the concepts of utility and scarcity as conceived in economics. The utility of knowledge is taken by Boisot (1995, 158) to be determined by two factors: (1) it is "a function of the number of people for which it has potential relevance – whether or not they are themselves capable of understanding such knowledge"; and (2) the degree of abstraction and codification of the knowledge item, which represents the "number of situations in which a given item of knowledge will have potential utility." According to Boisot (1995, 161), "Only when utility and scarcity are joined in this way does information actually acquire economic value." While, the value of information is precarious and in respects also indeterminate, the most important proposition of the I-space is that the value of a knowledge object is determined by its degree of abstraction and codification. A knowledge object that has a high degree of abstraction and codification will have high diffusibility, will be more likely to overcome communications constraints, and is thus more valuable.

The I-space is presented explicitly as a framework that is not only generally applicable to an economics of knowledge, but that is also a *necessary* foundation to any such economics: "This book develops the hypothesis that codification, abstraction, and diffusion have to be the constituent dimensions of an information economy..." (Boisot, 1995, 164). "The I-Space identifies codification, abstraction, and diffusion as foundational concepts for a political economy of information" (Boisot, 1999, 67). Thus, the I-space is explicitly put forward as a *general* theoretical framework for an economics of knowledge; it is general in that it sets out to explain the creation and distribution of *all* knowledge, and not some subset of knowledge.

Chapter 3

Boisot's commitment to evolutionary thinking

> *If Evolution is accepted, and life and mind are developments in and from the physical order, they are in that order, and it becomes impossible to continue to envisage the physical order as purely mechanical, as one in which they have no part or lot, in which they are no real factors, and from which they should be excluded. If Evolution is right, if life and mind have arisen in and from matter, then the universe ceases to be a purely physical mechanism, and the system which results must provide a real place for the factors of life and mind. To my mind there is no escape from that argument, and its implications must have a very far-reaching effect on our ideas of the physical order…*
>
> Jan Christiaan Smuts, *Holism and Evolution*, 1936

Boisot's project and the I-space are located among and proceed from philosophical antecedents, many of which are made explicit. These antecedents, taken together, in Dopfer's (2005, 4) terminology, constitute the "paradigmatic-ontological framework" of the project. The term "paradigmatic-ontological" is analogous to *Weltanshauung* or worldview, and like "[Kuhn's] paradigms and [Lakatos's] research programmes represent the most abstract views about the status of reality" (Dopfer, 2005, 6). Throughout this thesis it is held that evolutionary thinking constitutes a paradigmatic-ontological commitment: "The notion of evolution transcends the plane of theoretical discourse and features criteria that, on the basis of paradigmatic-ontological distinctions, mark the area of the various research areas" (Dopfer, 2005, 4).

This chapter explores evolutionary thinking in relation to Boisot's other paradigmatic-ontological antecedents. The exploration will be brief, as a detailed analysis of these antecedents falls outside the scope of this research. What is important is to demonstrate the extent to which evolutionary thinking is entwined with these other fundamental antecedents to form what may be justifiably referred to as an evolutionary paradigmatic-ontological framework.

3.1 Non-triviality of a commitment to evolutionary thinking

There are probably few concepts subject to as much misunderstanding and trivialization as the concept of evolution. One such form of trivialization is to refer to any type of change as evolutionary; another is to speak of evolution in contrast to revolutionary change. It is crucial to recognize that all change is not *necessarily* evolutionary. Evolution does not refer to all types of change processes. "Of course, not all change is necessarily evolutionary in origin…" (Metcalfe, 1998, 3) "… the simple assertion that past, present and future differ from one another is not in itself an evolutionary world view" (Levins and Lewontin, 1985, 1). Vromen (1995, 4) states that "a 'catchall' definition of 'evolution', such as 'evolution is the changing of something into something else over time' (Faber and Proops, 1991, 59), fails to discriminate between different sources of change." Sober (1993, 1) discusses how "evolution in ordinary parlance" simply refers to change in general. There is therefore the need to understand "which kind of economic processes may sensibly have the label 'evolutionary' attached to them" (Metcalfe, 1998, 3).

Van Parijs (1981, 51) makes the distinction between "evolutionist" and "evolutionary", defining the evolutionist perspective as:

> refer[ring] to any succession of changes which affect a system through time. An evolutionist perspective essentially consists in looking at history (whether biological or social) as development, as progress, as a succession of stages of increasing complexity or perfection. Its explanatory claims are often restricted to spelling out a logic of development: the succession of stages which it presents only reflects the fact that one stage is a precondition for the next one.

He regards "evolutionary" as a more restricted commitment to a specific type of process:

> An evolutionary perspective, on the other hand, focuses on mechanisms of filtering or trial-and-error, i.e. on mechanisms of selection between actual (as opposed to potential) alternatives.

Evolutionary thinking entails a logical framework for understanding a specific type of change process. To claim that an explanation – in the form of a theory or framework – is evolutionary is not a trivial or purely metaphorical claim in serious discourse; it means that that explanation should be demonstrably evolutionary. Thus, an evolutionary explanation should be consistent with certain core evolutionary principles: there should be some logical criteria by which an explanation can be considered an *evolutionary* explanation.

Nevertheless, as discussed in Chapter 1, what it means to be evolutionary *sensu stricto* is not a settled issue. Though there is substantial agreement between many authorities that evolutionary thinking means something specific and thus entails a real commitment, there is no complete agreement on the specific logical criteria for evolutionary explanations. Generalized Darwinism is an area of research that is particularly concerned with establishing specific principles and criteria for evolutionary explanations in general. Chapters 4, 5 and 6 of this thesis are dedicated to identifying such a set of criteria, and in doing so, draw heavily on the discourse of generalized Darwinism.

3.2 Evolutionary thinking entwined among the paradigmatic antecedents to Boisot's project

At the paradigmatic-ontological level, Boisot's project entails explicit commitments: to Least Action as a universal organizing principle; to the physical basis of information; to the paradigm shift from a predominantly mechanistic, deterministic worldview to one that incorporates systems thinking and acknowledges pervasive complexity, flux and non-linear processes; and to evolutionary thinking and evolutionary change in opposition to "Newtonian" mechanical thinking and mechanical change (Boisot, 1995, 11-34). The project also lies at the confluence of important streams of thought at a less abstract level: the burgeoning knowledge society and the need for an economics of knowledge; and the critique of the neoclassical paradigm in economics. At the theoretical level, the project draws on contemporary thinking in communication theory and connectionist psychology. This synthesis – which is challenging in its sheer breadth – culminates in the formulation of the I-space. According to Hovenden's review (1998, 230) of Boisot's 1995 work:

> [T]he areas that Boisot has drawn on place this work at the confluence of current fashionable ideas. He melds the legacy of "new physics", with its resurgent theme of chaos theory; the ideas about information and reasoning that were generated by the growth of information machines; and the related ideas of autopoeitic systems.

Evolutionary thinking is implicit in and entwined with Boisot's other antecedents, and has emerged as a powerful mode of thinking at both the paradigmatic-ontological and theoretical levels. "Looked at through evolutionary lenses, we see a world of continuous change and creative advance that incessantly unfolds into new forms. This process is inherently *historical*" (Dopfer, 2005, 14). Dopfer invents a name for this paradigmatic-ontological orientation; he calls it "histonomic" in opposition to the classical "nomological" framework which emphasizes the identification of law-like, deterministic relations in the physical world. Evolutionary thinking posits a histonomic paradigm, and according to Dopfer (2005, 14) "Darwin's thought challenged major ontological positions of the classical doctrine." Hull (1974, 46–50) also draws a fundamental distinction, pointing out two important differences of "form" between the deductive scientific paradigm and the evolutionary paradigm: “at one end of the spectrum are deductively organized theories that contain nothing but laws that are universal statements and terms that are defined in the traditional manner; at the other end are inductively organized theories that contain less than universal statements and terms that can be defined by properties which vary only statistically.” Mayr (2002, 80) deals with two worldviews that Darwinism challenged: Essentialism, which “taught that all seemingly variable phenomena of nature could be sorted into classes” that remained static through time; and Finalism, which is “the belief that the living world has the propensity to move toward ever greater perfection.” Mayr (2002, 134) is emphatic that “evolution is not deterministic.” Similarly, Prigogine (2005, 62) regards evolutionary thinking in opposition to determinism: “Classical science emphasised stability and equilibrium; now we see instabilities, fluctuations and evolutionary trends on all levels of science, from cosmology to chemistry to biology.” And according to Metcalfe (2005, 392), “[T]he central point to cling to is that evolution provides a non-equilibrium account of why the world changes.”

Darwinian evolutionary thinking has enjoyed a strong resurgence in contemporary times because it resonates with systems thinking and complexity; it provides a plausible explanatory framework for the spontaneous systemic orders that emerge under conditions of complexity. “For Darwin’s theory of natural selection showed that it is *in principle possible to reduce teleology to causation by explaining, in purely physical terms, the existence of design and purpose in the world*” (Popper, 1978, 267). Capra (1997, 47) points out that “Bertalanffy pinpointed a dilemma that had puzzled scientists since the nineteenth century, when the novel idea of evolution entered into scientific thinking. Whereas Newtonian mechanics was a science of forces and trajectories, evolutionary thinking – thinking in terms of change, growth, and development – required a new science of complexity.” The fundamental link between evolutionary thinking and complexity is also evidenced by their sharing of concepts: “…evolutionary theory is itself developing apace as the implications of self-organisation and complexity begin to be incorporated into modern thinking” (Depew and Weber, 1995).

The power of Darwinian evolutionary explanation is demonstrated by the tendency of many of the authors writing in the area of self-organization to incorporate natural selection in their frameworks. Nordgren (1994, 66–67) deals with the extent to which the proponents of self-organization also incorporate natural selection into their models of evolution. Nordgren (1994, 67) regards “Kauffman in his recent authorship, Jantsch, Brooks and Wiley, Maturana and Varela” – all leading thinkers in self-organisation – as advocates of “heavily modified models of self-organisation”; that is, heavily modified in the sense that they accept selection *and* self-organization “as necessary to explain the course of evolution”. Nordgren (1994, 65) points out that: "In an earlier stage of his authorship Kauffman emphasised self-organisation over natural selection. Nowadays he has given up this view and asserts instead that both self-organisation and natural selection are necessary to explain evolution. He says that they have entered into a kind of marriage."

Evolutionary thinking and the concept of complex systems are entwined to the extent that it would seem strange and incomplete to discuss one without referring to the other. Darwinian evolutionary thinking is so valuable precisely because it allows us to cope, to some measure, with changes in complex population systems, which we have come to realize occur in many domains beyond the organic. "Darwin's theory of evolution through variation and natural selection has been proposed as a general explanation of the organised complexity we see around us. Although the original intention was to explain living organisms, the paradigm of variation and selection has proved so powerful that it has been applied to an increasing number of other domains" (Heylighen, 2000).

Even if Boisot did not explicitly state evolutionary thinking as being among the aspects of his paradigmatic-ontological framework, it is so tightly entwined with the other antecedents to which he refers that a commitment to evolutionary thinking could be justifiably inferred. Thus, in the paradigmatic context of Boisot's project, the I-space should be evolutionary.

3.3 Boisot's stated commitment to evolutionary thinking

Boisot refers to evolution in many instances in Information Space, although it should be noted that in his later work (Boisot, 1999) he continues to refer to evolution in discussing the I-space and its applications. For example, he refers to the evolution of information systems (Boisot, 2004) and to the evolution of social computing (Boisot and Cox, 1999).

Boisot is explicitly committed to evolution in general:

> The postulate, I believe, is broadly consistent with the story of biological and, indeed, physical evolution as we know it (1995, 32).
>
> …Both advances show that the evolutionary potential of any system is ultimately linked to the existence of microscopic freedom, represented by stochasticity or "noise". Even a Newtonian mechanical system has stochasiticity at its core and hence offers scope for evolution (1995, 19).
>
> …[S]tochastic effects, far from being a minor and corrigible irritation to a modeller concerned with long-run equilibrium results, have the power to

drive an economic system from one state of organisation to another, in effect provoking *evolutionary* rather than *mechanical* change (1995, 20).

An important and original aspect of Boisot's paradigmatic framework is the evolutionary production function, which posits the substitutability of data and energy. Thus the use of energy resources may be reduced through the increased use of data resources. In this sense, data becomes a factor of production.

> Data thus drives learning processes, and its incorporation into our new production function transforms it from a timeless representation of reversible Newtonian physical processes into one that accommodates historical and hence evolutionary time (Boisot, 1995, 31).

Boisot does not simply hold that evolution is important in specific domains – he believes in a universal evolutionary principle. Though Brooks and Wiley believe that "only biological systems display evolutionary potential" because purely thermodynamic systems have no memory, Boisot believes that even thermodynamic systems can acquire rudimentary memory. "As Nicolis and Prigogine put it, 'the idea of complexity is no longer limited to biology. It is invading the physical sciences and appears to be deeply rooted in the laws of nature' " (1995, 32). It is thus clear that Boisot is a universal evolutionist.

> Even in the pre-biotic universe a form of rudimentary natural selection was at work: data-bearing structures replicated themselves, and spread out into space and time, clumping together into ever more robust combinations whose survival further contributed to the evolution of complexity and to the accumulation of data (Boisot, 1995, 32).

In addition to a stated general commitment to evolutionary thinking, Boisot also incorporates evolutionary thinking and concepts in the specifics of the I-space framework itself. The I-space has two epistemological facets: (1) the structuring of information aspect, which is subjective and concerned with "what is happening in an individual's head"; and (2) the information-sharing aspect represented by the diffusion dimension. The I-space explication refers to three nested evolutionary situations: (1) the *local* evolution of categories in neural networks of the individual brain; (2) the *local* evolution of subjective knowledge populations; and (3) the *global* evolution of knowledge populations. Thus, Boisot makes specific commitments to evolutionary thinking in all the various dimensions and aspects of the I-space. The first two of these evolutionary situations are restricted to the realm of the subjective; it is the global evolutionary situation that the I-space as a whole attempts to capture.

Connectionism – also described as a population theory of brain functions – is chosen by Boisot as his preferred model of human cognition in the I-space as opposed to a computing model of brain functions. Furthermore, Boisot extends the connectionist model to the distribution of knowledge in a population of data-processors. Connectionism is decidedly evolutionary:

> Our connectionist model, developed by Edelman, goes by the name of Neuronal Group Selection (NGS). It accounts for categorisation without making information processing or computing assumptions. It takes the brain to be a selective system dynamically organised into cellular populations containing individually variant networks, the structure and function of which are selected by different means during development and behaviour (Boisot, 1995, 43).
>
> …Active neuronal groups within particular repertoires receiving such signals are selected over others in a competitive fashion. Such selection is the basis of perceptual categorisation (Boisot, 1995, 44).

