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The *Prometheus* School of Information Economics

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ABSTRACT *This paper reviews 20 years of information economics in* Prometheus. *It finds broad coherence about the theme of information as knowledge-capital, as distinct from information as a message in a market-space. The paper suggests that micro-foundations for the* Prometheus *school of information economics should be based in evolutionary micro-economic theory rather than in neoclassical micro-economic theory.*

Keywords: information economics, evolutionary economics, growth of knowledge.

The Capitalization of Information

From the early days of Fritz Machlup's research agenda in the 1950s to the award of the Nobel Prize to Spence, Akerlof and Stiglitz in 2001, information economics has come of age as a respectable *Journal of Economic Literature* (JEL) classification and wealthy research area. In Australia, however, information economics is decidedly under-represented in the mainstream journals, and instead is virtually synonymous with *Prometheus* and its low-budget coterie.[1]

A further curiosity of information economics in *Prometheus* is that it tends to look very different to the information economics of top mainstream economics journals. There is a pronounced orthogonality about its aspect, and the difference is more than just the relative sophistication of the theory involved. (*Prometheus* papers do tend to be less mathematical and more discursive than mainstream information economics.) The difference extends to the very nature of the relation between information and the economic system. In mainstream information economics, information refers to the signals that are processed in markets (or market-like situations), but in *Prometheus*, information means in-formation as well as inform-ation. It refers to the embodied form of the information processes that structure the knowledge-base of the economic system. Where mainstream information economics worries about what happens to equilibria when information is less than perfect, information economics in *Prometheus* is concerned with measures and definitions of information components and information sectors. It is, in essence, concerned with the capital nature of information, and therefore with

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the ontological and analytical meaning of an information economy. In my view, the essence of the *Prometheus* school of information economics is the capitalization of information.

As such, there are two ways of inserting information into economics. The first way is to think of information in relation to markets in which information is *complete* (i.e. an information field),[2] and then to 'weaken' this to deal with situations when it is not. This, more or less, was what the Nobel Prize was awarded for, and as such now constitutes a new normal science of information economics with perhaps many further applications yet to be explored.

The other way, the way of the *Prometheus* school, is not to think about why information isn't perfect (an exchange problem), but rather to think about how information is useful and how it can be made more so (a production problem). Information is a concept relevant to both exchange and to production, but so far only the first has been widely recognized. Perhaps one day another Nobel Prize might be due for the information economics of production, capital and organization.

Prometheus in Australia

Prometheus is now an international journal, but it did not start out that way. From its very beginning it was shaped by live policy concern about the nature of Australia's industrial evolution from an old-world colonial farm to a confident (i.e. still prosperous and free) new-world economy. Could this process be explained in terms of the economics of information? The analytical and policy concerns surrounding this question became the subject matter for information economics in *Prometheus*, and for 20 years now it has been at the forefront of the endeavour to understand the general nature of the information content of the economic system and how it changes. The result is, arguably, perhaps the only uniquely Australian school of economics. Why has information between conceptualized differently in economics in Australia?

One obvious explanation is that Australian economics professors are, on the whole, not among the elite theorists, and so, in the absence of local theoretical leadership, the field remains esoteric and remote. Now Australian economists do of course sometimes contribute to the top journals,[3] and so perhaps in the coming years this diffusion of normal science will induce high-quality theory work on information economics in Australia. Perhaps, as in the language of growth-theory, we are still yet to catch-up.

Another possible interpretation has the order of leader and follower reversed. In this view, information economics has always been an Australian concern and Australian economists have pioneered a new way of thinking about information economics where information is not so much a theoretical puzzle about signal coherence, but rather a practical problem about the nature of a transforming and evolving industrial structure. Now maybe these issues are ultimately the same problem, but maybe also the mainstream approach to information economics is only part of a much bigger story about the use of information in an economic system. Perhaps information relates to the growth of knowledge as much as it does to optimal-choice modelling. Perhaps the concept of information is strictly necessary for theorizing about the structure and open-system dynamics of the economic system (perhaps it is more than an off-set dimension for theorizing about the efficiency of choice). (I have a theory that information was discovered in

economic systems in Australia because it was simply too obvious to be discovered anywhere else.)

In any case, the implication is that although not fully-fledged, and maybe another 20 years or more will be required before reaching maturity, the more pragmatic industry and policy-focused approach of the *Prometheus* school is also likely to be the more general foundation to information economics. This is because of its implicit ontological treatment of information as a resource (cf. a signal). The upshot is that the *Prometheus* framework is naturally well-suited to adopt and adapt microfoundations from the digital universe of evolving complex rule-systems of evolutionary microeconomics because of its prior understanding of the complex structure of information in economic systems.[4] And perhaps further along this path of the capitalization of information lies the foundations for genuine scientific progress in understanding the deep relation between information and economic systems.

