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The knowledge economy/society: the latest example of "Measurement without theory"?

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Abstract: The world has embraced a set of concepts (knowledge driven growth) which are seen as the 'core of future growth and wellbeing' without any commonly agreed notion of what they are, how they might be measured, and crucially therefore, how they *actually* do (or *might*) affect economic growth and social wellbeing. The theory of how the mechanism works lacks important detail.

Keywords: knowledge economy, knowledge society, theory of the firm

"But the decision not to use theories of man's economic behavior, even hypothetically, limits the value to economic science and to the maker of policies, of the results obtained or obtainable by the methods developed. This decision greatly restricts the benefit that might be secured from the use of modern methods of statistical inference."

Tjalling C. Koopmans, 'Measurement Without Theory', The Review of Economic Statistics, 29(3): 172, August 1947.

". . . as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say, we know there are some things we do not know. But there are also unknown unknowns - the ones we don't know we don't know."

Donald Rumsfeld, Department of Defence news briefing (transcript) February 12, 2002

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Introduction

In the United Kingdom the "Knowledge Economy" is/was seen as the core policy for economic growth. In the US, they have/had the 'Digital Economy', the 'New Economy' or the 'Innovation Economy'. Australia created the "National Office for the Information Economy" as an agency to stimulate economic growth. Add to these, the 'Information Society', the 'Network Society' and the 'Learning Society' and we have a potentially confusing mix of terminology, potential drivers and importantly, consequences of action and inaction. In New Zealand the central importance of the drive for a Knowledge-based economy was recently reiterated by the Minster of Finance in his 2006 address to the Association of University Staff (AUS) conference where he stated that "Our aim is a high income, knowledge based economy, which is both innovative and creative and provides a unique quality of life to all New Zealanders". He further noted that "the innovation that drives higher productivity comes from investment in science and technology; it comes from research and higher skill levels" (Cullen 2006).

Debates around the need to establish a knowledge society (and the implications of not doing so) emerged during the 1990s, as the impact of Information and Communication Technologies (ICTs) based upon the creation, recording, and distribution of knowledge and information became increasingly clear, as did the significance of New Zealand developing its own identity as a knowledge society within an increasingly global information network. "Knowledge Wave" and "World Summit on the Information Society (WSIS)" conferences championing education and Information Technology as the 'magic bullets' to create successes for all. The Knowledge Society should grow, so the argument goes, so that the economy grows and with it the welfare, health and wellbeing of all. "Knowledge" is assumed to be good for everyone (how can more knowledge be bad?) and we should strive to create ways to increase its quantity and quality, (perhaps) focussing specifically on science-based education.

The gloss may have been taken off some of these notions and expectations due to the dotcom and stock market crashes of 2000-2002, but Alcaly (2003: 3) claims:

> " [w]hile the euphoria of the late 1990s, like the melancholia that displaced it, was far overdone, there was always a more fundamental sense in which the economy of the 1980s and 1990s truly was new, a characterisation that has not been undermined by the corrections that inevitably, and temporarily, slowed its growth in the first few years of the twenty-first century."

When one digs deeper, however, the gloss does peel. The world has embraced a set of concepts (knowledge driven growth) which are seen as the 'core of future growth and wellbeing' without any commonly agreed notion of what they are, how they might be measured, and crucially therefore, how they *actually* do (or *might*) affect economic growth and social wellbeing. The theory of how the mechanism works lacks important detail. In economic theorising and policymaking, the relationship between knowledge, economic growth, and knowledge economy and knowledge society are not clearly articulated. In both academic and political debate, terms like knowledge economy, knowledge society and new economy, etc., are used interchangeably, but are they and do they have the same structural/causal interpretations/consequences? The current state of academic knowledge has not adequately and systematically addressed these fundamental issues.

Economic theory provides potential answers to part of the puzzle via 'modern growth theory' championed by Romer (1986, 1990), and Lucas (1988), which recognise the crucial importance of 'knowledge embodied in human beings', 'human capital, as an engine for growth', 'Research and Development (R&D) sectors', etc. However, this economics-based literature, though typically 'theoretical', is often too narrowly defined to consider social issues and hence not well placed to consider the knowledge society. It does, however, suffer from some significant 'problems of measurement'[1], but more fundamentally the emergence and domination in production of 'knowledge only firms' have the potential to challenge the textbook microeconomic 'theory of the firm' based on the work of Grossman and Hart (1986, 1987) and Hart and Moore (1990).

From a sociological perspective the knowledge society is, to some, the latest form of accumulation to become a significant part of economic wealth generation. The 'theory' underpinning the analysis is a mix of technological/economic 'determinism'. The knowledge society leads to the "emergence of new forms of economic production and management" Castells (1996). To others, however, knowledge is an enabling concept leading to a culture of innovation which creates the knowledge society. Recent analysis of social inclusion, social connectedness and social cohesiveness leads to an increased emphasis on education, human capital theories and schemes to reconnect those who have "fallen out of the system" and arguments around dependency. However, the current state of sociological thinking on the contours of the knowledge "society" remains rather indistinct and certainly lacks robust measures see, McLennan (2003) and Jessop (2000).

The "current state of knowledge" on the knowledge society, therefore comprises a range of partial, typically discipline specific and determined, limited views, thoughts and concepts. No robust measures of its size and importantly contours exist, and hence no rigorous, scientific analyses of its effects on wellbeing have or could have been undertaken.

What of the benefits and costs of the 'new' knowledge economy/society? Will those without specialised information processing\transformation skills remain 'outside the knowledge club' whilst those with these skills benefit at their expense. Just who will be the 'winners and losers'?

Many commentators have suggested a link between the computer revolution and increasing wage inequality. As Katz (2000: 217) points out,

> "[w]age inequality and educational wage differentials have expanded substantially in the United States over the past two decades. This widening of the wage structure has coincided with the rapid computerization of the workplace. Thus, it is not surprising that many labor market analysts have tried to draw a causal connection between rising earnings inequality and increases in the growth rate of the relative demand for more-skilled workers driven by technological and organizational changes associated with the computer revolution."

Driven by the increased access to information resulting from the ever expanding reach of ICTs more new information can be created by those with 'knowledge-creation capacities' than has been the case in the past. This may enable a new production paradigm less constrained by traditional diminishing returns to scale (the New Economy), but the distribution of resulting gains remains an unresolved issue.

Those talking of the 'New Economy' or 'Goldilocks Economy' seem to be alluding to what they perceive as a shift towards a post-industrial economy driven by the adoption of new technologies and business practices which expand the role of human capital in production. If knowledge, either disembodied or embodied in human capital, is the source of new economies of scale in production, then the lack of it in 'economically poorer' economies may actually exacerbate the 'knowledge divide' despite the appearance that the information\digital divide is narrowing. Accessing 'knowledge' we would argue necessarily requires accessing the creators\assimilators of knowledge and these are inherently 'human' and not technologies alone. ICTs and people are complements, not substitutes.

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If we accept we are in a knowledge economy\society, how large is it? How do we measure knowledge? What of their effects on the economy and society? Is it even meaningful to try and measure these things if we have no generally agreed upon definitions of knowledge, information, the knowledge economy\society? The meanings attached to knowledge and information in the literature are vague and imprecise. As for the idea of a knowledge or information economy\society, there are, seemingly, as many definitions as people writing about them. Some authors suggest that there is no coherent definition, at best we are dealing with an often used metaphor, rather than a well thought out concept.

To progress debate on the knowledge economy/society, this paper will raise a number of questions/challenges and propose a number of routes to the answers. In Section 2 the existing literature on the knowledge economy/society will be briefly reviewed. Section 3 will consider what is crucial in the search for 'measurement', the distinction between 'information' and 'knowledge'. This will be followed in Section 4 by a review of how authors currently attempt to measure what amounts to the impact of ICTs and considers the challenges a knowledge-based economy poses for System of National Accounts-type statistical framework. Section 5 returns to a core element of the theme of our paper, 'measurement without theory'. Here the issue of what modern economic theory has to say about the 'theory of the knowledge firm' is reviewed and generally it is found to be lacking. Section 6 considers some 'potential points of departure and potential for progress' and Section 7 concludes.

What is the knowledge economy/society?