Evolutionary thinking is also present in the I-space explication at the level of knowledge production processes: "The differential distribution of society's stock of knowledge, whether or not it results from communication constraints, inevitably skews the initial endowment and subsequent evolution of individual E-spaces" (Boisot, 1995, 107). Similarly, evolution is present at the level of knowledge distribution in the I-space: "Our newly created data field is structured by forces traceable in E-, U-, and C-spaces – let us for the sake of convenience bring them together and treat them as a single three-dimensional entity that we can label the Information Space or I-space – forces that channel the flow of knowledge and its distribution in the field; forces, then, which by implication give the field its evolutionary orientation over time" (Boisot, 1995, 166).

Boisot's commitment to evolutionary thinking is not trivial, nor does Boisot mean to apply evolutionary processes and concepts metaphorically. Thus, there is a strong commitment that may be subjected to an assessment of conceptual isomorphism.

Chapter 4

Applications and generalization of the Darwinian evolutionary framework

> *…[T]he process of variation followed by selection which Darwin discovered does not merely offer an explanation of biological evolution in mechanical terms, or in what has been slightingly and mistakenly described as mechanical terms, but it actually throws light on downward causation; on the creation of works of art and of science; and on the evolution of the freedom to create them. It is thus the entire range of phenomena connected with the evolution of life and of mind, and also of the products of the human mind, that are illuminated by the great and inspiring idea that we owe to Darwin."*
>
> (Popper, *Dialectica* 22, 3, 1978, 339–355)

In this chapter, the most important extant disciplinary applications of Darwinian evolutionary thinking – in evolutionary biology, evolutionary economics and evolutionary epistemology – are explored. A brief historical preview is provided in each case, but the emphasis is on obtaining qualitative insight into the *contemporary* logical conception of the Darwinian framework in each discipline. One of the causes of misunderstanding in evolutionary thinking is that many of its logical aspects are implicit, or are regarded as so obvious as to be taken for granted. Thus, the descriptive approach used in this chapter is a necessary precursor to a more rigorous isolation of criteria in Chapter 5. In addition, this chapter demonstrates the important – if not central – place that Darwinism occupies in evolutionary thinking in the various disciplines in which it has been applied.

The foundation of contemporary evolutionary biology is largely credited to Darwin and, at its logical core, remains fundamentally Darwinian. It was in the organic sphere that much of the technical language and concepts of evolutionary thinking were first hammered out. Thus, it is appropriate to begin with Darwinism in biology to gain qualitative insight to the *logical* structure and criteria of Darwinism. In this, great reliance is placed on the work of Ernst Mayr, an eminent biologist who is regarded as a leading contemporary strict Darwinist. As pointed out in Chapter 1, this should not be construed as a form of biological imperialism that seeks to apply organic evolution as a template for all other disciplines.

Evolutionary economics provides important insight to the ways in which Darwinism has been adopted paradigmatically and theoretically outside of biology. The discussion refers primarily to Nelson and Winter's prominent evolutionary economic theory. This does not mean that the notion of evolutionary change in economics begins with Darwinism or with Veblen's adoption of Darwinism, nor does it mean that Darwinism, as such, is the only extant conception of evolution in evolutionary economics. What it does mean is that Darwinian evolutionary principles have been generalized to economic phenomena, and specified in detail by Nelson and Winter, and that this is of use in this thesis.

At a higher degree of generality than evolutionary economics, Popper and Campbell's evolutionary epistemology adopts a "largely" Darwinian framework to explain the growth of knowledge. And it does so not in a metaphorical sense, but as a firm paradigmatic-ontological commitment. This well-known application of Darwinism is of particular relevance given that the I-space – the focus of this thesis – has been characterized in Chapter 3 as an *epistemological* framework for an economics of knowledge.

Generalized Darwinism is based on the principle that Darwinism is applicable beyond biology; that is, that Darwinism is not domain-specific, but is applicable to phenomena and processes that occur in multiple domains. It follows then that an important task of generalized Darwinism is to provide a generic, logical model of the Darwinian evolutionary processes that sets out the criteria that any putative generalized Darwinian model should satisfy. However, such a neat and broadly accepted model has not yet emerged, since there remain several areas of disagreement (these are discussed in Section 4.4.2). While this thesis adopts the notion of generalized Darwinism, it does so cautiously, taking note of the various objections and warnings that have been raised about the reckless application of the Darwinian principles of biological evolution in other disciplines, and especially in the social sciences.

Furthermore, various important issues and objections to generalized Darwinism have been raised. These polemical issues are identified and discussed in the context of this research at the end of the chapter; however, there is no intention to resolve them here. The discussion of these issues informs the laying out of a criteria set in Chapter 5, and the assessment of the I-space against these criteria, which follows in Chapter 6.

4.1 Contemporary Darwinian evolutionary biology

In contrast to natural theology, Darwin (1859) proposed, in the first edition of *The Origin of Species by Natural Selection*, the theory of natural selection as an explanation of the processes that give rise to "the full panoply of life" without having to accommodate a Creator. Although

Hull (1974, 51) points out that “Darwin retained vestiges of earlier biological theories in his work”, Mayr (1988, 209) notes: “His theory for the natural mechanism that would be able to direct evolutionary change was unique. There was nothing like it in the whole philosophical literature from the pre-Socratics to Descartes, Leibniz, or Kant.”

Hull (1974, 45) presents the various stages of the development of biological evolutionary theory as the classical (developed by Darwin during his lifetime), the genetical (with an emphasis on genes and gene frequencies using mathematical notation), and the synthetic (which synthesizes the classical view and the genetical). The period soon after 1859 is referred to as the first Darwinian revolution, during which the principles of evolution “as such” and common descent were widely accepted. Natural selection, following the publication of *Origin*, was controversial and “unacceptable to most early evolutionists” (Mayr, 1988, 133). It was only after the evolutionary synthesis in the 1930s and 1940s, or what is referred to as the second Darwinian revolution, that Darwin’s remaining three theories were generally accepted by biologists. The inheritance of acquired characters was refuted in the synthesis. Hull (1974, 57) points out that the synthesis of Mendelian genetics and Darwin’s theory of evolution resulted in a more powerful theory, despite “the initial flap about the incompatibility of Mendelian genetics and evolutionary theory.”

Following the birth of genetics and the formulation of what has come to be known as the Neo-Darwinian theory of evolution, “biologists soon came to see that these two theories were fully consistent. Darwin had formulated his theory of evolution assuming that there must be some mechanism for the production and maintenance of the type of variation it required. Mendelian genetics was precisely that theory” (Hull, 1974, 57). Thus, the Darwinian framework for evolution by natural selection was ultimately strengthened by its synthesis with genetics: “…[A]s a result of the evolutionary synthesis of the 1940s, selection seemed to have the field all to itself” (Mayr, 1988, 133).

Darwin proposed a compound theory that Mayr (1988, 198; 2002, 94) partitions into five theories: “(1) evolution as such, (2) common descent, (3) gradualism, (4) multiplication of species, and (5) natural selection”, which are independent; “...Darwinism cannot be a single homogenous theory...evolution consists of two essentially independent processes: transformation in time and diversification in (ecological and geographical) space.” Further evidence for the independence of each theory is that various authors have accepted certain of the theories while calling others into question.

According to Hull (1974, 54), contemporary Darwinism differs from the classical Darwinism of Darwin himself in the following respects: (1) acquired characters has been refuted; (2) the cause of variation has been identified and incorporated into the Darwinian framework in the modern synthesis; and (3) Darwin's theory of pangenesis has been refuted. However, Mayr (2002, 96) says that "the Darwinism accepted since the evolutionary synthesis is best simply called Darwinism, because in most critical aspects it agrees with the original Darwinism of 1859."

Despite the polemical nature of evolutionary theory in biology, the core Darwinian framework has remained intact (Mayr, 2002; Gould, 2002). The various polemics in specific aspects of evolutionary biology rage on the theoretical edges but the Darwinian *core*, especially Darwin's compound theory of natural selection, continues to be widely accepted and has even gained in strength since the modern synthesis. "... [N]atural selection, the theory that is usually meant by the modern biologist when speaking of Darwinism, is firmly accepted by nearly everyone" (Mayr, 1988, 212).

4.1.1 Evolution as such and population thinking

Darwinian evolution "as such" describes what evolution entails at the paradigmatic level; or what evolution entails when taken as a whole, prior to considering the logical structure of its parts. It describes the special type of change whereby populations of entities evolve over generations through a process of natural selection. This view of evolutionary change was introduced by Darwin, as a reaction against essentialism and typological thinking according to which "the essence or definition of a class (or type) is completely constant" (Mayr, 2002, 80). In typological thinking, a horse is a horse and was always a horse; there is no sense in which some other species of organism gradually became horses, nor is there a sense that horses continue to evolve. Each horse is an instance of the ideal type Horse, which is essentialistically conceived. Any change of the type Horse is not possible; there are only imperfect instances of the ideal Horse, but all horses share in the essence of the ideal type. "Typological thinking is concerned with ideal types in which the entities are regarded as fixed and identifiable in terms of a limited number of defining characteristics, characteristics which constitute the essence of the entity…By contrast, in population thinking, the focus of attention is on the variety of characteristics within the population and, pace typological thinking, variety is not a nuisance which hides the underlying reality…and which is the prerequisite for evolutionary change" (Metcalfe, 1998, 24).

The Darwinian conception of evolutionary change also challenged finalism, which Mayr (2002, 82) describes as "the belief that the living world has the propensity to move toward ever greater perfection." Finalism, in contrast to essentialism, accepts that there is evolutionary change but *contra* Darwinism, suggests that there is an overarching goal or directionality to that change; all the life forms thus "strive" toward perfection. "Those who adopted finalism assumed that evolution moved necessarily from lower to higher, from primitive to advanced, from simple to complex, from imperfect to perfect" (Mayr, 2002, 89). Thus, those who adopt finalism attempt to create schema that order organic life forms according to some criteria, typically placing *homo sapiens* at the pinnacle. Increased complexity is just one possible outcome of evolution – life forms can just as easily evolve towards simplicity, and in fact often do. "Through the years Darwin modified his theory somewhat, but two tenets which he steadfastly refused to change were that evolution occurs gradually and is in no significant sense directed towards some goal or goals" (Hull, 1974, 51).

An area of controversy that is related to Darwinism's opposition to finalism – and one that is of particular relevance in this thesis – has to do with the extent to which the outcomes of organic evolution in general, and natural selection in particular, are predictable. Finalism posits that evolution is predictable, since it follows a trend. On this point, Mayr is emphatic: "Probably nothing in biology is less predictable than the future course of evolution" (1998, 33). "Natural selection represents not only the rejection of finalistic causes that may have a supernatural origin, but it rejects any and all determinism in the organic world. Natural selection is utterly 'opportunistic', as G. G. Simpson has called it; it is a 'tinkerer' (Jacob, 1977)" (Mayr, 1988, 210). Mayr reiterates: "The development or behaviour of an individual is purposive; natural selection is definitely not" (1988, 31); "…[N]atural selection is strictly an *a posteriori* process which rewards current success but never sets up future goals. No one realized this better than Darwin, who reminded himself 'never to use the words higher or lower'" (Mayr, 1988, 43).

Mayr states further that even artificial selection, often taken to be highly directed, is characterized by unpredictability. "Breeders and students of natural selection have discovered again and again that independent parallel lines exposed to the same selection pressure will respond at different rates and with different correlated effects, none of them predictable" (1988, 33). The fact that there is no convergence of species provides further support for the unpredictability of natural selection; the tremendous diversity of life forms demonstrates that many solutions to the same environmental problem are possible. "Darwin designated as natural selection anything that favoured survival, whether this was an increase or decrease of body size, a broadening of the niche or its more efficient utilization, better protection against the environment or an increased tolerance of environmental extremes, a superior ability to cope with diseases or to escape enemies" (Mayr, 1988, 104). "In the ocean one can find representatives of as many as 15 or 20 phyla happily coexisting in the same general area. The enormous differences in their body plans do not prevent their perfect adaptation to their environment" (Mayr, 2002, 171).

Darwinism makes the statement that "the world is neither constant nor perpetually cycling but is steadily and perhaps directionally changing, and that organisms are being transformed in time" (Mayr, 1988, 198). Darwin's seminal achievement was to specify the physical processes of natural causation that explain how all of organic life in all its diversity emerged. The result is that both essentialism and finalism were completely displaced as paradigms in biology.

A central aspect of Darwinian evolution at the paradigmatic level is that it applies to populations. "Population thinking is one of the most important concepts in biology: It is the foundation of modern evolutionary theory and one of the basic constituents of the philosophy of biology" (Mayr, 2002, 81). In population thinking, organisms are not members of essentialistic classes or types, but rather belong to variable populations. "Each species is composed of numerous local populations. Within a population, in contrast to a class, every individual is uniquely different from every other individual" (Mayr, 2002, 81). "A local population (*deme*) consists of the community of potentially interbreeding individuals of a species at a given locality" (Mayr, 2002, 84). For Mayr, it is the population which is the *lowest* level of organization that evolves: individual organisms do not evolve over a lifetime; it is the evolution of the population that gives rise to new species of individuals that differ from their forebears. "Evolution is best understood as the genetic turnover of individuals of every population from generation to generation" (Mayr, 2002, 84).

4.1.2 Common descent (branching)

Common descent is the theory that every group of organisms descended from an ancestral species rather than simply appearing out of nowhere, so to speak, and evolving parallel to all other species (Mayr, 2002, 200). Darwin's theory of common descent is in contrast to Lamarck who "derived diversity from spontaneous generation and the vertical transformation of each line separately into higher states of perfection" (Mayr, 1988, 200). The theory of common descent points to the relatedness of all organic forms, and is widely accepted.

4.1.3 Gradualism

Gradualism marked a drastic departure from the dominant essentialist thinking, which required saltations to explain how species came to be. Darwin's famous statement "*natura non facit* *saltum*" (nature makes no leap) was unacceptable even to those who supported his other theories. However, population thinking favours gradualism. In population thinking, a species cannot originate instantaneously, or, in a word, saltatively. Mutations, or phenotypic discontinuities, both large or small, do occur at the individual level, but this new genotype would need to gradually influence the population over generations. Thus while population thinking does not exclude rapid change *per se*, it denies that an entire new species or population can originate out of nowhere; it is thus opposed to evolution by transmutation. "Nothing is said in the theory of gradualism about the rate at which the change may occur" (Mayr, 1988, 205).