Prometheus Lamberton

The unique shape of information economics in Australia is largely due to Don Lamberton, his colleagues, and his protégés. As Macdonald and Nightingale explain in their fine festschrift,[5] Lamberton became interested in information problems in economics about the same time as Machlup, but by the Oxford route of concern with production, profit and capital, rather than the Chicago concern with markets and choice. Two paths diverged in the woods, so to speak, and that has made all the difference.[6]

From the start, Lamberton's view of information economics was never exclusively focused about information as a potential problem in markets, although he clearly signalled that it could be, but rather about information as an essential aspect of the reality of capital, organization and production.[7] This foundational distinction between information as a problem in market-theory and information as a building block of economic activity lies at the heart of the *Prometheus* school of information economics, and this is nothing more than recognition that an economy is more than just a set of markets. An economic system is in reality a much more complex structure. It is also a coordinated structure of organization, capability, capital and industry. Moreover, it is an open system. From Oxford in the 1950s, nothing could have seemed more natural, but in the 1950s economic theory went the American way of Arrow and Debreu's complete market solutions and Lamberton came back to Australia. Two quite different conceptualizations of information economics subsequently developed. The first was the view of information as a message, or price-signal, operating in complete markets to compute equilibria. Information computes equilibria, and the essential theoretical challenge, as it turned out, was to understand why sometimes it didn't. This, the way of information imperfections, is now mainstream information economics.

However, the *Prometheus* way of information economics was the way of information as an organizing factor that performs work to transform energy and produce output. As a practical perspective on the value of knowledge, this makes intuitive sense, but, interestingly, it has not always made theoretical sense. The structural and dynamical aspects of information have never really been properly defined and the theoretical challenge remains to understand how information becomes knowledge, and how we might recognize it when it does. The theory and

policy issues surrounding this problem continue to grow in significance and importance.

Prometheus, redux

Information is a factor of production and a component of the structure of the economic system. Early examples of the *Prometheus* drive to classify the nature of the information-industries and information-economies are plainly apparent. This is the story of information as capital in-formation.

Of the first few editions, the classics are Tisdell[8] on 'the international realpolitik of science and technology policy', Lamberton[9] on 'exogenous factors in economic theory', Sless[10] on 'communication and the limits of knowledge', and Gold[11] 'on the potential requirements and limitations of information technology in manufacturing'. The theme is production functions and macro information, and Lamberton is particularly illustrative of this.[12] This paper reports on a serious critique of the ritual assumption of all manner of unexplained exogenous factors to account for the dynamics of economic systems, when, in just as many cases, it is change in information and knowledge that ultimately lies behind these supposedly exogenous changes in the economic system; and that, I think, is the basic point that underpins everything here.

The problem of exogenous factors in economic theory has an obvious solution that, as Lamberton argues, has been massively overlooked in the mainstream literature: in short, he says, capitalize information; make information and knowledge endogenous to the production function; make information a real factor in a complex production system and not just an ethereal message in a perfect market. With this ontological gesture masquerading as methodological critique, Lamberton sets the scene for all that follows in this journal of a theoretical nature. Capitalize information, he said, and then explore what follows. In my view, Don Lamberton's abstractly critical endorsement of these ideas about the nature of exogeneity in neoclassical production functions laid the foundation for the *Prometheus* school of information economics as a way of going beyond that.

It is important to note that Lamberton's elegant solution (the capitalization of information as a way of dealing with incongruities in production functions) is in fact strictly impermissible in the orthodox framework, because there information is already defined as a signal (i.e. prices as information). Otherwise, one would have to think of prices as capital goods, which is clearly nonsensical,[13] but the *Prometheus* school escapes this logical critique by redefining the concept of an information measure by hinging it not about market outcomes but instead about the growth of knowledge process. Information as a signal is only fleetingly thought of as knowledge; but information as a pattern of associations is the sort of information that can become knowledge and ultimately capital.[14]

This new vision of information economics was not entirely Lamberton's doing of course. New ideas about the nature of information in the economic system induced a slew of applications to science and technology policy, and to the idea of communication as an industry input. Surrounding this were issues of trade in data,[15] the nature of technology and knowledge,[16] technology policy,[17] technological change and employment[18] and some serious early analysis of the nature of information in high-tech industries.[19] Engelbrecht[20] wrote of an information-sector approach, Joseph and Johnson[21] wrote about the relation of this to governments, and Kwok and Au[22] wrote about the information industry,

multinational corporations and urbanization. Information is an industry, and a component of all industries they were saying; and they were right in the same sense that energy is an industry and a component of all industries. In the mid–late 1980s *Prometheus* (Cassandra?) had already identified the trends that were to define the *zeitgeist* of the coming decade and the staples of the top theory journals 15 years hence.