The emergence of a debate about the arrival of the "Knowledge Economy and Society" came when industrial societies began to be restructured and transformed into ones with a greater dependency upon "information" based areas of activity. One of the earliest authors to emphasise the importance of knowledge to society was Machlup (1962). Writers such as Drucker (1959, 1969, 1994) and Bell (1973) saw this as part of a move towards a "post-industrial" economy and society. The initial focus on "information" shifted in the 1970s to a greater emphasis on "knowledge". This was accompanied by a re-emphasis on 'human capital' as an individual good, which enhanced the earning capacity of the individual and recognised more strongly their contribution to overall wealth generation. This stimulated attention to innovators, entrepreneurs, and knowledge managers as the key to economic growth and change. Increased attention to the rights and capacities of the individual within

society more generally, as part of a wider liberalization and deregulation of economic and social activities, also gathered strength during the latter decades of the 20th century (Giddens 1991, 2001, Beck 1999). The linkages between the increased importance of knowledge as the reason for economic growth and wider social transformation became a theme in much of the writing that emerges. For example Stehr wrote that: ". . . central to my thesis is that the origin, social structure and development of the knowledge societies is linked first and foremost to a radical transformation to the structure of the economy" (Stehr 1994: 122).

Economists typically (but not exclusively) focus more narrowly than sociologists upon the changed role of knowledge in economic activity see Boulding (1966), Arrow (1962), Stiglitz (1999) and Cowan, David and Foray, (2000). The Organisation for Economic Cooperation and Development (OECD) for example, define Knowledge Based Economies (KBE) as ". . . economies, which are directly based on the production, distribution and use of knowledge and information" (OECD 1996: 7). In both the work of sociologists and economists it is the importance of the digital technologies, the Internet, computers, information and globalised networks that these technologies enable that have been stressed. It is now the "age of speed". Time and space have been compressed (Harvey 1989, Virillio 2004). There is an increasing shift of activities to computers rather than these being carried out in specific locations. Testing of products can now be done through simulation on the computer. People can work from home (Felstead et al 2005, Leonard and Thorns 2006). People can create virtual worlds in "my space" and live out their lives in cyberspace. Whilst not all are involved in these activities it does extend the range of possibilities and gives more prominence to 'mental' labour rather than physical labour carried out in discrete places. Knowledge is now seen as the primary source of competitiveness and the desire of governments is increasingly to create innovative and 'smart citizens'. Extending what constitutes knowledge to the "cultural and creative" sector is now incorporated into the discourse on the knowledge society as this sector has gained increased recognition as a potential contributor to economic growth.

One problem with the knowledge society debate is that there seems to be as many definitions of the knowledge economy\society as there are authors writing about it. Smith (2002: 6-7) asks "[w]hat does it mean to speak of the 'knowledge economy' however? At the outset, it must be said that there is no coherent definition, let alone theoretical concept, of this term: it is at best a widely-used metaphor, rather than a clear concept. The OECD has spoken of knowledge-based economies in very

general terms, as meaning "those which are directly based on the production, distribution and use of knowledge and information". This definition is a good example of the problems of the term, for it seems to cover everything and nothing: all economies are in some way based on knowledge, but it is hard to think that any are directly based on knowledge, if that means the production and distribution of knowledge and information products."

Foss (2002: 48) argues that, "[w]hatever we think of this journalistic concept [of the Knowledge Economy], it arguably does capture real tendencies and complementary changes." What might these 'new' tendencies be?

> "We define the knowledge economy as production and services based on knowledge-intensive activities that contribute to an accelerated pace of technical and scientific advance, as well as rapid obsolescence. The key component of a knowledge economy is a greater reliance on intellectual capabilities than on physical inputs or natural resources" (Powell and Snellnllan, 2004).

Here the 'modern' emphasis seems to be on 'knowledge' 'accelerated technical and scientific advance' and 'greater reliance on intellectual capabilities than physical inputs or natural resources'.

For an economist the question has been, Is the "Knowledge Economy" a new economic paradigm, with new fundamentals or is it just "hype"? Is this all new? Marshall (1920: Book IV Chapter 1 page 115) states that "[k]nowledge is our most powerful engine of production; it enables us to subdue Nature and force her to satisfy our wants." But the importance of knowledge to the economy goes much further back. When discussing the question, What happened to the Neanderthals? Tudge (1998: 25) argues

> "[t]he Cro-Magnons . . . got to know the habits of the animals they hunted and knew where to lie in wait; and different bands shared information, so hunting parties could be forewarned of migrations days in advance." He goes on to say "[m]ost importantly of all . . . the Cro-Magnons co-operated: that they traded tools - for which there is abundant evidence - and also traded information. Thus . . . the age of trade (and of information) is exceedingly ancient" Tudge (1998: 26).

So the argument that the knowledge economy is new, in a historical time sense, is unconvincing but it may be new in the relative importance of the factors of production compared to the past. In a crude sense, has knowledge changed from being 'a' factor of production to being 'the' factor of production?

The sociologists, on the other hand, have asked, Is the 'Knowledge Society' (KS) fundamentally different from what preceded it? The first issue we face is one of potentially viewing a process rather than an outcome. The past periods of transformation, such as the industrial revolution, have occurred. For those studying the 'knowledge society' the twin problems of definitional limitations and the potential lack of a complete historical lens complicate analysis. We may simply conclude 'the world is no different to the past' simply because change is incomplete.

From the work that has been done to date it is clear there is considerable disagreement as to the central components of either the knowledge economy or knowledge society which complicates the development of robust measures (Carlaw et al 2006). There have been a variety of attempts to create measures for the KBE and Knowledge Society (KS). For example Asia-Pacific Economic Cooperation (APEC) defined a KBE as "an economy in which production, distribution and the use of knowledge is the main driver of growth, wealth creation and employment across all industries" (APEC 2000: vii). However, they also acknowledge there are few indicators that directly measure the extent to which a country is already operating as a KBE as distinct from its capacity to become a KBE. The indicators that are favoured would be the percentage of Gross Domestic Product (GDP) contributed by the knowledge based industries and the percentage of the labour force that consists of knowledge workers. To apply these measures would still require the resolution of who are 'knowledge workers'. Is this to be determined by the task they perform, by their formal qualifications or by their outputs and degree to which they are dependant upon the global networks and new information flows? Further there is the consideration of the fact that to be a 'knowledge worker' implies that they transform information rather than just receive it passively. This leads us to a focus on the contribution of human capital and its generation and maintenance. There is also the complication of the differing forms of knowledge that are now being recognised, especially the difference between codified and tacit knowledge. Houghton and Sheehan (2000: 1) recognise this when they write, quoting the Department of Trade and Industry in the UK (Department of Trade and Industry 1998):

> "A knowledge economy is one in which knowledge is a key resource. ...one in which the generation and the exploitation of knowledge has come to play the predominate part in the creation of wealth. It is not simply about pushing back the frontiers of knowledge; it also about the more effective use and exploitation of all types of knowledge in all manner of economic activity."

To deal adequately with the dimensions identified would require measures that allow us to understand the knowledge inputs and outputs, flows of knowledge and the stock of knowledge (OECD 1996).One of the disputed areas here relates to what counts as knowledge. Here sociological work has pointed to this as a contested arena and reflective of local priorities and decisions about the privileging of particular forms of knowledge generating activity with respect to for example, the public funding of Research and Development (R&D). Widening the scope of what gets included is also being suggested as in the recent work of the US Progressive Policy Institute where they say

> ". . . the New Economy is about the transformation of all industries and the overall economy. As such, the New Economy represents a complex array of forces. These include the reorganization of firms, more efficient and dynamic capital markets, more economic "churning" and entrepreneurial dynamism, relentless globalization, continuing economic competition, and increasingly volatile labor markets" (Atkinson 2003: 4).

To provide a way of measuring these complex shifts they suggest 21 indicators divided into five categories which are knowledge jobs, globalization, economic dynamism and competition, transformation to a digital economy and technical capacity.

The idea of a knowledge society has been employed more, than the KBE, in wider discourse about change within society and the focus has been more on the creative potential and knowledge embodied in people. The United Nations (UN) work here sees

> "ICTs are best considered as tools or facilitators which may substitute under certain conditions for other means of knowledge creation in innovative societies (OECD 1996a). These technologies do not create the transformations in society by themselves; they are designed and implemented by people in their social, economic, and technological contexts" (Mansell and Wehn 1998: 12).