4.1.4 Multiplication of species

The theory of the multiplication of species is closely related to the theory of common descent, and explains the tremendous proliferation of species in the organic world. How could so many species come about? The diversity of life forms cannot be explained entirely by a horizontal process in which one species evolves over time to become another. The multiplication of species is also explained by taking vertical geographic factors into account in order to explain incipient species. "The problem is thus the acquisition of reproductive isolation in relation to other contemporary species" (Mayr, 1988, 206). Thus, it is environmental separation and environmental differences that ultimately explain the branching and multiplication of species.

4.1.5 Natural selection (variation and selection)

The compound theory of natural selection lies at the heart of the Darwinian evolutionary framework. "[Darwin] postulated that the inexhaustible genetic variation of a population, together with selection (elimination), is the key to evolutionary change" (Mayr, 2002, 126). It is a compound theory in that it comprises two separate processes or theories: step one, variation, involves the production of genetically differing individuals in every generation; step two, selection, is the differential survival and reproductive success of these individuals. "At the first step, that of the production of genetic variation, everything is a matter of chance. Chance plays a much smaller role at the second step: that of differential survival and reproduction, where the 'survival of the fittest' is to a large extent determined by genetically based characteristics" (Mayr, 2002, 133).

> The basic formulation, or bare-bones mechanics, of natural selection is a disarmingly simple argument, based on three undeniable facts (overproduction of offspring, variation, and heritability) and one syllogistic inference (natural selection, or the claim that organisms enjoying differential

> reproductive success will, on average, be those variants that are fortuitously better adapted to changing local environments, and that these variants will then pass their favoured traits to offspring by inheritance (Gould, 2002, 13).

A long-standing controversy in evolutionary biology is whether it is the phenotype or the genotype that is the target of selection. The distinction between phenotype and genotype – which was made in the evolutionary synthesis – is important in evolutionary biology: "phenotype refers to the totality of morphological, physiological, biochemical, and behavioural characteristics of an individual" (Mayr, 2002, 142); while "genotype is the genetic material itself which controls the production" (Mayr, 2002, 98) of the phenotype in its interaction with the environment. "The same genotype may produce different phenotypes in different environments" (Mayr, 2002, 142). According to Mayr (2002, 1988) it is the individual organism that is the object or target of selection; it is the phenotype that is "encountered by natural selection" and not the gene or genotype, "because these are not visible to selection." According to Mayr, "[I]t is the phenotype that is exposed to natural selection, and not individual genes directly" (2002, 99); and "It was not until about 1980 that reasonable unanimity was reached that the individual is the principal target of selection" (2002, 140),

4.2 Darwinism in evolutionary economics

Evolutionary thinking in the social sciences preceded the first publication of *Origin* (1859). Evolutionary thinking, in general, has a long and distinguished history among economists; indeed, the basis for evolutionary thinking was formulated at the birth of modern economics. Langlois and Everett (1994, 12) trace the origin of evolutionary thinking "as a novel *kind* of explanation" to the 18th century – to Adam Smith, David Hume and the other philosophers of the Scottish Enlightenment.

> Evolutionary propositions about cultural and social development were prominent in the writings of philosophers of the Scottish Enlightenment, for example, Bernard Mandeville (1724), David Hume (1739), and Adam Smith (1776), all long before *The Origin of Species* was published...Long before Darwin, these authors established that complex and efficacious outcomes could be the result of an evolutionary process operating over long periods of time, without any overall designer, whether human or divine (Nelson, 2007, 76).

However, Nelson (2007, 76) points out that Darwin's distinctive contribution is that he "specified the broad processes at work in evolution, a specification missing in the early evolutionary social science". Darwinism "influenced strongly evolutionary thinking in a number of subsequent writings on social and cultural phenomena. Thus Walter Bagehot (1872), William James (1897), Thorstein Veblen (1898, 1899), and others, argued that Darwinian mechanisms of evolution apply not simply to biology, but also to mental, epistemological, moral, social, and political evolution, although none of these authors fleshed out the details explicitly" (Nelson, 2007, 77). "Darwin's indebtedness to T. Malthus and the moral philosophers D. Hume and A. Smith is well documented. Conversely, many economists have been inspired by Darwinian (and Lamarckian) evolutionary theory" (Vromen, 1995, 5). Vromen also notes that the relationship between economics and biology goes deeper in that "the modes of explanation that are entertained in both disciplines show striking similarities." According to Harcourt (2004, 128), both Schumpeter and Marshall "saw in history and biology – evolution – the true Mecca through which to obtain an understanding of the development of capitalism over time." Nevertheless, Langlois and Everett (1994, 14) point out that "neither Marshall nor any of his Scots or English contemporaries extended the Scottish philosophers' notion of spontaneous order. Instead, the heir apparent was an Austrian, Carl Menger." In America, it was Thorstein Veblen who "at the end of the nineteenth century…proclaimed the end of pre-evolutionary economics" (Vromen, 1995, 1). "According to Veblen, the key concept would have to be 'cumulative causation': causal processes engender effects that provide the starting point for subsequent causal processes…" (Vromen, 1995, 1).

While evolutionary economics in the predominant Darwinian mould has a long history that includes the work of many luminaries, it is not without controversy. Objections and issues related to the application of Darwinism in evolutionary economics have been raised by authors such as Penrose, Schumpeter, Vromen and Metcalfe, among others, and are dealt with in more detail in Section 4.4.2. Joseph Schumpeter is a prominent example of an evolutionary economist who "was explicitly turned against any reference to Darwinian natural selection as an appropriate tool for understanding economic development and change" (Magnusson, 1994, 1).

Nevertheless, evolutionary economics is a fertile area of contemporary research. "Towards the end of the twentieth century, 'evolutionary economics' is gaining momentum. If the titles of newly appearing books, articles, papers, journals and societies are reliable indicators of current trends in the economics profession, engaging in evolutionary analyses may even be called fashionable among economists nowadays" (Vromen, 1995, 2); "The period since 1950 has witnessed the resurgence of the evolutionary framework" (Metcalfe, 1998, 38); "The last two decades have seen an explosion of research in economics inspired by evolutionary thinking" (Dopfer, 2005, 3); "Leading neoclassical economists such as Kenneth Arrow and Frank Hahn have turned away from mechanics, seeing biology as the possible inspiration for the economics of the future (Anderson, 1995; Arrow, 1995; Hahn, 1991, 48)" (Hodgson, 2005, 105); and "Over the last quarter-century, there has been a major renaissance of explicitly evolutionary theorizing in the social sciences…" (Nelson, 2007, 77).

Nelson and Winter loom large in the development of contemporary evolutionary economics. According to Langlois and Everett, "Present-day efforts in evolutionary economics almost all take their cues from Nelson and Winter…The work of Nelson and Winter is widely seen as seminal in the modern resurgence of evolutionary thinking in economics. Of course, Nelson and Winter themselves inherited a body of knowledge from previous economists. From Herbert Simon they acquired the notions of bounded rationality and satisficing, which they use to build models of search and selection. From Schumpeter they acquired a workable framework for variation. Adding the essential ingredient of routines, they are able to construct models and theories of evolution" (1994, 21).

> In our evolutionary theory, these routines play the role that genes play in biological evolutionary theory. They are a persistent feature of the organism and determine its possible behaviour (though actual behaviour is determined also by the environment); they are heritable in the sense that tomorrow's organisms generated from today's (for example, by building a new plant) have many of the same characteristics, and they are selectable in the sense that organisms with routines may do better than others, and, if so, their relative importance in the population (industry) is augmented over time (Simon and Winter, 1982, 12).

The above summary of Nelson and Winter's theory of the economic evolution of firms is closely analogous to the Darwinian framework, and this is borne out by the following statement: "…[O]ne borrowed idea that is central in our scheme [is] the idea of economic 'natural selection'" (Nelson and Winter, 1982, 7). However, it is also important to point out that Nelson and Winter (1982) describe their theory as "unabashedly Lamarckian". Furthermore, Nelson warns against a literal application of biological Darwinism in other disciplines. The issue of Lamarckism and generalized Darwinism are dealt with in more detail in Section 4.4.

4.3 Darwinism in Popper and Campbell's evolutionary epistemology

Beyond its application in disciplines such as biology and economics, the Darwinian evolutionary framework has been applied in philosophy as well. The most prominent application is Popper and Campbell's evolutionary epistemology, in which the Darwinian compound theory of natural selection is applied directly in a philosophical theory of the growth of knowledge. While the term "evolutionary epistemology" is credited to Campbell, it is Popper who first developed a cohesive evolutionary philosophy of science. "It is primarily through the works of Popper that a natural selection epistemology is available today" (Campbell, 1987, 47). Nevertheless, it is in Campbell's work that the core criteria of Darwinian natural selection are laid bare and generalized as "blind-variation-and-selective-retention" – or what has come to be referred to in the literature as BVSR. Mokyr (2005, 202) describes the approach of evolutionary epistemology of Campbell: "These models suggest an evolutionary modelling of the growth of new knowledge, in which new knowledge is produced by some kind of stochastic process and then subjected to a host of filters."

Nelson and Winter (1982) acknowledge the higher degree of generality of evolutionary epistemology: "Campbell (1969) provided an excellent survey of that broad field (sociocultural evolution) and argued for the merits of a variation and cultural selection-retention theory of sociocultural evolution. Our own work may be viewed as a specialised branch of such a theory." Mokyr (2005, 203) makes the point that Campbell's "model of 'cultural cumulations' was not based on an analogy with organic evolution *per se*, but rather from a general model of adaptive fit or quasi-teleological processes for which organic evolution was but one instance".

Popper describes evolutionary epistemology as fundamentally a Darwinian process of evolution:

> All this may be expressed by saying that the growth of our knowledge is the result of a process closely resembling what Darwin called "natural selection"; that is, the natural selection of hypotheses: our knowledge consists, at every moment, of those hypotheses which have shown their (comparative) fitness by surviving so far in their struggle for existence; a competitive struggle which eliminates those hypotheses which are unfit. This interpretation may be applied to animal knowledge, pre-scientific knowledge, and to scientific knowledge...This statement of the situation is meant to describe how knowledge really grows. It is not meant metaphorically, though of course it

> makes use of metaphors. The theory of knowledge which I propose is a largely Darwinian theory of the growth of knowledge (Popper, 1978, 261).

The above quotation is significant because Popper says that *all* knowledge growth is Darwinian evolutionary, while his philosophy of science deals more specifically with the demarcation problem, or what would constitute *scientific* knowledge. Campbell (1987, 91), in close accord with Popper, identifies the "one theme recurrent in most knowledge processes" as follows:

> a. A blind-variation-and-selective-retention process is fundamental to all inductive achievements, to all genuine increases in knowledge, to all increases in fit of system to environment.
>
> b. The many processes which shortcut a more full blind-variation-and selective-retention process are in themselves inductive achievements, containing wisdom about the environment achieved originally by blind variation and selective retention.
>
> c. In addition, such shortcut processes contain in their own operation a blind-variation-and-selective-retention process at some level, substituting for overt locomotive exploration or the life-and-death winnowing of organic evolution.

Thus, the BVSR process is said to underlie all growth of knowledge, even in cases that appear to be highly directed and purposive when taken in isolation. For Popper and Campbell, all knowledge is achieved through trial-and-error evolutionary processes in which variations are offered and are winnowed through selective retention. "The general model for such inductive gains is that underlying both trial-and-error problem solving and natural selection in evolution, the analogy between which has been noted by several persons (e.g. Ashby, 1952; Baldwin, 1990; Pringle, 1951)" (Campbell, 1987, 92). Campbell goes further, arguing "that evolution – even in its biological aspects – is a knowledge process, and that the natural-selection paradigm for such knowledge increments can be generalized to other epistemic activities, such as learning, thought, and science" (Campbell, 1987, 47). The BVSR model is logically isomorphic with Darwin's compound theory of natural selection, and is useful in this thesis because it isolates the criteria of natural selection in a strict sense: "Three conditions are necessary: a mechanism for introducing variation, a consistent selection process, and a mechanism for preserving and reproducing the selected variations" (Campbell, 1987, 92).

4.4 Generalized Darwinian evolutionary thinking

It has been long held that Darwinian evolutionary thinking could be "generalized" to evolutionary change processes beyond the organic sphere. Hodgson (2005, 899) points out that "Darwin himself speculated that his evolutionary principles of variation, inheritance, and selection might apply to the evolution of human language, as well as to moral principles and social groups (1859, 1871)." Almost a century ago, Veblen stated that "Any evolutionary science...is a close-knit body of theory. It is a theory of a process, of an unfolding sequence...of cumulative causation. The great deserts of the evolutionist leaders...lie...in their having shown how this colorless impersonal sequence of cause and effect can be made use of for theory proper, by virtue of its cumulative character" (Veblen, 1919, 58–61 in Hodgson, 2003, 87).

The interest in generalized Darwinian evolutionary thinking has persisted and blossomed in contemporary times. "The last quarter-century has seen a renaissance of the proposal that the processes Darwin put forth as driving biological evolution also provide a plausible theoretical framework for analysis of the evolution of human culture" (Nelson, 2007, 73). "Although the concept of evolution has become firmly identified with organic evolution, the history of living organisms on earth, the theory of the evolution of life is only a special case of a more general world view that can be characterized as 'evolutionism'" (Levins and Lewontin, 1985, 1). In citing the antecedents and authors that they have drawn on, Nelson and Winter (1982) refer to "a common evolutionary philosophy" that underlies their theoretical work. They also point out that "all of the natural sciences are today evolutionary in fundamental respects" (Nelson and Winter, 1982, 8).

Hodgson (2007, 269) makes the point "that generalized Darwinism is not essentially about analogy or metaphor but about ontological communality at a highly abstract level (Hodgson, 2002)." Mokyr (2005, 203) concurs: "Darwinian models transcend biology, and…indeed evolutionary biology is just a special case of a much wider and broader set of models that try to explain how certain kinds of systems evolve over time." The kinds of systems that Mokyr refers to are characterized by Hodgson (2005, 899): "This idea that Darwinism may have a broad applicability to other open and evolving systems has been developed in different ways by several contemporary authors, including Richard Lewontin (1970), Henry Plotkin (1994), Daniel Dennett (1995), and David Hull (1988, Hull et al. 2001)."