Lamberton's initial idea about what information in an economic system had already been imaginatively and insightfully fleshed out by the mid-1980s.[23] There was emerging a growing confidence in the generality of this approach, and soon these industrial and macroeconomic concerns with the nature of information came to be both refined in manner and enlarged in scope. Several interesting papers about this period were well before their time. Widdows,[24] for example, wrote about information and choice as an extension of production theory to consumer theory, in a way that Earl was to then later build upon with an innovative and prescient analysis of the economic rationale of universities as both producers and consumers of information.[25] Along with the rise of issues about analysis of changing information and communication structures,[26] came a turn towards the nature of information societies.[27]

It is important to remind ourselves here that these were times *before* the Internet, and well before talk of a connected (or networked) knowledge-based society became commonplace. These were bold and vanguard works rethinking the basic idea of what an economic system actually was that, in many instances, flew in the face of orthodox microeconomic theory. But they are not yet archival papers. For there is much in these reports from the frontiers deserving of on-going re-appraisal from the new perspectives such as complex systems theory and evolutionary economics, a point I shall return to in conclusion.

By the 1990s, the *Prometheus* school had begun to integrate concepts of 'knowledge, technological change and industrial innovation' into its understanding of information as capital structure.[28] The line of thinking was moving from knowledge industries to knowledge societies. Soon enough, they began to think again about deeper foundations. Vogel[29] wrote about the thermodynamic approach to resource allocation, Ritcketson[30] about technological change and intellectual property-rights, and Newton[31] about information landscapes.

It was about this point that policy issues starting moving to centre stage in the writings of Robertson, Fransman and Metcalfe, on evolution, technology, and technology policy and management.[32] There was a clear sense that these nascent ideas might actually be immediately useful in the analysis and management of the process of industrial evolution. Again, these issues have not dated at all. Contemporary writings of Robertson, Fransman and Metcalfe have largely been elaborations on the same germinal themes first laid down in *Prometheus*.

There did not seem to be much pure information economics content in 1995 or 1996, but 1997 brought a slew of papers of industrial information strategy.[33] The theme soon turned to intellectual property and the diffusion of technology.[34] Stroeken and Couman[35] wrote an insightful paper about the use of technology in firms. It was becoming clear by this stage that information was knowledge and knowledge could be managed. At the macro-policy level, new thinking about national systems of innovation began to surface,[36] and Rooney and Mandeville presented an elegant and deep essay on 'The knowing nation: a framework for public policy in a post-industrial knowledge economy'.[37] I think many of these papers deserve to be re-read.

Recently, once again, the meaning and definition of a *knowledge* economy (*cf.* an *information* economy, *circa* the early 1980s) has come to dominate theoretical and analytical discussion.[38] Now, perhaps it is too early to tell, but recent themes—'the drive to codify',[39] 'why do people pay for information',[40] 'accelerating technology',[41] 'following successfully'[42]—seem to have taken a decided turn towards understanding human economic agents and technologies as increasingly related.[43]

A summary review of 20 years of *Prometheus* papers on information economics reveals a clear pattern. In the beginning was the study of information production (which as I pointed out was both a practical and theoretical concern), which, via the theory of classification became the concept of an information society. That was by the end of the 1980s. Through the 1990s this evolved into the concept of a knowledge-base for an evolving economic system, and that is where we are now. This section has presented a quick and dirty overview of the themes and topics in *Prometheus* over the past 20 years. It was intended to be neither comprehensive nor definitive, but rather illustrative of the simple point that the orientation of information economics in *Prometheus* is very much in the manner of information as a component of industry, macroeconomies and societies, and therefore an issue of policy.

In my review of *Prometheus*, I found exactly no papers that were principally about the theory of information asymmetries in non-cooperative games, and, moreover, just as many about the indefiniteness of equilibria in non-compact sets; but I did find an awful lot of papers about the definition of an information sector and the dynamics of a knowledge-based economy. That, it seems to me, is the essential point. The *Prometheus* school has for its first 20 years worked to refine the definition and measure of the information contribution to a knowledge-based economic system. There is much work that remains to be done, including the development of a coherent theoretical framework.

Toward a *Prometheus* School of Evolutionary Economics

Prometheus has so far struggled to define a set of core theoretical propositions about the nature of information in economic systems. Perhaps evolutionary micro-economics can provide these.