The UN has developed two measures to attempt to measure these changes . The first, being the 'ICT Diffusion Index' (United Nations Conference on Trade and Development 2006) which is designed to measure ICT connectivity (number of Internet host per capita and number of telephone lines per capita) and the second the 'Index of Knowledge Societies' (Department of Economic and Social Affairs 2005) which attempts to measure the 'foresightedness a country displays in its quest to become a "knowledge society"'. However, much ambiguity still exists and the measures are not precise as the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Report 'Towards Knowledge Societies' acknowledges where it states,

> "While there is general agreement on the appropriateness of the expression (Knowledge Societies), the same cannot be said of the content. Which types of knowledge are we talking about? Do we have to endorse the hegemony of the techno-scientific model in defining legitimate and productive knowledge? And what of the imbalances that mark access to knowledge and the obstacles confronting it both locally and globally?" (UNESCO 2005: 5).

One of the more comprehensive attempts to create such a range of measures is the INEXSK framework (Infrastructure, Experience, Skills, and Knowledge), see Mansell and Wehn (1998). It uses eight indicators chosen on the basis of their availability and value in provoking thought about different patterns of development in Knowledge Societies. The eight indices are - personal computers per capita, main telephone lines per capita, electronics consumption, proportion of technical graduates, literacy share (percentage population literate), Internet hosts and televisions sets per 1000 population. This range certainly extends the areas being examined but still to a large extent is driven by data availability and provides at best only a fairly crude metric. For example, the number of Internet connections or ownership of personal computers does not show the speed or utilisation or quality of these devices and connectivity both of which are crucial to the ability to maintain access to the expanding world of information and knowledge now available.

Forms of information and knowledge

As shown in Carlaw et al (2006), the words 'information' and\or 'knowledge' are attached to various definitions or concepts. The recent UNESCO Report (2005) uses the terms interchangeably, for example,

> "the rise of the global information society has allowed a considerable mass of information or knowledge to be disseminated via the leading media. However, the different social groups are far from having equal access and capacity to assimilate this growing flow of information or knowledge" (UNESCO Report 2005: 160)

Beyond knowledge we have 'wisdom' which in McKenna and Rooney (2005) is defined as something that "coordinates knowledge and judgements about the 'fundamental pragmatics of life' ...knowledge with extraordinary scope, depth and balance . . . excellence of judgement and advice." The picture becomes only more confusing when the term 'data' is also used. Despite efforts by various authors to define terms like 'data', 'information' and 'knowledge', the terms are used, in many

cases, casually, with information and knowledge often being used interchangeably. Stenmark (2002: 1), argues that the definitions of the three terms are usually imprecise and vague. In addition, as Stenmark also points out, the relationship between the terms, although far from trivial, is seldom clarified.

One interesting approach to the problem of definition is that of Howitt who defines knowledge

> ". . . in terms of potentially observable behaviour, as the ability of an individual or group of individuals to undertake, or to instruct or otherwise induce others to undertake, procedures resulting in predictable transformations of material objects. The knowledge can be codified, as when it is transmitted by mathematical theorems or computer programs that can be reproduced through known procedures; or it can be tacit, as when it exists only in the minds of particular individuals or in the established routines of organizations, and is not capable of routine transmission or reproduction" Howitt (1996: 11).

Such a definition places restrictions on whom or what can possess knowledge. In particular knowledge is restricted to the capabilities of individuals and organisations. This definition also rules out knowledge in the abstract. For Howitt things like books, blue-prints and computer programs are tools that people can use for creating similar knowledge not just ways for them to use previously existing knowledge. Howitt's view changes the usual distinction between the production and diffusion of knowledge. This is so because it suggests that the reader of a book, say, creates knowledge much as the original writer did. The difference between the two is the process by which the knowledge is created and the degree to which the new knowledge substitutes for already existing knowledge. The book's author would, we assume, have spent much more time and effort on creating knowledge than would the reader, and the knowledge created would have had much greater scarcity value at the time of writing than the knowledge created by any reader of the work. Any time a reader of the book sets out to learn from the book, most of the knowledge gained will come from the book, but some will be novel.

Jensen and Meckling (1995: 4) make a distinction between "specific knowledge [which] is knowledge that is costly to transfer among agents and general knowledge [which] is knowledge that is inexpensive to transmit." These ideas seem closely related to tacit and codifiable (or explicit) knowledge. Tacit knowledge because of its very nature is costly to transfer while explicit knowledge is cheaper and easier to convey to others.

ICTs embody knowledge, typically in the form of physical devices like cellphones, computer terminals, etc. Such devices utilise or transmit and\or receive information, but enumerating them reveals nothing about society's 'knowledge stocks or flows'. Counting computers does not tell us anything about the knowledge and understanding of their users. Knowledge will be required to create ICTs, but their existence, stock and growth rates alone do not represent the growth or otherwise of the knowledge society\economy. They may however represent and measure the growth of an information using society, though it will be imperfect unless we know something about utilisation rates rather than simple stocks levels. Creating more and cheaper access to the Internet via broadband, computer terminals, freeware etc., may increase the flow and diffusion of information but this does come with an associated risk of a decrease in the quality of the 'information' - for example in such sources as Wikipedia. Wikipedia entries can be written by anyone no matter what their level of knowledge of the subject matter. Such a process lacks the more traditional quality assessment of, say, a refereeing process for a book or journal article. There may be more apparent equity in access to the inputs, but there still remains an elite of knowledge-output creators\diffusers.

Investing more in R&D may facilitate the creation of knowledge, but this requires the knowledge creators\diffusers to work with the necessary R&D equipment to create this new knowledge. Once codifiable, this knowledge may be disseminated as a form of 'new information'. Those receiving this new information must be able to assimilate\use it - that is they need to have the necessary mental tools (human capital) to process it and potentially use it to create yet more new knowledge. Education has an important role here as a means of processing\producing knowledge from the accessible information. Patents are a particular form of 'codified technical knowledge', which often results from R&D, measures of which are easily accessible. However, 'secrecy' is sometimes used to protect commercially valuable technical knowledge as the patent application requires the full disclosure of the new technology. The classic case here is the obvious one of the Coca Cola recipe.

Mr Bean(counter) measures the economy

Much time and effort is expended by many national and international organisations in an attempt to measure the economy or economies of the world. While the measuring of the "standard" economy is funny enough, when we move to the measurement of the "knowledge economy" measurement goes from the mildly

humorous to the outright hilarious. Most attempts to measure, or even define, the information or knowledge economy border on the farcical: the movie version should be called, *Mr Bean(counter) Measures the Economy.*

There are substantial challenges to be overcome in any attempt to measure the knowledge society\economy. These are at both the theoretical and the method level. A more consistent set of definitions are required as are more robust measures that are derived from theory rather than from what is currently or conveniently available. In order to identify the size and composition of the KBE one inevitably faces the issue of quantifying its extent and composition. Economists and national statistical organisations are naturally drawn to the workhorse of the 'System of National Accounts' as a source of such data. Introduced during WWII as a measure of wartime production capacity, the change in Gross Domestic Product (GDP) has become widely used as a measure of economic growth. However, GDP has signicant difficulties in interpretation and usage (especially as a measure of wellbeing) which has led to the development of both 'satellite accounts' - additions to the original system to handle issues such as the 'tourism sector'; 'transitional economies' and the 'not-for-profit sector' and alternative measures for example, the Human Development Indicator and Gross National Happiness . GDP is simply a gross tally of products and services bought and sold, with no distinctions between transactions that add to wellbeing, and those that diminish it. It assumes that every monetary transaction adds to wellbeing, by definition. Organisations like the ABS and OECD have adopted certain implicit\explicit definitions, typically of the Information Economy-type, and mapped these ideas into a strong emphasis on impacts and consequences of ICTs. The website (http://www.oecd.org/sti/information-economy) for the OECD's Information Economy Unit states that it:

> ". . . examines the economic and social implications of the development, diffusion and use of ICTs, the Internet and e-business. It analyses ICT policy frameworks shaping economic growth productivity, employment and business performance. In particular, the Working Party on the Information Economy (WPIE) focuses on digital content, ICT diffusion to business, global value chains, ICT-enabled off shoring, ICT skills and employment and the publication of the OECD Information Technology Outlook."