4.4.1 Generalizing Darwinism – a cautionary statement

Many evolutionists have cautioned that while Darwinism may be generalized to disciplines other than biology, there is a need to tread carefully when doing so.

> In using the language of evolutionary theory to confront and treat problems relating to the advancement of knowledge, one should not forget that the mechanisms of organic evolution and those of cultural and intellectual evolution are not identical, despite their close parallels (Bartley, 1987, 450).

Mokyr (2005) also warns against taking isomorphisms between sciences too literally, and points out that there are differences (such as differences in time scales, for example), that should be taken into account. Metcalfe (1998, 6) sounds a warning that "there is in the air a sense of evolutionary imperialism so perhaps one needs to be particularly careful in understanding what evolutionary processes entail."

Nelson (2007, 74) points out that "scholars involved in discussion of Universal Darwinism, and those involved in developing an evolutionary social science, are only dimly aware of each other." Two approaches are identified by Nelson: one group "sticks closely" with the biological evolutionary theory and proposed generalizations of the various biological concepts, for example, Dawkins (1989, 189). The other group (Hull, Ziman) explore "more openly how an evolutionary theory needs to be structured if it is to encompass the processes of change in human cultures as well as in biological species"; "The second group tends to be much more cautious about using or insisting on direct analogs between the concepts of biological evolutionary theory and cultural concepts" (2007, 74). Those pursuing evolutionary social science are not motivated in the first instance to "try to apply Darwinian ideas to the dynamics of human culture, social structures, economic activity and systems, and politics" (Nelson, 2007, 75). Nelson (2007, 75) points out, for example, that "David Hull has put forth the alternative label 'general selection processes' (1988, 2001) in opposition to 'Universal Darwinism' which smacks too much of biology".

Hodgson (2007, 265), on the other hand, explains his and Thorbjorn Knudsen's preference for the term "generalized Darwinism" in favour of "universal Darwinism" because "the word 'universal' suggests that it covers everything".

> There are clearly some interesting similarities between the theory in the examples of evolutionary social science...and modern biological theories of the evolution of species, but also some important differences. In both arenas, modern scholarship is firmly committed to a broad Darwinian theory of change through variation, selection, renewed variation...On the other hand, the details of the structures and process involved clearly differ in important ways. In my view, a Universal Darwinism is acceptable, welcome, if the character of evolutionary process associated with that conception is broad

> and general enough to square with the details of what is going on in both arenas (Nelson, 2007, 85).

It is important to note that Nelson draws a distinction between "broad Darwinian theory" and "the details". In this research, the approach of insisting on direct analogs is not used, and there is no need, given its highly conceptual nature. Having heeded Nelson's warning and taken note of Hull's alternative term "general selection processes", this research uses "generalized Darwinism" following Hodgson:

> We refer to a broad class of systems and populations of entities, including all feasible manifestations of development and change. We then show, under some minimal conditions, that ongoing change in such systems is inevitably Darwinian in the sense that it must involve Darwin's central principles of variation, inheritance and selection (Hodgson and Knudsen, 2006, 2).
>
> …Note also that the idea of generalizing Darwinism does not rely on the mistaken idea that the mechanisms of evolution in the social and biological world are similar. Not only do natural and social evolution differ greatly in their details, but also detailed mechanisms differ greatly *within* the biological world…Darwin's principles of evolution do not themselves provide a complete explanation. Darwinism does not provide a complete theory of everything, from cells to human society. Instead, these principles are a kind of metatheory, or a theoretical framework wherein particular explanations must be placed (Hodgson, 2007, 268).

It is on this basis that this research proceeds. But it does so taking care to avoid literal comparisons with biological Darwinian mechanisms. Great effort has been expended to consider the logical conceptual aspects of Darwinism more broadly than the biological application. Thus, Metcalfe is followed: "A decade from now evolutionary thinking may well be quite different in content from today, but my claim is that – whatever developments take place – the variation-selection-development mode of reasoning…will remain intact in its essentials" (Metcalfe, 2005, 393).

In the words of Hodgson (2003, 86), "The importance and enduring value of Darwinism is its elaboration of a causal mechanism of evolution involving variation, inheritance, and selection. In principle, this mechanism could apply to any open and evolving system with a variety of units. Darwinian evolution occurs when there is some replicating entity that makes imperfect copies of itself and these copies do not have equal potential to survive."

4.4.2 Substantive polemics in generalized Darwinism

Evolutionary thinking is directed at the task of explaining the change process in complex population systems. Such a task cannot be approached deterministically, since it is situated in the realm of the complex. It is no wonder that evolutionary thinking can be difficult to grasp and to apply; in many ways, it reflects the complex process that is its subject of explanation. Another implication of this – and its long, active history – is that evolutionary thinking, its philosophical considerations, and the status of its theories have been contentious.

> From its inception, philosophers and scientists have not been satisfied with evolutionary theory as a scientific theory. It is false. It is unfalsifiable. One of its basic principles, the claim that fitter organisms tend to survive to reproduce themselves more frequently than those organisms that are less fit, is tautological. The organisation of evolutionary theory is too loose to permit any judgments about its logical form. It entails inevitable progress. It precludes any estimations of higher or lower. It does not provide the necessary basis for predictions about the future development of particular lineages but can be used to explain these events once they have occurred. Most of these objections to evolutionary theory rest on ignorance or the failure to make some fairly simple distinctions. Several, however, concern fundamental issues in the philosophy of science (Hull, 1974, 46).

This section treats four prominent polemical issues in evolutionary thinking that involve philosophical aspects of generalized Darwinism. Each of these issues relates to the core of generalized Darwinism, and their treatment here is a precursor to Chapter 5, which posits a model and specific criteria of generalized Darwinism.

4.4.2.1 The "survival of the fittest" as a tautology

Hull (1974, 66) notes, "The most serious and persistent criticism of evolutionary theory throughout its history is that the principle of natural selection or the survival of the fittest is a tautology." This criticism runs as follows: the fittest organisms are those that survive and reproduce the most; those organisms that survive and reproduce the most are the fittest; thus, natural selection is tautological; the statement "survival of the fittest" is always true, but trivially so as its terms are equivalent; it is like saying "A=A". Such an argument, however, is based on a misunderstanding of the concept of "fitness" in natural selection, which Mayr (1988, 128) points out is subject to "considerable confusion". Sober (1993, 69) also argues that the charge that natural selection is tautological is "misguided".

"The fitness of an organism is its propensity to survive and reproduce in a particular specified environment and population" (Mills and Beatty 1979, 42; Brandon 1978 in Mayr, 1988, 97). Thus "fitness" is a dispositional quality and does not refer to a certainty of survival or reproductive success. In this view, a particular entity may ostensibly have a high fitness value, but this does not guarantee *ex ante* that it will actually prevail from a selection point of view over other entities which have ostensibly lower fitness values. "If only we had 'complete' knowledge and an all-encompassing theory, the fate of every individual organism could be predicted with absolute certainty, and the survival of the fittest would become a tautology" (Hull, 1974, 69). Hull (1974, 67) sums up why certain accounts of evolution are tautological: "All of these versions of the principle of natural selection have several features in common: each specifies a necessary condition in evolution by natural selection, each errs in treating that necessary condition as if it were sufficient, and each omits any mention of the causal mechanisms responsible for the differential perpetuation specified. The end result is that each of the three versions taken separately degenerates into a tautology."

> This brings us directly to the question of fitness which we define as follows. Economic fitness is a measure of rates of expansion and decline of activity and, since it applies to the business unit, it is partly determined by the capabilities and intention of that unit. However, the crucial property of economic fitness is that it is not a property of the business unit alone, but arises from the interaction between rival business units in a given market environment. It follows that a change in environment will normally entail a redistribution in economic fitness across the population (Metcalfe, 1998, 30).

It is more accurate to say that it is the *fitter entities that survive and reproduce on average*. "This is precisely the process of natural selection, which on the average, favours those that are 'better adapted'" (Mayr, 1988, 135). Thus, fitness, taken as a *propensity* for selection, and actual *a posteriori* selection are not equivalent; and furthermore, the statement "survival of the fittest" is not a tautology. "As it now stands, the principle of the survival of the fittest is officially a tautology in certain operationally oriented versions of evolutionary theory, and these versions suffer accordingly. It is not a tautology in those versions of evolutionary theory which recognise the key role played in evolution by the organism-environment relation" (Hull, 1974, 69).

4.4.2.2 Human intentionality versus "random" variation versus "blind" variation

An important objection is that raised by Penrose (1952), who objected to the application of natural selection to economic phenomena. Her criticism relates to the "randomness" of variation in the organic sphere, which she contrasts with the deliberate actions of economic agents in the economic sphere. "Although her criticisms move along several lines, her main thrust concerns reproduction, imitation, heritability, and their relation to the role of purposive behaviour. She warns that an assumption of purposive behaviour is a must, and 'if we abandon this assumption, and particularly if we assume that men act randomly, we cannot explain competition, for there is nothing in the reproductive processes of firms that would ensure that more firms would constantly be created than survive' (1952, 812)" (Langlois and Everett, 1994, 19).

In more recent times, this criticism has been represented by Metcalfe (1998, 6) who "insist[s] that economic evolution is not Darwinian in the sense in which this uniquely biological mode of evolution is normally understood. Economic variation is simply not random enough for the Darwinian process to work." While Metcalfe makes the distinction between the logical, conceptual aspect of the Darwinian evolutionary framework, and Darwinism in its more specific biological form, he construes "Darwinian evolution" to mean "biological Darwinian evolution". "Thus, as economists applying evolutionary ideas to economic phenomena, we can learn from the debates on evolutionary biology in order to better understand the logical status of concepts such as fitness, adaptation and unit of selection, without in any sense needing to absorb the associated biological context. This does not mean that economic evolution is similar to Darwinian evolution. It is not" (Metcalfe, 1998, 22). Both Penrose (1952) and Metcalfe (1998) – in saying that the variation process in economics must incorporate purposiveness *as opposed* to the randomness of variation in biology – are not questioning that economic change might be evolutionary, but are saying, in effect, that randomness is not a necessary criterion of variation for evolution in general.

Metcalfe is concerned to avoid the notion that there must be necessary analogies with biological evolution. However, he also regards "Darwinian evolution" as equivalent with "biological evolution". Other thinkers, while they are also keen to avoid the use of biological analogies, do not shy away from calling the generic evolutionary model Darwinian, nor do they shy away from referring to evolutionary economics as Darwinian. "The…Darwinian laws mark the 'logic of history' of an evolutionary process" (Dopfer, 2005, 16). While Dopfer (2005, 17) points out that other principles are conceivable, he says that "[t]he explanatory principles or non-classical laws stated are derived from Darwin's model."

In contrast to Penrose and Metcalfe, other authors do insist that the variation process must be "blind", irrespective of which particular phenomenal domain is being considered. Thus, these authors regard the "blindness" of variation as a criterion of evolution in general. It was Campbell (1987) who put forward the notion of "blind variation" as a criterion of variation in his explication of Popper's evolutionary epistemology. Campbell's notion of "blindness" is crucial in his "blind-variation-selective-retention" (BVSR) logical scheme, and is very different to the concept of "randomness" that Penrose finds unacceptable. Blind variation means that the specific variations that present themselves are not in any way the result of an "awareness" of which variations or traits will be selected. Thus, the variations are "blind" in the sense that there is no *ex ante* causal link between the variation and selection processes. It is very important that "blind variation" not be misconstrued to mean "random variation":

> The word "blind" is used rather than the more usual "random" for a variety of reasons…Equiprobability is not needed, and is definitely lacking in the mutations which lay the variation base for organic evolution…for the generalisations essayed here, certain processes involving systematic sweep scanning are recognised as blind, insofar as variations are produced without prior knowledge of which ones, if any, will furnish a selectworthy encounter. An essential connotation of "blind" is that the variations emitted be independent of the environmental conditions of the occasion of their occurrence (Campbell, 1987, 56–57).

Sober (1993, 36) explains why natural selection is not a random process: "Natural selection involves unequal probabilities, and for this reason, it is not a random process" (Sober, 1993, 36). "Evolutionists sometimes use the word 'random' to describe the mutation process but in a sense slightly different from the one I just described. Mutations are said to be 'random' in that they do not arise because they would be beneficial to the organisms in which they occur" (Sober, 1993, 37). It appears that those authors – such as Campbell, Sober and Hodgson – who are concerned with generalized evolution tend to favour "blindness" as a logical criterion of the variation process in the generalized evolutionary framework. On the other hand, those authors – such as Penrose and Metcalfe – who are more concerned with the *application* of evolutionary thinking in economics tend to be wary of "randomness" and "blindness" as strict criteria.

Nelson and Winter (1982, 9) take a different approach, adopting a compromise that denies the mutual exclusivity of "blindness" and intentionality: "[S]ome people who are particularly alert to teleological fallacies in the interpretation of biological evolution seem to insist on a sharp distinction between explanations that feature the processes of 'blind' evolution and those that feature 'deliberate' goal-seeking"; "It is neither difficult nor implausible to develop models of firm behaviour that interweave 'blind' and 'deliberate' processes. Indeed, in human problem solving itself, both elements are involved and difficult to disentangle" (Nelson and Winter, 1982, 8).

In this thesis, Campbell, Mayr and Hodgson are followed in their assertion that "blindness" is a criterion of the variation process. This is not a denial that human intentionality and purposiveness play an important role in change processes in the social sciences; rather, it means that the generalized Darwinian evolutionary process of variation must be "blind"; moreover, that the concept of "blindness" is not mutually exclusive of human intentionality.

> Human intentionality is very important in the social sphere. Humans have unique capacities for prefiguration and deliberation. Human social interaction also involves the imputation of such powers to others with whom we interact. However, nothing in Darwinism excludes or belittles human intentionality, prefiguration, deliberation, and choice" (Hodgson, 2007, 270).

4.4.2.3 Self-organization versus natural selection as the driver of evolution

Hodgson and Knudsen (2006, 6–10) discuss the controversial stance which holds that self-organization – and not natural selection – is the primary driver of the evolutionary process. The issue is that some authors have proposed that self-organization "is sufficient as an evolutionary explanation of all complex phenomena" (6). Hodgson and Knudsen (2006) identify Kauffman (1993), Foster (1997) and Witt (1997) as authors who propose self-organization as a sufficient evolutionary explanation. Kauffman, a leading proponent of self-organization as a major driver of evolutionary change, initially relegated natural selection to a secondary role, but has since shifted his position to accept an equal role for natural selection. "Kauffman (1993, 465) saw a 'natural marriage of self-organisation and selection'" (Hodgson and Knudsen, 2006, 7).