The central questions in evolutionary economics are about the endogenous processes of change and growth in market-capitalist systems. Evolutionary economists believe that knowledge is the basic building block of economic systems, which are then conceived of as complex networks of rules and statistical populations of rule-actualizations.[44] Economic evolution is then viewed as a process of change in the graphical and populations structure of (meso) knowledge.[45] The micro domain of agents carrying knowledge and the macro domain of interacting populations of rules condition this process. Although space does not permit detailed discussion of this here, the essential points of overlap between the *Prometheus* school and the evolutionary meta-framework seem, to me, as follows.

1. Information and knowledge are productive assets (i.e. rules) in an economic system.
2. Change in the productive capabilities of an economic system is caused by changes in the content of information and knowledge (the transformation of rules, $Z^n \rightarrow Z^n$), and also by the way that information and knowledge is connected together (the measure of Z^n). The mechanisms of change are evolutionary in nature (i.e. operations on Z^n).

3. Issues of property rights and intellectual capital are much more cogently approached from the theoretical perspective of information as capital than they are from information as signal. Indeed, only from here can we be sensible about economic policy for new economies.
4. Information and knowledge are generating functions. As knowledge interacts with other knowledge it has the potential to generate new knowledge as an autocatalytic process. In general theory, rules interact to form new rules.
5. Capital is a species of rule, rules are carried by agents. The dynamics of information and the dynamics of economic systems are the dynamics of complex open networks of rules.

It seems that the ontology of information economics in *Prometheus* overlaps almost exactly with the analytical basis of evolutionary economics. That bodes well for future developments, for the basic challenges that lie ahead are precisely the challenges that Lamberton identified over 40 years ago. It is becoming more widely appreciated that the limiting factor on further theoretical growth is an analytical definition of information as capital (from which the return is profit and the form is organization, and about which property rights are sensibly attached). So let me conclude with a final speculation: what is also now needed is a return to pioneering empiricism in order to map the (network) information structure of an economic system. This would make a perfect joint venture for *Prometheus* and evolutionary economics.

Notes and References

1. Of course contributors to *Prometheus* come from all over the world and not just Australia. My argument is simply that the editorial themes have been largely shaped by Australian conditions and circumstances. For rhetorical convenience, I shall sacrifice accuracy and polarize this debate along an axis of Mainstream (USA) and *Prometheus* (Australia).
2. See J. Potts, *The New Evolutionary Microeconomics: Complexity, Competence and Adaptive Behaviour*, Edward Elgar, Cheltenham, UK, 2000, especially chapter 2 on the geometry of economic space.
3. Although in many cases in the manner of 'follow the leader' papers that preserve the career rank-order of Australian economics.
4. K. Dopfer, J. Foster and J. Potts, 'A new analytical framework for evolutionary economics', *Journal of Evolutionary Economics*, forthcoming.
5. S. Macdonald and J. Nightingale (eds), *Information and Coordination: A Tribute to the Work of Don Lamberton*, North-Holland, London, 1999.
6. Lamberton himself sees these two origins as much more closely intertwined than I am suggesting here. See D. Lamberton, 'Fritz Machlup: "How one thing led to another"', in J. Laurent (ed.), *Evolutionary Economics and Human Nature*, Edward Elgar, Cheltenham, UK, 2003, pp. 184–94.
7. See the introduction to Macdonald and Nightingale, *op. cit.*
8. C. Tisdell, 'International realpolitik of science and technology policy', *Prometheus*, 1, 1, 1983, pp. 127–43.
9. D. Lamberton, 'Exogenous factors in economic theory', *Prometheus*, 2, 1, 1984, pp. 128–33.
10. D. Sless, 'Communication and the limits of knowledge', *Prometheus*, 3, 1, 1985, pp. 110–8.
11. B. Gold, 'On the potential requirements and limitations of information technology in manufacturing', *Prometheus*, 4, 2, 1986, pp. 254–71.
12. This paper reported on early stages of the IDEA (Interdisciplinary Dimensions of Economic Analysis) project organized by the International Social Science Council. Lamberton's own

paper presented at an IDEA Conference in the Fall of 1984 at Maison des Sciences de l'Homme, Paris appeared much later as 'Information economics: "threatened wreckage or new paradigm?"', in Ulf Himmelstrand (ed.), *Interfaces in Economic and Social Analysis*, Routledge, London, 1992, pp. 113–23.