Furthermore, the OECD's Working Party on Indicators for the Information Society has

> ". . . agreed on a number of standards for measuring ICT. They cover the definition of industries producing ICT goods and services (the "ICT sector"), a classification for

> ICT goods, the definitions of electronic commerce and Internet transactions, and model questionnaires and methodologies for measuring ICT use and e-commerce by businesses, households and individuals. All the standards have been brought together in the 2005 publication, Guide to Measuring the Information Society . . . "
> (http://www.oecd.org/document/22/0,3343,en_2649_201185_34508886_1_1_1_1, 00.html).

The whole emphasis is on ICTs. For example, the OECD's "Guide to Measuring the Information Society" has chapter headings that show that their major concern is with ICTs. Chapter 2 covers ICT products; Chapter 3 deals with ICT infrastructure; Chapter 4 concerns ICT supply; Chapter 5 looks at ICT demand by businesses; while Chapter 6 covers ICT demand by households and individuals.

As will be shown below several authors have discussed the requirements for, and problems with, the measurement of the knowledge\information economy. As noted above most of the data on which the measures of the knowledge economy are based comes from the national accounts of the various countries involved. This does raise the question as to whether or not the said accounts are suitably designed for this purpose. There are a number of authors who suggest that in fact the national accounts are not the appropriate vehicle for this task. Peter Howitt argues that:

> ". . . the theoretical foundation on which national income accounting is based is one in which knowledge is fixed and common, where only prices and quantities of commodities need to be measured. Likewise, we have no generally accepted empirical measures of such key theoretical concepts as the stock of technological knowledge, human capital, the resource cost of knowledge acquisition, the rate of innovation or the rate of obsolescence of old knowledge" (Howitt 1996: 10).

Howitt goes on to make the case that because we can not measure correctly the input to and the output of, the creation and use of knowledge, our traditional measure of GDP and productivity give a misleading picture of the state of the economy. Howitt further claims that the failure to develop a separate investment account for knowledge, in much the same manner as we do for physical capital, results in much of the economy's output being missed by the national income accounts.

In Carter (1996) six problems in measuring the knowledge economy are identified:

1) The properties of knowledge itself make measuring it difficult,
2) Qualitative changes in conventional goods: the knowledge component of a good or service can change making it difficult to evaluate their "levels of output" over time,
3) Changing boundaries of producing units: for firms within a knowledge economy, the boundaries between firms and markets are becoming harder to distinguish,

4) Changing externalities and the externalities of change: spillovers are increasingly important in an knowledge economy,
5) Distinguishing 'meta-investments' from the current account: some investments are general purpose investments in the sense that they allow all employees to be more efficient,
6) Creative destruction and the "useful life" of capital: knowledge can become obsolete very quickly and as it does so the value of the old stock drops to zero.

Carter argues that these issues result in it being problematic to measure knowledge at the level of the individual firm. This results in it being difficult to measure knowledge at the national level as well since the individual firms' accounts are the basis for the aggregate statistics and thus any inaccuracies in the firms' accounts will compromise the national accounts.

Haltiwanger and Jarmin (2000) examine the data requirement for the proper measurement of the information economy. They point out that changes are needed in the statistical accounts which countries use if we are to deal with the information\knowledge economy. They begin by noting that improved measurement of many "traditional" items in the national accounts is crucial if we are to understand fully Information Technology (IT's) impact on the economy. It is only by relating changes in traditional measures such as productivity and wages to the quality and use of IT that a comprehensive assessment of IT's economic impact can be made. For them, three main areas related to the information economy require attention:

1) The investigation of the impact of IT on key indicators of aggregate activity, such as productivity and living standards,
2) The impact of IT on labour markets and income distribution and
3) The impact of IT on firm and on industry structures.

Haltiwanger and Jarmin outline five areas where good data are needed:

1) Measures of the IT infrastructure,
2) Measures of e-commerce,
3) Measures of firm and industry organisation,
4) Demographic and labour market characteristics of individuals using IT, and
5) Price behaviour.

In Moulton (2000) the question is asked as to what improvements we can make to the measurement of the information economy. In Moulton's view additional effort is needed on price indices and better concepts and measures of output are needed for financial and insurance services and other "hard-to-measure" services. Just as serious are the problems of measuring changes in real output and prices of the industries that intensively use computer services. In some cases output, even if defined, is not directly priced and sold but takes the form of implicit services which at best have to be indirectly measured and valued. How to do so is not obvious. In the information economy, additional problems arise. The provision of information is a service which in some situations is provided at little or no cost via media such as the web. Thus on the web there may be less of a connection between information provision and business sales. The dividing line between goods and services becomes fuzzier in the case of e-commerce. When Internet prices differ from those of brick-and-mortar stores do we need different price indices for the different outlets? Also the information economy may affect the growth of Business-to-Consumer sales, new business formation and in cross-border trade. Standard government surveys may not fully capture these phenomena. Meanwhile the availability of IT hardware and software results in the variety and nature of products being provided changing rapidly. Moulton also argues that the measures of the capital stock used need to be strengthened, especially for high-tech equipment. He notes that one issue with measuring the effects of IT on the economy is that IT enters the production process often in the form of capital equipment. Much of the data entering inventory and cost calculations are rather meagre and needs to be expanded to improve capital stock estimates. Yet another issue with the capital stock measure is that a number of the components of capital are not completely captured by current methods, an obvious example being intellectual property. Also research and development and other intellectual property should be treated as capital investment though they currently are not. In addition to all this Moulton argues that the increased importance of electronic commerce means that the economic surveys used to capture its effects need to be expanded and updated.

In Peter Howitt's view there are four main measurement problems for the knowledge economy:

1) The "knowledge-input problem",
2) The "knowledge-investment problem",
3) The "quality improvement problem",
4) The "obsolescence problem".

To deal with these problems Howitt makes a call for better data. But it's not clear that better data alone is the answer, to both Howitt's problems and the other issues outlined here. Without a better theory of what the "knowledge economy" is and the use of this theory to guide changes to the whole national accounting framework, it is far from obvious that much improvement can be expected in the current situation.

One simple question is to which industry or industries and\or sector or sectors of the economy can we tie knowledge\information production? When considering this question several problems arise. One is that the "technology" of information creation, transmission and communication pervades all human activities so cannot fit easily into the national accounts categories. It is language, art, shared thought, and so on. It is not just production of a given quantifiable commodity. Another issue is that because ICT exists along several different quantitative and qualitative dimensions production can not be added up. In addition if much of the knowledge in society is tacit, known only to individuals, then it may not be possible to measure in any meaningful way. If on the other hand knowledge is embedded in an organisation via organisational routines, see Becker (2004) for a review of this literature, then again it may not be measurable. Organisational routines may allow the knowledge of individual agents to be efficiently aggregated, much like markets aggregate information, even though no one person has a detailed understanding of the entire operation. In this sense, the organisation "possesses" knowledge which may not exist at the level of the individual member of the organisation. Indeed if, as Hayek can be interpreted as saying, much of the individual knowledge used by the organisation is tacit, it may not even be possible for one person to obtain the knowledge embodied in a large corporation.

There has also been considerable effort made to measure the information\knowledge society by national and international organisation such as UNESCO, the UN and the EU. That these efforts differ in their outcomes reflects, to a certain degree, different understandings of what the knowledge society is and thus different ways of modelling it. Some documents follow the process of knowledge production to sort out indicators, themes and tend to include measures on i) prerequisites for knowledge production (information infrastructure, knowledge, skill and human capital) and ii) knowledge production (R&D) itself. For example, in "Advancement of the Knowledge Society: Comparing Europe, the US and Japan" (European Foundation for the Improvement of Living and Working Conditions 2004), all indicators are sorted by whether they measure a prerequisite for the advancement of the knowledge society or whether they measure the outcomes of a knowledge society.

Other documents use different criteria to select indicators. The UN model initiated in "Understanding Knowledge Societies in Twenty Questions and Answers with the Index of Knowledge Societies" (Department of Economic and Social Affairs 2005), for example, categorises indicators along three dimensions: assets, advancement and foresightedness. When putting together its "Knowledge Society Barometer" (European Foundation for the Improvement of Living and Working Conditions 2004a), 'The European Foundation for the Improvement of Living and Working Conditions' considers notions such as information, knowledge, knowledge-value societies and sustainable development as parts of a 'jigsaw puzzle' which makes up their knowledge society framework. It seems to indicate that the knowledge society is viewed as a result of the integration of concerns of the previous conceptualisation of societies. Thus, the different frameworks also suggest the influence of organisational agenda\priorities in defining the knowledge society.