> Self-organisation is also very important in nature. We can observe intricate patterns and complex outcomes that are the result of interactions and accumulated steps. Just as self-organisation reminds us that not every human creation is the result of a plan, it also removes the hand of God from explanations of many wonders in nature. But is self-organisation sufficient to explain the origin of species and all complex biological phenomena? The definite answer is no. Darwin's principle of selection is also required" (Hodgson and Knudsen, 2006, 6).

Hodgson and Knudsen (2006, 8) point out why natural selection is crucial to evolutionary explanations: "An exclusive focus on self-organisation concentrates on the development of the entity, with a relative neglect of its interactions with its environment and no adequate explanation of how the entity comes to be adapted to survive in this environment." Self-organization and natural selection operate from different points of view; self-organization is an internal orientation, while natural selection is "populational" and takes both the variation of the organism and the environment into account. Ontogeny refers to the growth and development of a single organism, while phylogeny refers to the evolutionary history of a population. "Natural selection is *always* phylogenetic as well as ontogenetic, in that it addresses the evolution of whole populations or organisms or structures as well as the development of individual organisms. In general, ontogeny may but does not necessarily incorporate phylogeny; but phylogeny always incorporates ontogeny. The status of the two concepts is thus unequal, as phylogeny is more general than ontogeny" (Hodgson and Knudsen, 2006, 10). "Whereas self-organisation allows a system to develop autonomously, natural selection is responsible for its adaptation to a variable environment" (Heylighen, 2000, 4). In biological terms, self-organization is the organism – as system – asserting itself; natural selection subsumes self-organization and also incorporates the environment asserting itself systemically on the organism. Thus, self-organization and natural selection are not mutually exclusive. However, natural selection does subsume the effects of self-organization as "blind" variation.

4.4.2.4 Directionality, progress and predictability of evolutionary change

Does evolutionary change necessarily imply progress, or is such a notion precluded from the logic of evolutionary change? Are we able to predict the course of evolution? These related questions, taken together, represent one of the longstanding controversies of evolutionary thinking. Levins and Lewontin (1985, 1), for example, point out that "Theories of the evolution of the inorganic world, like cosmology and thermodynamics, generally include only change and order, while biological and sociological theories add the idea of progress and even perfectability as elaborations of their theoretical structure."

In Darwinism, progress and perfectability could only be achieved in a static environment; thus, through successive generations of selection, a species in such an environment would "progress" and "reach a point of optimum adaptiveness and oscillate around this point" (Hull, 1974, 50). However, the very notion of a static environment is absurd from an evolutionary point of view. "…[F]itness or efficiency is context dependent: what are fit or efficient in one context can be less efficacious in another… nothing in the technical definition of selection – based on the work of George Price (1970; 1995) – requires that selected outcomes necessarily involve improvement in any sense, including fitness or efficiency" (Hodgson, 2007, 271).

If not progress and perfectability, could we say that evolutionary change unfolds according to some global trend or in some general direction? Is organic evolution not directional in that it proceeds from the simple single-celled organism to *homo sapiens* as the most complex pinnacle of evolution? As was discussed in Section 4.1.1, Mayr throughout his career was quite emphatically against the notion of progress in evolution. "The development or behaviour of an individual is purposive; natural selection is definitely not" (Mayr, 1998, 31). "…[N]atural selection is strictly an *a posteriori* process which rewards current success but never sets up future goals. No one realized this better than Darwin, who reminded himself never to use the words higher or lower" (Mayr, 1988, 43). Hull (1974, 51) also points out that Darwin himself rejected the notion of a directionality of evolution: "Through the years Darwin modified his theory somewhat, but two tenets which he steadfastly refused to change were that evolution occurs gradually and is in no significant sense directed towards some goal or goals." Similarly, Hodgson (2003, 88) discusses Veblen's view: "In the Darwinian scheme of thought, the continuity sought in and imputed to the facts is a continuity of cause and effect. It is a scheme of blindly cumulative causation, in which there is no trend, no final term, no consummation."

A good example from biology (of the lack of global directionality in evolutionary processes) is that of the albatross species, which actually have reduced fertility (one chick every two years), since this is favoured by the particular selection forces that they are exposed to – that is, such extreme and stormy conditions that make experience an important factor for survival. Thus, contrary to any directionality, the reduced fertility of the albatross is an adaptation! (Mayr, 1988, 156). "Darwin designated as natural selection anything that favoured survival, whether this was an increase or decrease of body size, a broadening of the niche or its more efficient utilization, better protection against the environment or an increased tolerance of environmental extremes, a superior ability to cope with diseases or to escape enemies" (Mayr, 1988, 104).

This brings us to the issue of predictability. If we acknowledge that evolution, as a process, is not progressive or directional, is there any sense or set of circumstances in which an evolutionary explanation may still be predictive? Here again, Mayr (1988, 33) is emphatic:

> Probably nothing in biology is less predictable than the future course of evolution…Unpredictability also characterizes small-scale evolution. Breeders and students of natural selection have discovered again and again that independent parallel lines exposed to the same selection pressure will respond at different rates and with different correlated effects, none of them predictable.

Similarly, other thinkers point out that evolutionary processes are not predictable in the same way that events are predictable in the physical sciences. Langlois and Everett (1994, 19) note that “[A] natural selection theory only explains events and does not, in general, predict them.” And Hull says: “The evolutionary development of particular species or populations as such cannot be predicted with any reasonable degree of certainty” (Hull, 1974, 68).

Chapter 5

Structure and criteria of the generalized Darwinian evolutionary framework

> *Heraclitus somewhere says that all things are in process and nothing stays still, and likening existing things to the stream of a river he says that you would not step into the same river.*
>
> Plato, *Cratylus*, 402a

This chapter attempts to identify generalized criteria that putative *global* evolutionary explanations should satisfy in order to be considered Darwinian evolutionary. As would be expected, population thinking and natural selection lie at the heart of generalized Darwinism, and thus largely constitute these minimum criteria. In the previous chapter, the application of the Darwinian framework at various levels of explanation was explored: at the disciplinary level in biology and economics, at the more general level of epistemology, and ultimately at the paradigmatic-ontological level of generalized Darwinism. It is generalized Darwinism that is concerned with the logical criteria of an evolutionary explanation irrespective of the phenomenal domain that is being brought into focus by that explanation. Thus, for example, evolutionary biology would reasonably be expected to satisfy all the generalized criteria in order to be construed as an evolutionary explanation of change in the domain of organic life; and, to the extent that it does "cover" the entire domain of organic life, we may say that it is a global explanation. A global evolutionary explanation encompasses *all* the entities that are designated by the unit of selection, as a universal set. A local evolutionary explanation is one that brings into focus a relatively small subset of this universal set. As an example, the evolutionary explanation that focuses on the traits of species of finches on the Galapagos is local, and thus very specific to that particular evolutionary situation. It is precisely these disciplinary "specifics" that Hodgson (2006, 15) refers to when he says: "Crucially, explanations additional to natural selection are always required to explain any evolved phenomenon." This does not mean that local evolutionary explanations are to be avoided, or are somehow less evolutionary. However, generalized Darwinism is concerned with the global explanatory level, and transcends local explanations to the extent that it would be illogical to expect local evolutionary explanations to satisfy the general Darwinian criteria. The distinction between global and local levels of explanation is crucial in this thesis, since the I-space may only be subjected to an assessment against the generalized Darwinian criteria if it is a *global* evolutionary explanation. That the I-space is indeed put forward as a general evolutionary framework that explains the creation and distribution of *all* knowledge and not some special subset of knowledge is discussed in Chapter 3, and this allows the conceptual assessment that is undertaken in Chapter 6.

The compilation of the criteria that follows has been undertaken with caution. Cognisance has been taken of the various warnings, discussed in Section 4.4, about using the biological application of Darwinism as a comparative template. Overtly biological language has been used with care and avoided where possible. However, it is not possible to completely avoid using the more fundamental Darwinian evolutionary terms that were first defined in biology. The analysis and selection of the criteria is based firstly, on the common features of the application of the Darwinian framework in evolutionary biology, evolutionary economics and evolutionary epistemology; secondly, it draws on the discourse in generalized Darwinism; and thirdly, logical argument using counterfactuals is used to support the criteria identified.

In describing natural selection, a descriptive circularity creeps in out of necessity, and, as pointed out in Chapter 1, this bedevils attempts to set out clearly its conceptual structure and criteria. Of course, this circularity does not point to a failure of logic, but rather reflects the conceptual interrelations inherent in describing a complex process. It is not possible, for example, to fully discuss the population criteria without reference to variation; or to discuss variation in complete isolation from population thinking. It is for this reason that many of the concepts were first introduced in a descriptive manner in Chapter 4.

5.1 Criteria of the generalized Darwinian evolutionary model

The discussion in Chapter 4 suggests that the generalized Darwinian framework is hierarchically organized. At the most fundamental level is the notion of evolutionary change "as such" and population thinking, which is shared by the authorities (Mayr, 2002, 1998; Hodgson, 2006; Mokyr, 2002), and demarcates the broad frame of evolutionary thinking. Within this broad frame is the compound Darwinian theory of natural selection. Natural selection is central in all the accounts of evolutionary thinking and theorizing discussed in Chapter 4, of the ways in which Darwinism has been applied in biology, evolutionary economics and evolutionary epistemology, as well as generalized Darwinism. Even Metcalfe (1998, 22) – who eschews the term

“Darwinian” and prefers “general selection theory” – points out that the Darwinian natural selection principles of variation, replication/inheritance and selection are widely accepted as the cornerstone of what it means to be evolutionary *in general*. Furthermore, those authors who believe that self-regulation is an important driver of evolutionary change locate their theories *within* the natural selection framework and not as an alternative to it. Metcalfe (1998, 22) regards variation, heredity and selection as “three widely accepted ideas which jointly define an evolutionary process. Hodgson (2007, 265–266) states the case more strongly, regarding variation, inheritance and selection as necessary to an evolutionary explanation:

> …we propose that Darwinism addresses a particular type of complex phenomena that we describe as “complex population systems…the evolution of such a system *must* involve the three Darwinian principles of variation, inheritance, and selection. These abstract principles do not themselves provide all the necessary details, but nevertheless they must be honoured. Otherwise, the explanation of the evolution will be inadequate.

5.1.1 Population thinking

Criterion 1 – Multiple populations of entities are necessary

Population thinking is central in the Darwinian framework. In Mayr’s (1988, 2002) account of Darwinism, the centrality of the population concept is made explicit: “the population is the lowest level that evolves” – thus, Darwinism is fundamentally about the evolution of populations. The individual entities in the population do not evolve; it is the population that evolves by definition. In evolutionary economics, Nelson and Winter’s theory, for example, explains the evolution of populations of business units, and in Popper and Campbell’s epistemology it is populations of knowledge that evolve. That there must be populations of entities for evolution to happen is so implicit that it is often taken for granted. A single entity – that is, a population of one – does not allow the crucial aspects of variation or selection to come into play. This does not mean that the single entity does not change, or even that it does not replicate. Rather, evolution *per se* is what happens at the level of populations (phylogeny) and not at the level of the individual entity (ontogeny).

Can a global Darwinian evolutionary explanation apply to a single population, or must it always involve multiple populations? This is an intriguing question, and one that is not often posed. Hodgson (2007, 265) points out that evolutionary thinking is concerned with complex population systems and that “the complex systems considered here involve populations of entities”. Logically, a global, single population of replicating entities could only persist as a single population if the entities replicate perfectly, *and* there are no mutations, *and* there is a uniform environment. Of course, in such an imagined situation, there could be no change at all, much less evolution. Any differences in the environment *necessarily* result in differential replication that will ultimately lead to the splitting of populations. It thus seems safe to conclude that any *global* Darwinian evolutionary explanation must involve multiple populations and – by implication – the splitting of populations (which is precisely what Darwin meant by "the theory of the multiplication of species"). The singling out of a local population for a local explanation is not precluded by this criterion; however, it does preclude a global explanation based on a single population.

Criterion 2 – Populations must be classified according to shared exposure to selection pressure

How individual entities are allocated to populations is important in evolutionary explanations:

> An evolutionary argument explains changing patterns of co-existence between certain kinds of entities, the patterns being described in terms of relative frequency measures of the relative importance of the entities. What is the criterion for meaningful comparison? It is that the entities are elements in the same population (Metcalfe, 1998, 22).

Populations, therefore, cannot be arbitrary collections of entities. Rather, a population is defined according to the criterion that all its entities compete with each other and thus face the same selection pressures. For Hodgson (2007, 266) "a complex population system involves populations of non-identical (intentional or non-intentional) entities that face locally scarce resources and problems of survival." This is significant, as populations, especially in biology, are intuitively taken to be defined according to shared physical characteristics. This view is supported by Metcalfe (1998, 26):

> A major issue which arises within the population perspective relates to the criteria by which an entity is to be assigned to a particular population…What matters in defining the members of the population is not their characteristics *per se* but that they be subjected to common environmental and selective pressures…Similarly, entities which appear to be radically different in their characteristics can still compete within the same population. All this means that the entities are classified not by their attributes but by the fact of their competing in common environments.

5.1.2 The unit of selection and the environment

Criterion 3 – The unit of selection must be identified in the explanation

Biological evolutionary theories have identified different units of selection: the individual organism, the gene and the group. Darwin firmly believed that in the organic world, the organism was the unit of selection, and this is the prevalent view among contemporary Darwinians (Mayr, 2002; 1988). From a generalized perspective, the unit of selection – as a category – must be identified in some way. It does not matter what is taken to be the unit of selection: whether one chooses to identify the individual organism or the gene in biology, or the firm or the business unit or the industry in economics, is not the issue. What is important is that an evolutionary explanation must identify the category it will explain; in other words, it must identify the unit of selection. Defining the unit of selection is a more basic requirement than the classification of populations, since the members of all the populations, however defined, will also be members of the category defined by the unit of selection. If the unit of selection is not identified in a global evolutionary explanation, there is no way of knowing what is being explained.