13. Which is to say that the concept of human capital is still qualitatively different, because, for it to be defined, information must lose all its information qualities in order to complete the metaphorical transfer.
14. Prometheus stole fire from Zeus and gave it to man. He gave man information that became knowledge (how to make fire) that became capital (how to make fire make other goods). According to the Prometheus myth, the sort of intellectual property rights infringements that attract the wrath of vultures and other lawyers is the sort of information that becomes catalytic. When one thing leads to another, we are dealing with information as knowledge and the basis of capital as a mechanism. That is what *Prometheus* the journal has always sought to understand.
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17. S. Macdonald, 'High technology policy and the Silicon-Valley model', *Prometheus*, 1, 2, 1983, pp. 330–49.
18. K. Newton, 'Simple analytics of employment impact of technological change', *Prometheus*, 2, 2, 1984, pp. 233–48; T. Mandeville and S. Macdonald, 'Technological change and employment in the information economy', *Prometheus*, 3, 1, 1985, pp. 71–85.
19. I. Schmoranz, 'Macroeconomics and microelectronics', *Prometheus*, 2, 2, 1984, pp. 167–75; B. Johnson *et al.*, 'Emerging biotechnologies', *Prometheus*, 3, 1, 1985, p. 1–24; Gold, *op. cit.*; C. Thompson, 'Defining high technology industry', *Prometheus*, 5, 2, 1987, pp. 237–62.
20. H. J. Engelbrecht, 'An exposition of the information sector approach', *Prometheus*, 3, 2, 1985, pp. 370–86.
21. R. Joseph and R. Johnson, 'Market failure and government support for science and technology', *Prometheus*, 3, 1, 1985, pp. 138–55.
22. R. Kwok and B. Au, 'The information industry, multinational corporations and urbanization in the Asian Pacific countries', *Prometheus*, 3, 2, 1985, pp. 349–69.
23. As a popular historical aside, it is perhaps worth observing that the contents of the top mainstream economics journals (I have in mind AER, JPE, EJ) are only now beginning to look like the *Prometheus* themes of the mid–1980s. I would of course invite histographic and textual analysis of that proposition.
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25. P. Earl, 'The economic rationale of universities', *Prometheus*, 12, 2, 1994, pp. 131–51.
26. W. Melody, 'Examining the implications of changing information and communications structures', *Prometheus*, 5, 2, 1987, pp. 221–36.
27. J. Peet and K. Peet, 'Turning data into wisdom: who decides?', *Prometheus*, 5, 2, 1987, pp. 395–408; A. Baklien, 'Technology in turmoil', *Prometheus*, 6, 2, 1988, pp. 351–67; A. Watt, 'The advanced information society: a suitable utopia for Australia?', *Prometheus*, 6, 2, 1988, pp. 368–81; B. Ross, 'Strategic commitment, unknowledge and the nature of entrepreneurial activity', *Prometheus*, 6, 2, 1988, pp. 270–84; J. A. Mathews, 'New production concepts', *Prometheus*, 7, 1, 1989, pp. 129–48; C. Kearton and B. Martin, 'Technological vulnerability: a neglected area in policy-making', *Prometheus*, 7, 1, 1989, pp. 49–60; S. Macdonald, 'Human qualities necessary for invention: independent inventors and the stimulus of adversity', *Prometheus*, 7, 2, 1989, pp. 333–48; I. Inkster, 'The low down on high tech down under, or the plain person's guide to the multifunction polis', *Prometheus*, 8, 2, 1990, pp. 320–30; T. Forester and P. Morrison, 'Computer crime: new problem for the information society',

Prometheus, 8, 2, 1990, pp. 257–72; G. Gregory, 'The human side of technology transfer: a viewpoint', *Prometheus*, 12, 1, 1994, pp. 19–28.

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41. A. Michael Noll, 'Accelerating technology: the pace of transmission systems', *Prometheus*, 20, 1, 2002, pp. 15–20.

42. P. Hall and I. Densten, 'Following successfully: followership and technology adoption', *Prometheus*, 20, 2, 2002, pp. 87–106.
43. My own intuitions on this matter are that this 'cyborg' turn toward making information and knowledge assets integral to understanding the nature of the human economic agent is certainly the direction of the future. See P. Mirowski, *Machine Dreams; How Economics Became a Cyborg Science*, Oxford University Press, Oxford, 2000, for a magisterial history of cyborg conceptions of economic agents. Also J. Potts, 'Toward an evolutionary theory of *homo economicus*; the concept of universal nomadism', in Laurent (ed.), *op. cit.*, pp. 195–216.
44. See Dopfer *et al., op. cit.*
45. For example, see Potts, 2003, *op. cit.*; J. Foster and J. S. Metcalfe, *Frontiers of Evolutionary Economics*, Edward Elgar, Cheltenham, 2001; Dopfer *et al., op. cit.*