Despite the difference in frameworks and indicators, there are some common themes. These include human capital, innovation, ICT development and the context dimension. The human capital theme includes variables on the levels of people's skills and education which reflect the size of the pool of educated people. Included in the innovation theme are variables showing innovation investment, procedures, capacities and networks. There are diverse indicators under the ICT theme; yet, they can be categorised as either resources or access. The former refers to the information infrastructure while the latter is related to the accessibility of information in people's life and work. The context dimension always includes variables on socio-economic, political and institutional conditions for knowledge production.

Obviously, these themes are crucial for measuring the knowledge society. However, these measures are not without their pitfalls. One basic problem for these measures is caused by the "knowledge problem". In some cases, knowledge is understood partially and information and knowledge are treated as exchangeable terms. As a result, some documents focused entirely on measuring the information economy while talking about the knowledge economy and society. Other documents mentioned the difference between tacit and explicit knowledge, the distinction between information and knowledge, and thus, the distinction between the information society and the knowledge society while they failed to employ appropriate variables to reflect the distinctions, due to data availability. Among these documents, we do see a gradually shifting understanding and discourse on the knowledge society. For example, "UNESCO World Report: Towards Knowledge Societies" could be seen as a leading document in initiating the paradigm shift

from the information society to the knowledge one. It acknowledges that "the idea of the information society is based on technological breakthroughs. The concept of knowledge societies encompasses much broader social, ethical and political dimensions" (UNESCO 2005: 17). At the same time, another document prepared by UNESCO on statistical challenges shows difficulties in identifying the relevant data within the existing measurement frameworks.

In addition, the knowledge problem raises other issues to do with the choice of indicators in each of the major themes. For example, human capital is measured according to people's formal education and skills based on human capital approaches. This inevitably ignores people's tacit knowledge and knowledge between people. There are a number of sociological studies which show that even within the economic domain people are not rational actors but their economic performance is signicantly affected by social, cultural and political structures in which they are embedded.

Similarly, the measurement of innovation in these documents seems to focus mainly on the production of scientific knowledge in laboratories. This is inconsistent with the Mode-2 knowledge production initiated by Gibbons (1994) in the knowledge society in which science and society co-evolve. Also the measurement of innovation fails to distinguish the role of inventions from that of innovations. Consequently, it is difficult to see how they can measure the economic value of innovation and at the same time attach a social value to it. Regarding ICTs, it seems that the widely accepted practice is to enumerate the physical infrastructure or, at best, measure access to information. There is a misunderstanding on the relationship between technology and human beings here. It is not technology but human beings and their interactions that constitute so-called society and its institutions. Thus, the function of ICTs is not only their capacity to provide additional new connections but also their potential for opening or closing forms of personal, social and economic capacities, relationships and power-plays (Dutton, 2004). Mansell and Wehn's (1998) INEXSK approach would be a valuable endeavour to integrate the dimension of human beings, their knowledge and ICTs in the knowledge society measurement (Mansell and Wehn 1998).

Another problem with measures of the knowledge society is confusing the knowledge economy with the knowledge society. Generally, there are two kinds of documents on the measurement of the knowledge society. One group focuses on measuring the knowledge economy although they mention the concept of the knowledge society. The foci of the measurement are human capital, innovation and ICT development. A representative document is "Measuring a Knowledge-based Economy and Society: An

Australian Framework" prepared by the Australian Bureau of Statistics. The document's author claims that this framework

> "does not attempt to cover all knowledge in the economy and society . . . [and] offer a comprehensive treatment of a knowledge-based society although it does address those social elements which potentially affect economic change or are affected by it" (Australian Bureau of Statistics 2002: 15)

Another group of documents considers both economic and technological features and social conditions and outcomes of the knowledge society. Two representative documents here would be, "Advancement of the Knowledge Society: Comparing Europe, the US and Japan" (European Foundation for the Improvement of Living and Working Conditions 2004) and "Knowledge Society Barometer" (European Foundation for the Improvement of Living and Working Conditions 2004a) published by the European Foundation for the Improvement of Living and Working Conditions. There are some variables reflecting social issues such as social inclusion, quality of life and gender equality in the two documents. However, they failed to see that both the economic and the social are equally important and integrated components in the measurement frameworks. Instead, the social is still treated as the 'leftover' after having identified 'significant' and 'measurable' components for national accounting.

In light of these issues it would seem that a necessary first step along the path towards the correct measurement of the knowledge society\economy would entail the development of a theory of the knowledge society\economy. Such a theory would tell us, among other things, what the knowledge economy is, how - if at all - the knowledge economy\knowledge society differ, how they change and grow, and what the important measurable characteristics are. Based on this, a measurement framework could be developed to deal with, at least some of, the problems outlined above.

The (non)theory of the knowledge firm

As has been emphasised by Carter (1996) it is problematic to measure knowledge at the national level in part because it is difficult to measure knowledge at the level of the individual firm. Part of the reason for this is that none of the orthodox theories of the firm offer us a theory of the "knowledge firm" to guide our measurement.

The model of the "firm" found in most microeconomic textbooks does not incorporate knowledge - individual or institutional - or the knowledge worker; it

can't since it isn't a "theory of the firm" in any meaningful sense. The output side of the standard neoclassical model is a theory of supply rather than a true theory of the firm. In neoclassical theory, the firm is a 'black box' there to explain how changes in inputs lead to changes in outputs. The firm is a conceptualisation that represents, formally, the actions of the owners of inputs who place their inputs in the highest value uses, and makes sure that production is separated from consumption. The firm in neoclassical theory is no more or less than a specialized unit of production, but it can be a one-person unit" (Demsetz 1995: 9).

Given there is no serious modelling of the firm in neoclassical theory, there is no way to deal with the knowledge firm within this framework. There are no organisational problems or any internal decision-making process, in fact, there is no organisational structure at all and thus the advent of the knowledge economy cannot alter this nonexistent structure. As there is no role for managers or employees there can be no knowledge workers in the firm. But the growth in knowledge workers is one of the most important aspects in the development of the knowledge society. And their advent will change the way we think about firms.

Knowledge creators\workers\owners have the potential to be highly internationally mobile (unlike the physical capital or land in the old economy) which has the capacity to either reduce the knowledge divide or increase it, but importantly at much higher speeds. Buying the necessary knowledge creators\assimilators is like buying physical capital except the ownership of the 'means of production' is now vested more with the capital itself (human) than in the past modes of production. This has a number of important implications including helping understand who wins and who loses from the knowledge economy and this has the potential to affect our understanding\modelling of the traditional 'theory of the firm' - in terms of the Grossman/Hart/Moore (GHM) approach - which is vested in the ownership of physical capital alone.

The modern theory of the firm is based on the work of Grossman and Hart, (1986, 1987) and Hart and Moore (1990). Within the GHM approach ownership is defined in terms of residual control over non-human assets, things such as machinery, inventories, buildings, patents, client lists, firm's reputation etc. Owner-managers employ labour that cannot work without the physical capital these firms own. Dismissal\resignation of the labour requires them to find other physical capital owning organisations (firms) to employ them. On liquidation of the firm, physical capital can be sold and the proceeds disbursed to the owners (shareholders). The standard theory of the firm is based on the role of non-human

capital in the firm. The definition of a firm, the determinants of the boundaries of a firm - that is, the determinants of vertical integration of firms, the meaning of ownership of the firm, the nature of authority within the firm are all functions of control rights over the firm's *non-human assets*. Making non-human assets the centre of the theory means that questions to do with the ownership and control of the physical information technology can be addressed, but this concentration on non-human assets means that the theory doesn't deal with firms based on human assets. However it had been noted from the beginning that the theory could be extended to include human capital. As Hart (1988: 151) argues:

> ". . . one difference with previous work is the emphasis on how integration changes control over physical assets. This is in contrast to Coase's 1937 paper which focuses on the way integration changes an ordinary contractual relationship into one where an employee accepts the authority of an employer (within limits). Note that these approaches are not contradictory. Authority and residual rights of control are very close and there is no reason why our analysis of the costs and benefits of allocating residual rights of control could not be extended to cover human, as well as physical, assets."