Criterion 4 – The unit of selection must be persistent throughout the explanation

In a complete evolutionary explanation, the unit of selection may not change throughout the explanation. There is a changing environment, the population evolves, and the entities themselves change (both in terms of ontogeny and from one generation to the next); but the category that defines the unit of selection may not change in an evolutionary explanation. It would be confusion if one started with one unit of selection and then switched to another in the course of a single evolutionary explanation. Thus, evolutionary change does not encompass a situation in which, during the course of a process of change, an entity belonging to a certain category *becomes* an entity of a different category. To illustrate: if an evolutionary explanation defines "firm" as the unit of selection, this category cannot become something other than "firm" in the course of the explanation. To change the unit of selection is thus to change the explanatory level.

> Selection, as a theory of forces, must consider the role of active competition as establishing what the unit if selection is; that is, the proper question is (and we think few would disagree), what is competing for survival? Here, we also hold that depending on what we are trying to explain, the unit may change, but not its kind (Langlois and Everett, 1994, 31).

Criterion 5 – There must be interaction between the entities and an environment

In biological terms, the genotype is expressed as the individual organism – the phenotype – in its interaction with the environment. "In biological evolution, the phenotype (usually thought of as the organism) interacts with the environment (producing differential reproduction and survival), while heritable genotypic variations (replicating genes) give rise to the phenotype that interacts with the environment" (Langlois and Everett, 1994, 23).

Interaction with the environment is crucial in evolutionary theory, given that selection is pressure exerted by the environment on the unit of selection. All evolutionary situations take place in an environment; and it is crucial that the entities, while they belong to populations, interact with that environment. Thus, the entities may not be taken to be closed systems of any kind. That there must be interaction between the entity and the environment is such a basic evolutionary criterion that it needs no further justification.

5.1.3 Replication and inheritance

Criterion 6 – Replication of the entities is necessary

Darwinian evolutionary models explain the evolution of populations through generational change.

> For natural selection to be a causal factor in evolution, two requirements must be met: There must be interaction of something with the environment and there must be replication (Langlois and Everett, 1994, 23).

What would happen in the logically possible case of a population of mortal, non-replicating entities? Clearly, the entire population will simply perish – no evolution would be possible. Therefore, the entities in the mortal population must replicate in some way for evolution to be possible.

Consider the imagined, logically possible situation in which there is a population of immortal entities that do not replicate. Could a Darwinian evolutionary explanation hold for such a population? It could not, since selection could not operate where there is no replication.

Criterion 7 – Inheritance of the properties of the entities is necessary

Metcalfe (1998, 22) regards heredity as one of the "three widely accepted ideas which jointly define an evolutionary process", where heredity is "…the principle...that there exist copying mechanisms to ensure continuity over time in the form and behaviour of the entities in the population." Sober (1984, 100) distinguishes between "selection of" certain entities in a population, and "selection for" certain attributes of those entities.

What would happen in the case of a population of replicating entities without heritable properties – in which, for instance, each newly replicated entity ends up with a random set of properties that is completely independent of the properties of its parent or parents? In such a situation, there can be no Darwinian evolutionary process, as there is no selection – the property set is left entirely to chance. Thus, the properties of the entities must be heritable from one generation to the next.

5.1.4 Natural selection

The logical components of natural selection are identified by Campbell (1987) as blind-variation-selective-retention. These components are both necessary to cause evolutionary change, and this theory is thus referred to as a compound theory. It is possible to vary the emphasis placed on each of the components of natural selection, but to remove one of them would subvert the compound theory. Nevertheless, while variation and selection are both causally necessary for natural selection to occur, they are causally independent of each other (Mayr, 2002).

> …influential writers such as Mayr (1982) have categorized evolution as a two-step process: variety is generated by some mechanism, and variety is subsequently selected to produce a pattern of change within the relevant population (Metcalfe, 1998, 22).

5.1.4.1 Blind variation

Criterion 8 – Variation of the entities in a population is necessary

Metcalfe (1998, 22) regards variation as one of the "three widely accepted ideas which jointly define and evolutionary process…the principle of variation, that members of a relevant population vary with respect to at least one characteristic with selective significance…" If there is no variation at all between the entities in a population, then selection has no foothold; there would be no differences upon which selection pressure could be differentially exerted.

While variation in general is a criterion of the generalized Darwinian model, it is not necessary to specify how the variations come about: "…the population perspective does not require a theory of how variety is generated. It is sufficient to take variety as given and work through the consequences" (Metcalfe, 1998, 24).

Criterion 9 – The variation of the entities must be blind

The criterion of blindness in the variation of the entities is discussed in Section 4.4.2.2, and is supported by several authorities (Campbell, 1987; Mayr, 1988; Sober, 1993; Hodgson, 2007). Blind variation is often misunderstood to mean that the variations must be random: "Natural selection involves unequal probabilities, and for this reason, it is not a random process" (Sober, 1993, 36). Following Campbell (1987), blind variation is taken to mean that variations do not occur as a result of "foreknowledge" of the traits that will be selected; they are not generated *because* they will be selected. Van Parijs (1981, 52) describes the blindness criterion as follows: "Even in the pure case, the variation on which the selection operates need not be random, it can be biased. But it must be blind, in the sense that the bias must not be connected with the criterion of selection."

5.1.4.2 Selective retention

Criterion 10 – Selective retention (or elimination) of the entities is necessary

Metcalfe (1998, 22) regards selection as one of the "three widely accepted ideas which jointly define an evolutionary process…the principle of selection, that the characteristics of some entities are better adapted to prevailing evolutionary pressures and consequently increase in relative significance compared to less adapted entities." Vromen (1995, 5) also points out that "selection mechanisms are crucial parts of what will be called evolutionary mechanisms." There must be differential survival and replication of the entities from one generation to the next in order for evolutionary change to take place. Differential survival is the effect of selection pressure on the population of entities that vary in terms of their attributes. Where there is variation among competing, replicating, mortal entities, there will be differential survival – selective retention, in other words.

Criterion 11 – Neither global fitness nor the global criterion of selection may be defined in terms of pre-specified traits

Fitness in the global evolutionary explanation is the propensity of the entity to survive and replicate relative to other entities. It is an *ex ante* disposition or potential, which is different from the *a posteriori* outcome of actual selective retention. Thus, fitness is not equivalent to selective retention, and, more importantly, it is not a sufficient condition for actual selective retention, as discussed in detail in Section 4.4. In this thesis, the global criterion of selection describes what *a posteriori* selective retention would entail in the global evolutionary explanation; what actual selection would mean in terms of a generally stated outcome. Thus, global fitness is the propensity of the entity to achieve the global criterion of selection.

In biology, the general criterion of selection is *a posteriori* relative to survival and reproductive success, while fitness denotes the propensity of the organism to achieve relative survival and reproductive success in its population. Neither organic fitness nor the global criterion of selection can be specified in terms of specific traits. In Nelson and Winter's (1982) theory, the general criterion of selection is the relative weight of the firm, while fitness is the propensity of a firm to achieve success, in terms of relative weight, in its industry. In all these cases, both fitness and the general criterion of selection are formulated in general terms, and not in terms of a set of pre-specified traits or attributes. While Nelson and Winter identify the "routines" of the firms as the heritable attributes of firms that are selected for, they do not – and cannot – specify a finite set of specific routines that have global significance.

> As Nelson has pointed out (1995, 55), the theory's power depends on its ability to specify what precisely these selection criteria are. The general answer must be that they are historically contingent. It would be nice if all selection criteria could be collapsed into a profit maximisation motive, but this would be silly. For instance, some societies – such as the nineteenth-century United States – emphasized price and production efficiency above all, whereas others – such as France – selected against mass production and large factories and preferred techniques based on individually manufactured custom-made products wherever possible (Mokyr, 2005, 207).

While the specific selection criteria – or what are referred to in this thesis as attributes or traits with selective significance – cannot be specified in the global evolutionary explanation, the general criterion of selection can and should be described. However, how this is described must be approached with care to avoid describing an intermediate criterion – such as the "profit maximization motive" in the above quotation, which is too specific.

It may be held that the fitness of entities in a particular local population is increased by the presence of a specific trait, such as, for example, speed in a population of zebra that share a geographical area with lions. However, may such a statement be made about fitness globally? That is, is it admissible in a global evolutionary explanation to express fitness in terms of a finite set of traits? The answer is an emphatic no. The example of the zebra in lion country is local in two important ways: firstly, it is local in that it isolates two interacting populations and ignores all other populations; and secondly, it is local in terms of time – in the sense that it freezes environmental change for the purpose of explaining that particular situation. It is the latter aspect of the local explanation that is particularly problematic in the global evolutionary explanation. Section 4.4.2.4 provided detailed support for the view that the course of evolutionary change is not predictable at the global level. Fitness in the global evolutionary explanation may only be expressed as a global propensity for selective retention; to specify fitness in terms of specific traits freezes the environment in terms of what is being selected for, and a static environment is an absurdity in evolutionary thinking. There is no problem with saying that a particular trait or set of traits contributes to the higher fitness of an entity or a population; but to say that a finite set of traits determines fitness *globally* – which is to say that it does so now and forever – is obviously inadmissible. In certain local situations, speed is a trait that contributes greatly to the fitness of certain animals. However, in other situations camouflage and the ability to keep very still, for instance, contribute greatly to fitness.

> As the philosopher C.S. Peirce recognized quite early, the form of evolutionary theory differed markedly in this respect from the Newtonian paradigm. Given the relevant data and evolutionary theory, no reasonable inferences were possible concerning the fate of a particular organism (Hull, 1974, 59).

Selection is thus highly contingent: a static definition of fitness or general selection criterion ignores the possibility of environmental change; it makes fitness a static function of a few pre-specified traits.

5.2 Other putative "criteria" not admitted to the minimum set

There are a number of features of evolutionary thinking that have consciously not been included in the minimum set discussed in Section 5.1: gradualism; the exclusion of acquired characters; and the specification of the replicator. These features are included in some accounts of evolutionary thinking, and are putative in that sense. It is therefore necessary to explain why these are not admitted to the minimum set of criteria identified in this thesis.

5.2.1 Gradualism

One of the tenets of evolution that Darwin steadfastly espoused was that evolutionary change is necessarily a gradual process. Darwin's dictum "*natura non facit saltum*" (nature makes no leap) captures this view; thus gradualism is contrasted with saltative change. This is often misunderstood to mean that evolutionary change, in general, must be slow and that it typically occurs over geological stretches of time. In ordinary language, the term "evolution" is contrasted with "revolution", the latter taken to mean that change happens rapidly and in the form of an upheaval as opposed to a slow and steady process of change.

What gradualism actually means in the Darwinian scheme is that the attributes of an *entire* population of entities cannot – through natural selection – change saltatively within a single generation. "In saltative evolution, numerous characteristics change abruptly in the space of a single generation" (Langlois and Everett, 1994, 18); while, in gradual evolution, any attribute that increases the fitness of the entities will only gradually come to be distributed throughout the population over multiple generations of selective retention. Thus, for example, a population of giraffes did not suddenly develop long necks within a single generation, but did so gradually over many generations as that trait was selected for.

Mayr (1988) explains that evolutionary tempo does not mean that rapid change cannot happen: "[T]here is nothing in the theory of evolution by natural selection that says changes must be small or large, slow or rapid." Langlois and Everett (1994, 18) point out that "Darwin's intuitions on the matter were basically correct. The only genetic mechanism that has been discovered that produces the saltative evolution Darwin argued against is polyploidy; but in the vast majority of cases, evolution is gradual, not saltative." Nelson and Winter point out that there is no need to exclude rapid change: "There are other connotations that have at most a qualified relevance to our own evolutionary approach. For example, there is the idea of gradual development, often invoked by an opposition between 'evolutionary' and 'revolutionary'. Although we stress the importance of certain elements of continuity in the economic process, we do not deny (nor does contemporary biology deny) that change is sometimes very rapid" (Nelson and Winter, 1982, 8).

Nevertheless, the question here is, Why is gradualism excluded from the set of criteria derived in Section 5.1? While gradualism may be defended as a feature of Darwinism, it is not a logical criterion of the explanatory framework, but a logical implication thereof. Gradualism is an implication – or outcome – of the evolution of populations of entities by natural selection. Thus, it is excluded from the minimum criteria set.

5.2.2 The exclusion of acquired characters

The transmission of acquired characters from one generation to the next is not accepted in contemporary biological evolution, since the genotype is not exposed to the environment (Mayr, 2002). However, even Darwin himself did not exclude acquired characters. Hodgson and Knudsen (2006, 13) point out that Darwinism and Lamarckism are not mutually exclusive:

> Accordingly, Lamarckism is not an alternative to Darwinism, even in the social sphere. It is erroneous to see them as rivals because Lamarckism depends on Darwinian natural selection to complete its explanations. Hence, Witt (1999,

> 288) and many others are wrong to presume that social learning and social evolution are "more akin to Lamarckian than to Darwinian evolution". There is nothing in social evolution that contradicts the core Darwinian principles, and these general principles do not themselves exclude the possibility of acquired character inheritance.

Nelson and Winter also incorporate Lamarckism in their evolutionary theory: "[O]ur theory is unabashedly Lamarckian: it contemplates both the 'inheritance' of acquired characteristics and the timely appearance of variation under the stimulus of adversity" (1982, 9). Thus, while acquired character inheritance has been refuted in biological evolution, it is not *logically* excluded from the generalized Darwinian framework.

5.2.3 Specification of the replicator is not necessary

David Hull (1989, 96) describes a "replicator" as "an entity that passes on its structure largely intact in successive replications," and an "interactor" as "an entity that interacts as a cohesive whole with its environment in such a way that this interaction causes replication to be differential." In biological evolutionary explanations that identify the organism as the "interactor", the gene is typically identified as the "replicator". In Simon and Winter's (1982) model, the firm or business unit is the interactor, while the routine is identified as the replicator. In Campbell's model, the unit of selection (and the interactor) is knowledge, but it is not made clear what the replicator might be.

Is it logically necessary to identify the replicator in a Darwinian explanation? Hodgson (2007, 267) argues that in an adequate evolutionary explanation – in the context of complex population systems – "there must be an explanation of how useful information concerning solutions to particular adaptive problems is retained and passed on." Thus, Hodgson requires that the replicator be identified in a generalized Darwinian evolutionary explanation. The view taken in this thesis is that while it is desirable to identify the replicator in specific evolutionary situations, it is not strictly necessary in the generalized Darwinian model to do so. Metcalfe (1998, 22), for example, does not insist on identifying the replicator, although he regards heredity as one of the "three widely accepted ideas which jointly define an evolutionary process", where heredity is the principle "that there exist copying mechanisms to ensure continuity over time in the form and behaviour of the entities in the population." For Metcalfe, there is no need to specify what the copying mechanism is. What is necessary is that there is inheritance of properties in general. Similarly, Langlois and Everett (1994, 23) do not insist that the replicator be specified: "[F]or natural selection to be a causal factor in evolution, two requirements must be met: There must be interaction of something with the environment and there must be replication."