Once we move to a situation where firms may own\need little physical capital, then the modern theory of the firm loses much of its main reason for being. Once human capital (labour) becomes the most important\sole creator of wealth\value added then modern economic theory is in need of modification. The theory does not, however, lose all relevance. As Hart (1995: 56-7) explains, at least some, nonhuman assets are essential to a theory of the firm. To see why this may be so consider a situation where 'firm' 1 acquires 'firm' 2, which consists entirely of human-capital. The question Hart raises is, What is to stop firm 2's workers from quitting? Without any physical assets, e.g. buildings, firm 2's workers would not even have to relocate themselves physically.

If these workers were linked by telephones or computers, which they themselves own, they could simply announce one day that they had decided to become a new firm. For the acquisition of firm 2 by firm 1 to make economic sense there has to be a source of value in firm 2 over and above the human-capital of the workers. It makes little sense to buy a 'firm' if that 'firm' can just get up and walk away. Hart argues there must be some 'glue' holding firm 2's workers in place.

The value which acts as this glue may consist of as little as a place to meet; the firm's name, reputation, or distribution network; the firm's files, containing important information about its operations or its customers; or even a contract that

prohibits firm 2's workers from working for competitors or from taking existing clients with them should they quit. The source of value may even just represent the difficulty firm 2's workers face in co-ordinating a move to another firm. But, Hart points out, without something binding the firm together, the firm becomes a phantom, and as such we should expect that such firms would be flimsy and unstable entities, constantly subject to the possibility of break-up or dissolution.

Thus even a human-capital based firm will involve some nonhuman-capital, but the human capital will play the dominate role. The important characteristic of human-capital is that it embodies information and knowledge. A theory of the human-capital based firm has to model this co-existence of the human and nonhuman-capital. Brynjolfsson (1994) deals with the issue by extending the property rights approach to the firm to include information whether this information is embodied in humans, in the form of human-capital, or in artifacts. Rabin (1993) also works within the property rights framework, but extends it by assuming that an agent has information about how to make production more productive which they are willing to sell.

If the firm comprises human capital resources (eg., a legal or accounting firm) whose accumulated knowledge is the source of wealth creation, the balance of power stemming from the "ownership of the means of production", has changed. Likewise predictions about what would happen at the dissolution of a knowledge-firm, is also unclear. Who has the rights to the sell-off of the assets, where these assets are embodied in human beings? How can these assets be sold-off? These issues, although important in the context of the economic theory of the firm may have less importance when trying to measure the size\scale of the knowledge economy. However they are likely to have profound effects on the idea of a Knowledge Society where the balance of (economic) power will change - owners of physical capital losing this to owners of human capital, which without slavery map one-to-one to each individual. An individual's own economic power would likely vary with their different stocks of human capital as would the price they charge to hire it to others in the form of employment. This in turn affects who wins and who loses from the knowledge society.

While the Brynjolfsson model is distinct from the Rabin model, they are complementary. The relationship between information, ownership and authority is central to both papers. Rabin works within a framework of an adverse selection model and shows that the adverse selection problems can be such that, in some cases, an informed party has to take over the firm to show that their information is indeed

useful. The Brynjolfsson model is a moral hazard type framework which deals with the issue of incentives for an informed party to maximise uncontractible effort.

As has been discussed Hart (1995: 17) noted that the neoclassical model tells us nothing about where a firm's boundaries will lie or about the size or location of a plant or factory within a given firm. This approach is consistent with every existing firm being a plant or division of one huge firm which produces everything. It is also consistent with every plant or division of each existing firm being a separate and independent firm in their own right. Thus it is not clear in what organisational form production will occur. Will it be organised as a single large factory, several smaller factories or a household? The GHM approach does delineate the boundaries of the firm but still does not tell us anything about the location or size of a plant or factory which is part of the firm. Again the form of production organisation is indeterminate. What will be argued below is that the division of knowledge is one important influence on the form of organisation in which production takes place. The most obvious issue has to do with the determination of whether or not work occurs in a centralised factory or in separate households or some combination. This has been an issue since at least the industrial revolution.

The development of ICTs has meant that the costs of moving people as opposed to moving information have risen sharply. The costs involved in sending and receiving information have fallen thanks to technologies such as email and the Internet along with falls in the costs of long distance phone calls and the expanding use of cellular networks. The costs of people moving have not fallen however. Commuting to work via congested city and suburban streets, for example, is at least as difficult as it was two decades ago. The increasing interest in congestion pricing in many cities around the world suggests that traffic problems are not lessening. The ever increasing relative cost of moving people would suggest that the size of the "unit of production" should be moving away from the large factory, so dominant for the last two centuries, towards more home based production, as in the period before the industrial revolution.

The previous sections have briefly outlined the effects of the increasing importance of knowledge for the mainstream theory of the firm. It was argued that the neo-classical production function approach is not a true theory of the firm, but rather the firm is portrayed as a uninvestigated perfectly efficient 'black box' which simply turns inputs into outputs without organisation structure. The extensions of the GHM framework offered by Brynjolfsson (1994) and Rabin

(1993) inherits the implicit owner\manager restriction of the original GHM framework and thus are of limited value when modelling the knowledge firm. When we turn to the location of production the models suggest that we should, in general terms, see a movement back towards home production but we are not given a specific relationship between knowledge and plant size or production location.

We are left with an unsatisfactory model of the (knowledge) firm and thus we are unable to give guidance on either empirical or policy questions that flow, via changes to the firm, from the development of the knowledge economy. Firm's organisational structures are changing in response to the increased prominence of information and knowledge in the production process. In the new economy, not only will we see changes in the location of production, but even if production still takes place within a traditional firm, a factory or office, that firm may have a very different structure and organisation from that which we see today. Rajan and Zingales (2003: 87) argue that we are in fact seeing a new "kinder, gentler firm". This is in response to the increase in the importance of human capital, along with increased competition and access to finance, all of which have increased the worker's importance and improved the outside options for workers, thereby changing the balance of power within firms. In Rajan and Zingales's view "[t]he single biggest challenge for the owners or top management today is to manage in an atmosphere of diminished authority. Authority has to be gained by persuading lower managers and workers that the workplace is an attractive one and one that they would hate to lose. To do this, top management has to ensure that work is enriching, that responsibilities are handed down, and rich bonds develop among workers and between themselves and workers" (Rajan and Zingales 2003: 87).

Cowen and Parker (1997) make a similar point about changing organisational structures. For them, "[i]nformation as a factor of production is making old functional structures and methods of organisation and planning redundant in many areas of business. The successful use of knowledge involves not only its generation, but also its mobilisation and integration, requiring a change in the way it is handled and processed." (Cowen and Parker 1997: 12). Organisational change, as far as Cowen and Parker are concerned, is the consequence of the increasing need to make use of market principles within the firm and the growing importance of human capital. They note that as far as a firm's labour force is concerned, "[t]he emphasis now is upon encouraging knowledge acquisition, skills and adaptability in the workforce as critical factors in competitive advantage." (Cowen and Parker 1997: 32). Firms are obliged to rely more on market based

mechanisms as the most efficient way of processing and transmitting information and giving the firm the flexibility and yet also focus it requires. Companies are decentralising their management systems as a way of coping with the uncertainty and pace of change in their markets. The aim is to ensure that those with the required knowledge and right incentives are the ones making the decisions and taking responsibility for the outcomes. Cowen and Parker (1997: 25-8) emphasise how advances in ICTs underlie the ability to be able to combine the advantages of this organisational flexibility with mass production.

But little of these types of changes are captured or explained by the mainstream theory of the firm. Expanding the orthodox view of the firm to include the new reality of the knowledge economy should be an urgent issue on the economic research agenda. It should be noted that such changes to the firm help determine who are the "winners and losers" from economic change in general. As in all previous "economic revolutions", this is the ultimate issue to do with the knowledge economy.

Points of departure and potential for progress

The discussion above suggests that some of the important features and issues that arise with the movement towards an information\knowledge based society are:

1. The increasing (but not exclusive) importance of ICTs in economic and social activities. The access to such technologies will be both enabling General Purpose Technologies (GPTs) and have the potential for exclusion and differential effects - 'winners and losers'. This is not new - the introduction of new technologies has lead historically to winners and losers, both in the short and longer term.
2. The increasing proportion of 'human capital' involved in productive activities.
3. The changing role and importance (and ownership) of intellectual property in productive activities. When information is a key input in economic activity its ownership and control will assume greater importance. Intellectual 'property' v. Intellectual 'commons' will affect access to this resource and there will be winners and losers in the Information Economy as a consequence.
4. The changing nature of the 'theory of the firm'. The current economic theory of the firm is based upon firms having ownership and control of physical capital where 'workers' are employed by owner-managers to work with this owned physical capital. As we move to 'human-capital intensive' firms, the modern theory of the firm is left without much of its theoretical substance.

The distinction between owners (of capital) and workers (human capital) becomes blurred and economic theory stumbles.

5. The Information Economy has typically focused upon ICTs, however, the KBE surely stretches into biogenetic engineering issues where intellectual property, human capital and 'knowledge' have a dominant role. The economic and social impacts of genetic engineering and nanotechnology have typically not been established.

6. Measuring the extent and effects of the KBE can be done either directly (physical\monetary values of its effects - both positive and negative) and\or indirectly via the consequences of the growth of knowledge where it impinges upon areas such as work practices, employment patterns, social inclusion, health\wellbeing\crime\surveillance, environmental and especially energy use consequences etc.

From this it is clear that the key to a quantitative measure of the size, extent and effects of a KBE is a theoretical definition which would necessarily have an important (but not exclusive) role for ICTs; a measure of the size and distribution of 'human capital' and some boundaries where knowledge does and does not contribute to the economy\society.

On the basis of currently available data from the System of National Accounts (SNA) we can measure "OECD-type" measures of the Information Economy. It is generally quite easy to measure the extent and growth of ICT-related goods and services such as, computers per person; Internet hosts; Internet Provider (IP) addresses; email addresses; Internet companies; mobile phones, etc., but without other data on things such as speed of connection; use of computers, these summary measures remain simply that, a largely uninformative summary. Furthermore, what are the critical levels of these measures that determine when the economy is to be deemed an "Information Economy" or a "developing Information Economy"? To answer these questions requires a clearer theoretical base to inform the statistical measurement.

We can focus more explicitly on some possible implications of a more networked economy\society. Possible indicators include the composition of labour force transitions including; Hours worked; Flexible work environment (i.e., home based work); Service workers; Knowledge intensive versus non-knowledge intensive sectors. In addition the size, composition and growth of new and emerging sectors could be measured and tracked. The role of ICTs as General Purpose Technologies (GPTs) is postulated to have had effects (mostly delayed) on productivity. One way to track the

influence of knowledge on the economy is to measure productivity effects via Total Factor Productivity (TFP) as well as direct measures of technological change[2].

A key feature of the KBE is the prominence of human capital. Discussion of the role of human capital has a long history in economics going back to at least Smith (1776) and its measurement goes back even further, beginning with Petty (1690). For up-to-date surveys on the area see Woßmann (2003) and Le et al (2003). However, these types of measures remain mainly 'academic' and the national systems of accounts would typically only include such things as occupational and industry level employment\participation\hours of work data; employment by ethnicity; regional employment differences; qualifications of the employed workforce. These educationally related data can be enhanced directly from University Calendars; educational attainment and curricula composition shift data (from say arts to computer science etc.), however, these are typically anonymous and not linked to specific industry employment\output effects.

Conclusions

It should be clear from what has been said above that one of the most pressing problems faced when dealing with the whole notion of a knowledge economy\society is the lack of a theory of both the knowledge firm and the knowledge economy\society, more generally. Without such a theory, measuring the knowledge economy and saying anything useful in terms of policy seems impossible. We are in a world of 'measurement without theory', as Koopmans put it. Much of what passes for measurement of the knowledge society is based not on a rigorous theory of the knowledge society, which determines what should be measured and how it should be measured, but more on whatever data is convenient and available. This approach greatly limits the value to economic and sociological research on the knowledge society, of any conclusions it might reach, as well as offering little in the way of guidance to policy makers. It has lead to a debate which is characterised by confusing definitions and underdeveloped theorising. This debate has failed to adequately distinguish between the changing role of information within contemporary economies associated with the rise of new communication technologies, the place of knowledge as a component within economic production linked to the shift to human capital as the key cause of innovation and change, and the wider concern to create a society that values open access to increased knowledge for all. Building a more comprehensive "nested" definition of the interrelated

elements that make up the KBE\KS is necessary to ensure that public policy and debate about future "transformational" strategies is structured to ensure that outcomes can be monitored, and achieved in the most effective manner.

Unlike many authors we do not see the problems being resolved by simply gathering better data. Without well thought out theory, the data we would be seeking to find would be yet another "known unknown".

Endnotes

[1] See Woßmann, (2003).

[2] There are difficulties, however, in using TFP as a measure of technological change see for example, Carlaw and Lipsey (2004)

References

Alcaly, Roger, (2003). *The New Economy: What it is, How it Happened, and Why it is Likely to Last,* New York: Farrar, Straus and Griroux.

Arrow, Kenneth J. (1962). The Economic Implications of Learning by Doing. Chapter 7 in Arrow, Kenneth J. (ed.). 1985. *Collected Papers of Kenneth J. Arrow. Volume 5 Production and Capital*. Cambridge, Massachusetts: The Belknap Press of Harvard University Press. Reproduced from *Review of Economic Studies* 29 (1962):155-173.

Asia-Pacific Economic Cooperation (2000). *Towards Knowledge-Based Economies in APEC*, Report by APEC Economic Committee, November.

Atkinson, Robert D. with assistance from Rick Coduri (2002). *The 2002 State New Economy Index Benchmarking Economic Transformation in the States*, Progressive Policy Institute Technology and New Economy Project, Washington, DC: Progressive Policy Institute, June.

Australian Bureau of Statistics (2002). Measuring a Knowledge-Based Economy and Society: An Australian Framework, Discussion Paper 1375.0, Canberra.

Beck, U. (1999). *World Risk Society*, Cambridge: Polity Press.

Becker, Markus, (2004). Organisational Routines: A Review of the Literature, *Industrial and Corporate Change*, 13, 643-677.

Bell, D. (1973). *The Coming of Post Industrial Society*, New York: Basic Books.

Boulding, Kenneth E, (1966). The Economics of Knowledge and the Knowledge of Economics, *American Economic Review,* 56, 1(2), 1-13.

Brynjolfsson, Erik (1994). 'Information Assets, Technology, and Organization', *Management Science*, 40(12): 1645-62.

Carlaw. Kenneth and Richard. G. Lipsey (2004) Productivity, Technology and Economic Growth, in D. George, L. Oxley and K. I. Carlaw (eds.) *Surveys in Economic Growth: Theory and Empirics*, (Blackwell: Oxford), 231-70.

Carlaw, Kenneth, Michael Nuth, Les Oxley, David Thorns and Paul Walker (2006) Beyond the Hype: Intellectual Property and the Knowledge Society/ Knowledge Economy. *Journal of Economic Surveys,* 20(4) September: 633-90.

Carter, Anne P. (1996). Measuring the Performance of a Knowledge-Based Economy. In D. Foray and B. A. Lundvall (eds.), *Employment and Growth in the Knowledge-Based Economy*, Paris: OECD.

Cowan, Robin, David, Paul A and Foray, Dominique, (2000). The Explicit Economics of Knowledge Codification and Tacitness, *Industrial and Corporate Change*, Oxford University Press, 9(2), 211-53.

Cowen, Tyler and David Parker (1997). *Markets in the Firm: A Market-Process Approach to Management*, London: Institute of Economic Affairs.

Cullen, Michael (2006). Universities and Tertiary Reform. Speech notes for address to Association of University Staff Conference, Wellington. http://www.beehive.govt.nz/speech/universities+and+tertiary+reform

Demsetz, Harold (1995). *The Economics of the Business Firm: Seven Critical Commentaries,* Cambridge: Cambridge University Press.

Department of Economic and Social Affairs (2005). *Understanding Knowledge Societies in Twenty Questions and Answers with the Index of Knowledge Societies*, New York: United Nations.