Chapter 6

A generalized Darwinian conceptual assessment of the I-space

In going beyond what is already known, one cannot but go blindly.

Donald T. Campbell, 1987

In this chapter, the criteria identified in Chapter 5 are applied in an assessment of the I-space framework. In preceding chapters, the I-space has been characterized in a number of ways that inform the assessment. To review: the I-space is a *general conceptual framework for an economics of knowledge*; the I-space is also an *epistemological framework*, since it is primarily concerned with the form, creation and distribution of knowledge; and it is a putative *global evolutionary explanation* in the sense that it sets out to explain the evolution of knowledge *in general*. Although the I-space also involves the evolution of knowledge at the *local* subjective level, its focus, and the focus of this research, is the evolution of knowledge as a global evolutionary category.

Boisot's general commitment to evolutionary thinking and the specific commitment to evolutionary thinking in the I-space have been discussed in Chapter 3. However, the I-space has not been explicitly formulated according to the Darwinian framework, nor is Boisot concerned, in the first instance, with a demonstration of the evolutionary aspect of the I-space. While some explicitly evolutionary statements are made, these are not assembled in a coherent discussion of the evolutionary aspect. Thus, there is a need in this thesis to identify and piece together the evolutionary aspect of the I-space. In this regard, a difficulty with Boisot's (1995; 1999) discussion of the I-space is that there is a need to distinguish between the *explication* of the I-space and what, strictly speaking, it incorporates as a defined theoretical framework. The explication of the I-space is much wider than the I-space *per se*, in that the explication includes a discussion of concepts, exceptions and qualifications that are not represented in the I-space framework itself. While the assessment that follows in this chapter does distinguish between the I-space *per se* and its explication, both are referred to in order to identify the criteria; this thesis errs on the side of caution, since the wider explication is not excluded in the assessment.

From an evolutionary perspective, the subjective and social aspects of the I-space present very different evolutionary situations. Three of these are treated in Boisot's work: (1) the evolutionary process of trial-and-error selection of attributes and categories through coding and abstraction; (2) the evolution of the populations of expectations in the individual data-processor, which may be described as the evolutionary situation that arises in the context of an individual E-space structured according to the connectionist neural network model; (3) the evolution of knowledge populations in populations of data-processors. The three evolutionary situations are nested and co-evolve. The evolution of categories is of a lower level than the evolution of individual E-spaces, which is at a lower level than the evolution of knowledge in society. Although they are nested, they operate at different, and separable, levels of evolutionary explanation. There is no objection to multiple levels of evolutionary processes or co-evolutionary situations; however, in the context of this research, it is the third level of evolutionary explanation – the global evolution of knowledge populations in populations of agents – that will be assessed in detail.

The trial-and-error selection of categories to form codifications and abstractions may be interpreted from a Darwinian perspective as referring to the evolution of populations of *attributes* and *categories* in the brain.

> Like coding, abstraction economises on categories by an act of selection from competing alternatives. Edelman aligns such selection with evolutionary processes…The theoretical principle I shall elaborate here is that the origin of categories in higher brain functions is somatic selection…In other words, I shall take the view that the brain is a selective system more akin in its working to evolution than to computation or information processing (Boisot, 1995, 59).

This evolutionary situation occurs *locally* in the individual data-processor; and the primary unit of selection in the case of the abstraction process would be the "abstract category". An explanation of the evolution of the expectations, or knowledge, *in the individual data-processor* is also a *local* evolutionary explanation. It encompasses only the knowledge populations of a single data-processor, which is a subset of the global set of knowledge populations held by all data-processors. Whether these data-processors interact or not, or have similar knowledge or wildly different knowledge from each other, is irrelevant in making this distinction, since the global evolutionary explanation must encompass *all* the entities that belong to the category fixed by the unit of selection – which in this case, is knowledge. Thus, this research is concerned with the extent to which the I-space is a generalized Darwinian explanatory framework for the global evolution of knowledge. Of course, this is not an arbitrary choice, but one that goes to the crux of the I-space as a general theoretical framework for the creation and distribution of knowledge.

6.1 Assessment of the criteria for population thinking

Criterion 1 – Multiple populations of entities are necessary

The I-space formulation does refer directly to knowledge populations:

> What we need to note here is that the more coded and abstract the epistemological objects that populate W3 can be made, the more adapted they will be to transmission by means of artificial channels (Boisot, 1995, 104).

Boisot (1995) also refers explicitly to populations of data-processors, and it is clear that such populations are "carriers" of the knowledge populations:

> Figure 3.2 describes the diffusion of a given item of information in a target population of data processors as a function of time. The population chosen for the exercise could be of any size ranging from a handful of people to a nation-state or larger. It need not even refer to people necessarily: any entities capable of receiving, processing, storing, and transmitting information – dolphins, nerve cells...could make up a diffusion population for our purposes (1995, 105).
>
> …If the concept of population is to be analytically useful...it should amount to more than just a random assortment of data-processing agents. How are these to be selected? The answer is, with reference to the potential relevance to them of the data being processed and shared (Boisot, 1999, 52).

The above quotations illustrate the type of situation that Boisot uses the I-space to describe: the creation of the single knowledge item, which becomes a knowledge population through diffusion in a population of data-processors. Nevertheless, a knowledge population may thus be inferred; but it should be noted that the subsequent, and ongoing, evolution of the knowledge population created in the first step is not discussed in detail in the I-space explication.

From the above, it is clear that the I-space does not assume a single global population or species of knowledge. Indeed, the I-space stratifies knowledge in many ways along its various dimensions. Figure 9 (already seen in Chapter 2) provides one example of an I-space classification based on the degree of abstraction and diffusion of knowledge.

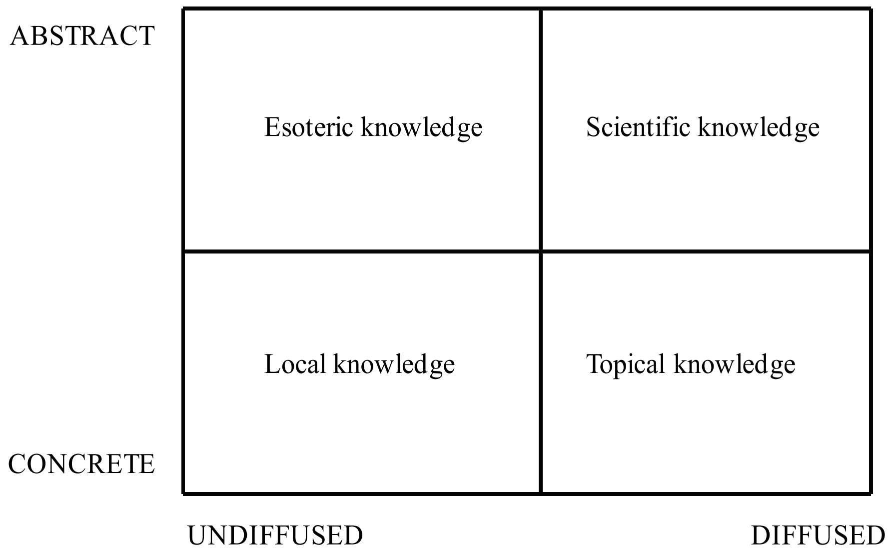

Figure 9
Knowledge categories in the U-space
Boisot (1995, 122)

Criterion 2 – Populations must be classified according to shared exposure to selection pressure

In the discussion of Criterion 1 above, it is established that the I-space does not assume a single population of entities, but does accommodate multiple populations. However, we also need to ask: in what way are knowledge items identified and classified as populations of competing entities? Here too, the I-space explication is not entirely clear, and there is a need to go beyond the explication and follow the process step-by-step. The diffusion of a new knowledge entity in a local population of data-processors is described as occurring through a combination of broadcasting and one-to-one interactions. The knowledge entity varies as it is replicated in each data-processor as a result of communication problems and interpretation differences. In some cases, the new knowledge may eliminate or modify an existing knowledge object, and in some, it will be rejected by the data-processor. In this way, through continual cycles, competing populations of knowledge entities held in the populations of data-processors will arise.

Given the evolutionary situation described, the question is: are knowledge entities classified into *competing* populations in the I-space? Boisot does indeed identify many categories of knowledge, but can these be called populations in the evolutionary sense? All the I-space classifications of knowledge are made on the basis of one or both of the qualitative dimensions of the I-space: abstraction and codification (Boisot, 1995). Thus, all the I-space classifications are based on the particular attributes – or traits – of the knowledge entity. This approach to classifying knowledge populations, however, is not sufficient for an evolutionary explanation. Populations cannot be based purely on the of degrees of abstraction and codification of the knowledge entities, as these are attributes that do not *by themselves* mean that entities that share those attributes compete with each other and may thus be placed in the same population. The classification of populations on the basis of attributes can be very misleading. Consider an example in the economic sphere: two business firms are of equal size in terms of total net assets and number of employees; they differ in that one is a state-owned enterprise, while the other is a private company; one operates in the defence industry, while the other operates in retail. To classify these two entities as occurring in the same population on the basis of the attributes of total net assets and number of employees would be incorrect, as there is almost no way in which they may be said to compete with each other. They do not compete for customers, nor do they compete for capital. Consider an example from the I-space itself: assume that two knowledge entities have precisely the same degrees of abstraction and codification; one is an economic theory of consumer demand, while the other is a theory of the functioning of the human heart. There is no significant sense in which these two theories – which set out to explain entirely different phenomena – may be said to compete with each other; it is even doubtful that they compete for cognitive attention.

Thus, the I-space classifications of populations according to the attributes or traits of knowledge are not sufficient as an evolutionary classification of populations. While the universal set of knowledge objects is stratified in various ways in the I-space framework, these subsets do not satisfy the criterion for the classification of populations according to shared exposure to selection pressure.

6.2 Assessment of the criteria for the unit of selection and the environment

Criterion 3 – The unit of selection must be identified in the explanation

It is not clear, in the explication of the I-space, what the unit of selection is.

> Cultural evolution, like biological evolution, is a matter of generating variety, selecting from it, and transmitting what has been selected to contemporaries and descendents. But its chosen vehicle for the generation and transmission of variety is artefacts instead of genes, information-bearing W3 products communicate, therefore – i.e., pass on their information content – is crucial to

their chances of being selected and adopted, and hence their future prospects for survival (Boisot, 1995, 100).

The above quotation identifies two categories that may be used as the unit of selection: "artefacts", and "information-bearing W3 products". However, in most other instances, Boisot refers to information and knowledge as if they are the units of selection:

> The social trajectory of a new piece of information or knowledge, whether embodied in objects, documents, or in minds, is thus given by an interplay of internal and external forces that can profoundly modify a message's form and content in the course of its travels through a given population. Yet not only will the first and the last recipients of a given message in a population then gain access to different information, they will also bring to its interpretation quite different contexts and orientation (1995, 110).

Information, in Boisot's conception, is different from knowledge; the stock of knowledge, held by the data-processor, is either modified or added to by information flows. Such flows are not informational if they have no effect on the knowledge set held by the data-processor – they are "non-informational". Taking information to be the unit of selection would therefore involve a different evolutionary situation.

The global unit of selection in the I-space is implicitly identified as knowledge. Indeed, a large part of this research has made the case for characterizing the I-space as a putative evolutionary *epistemological* framework for an economics of *knowledge*. The unit of selection is thus taken to be knowledge, which, in Boisot's conception, refers to "expectations" and "dispositions to act" that are held by data-processors.

Criterion 4 – The unit of selection must be persistent throughout the explanation

As discussed above, Boisot refers to numerous potential units of selection, and it is only by isolating knowledge as the intended unit of selection that this analysis may continue. A further complication arises from Boisot's (1995) treatment of the "structuring of information" which – if it is incorrectly taken to describe an evolutionary process – may be construed as a lack of persistence of the unit of selection, since it traces the process by which information is *extracted* from data in what is described as a metabolic process. Hence there is the need, for the purpose of this analysis, to isolate the evolutionary situations being dealt with in the I-space and furthermore to focus on the one of interest.

The question is: once we have isolated knowledge as the unit of selection, is it used persistently throughout the explanation? Since no detailed and explicitly Darwinian evolutionary explanation is provided, it is impossible to provide a direct answer to this question. Nevertheless, the criterion may be phrased differently to make an assessment tractable under these conditions: *The unit of selection must not be assumed to change, as a category, throughout the global evolutionary explanation*. Phrased in this way, we may say that while Boisot refers to various evolutionary situations and units of selection, it is not assumed anywhere in his work that the knowledge category "morphs" into something else within a single line of evolutionary reasoning.

Criterion 5 – There must be interaction between the entities and an environment

The I-space *per se* and Boisot's explication of the I-space both refer to the environment in several ways. In the I-space framework, knowledge is modified by information extracted from data and is thus affected by the environment in general. Moreover, the data-processors are also described as testing knowledge in Popper's W1 – the world of phenomena. From this perspective, the knowledge entities are open to the general environment that impinges on them. Thus, the I-space satisfies the criterion that there must be interaction between the entities and an environment.

Boisot also identifies the environment more specifically as the I-space itself, which is referred to as the "data field". Thus, the data field acts environmentally upon knowledge and influences it; knowledge populations therefore evolve *in* the data field.

> Our newly created data field is structured by forces traceable in E-, U-, and C-spaces – let us for the sake of convenience bring them together and treat them as a single three-dimensional entity that we can label the Information Space or I-space – forces that channel the flow of knowledge and its distribution in the field; forces, then, which by implication give the field its evolutionary orientation over time (Boisot, 1995, 166).

In addition to the data field, "artificial channels" are identified as an important aspect or condition of the environment: "What we need to note here is that the more coded and abstract the epistemological objects that populate W3 can be made, the more adapted they will be to transmission by means of artificial channels" (Boisot, 1995, 104). In this quotation, it is the use of the word "adapted" which suggests that communications channels form part of the environment. However, this aspect is more a part of the explication of the I-space than the I-space *per se*. Another more implicit view of the environment included in the explication of the I-space relates to the population of data-processors as the environment for the knowledge entities. A population of knowledge entities thus resides in the population of data-processors. In this sense, a population of data-processors is the environmental niche for a particular knowledge population.