Department of Trade and Industry (1998). *Our Competitive Future: Building the Knowledge Driven Economy*, Department of Trade and Industry Government White Paper, London: HMSO.

Drucker, Peter (1959). *Landmarks of Tomorrow*, London: Heineman.

Drucker, Peter (1969). *The Age of Discontinuity: Guidelines to our Changing Society*, London: Heineman.

Drucker, Peter (1994). The Age of Social Transformation', *Atlantic Monthly*, 174: 53-80.

Dutton, W. H. (2004). *Social Transformation in an Information Society: Rethinking Access to You and the World.* Paris: UNESCO.

European Foundation for the Improvement of Living and Working Conditions (2004). *Advancement of the Knowledge Society: Comparing Europe, the US and Japan*. Dublin: European Foundation for the Improvement of Living and Working Conditions.

European Foundation for the Improvement of Living and Working Conditions (2004a). *Knowledge Society Barometer*. Dublin: European Foundation for the Improvement of Living and Working Conditions.

Felstead, A., N. Jewson and S. Walters (2005). *Changing Places of Work*. New York: Palgrave Macmillan.

Foss, Nicolai J. (2002). Economic Organization in the Knowledge Economy: An Austrian Perspective. In Nicolai J. Foss and Peter G. Klein (eds.). *Entrepreneurship and the Firm: Austrian Perspectives on Economic Organization*, Cheltenham UK: Edward Elgar, 2002.

Gibbons, M. (1994). *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. London; Thousand Oaks, Calif.: SAGE Publications.

Giddens, Anthony (2001). *The Global Third Way Debate*, Cambridge: Polity Press.

Giddens, Anthony (1991). *Modernity and Self-Identity: Self and Society in the Late Modern Age*, Cambridge: Polity Press.

Grossman, Sanford J. and Oliver D. Hart (1986). The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration. *Journal of Political Economy*, 94(4): 691-719.

Grossman, Sanford J. and Oliver D. Hart (1987). 'Vertical Integration and the Distribution of Property Rights'. In Assaf Razin and Efraim Sadka (eds.), *Economic Policy in Theory and Practice,* London: Macmillan Press.

Haltiwanger, John and Ron S. Jarmin (2000). Measuring the Digital Economy. In Erik Brynjolfssonand Brian Kahin (eds.), *Understanding the Digital Economy: Data, Tools, and Research*, Cambridge Mass.: The MIT Press.

Hart, Oliver D. (1988). Incomplete Contracts and the Theory of the Firm, *Journal of Law, Economics, and Organization*, 4(1) Spring: 119-39.

Hart, Oliver D. (1995). *Firms, Contracts, and Financial Structure*, Oxford: Oxford University Press.

Hart, Oliver D. and John Moore (1990). Property Rights and the Nature of the Firm. *Journal of Political Economy*, 98(6): 1119-58.

Harvey, D. (1989). *The Condition of Post Modernity*, Oxford: Basil Blackwell.

Hayek, F.D., von (1945). The Use of Knowledge in Society, *American Economic Review*, 39, 519-530.

Houghton, John and Peter Sheehan (2000). A Primer on the Knowledge Economy, CNES Working Paper No.18, Centre for Strategic Economic Studies, Victoria University of Technology, February.

Howitt, Peter (1996). On Some Problems in Measuring Knowledge-based Growth. In Peter Howitt (ed.), *Implications of Knowledge-Based Growth for Micro-Economic Policies*, Calgary: University of Calgary Press.

Jensen, Michael C. and William H. Meckling (1992). Specific and General Knowledge and Organizational Structure. In L. Werin and H. Wijkander (eds.). *Contract Economics,* Oxford: Basil Blackwell Publishers.

Katz, Lawrence F. (2000). Technological Change, Computerization and the Wage Structure. In Erik Brynjolfsson and Brian Kahin (eds.), *Understanding the Digital Economy: Data, Tools, and Research*, Cambridge Mass.: The MIT Press.

Le, Trinh, John Gibson and Les Oxley (2003). Cost- and Income-based Measures of Human Capital, *Journal of Economic Surveys*, 17(3): 271-307.

Leonard, L. and D. C. Thorns (2006). On-Line Workers Working From Home. Paper presentedat the SANNZ Conference November Hamilton.

Lucas, Robert E. Jr., (1988). On the Mechanics of Economic Development. *Journal of Monetary Economics* 22(1) pp. 3-42.

Machlup, Fritz, (1962). *The Production and Distribution of Knowledge in the United States*, Princeton: Princeton University Press.

Mansell, R. and U. Wehn (eds.) (1998).*Knowledge Societies: Information Technology for Sustainable Development,* Oxford: Oxford University Press.

Marshall, Alfred (1920). *Principles of Economics: An Introductory Volume*, Eight Edition, London:The Macmillan Press. (First edition published 1890).

McKenna, B. and D. Rooney (2005). Wisdom management: Tensions between theory and practice. Paper presented at the Second Annual International Conference on Knowledge Management in Asia Pacic - Building Knowledge Society Linking Government, Business, Academia and the Community, Nov. 28-29, Wellington.

Moulton, Brent R. (2000). GDP and the Digital Economy: Keeping up with the Changes. In Erik Brynjolfsson and Brian Kahin (eds.), *Understanding the Digital Economy: Data, Tools, and Research,* Cambridge Mass.: The MIT Press.

Organisation for Economic Cooperation and Development (1996). *The Knowledge-Based Economy*, Paris: OECD.

Organisation for Economic Cooperation and Development (1996a). *Measuring What People Know: Human Capital Accounting for the Knowledge Economy*, Paris: OECD/DSTI/ICCP.

Petty, William (1690). Political Arithmetik. Reprinted in C. H. Hull (1899), *The Economic Writings of Sir William Petty*, Cambridge: Cambridge University Press.

Powell, W. W. and Snellnlan, K. (2004). The Knowledge Economy. *Annual Review of Sociology*, 30: 199-220.

Rabin, Matthew (1993). Information and the Control of Productive Assets, *Journal of Law, Economics, and Organization*, 9(1) Spring: 51-76.

Rajan, Raghuram G. and Luigi Zingales (2003). *Saving Capitalism from the Capitalists: Unleashing the Power of Financial Markets to Create Wealth and Spread Opportunity*, New York: Crown Business.

Romer, Paul M., (1986) Increasing Returns and Long-Run Growth. *Journal of Political Economy* 94(5), 1002-37.

Romer, Paul M., (1990) Endogenous Technological Change. *Journal of Political Economy* 98(5), 71-102.

Smith, Adam (1776). *An Inquiry into the Nature and Causes of the Wealth of Nations*, Volumes I and II, R. H. Campbell and A. S. Skinner (general eds.), W. B. Todd (textual ed.), Indianapolis: Liberty Classics, 1981.

Smith, K. (2002). What is the 'Knowledge Economy? Knowledge Intensity and Distributed Knowledge Bases, United Nations University, Institute for New Technologies, Discussion Paper Series, 2002-2006, June.

Stehr, N. (1994). *Knowledge Societies*, London: Sage.

Stenmark, Dick (2002). Information vs Knowledge: The Role of intranets in Knowledge Management, Proceedings of the 35th Hawaii International Conference on System Sciences 2002.

Stiglitz, Joseph, E. (1999). Knowledge as a Global Public Good, in *Global Public Goods: International Cooperation in the 21st Century*, Inge Kaul, Isabelle Grunberg, Marc A. Stern (eds.), United Nations Development Programme, New York: Oxford University Press, 1999, 308-325.

Tudge, Colin (1998). *Neanderthals, Bandits and Farmers: How Agriculture Really Began*, New Haven:Yale University Press.

United Nations Conference on Trade and Development (2006). *The Digital Divide Report: ICT Diffusion Index 2005*, New York: United Nations.

UNESCO (2005). *Towards Knowledge Societies*, Paris: UNESCO Publishing.

Virillio, P. (2004). The Third Interval. In S. Graham (ed.), *Cyber Cities*, London: Routledge.

Williams, Philip L. (1978). *The Emergence of the Theory of the Firm: From Adam Smith to Alfred Marshall*, London: The Macmillan Press.

Woßmann, L. (2003). Specifying human capital, *Journal of Economic Surveys*. 17(3): 239-70.

Working Party on Indicators for the Information Society (2005). *Guide for Measuring the Information Society*, Paris: OECD.

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