6.3 Assessment of the criteria for replication and inheritance

Criterion 6 – Replication of the entities is necessary

Replication occurs in the I-space by the diffusion of knowledge objects in populations of data-processors. Boisot (1995, 121) refers to two broad types of replication mechanism: "broadcasting" and "one-to-one". Thus, this criterion is quite clearly satisfied both in the I-space framework and its explication.

Criterion 7 – Inheritance of the properties of the entities is necessary

Inheritance is not explicitly dealt with in the I-space explication or in the framework itself. However, it may be inferred from the description of the diffusion process that there is indeed an inheritance of properties as knowledge replicates from one data-processor to another.

What might be the heritable properties of knowledge objects in the I-space? Boisot identifies "artefacts" and "information content" as the replicators in the diffusion process, but does not delve into this aspect.

> Cultural evolution, like biological evolution, is a matter of generating variety, selecting from it, and transmitting what has been selected to contemporaries and descendents. But its chosen vehicle for the generation and transmission of variety is artefacts instead of genes, information-bearing W3 products communicate, therefore – i.e., pass on their information content – is crucial to their chances of being selected and adopted, and hence their future prospects for survival (Boisot, 1995, 100).

However, in the I-space framework the only dimensions of variation are in the degree of abstraction and codification. Since the identification of the replicator is not necessary (as discussed in Chapter 5), the criterion that there be some form of inheritance is implicitly satisfied in the explication of the I-space.

6.4 Assessment of the criteria for natural selection – variation

Criterion 8 – Variation of the entities in a population is necessary

Variation is explicitly identified in the I-space explication:

> The social trajectory of a new piece of information or knowledge, whether embodied in objects, documents, or in minds, is thus given by an interplay of internal and external forces that can profoundly modify a message's form and content in the course of its travels through a given population. Yet not only will the first and the last recipients of a given message in a population then gain access to different information, they will also bring to its interpretation quite different contexts and orientation (Boisot, 1995, 110).

Boisot (1995, 111) also refers to variation in his discussion of deviance and conformity in society: "In the long term, however, a society without deviants deprives itself of the cognitive variety essential to social evolution."

However, it should be noted that the "interplay of internal and external forces" and the "problems" referred to are not represented in any way in the I-space framework itself. These forces, while they condition the variation of the entities as they replicate across data-processors, are exogenous to the I-space framework. Nevertheless, the criterion that there must be variation of the entities is met in the I-space explication.

Criterion 9 – The variation of the entities must be blind

According to the quotations given in the discussion of Criterion 8, the variation described in the I-space explication does indeed appear to be blind. The variations of the attributes of new knowledge entities are not taken in the I-space or its explication to be designed with foreknowledge to assist selective retention or – in I-space terms – to assist diffusion. The variations occur without any "forethought" or tendency towards any traits that may be more selective. Indeed, Boisot (1995, 109–111) explicitly refers to the acts of personal "invention" and idiosyncratic "imitation" that result in a blind process of variation, as these acts are not undertaken in the first instance with diffusion in mind.

> In sum, a blend of technical, semantic, and pragmatic problems ensures that a given item of knowledge at one time and place is not necessarily the same product it might be at another (Boisot, 1995, 121).

6.5 Assessment of the criteria for natural selection – selective retention

Criterion 10 – Selective retention (or elimination) of the entities is necessary

Selective retention is explicitly discussed in the explication of the I-space. That knowledge entities vary and have differential diffusion is a central idea in the I-space and its explication

(Boisot, 1995; 1999). Knowledge entities held by data-processors persist until they are modified or replaced by new information, or the incoming information is rejected and is non-informational. In this way, the data-processor's knowledge populations evolve as fitter knowledge entities persist and less fit knowledge entities perish.

Criterion 11 – Neither global fitness nor the global criterion of selection may be defined in terms of pre-specified traits

What is the global criterion of selection in the I-space? It is *diffusion* that best fits the bill. Thus, selection in the I-space means the actual diffusion of knowledge among data-processors. What does fitness mean in the I-space? Boisot (1999, 52–53) refers to "diffusibility", which is the *propensity* for diffusion rather than actual diffusion: "[I]t is clear that we are talking about the diffusibility of information and not about the rate at which it is actually taken up." For Boisot (1995, 143), diffusability is "the percentage of a given population of data processors that can be reached in a given unit of time with a particular message..." Boisot's concept of diffusability is a propensity for selective retention, and is thus precisely conceptually equivalent to the concept of fitness in generalized evolutionary thinking.

These definitions of fitness and the general criterion of selection would be acceptable in a global evolutionary explanation. However, Boisot does not stop there; the I-space goes on to *predict* which types of knowledge are *more likely* to be diffused according to pre-specified attributes. That is, it grades the fitness of knowledge objects according to their degrees of abstraction and codification. In doing this, the I-space essentially pushes out of the I-space framework other factors that may have selective significance, rendering them exogenous to the I-space. Sober (1993, 73) describes the problem as stemming from the asymmetry of fitness and the entity's physical properties:

> The physical properties of an organism and the environment it inhabits determine how fit that organism is. But the fitness that an organism possesses – how viable or fertile it is – does not determine what its physical properties must be like. This asymmetrical relation between the physical properties of the organism in its environment and the fitness of the organism in its environment means that fitness supervenes upon physical properties (Rosenberg 1978, 1985)…A cockroach and a zebra differ in numerous ways, but both may happen to have a 0.83 probability of surviving to adulthood.

The problem with the I-space approach is that such a predictive explanation defines fitness statically in terms of the degree of abstraction and codification. If these are indeed the only traits of knowledge that have selective significance, then the evolution of knowledge would quickly reach an optimum point and oscillate around that optimum. In a generalized Darwinian evolutionary explanation, the *ex ante* identification of traits as specific selection criteria is highly problematic. Thus, the I-space does not satisfy this particular criterion.

Chapter 7

The search continues

> *My more modest role has been to emphasise that the existence of values, and therefore also of economic values, is in line with our present description of the physical universe. To describe nature, including our position in nature, we are looking for a narrow path – somewhere between the deterministic description which leads to alienation and a random world in which there would be no place for human rationality. In all fields, whether physics, cosmology or economics, we come from a past of conflicting certitudes to a period of questioning, of new openings. This is perhaps one of the characteristics of the period of transition we face at the beginning of this new century.*
>
> Prigogine, 2005, 69

7.1 Research outcome

Max Boisot's I-space, as set out in 1995, is characterized in this thesis as a putative global evolutionary framework for an economics of knowledge that should be evolutionary in a strict sense, given Boisot's paradigmatic-ontological commitment to evolutionary thinking, and in terms of his stated commitment to evolutionary principles. Thus, the I-space framework and its explication have been subjected to a comparative conceptual analysis against a derived set of criteria for a global evolutionary explanation in the dominant contemporary Darwinian conception of what it means to be evolutionary. The findings of this research are that the I-space does not satisfy all the criteria; and the I-space is therefore not a Darwinian global evolutionary framework.

The I-space does satisfy numerous criteria, at times explicitly in the I-space framework itself, but in other cases only on the basis of interpretation and inference from the broader I-space explication. The criteria that are satisfied are: Criterion 1 – multiple populations of entities are necessary; Criterion 3 – the unit of selection must be identified in the explanation; Criterion 4 – the unit of selection must be persistent throughout the explanation; Criterion 5 – there must be interaction between the entities and an environment; Criterion 6 – replication of the entities is necessary; Criterion 7 – inheritance of the properties of the entities is necessary; Criterion 8 –

variation of the entities in a population is necessary; Criterion 9 – the variation of the entities must be blind; and, Criterion 10 – selective retention (or elimination) of the entities is necessary.

Two criteria are not satisfied: Criterion 2 – populations must be classified according to shared exposure to selection pressure; and, Criterion 11 – neither global fitness nor the global criterion of selection may be defined in terms of pre-specified traits. The most crucial failing of the I-space from the perspective of evolutionary thinking is that it defines *ex ante* a finite set of attributes – degree of abstraction and degree of codification – as constitutive of global fitness. Although evolutionary theory is of predictive value in certain local evolutionary situations, it is inadmissible in a global evolutionary situation to specify *ex ante* specific selection criteria in terms of a finite set of traits, and to predict evolutionary outcomes on that basis. In doing so, the I-space ignores the contingency of knowledge creation and diffusion in a varied and changing environment, and makes exogenous to the I-space myriad other factors at play in such a process. In identifying *ex ante* a finite set of traits that predict the selective retention of knowledge entities, the I-space cannot be a global evolutionary explanation in a fundamental sense because it defines global fitness and – by implication – the global selection criterion too narrowly.

The second "failing" – which is closely related to the first – is that the I-space does not define knowledge populations according to shared exposure to selection pressure. Rather, knowledge is stratified according to shared attributes along the I-space dimensions of degrees of abstraction and codification. And in so doing, the I-space may bring non-competing entities into the same population even though such entities are not exposed to similar selection pressure.

The failure of the I-space to satisfy these criteria points to the contravention of an assumption of evolutionary thinking that is so fundamental that it is difficult to describe as a criterion. This refers to the implicit assumption in evolutionary thinking that the environment is infinitely varied in the present and always changing into the future. In other words, to assume a uniform and constant environment is contrary to the entire mode of evolutionary thinking. In complex population systems that exist in varied and changing environments, what constitutes fitness cannot be reduced to a finite set of traits that specify global fitness. Such a specification removes the inherent contingency of evolutionary outcomes that results from the interaction of entities in a complex environment, rendering evolutionary theory insipid and of little use. The beauty and power of the Darwinian evolutionary model is that it provides a non-predictive explanation of change and spontaneous orders under conditions of complexity without having to fix the environment by using *ceteris paribus* assumptions. The Darwinian framework embraces the historical nature of evolutionary change, which determinism ignores.

7.2 Implications

What does the research outcome of this thesis mean? What are its implications for the I-space, which is boldly and urgently put forward as a general evolutionary groundwork for an economics of knowledge? The outcome of this thesis suggests, in light of the contemporary dominance of the Darwinian conception of evolution, and contrary to Boisot's claim, that the I-space is *not* a general theory of the evolution of knowledge. If the strict Darwinian conception of evolution set out in the literature (and in this thesis) is adopted, then the I-space cannot be said to lay the groundwork for an evolutionary economics of knowledge. In isolating specific traits of knowledge as a complete and hence a predictive specification of fitness, the I-space forgoes generality and becomes a local explanation that isolates certain traits and ignores the selective significance of other traits; its explanations cannot be said to apply globally to the evolution of *all* knowledge. Thus, the I-space itself shifts to the deterministic nomological mode of explanation, with the result that its status as a general theory – and as the foundation of any future economics of knowledge – is weakened. This does not mean that the I-space cannot lead to other theories; but it does mean that any such theories, as conceptual consequences of the I-space, will either be of the same degree of generality, or more local and specific than the I-space. Conversely – and this is the central implication of this thesis – it means that the I-space will not give rise to an evolutionary microeconomics of knowledge, since such a microeconomics will be of a higher order of generality than the I-space.

This is borne out by the absence of any published attempt at such a theory on the basis of the I-space since its first publication in 1995 until the present time in 2008. On the other hand, and in further support of this contention, the I-space has proven to be useful in the analysis of certain local evolutionary situations in which abstraction and codification are particularly important traits; and as a visualization tool with which to illustrate knowledge creation and diffusion. The practical usefulness of the I-space is evidenced by the ways in which it has been applied in local settings, especially those that deal with information systems design (Ashford, 1997; Daizadeh, 2006; Botha, 2006).

This thesis, like Boisot's project, lies at a confluence of fashionable ideas: the burgeoning phenomenon of the knowledge economy and society; the possibility of an economic theory of knowledge; and evolutionary thinking as inherent in a paradigmatic-ontological alternative to neoclassical economics and determinism. Nevertheless, and in spite of the nagging awareness among academics that determinism is unrealistic and simplistic, the old physics is used every day by thousands of engineers, and the neoclassical form of economics is taught to and applied by economists all over the world. The alternative paradigm has been burgeoning for a long time, but has it been fruitful of theory, and has it informed real-world practice?

Evolutionary thinking is explanatory, but it will not support predictions of the deterministic kind that we are accustomed to in the old physics or in neoclassical economics. So what does this mean for an economics of knowledge? Is an evolutionary economics of knowledge possible? And if it is, will it be useful? I believe that a useful and tractable economics of knowledge is indeed possible, provided we are prepared to search for Prigogine's "narrow path" that accounts for evolutionary change and complexity, but also acknowledges our bounded rationality in the face of such complexity. Just how onerous Prigogine's "narrow path" is to find and keep to is demonstrated by the I-space, which, according to this thesis, has veered too far from the evolutionary paradigm in the direction of determinism.

Boisot is implicitly aware that there is a "narrow path", as he is undecided about whether a new, more general economics that also explains knowledge should be developed, or if an economics of knowledge should be developed alongside the neoclassical economics. On the one hand, Boisot (1995, 21) says: "If economists want to be listened to they will have to accommodate information-based concepts of wealth *alongside* the energy-based ones they have been working with up until now." On the other hand, he calls for a new paradigm that is fundamentally different to the Newtonian one. While we strive to cope with complexity by attempting to explain at the general, systemic level, there is also a need for humility when we attempt prediction, since any such prediction or predictive theory can only hold at the local and analytical level. The implication for Boisot's project and his strategy – of developing an evolutionary paradigmatic-ontological basis upon which he sets out to construct an evolutionary general theoretical framework – is that global evolutionary theory may explain, but it cannot predict. Rather, it is the task of specific, local evolutionary theories that are constructed on the basis of general theory to predict.

> The main conclusion that an evolutionary history comes up with is that history is not inexorable; what happened did not have to happen. Neither the forces of omnipotent "invisible hands" nor those of the material relations of production are able to remove contingency from history. There is strong path dependence in both the evolution of living beings and that of technology, and the outcomes we observe are indeterminate *ex ante* and depend a great deal on accidental events...Such contingency is part and parcel of modern evolutionary thinking, even if few people are willing to go as far as Stephen

> Jay Gould, whose belief in indeterminacy is rather extreme (Mokyr, 2005, 213).

The final implication of this thesis is that the search for an economics of knowledge continues, and will probably become increasingly urgent as the knowledge economy unfolds and our ability to quantify it improves. How long will it be before Google launches a premium knowledge search facility for which it charges on a per search basis? And how will Google arrive at a price for delivering such valuable knowledge products? In the absence of a plausible microeconomic theory of knowledge, such pricing will almost certainly be based on what the market will bear. Or will such products not be offered at all in the absence of a microeconomic theory of knowledge?

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