

Capitalising on Human Knowledge in Global Networked Society

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Abstract. TERRA2000 combines models and scenario analyses to investigate the sustainability and policy implications of the unfolding global networked knowledge society (GNKS). Human capital is a central theme of this research; this paper frames the issues, identifies the policy concerns and presents exemplary analyses of two central features of human capital in the GNKS: networking and complementarity. The knowledge explosion has potential rebound effects, e.g. cheaper transmission increases personal costs of dealing with the resulting flood of information. Human capital *investments* of different types drive productivity growth; *returns* drive income growth and distribution. Unlike physical capital, human capital isn't easily bound by contingent contracts and surely depreciates unless used. Supply-orientated policies had mixed success and unforeseen consequences. Rapid change calls for education favouring self-determination, transferable skills and incentives to share knowledge. Demand-side policies can improve use of existing skills and articulation of skill needs. Networking and complementarity raise new issues and profoundly affect the way policies can be used to meet the coming challenges.

1. Introduction

Today's economic changes and their impact on society in general began during the latter half of the 20th century and have been gathering pace. The past decade's rapid, widespread and potentially profound shifts appear to challenge conventional understanding of relations among the economy, environment, society and culture. These changes are labelled the New Economy, the Information Society, the weightless economy, etc. Public and private policy makers have to use "policy levers" in times of rapid change and information overload to foster cultural, economic, environmental and social sustainability. To better understand the new economic and social mechanisms policy makers need independent, transparent analyses to map likely effect of decisions under a range of possible futures (scenarios).

To address this, Terra2000 analyses the *Global Networked Knowledge Society (GNKS)*:

- **Global:** through Internet, global business, media and increasing travel, no society remains totally isolated and many central problems and potential solutions are global;
- **Networked:** through telecommunications and ICT, geographic distance no longer has the same effect on interaction and teaming. Some businesses, governments, consumers and citizens around the globe have direct network access – but in 2001, ITU estimates less than 20% of world population has a telephone line and only about 8% has Internet access; these are not "equally spread" across regions or socio-economic groups.
- **Knowledge society** (more than "Information Society" in the narrowest sense): information access can be relatively easy and inexpensive but the knowledge required to use it effectively requires insight, education and tools that are difficult and expensive to acquire and share. The word 'society' is included as a reminder that the knowledge transformation transcends the economy.

Arguably, the "newest" aspects of the New Economy are globalisation and knowledge in a mutually reinforcing relationship with networking and information as the basis for

economic growth. The knowledge-based economy trades intellectual and access rights rather than physical products and ownership rights. Knowledge stimulates economic growth in three ways - as a source of innovation, as a necessary input to symbol manipulation and as a carrier of 'soft' interpersonal skills. It remains expensive and difficult to transmit: it is crucially a human attribute, reinforcing the centrality of humans in this new era. The operational definition of human capital used in TERRA2000 is:

The knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well being.

It is produced from: innate competencies, aptitudes and attitudes; education, training and experience and physical, mental, emotional, social and cultural factors influencing human motivation and behaviour.

TERRA2000's analysis of the sustainability impact of GNKS proliferation is built on three thematic perspectives: human capital; equity and growth; and information age sustainability. This paper is based on first perspective, which sheds important light on economic sustainability and also affects societal (particularly through income distribution) and environmental sustainability (particularly through telework).

The analysis combines methodological perspectives. The central activity is scenario analysis supported by integrated modellingⁱ and complemented by theoretical (economic and game-theoretic) modelling of networking and related fundamental aspects of the GNKS and policy analysis. These are used to render policy issues and levers into terms suitable for scenario analysis and, subsequently, to translate the resulting insights into policy targets.

The next section briefly outlines TERRA2000 research perspectives on the GNKS and human capital to identify policy levers. Subsequent sections describe some policy concerns and develop some theoretical points relating to the development of appropriate policiesⁱⁱ.

2. Research perspectives on the GNKS and human capital and policy levers

2.1. How the GNKS affects demand for human capital

Skills demanded by the economy. Policy has concentrated on supplying skills demanded by employers, but has not even eliminated unemployment among skilled workers. Demand-side policies could promote efficient use of current stocks of human capital.

Skills needed by society. 'Human capital in the Information Age' is not limited to skills, motivations and knowledge used in private sector production, but also those used to provide public services, engage in civil society interactions, etc. It is far from clear that skills shaped solely by economic incentives suffice to support a fulfilling Information Society.

Changes in the way individuals work together. Under Fordist techniques, productivity depends on the 'weakest link' and work organisation is protected by a degree of redundancy. Productivity in holistic, team-based organisation appropriate to the GNKS can depend on the 'strongest link' or other production functions linking individual performance to overall output. This affects demand for skills and remuneration; there may be more organisational learning and overall efficiency may be raised by co-operation and complementarity and impaired by decreased individual responsibility.

2.2. How the GNKS affects supplies of human capital

Changes in skills supplied to the economy. The GNKS needs motivated and trained innovators to ensure continued growth and problem solving. This Schumpeterianⁱⁱⁱ model links GDP growth to R&D skill levels. The increasingly 'information-rich' economy also needs "symbol manipulators" [Reich] – GDP growth depends on *growth* of these skills.

Finally, GDP growth in a ‘de-industrialised’ economy depends on *growth* in the stock of “soft” (interpersonal) skills.

Changes in skills acquired and the balance between formal and on-the-job learning. The GNKS requires flexibility, and thus high levels of basic education to enable individuals to learn rapidly and communicate their knowledge to others. At the same time, pressure for economically relevant skills tends to favour on-the-job learning. Firms have an incentive to limit transferability of skills (and thus loss of the firm’s investment in the worker).

Changes in returns to human capital. There is compelling evidence that the GNKS has eroded the relative position of the less skilled. In the US, the UK and other ‘market dominance’ economies, this shows up as increasingly unequal income distributions. In the ‘social market’ economies of Continental Europe, income (or welfare) distributions did not erode as much – particularly after tax and benefit adjustment – but unemployment levels and durations tend to be much higher, particularly among the unskilled. Three explanations have been put forward for this phenomenon:

- Trade: in the simplest model, the richer ‘North’ exports relatively skill-intensive goods to the skill- and income-poor ‘South.’ Skilled northern workers face global markets and earn more. Their less-skilled compatriots face more competition and sell their labour only in local markets. This model explains international patterns, but observed shifts in return are far larger than current trade flows can reasonably account for.
- Technological change: modern ‘skill biased’ technological change concentrates returns on those whose skills are increasingly in demand. This explains increasing disparities *within* skill groups since markets for information-rich ‘hard skills’ used in the ICT sector tend to winner-take-all equilibria since the information and knowledge of a few can serve the whole economy. It also distinguishes creative workers from symbol manipulators, but does less well at explaining returns to soft skills.
- Migration: in many ways, this model synthesises elements of the others. It considers flows of skilled personnel in response to changing patterns of reward: e.g. ‘brain drain.’ It should be broadened to include demand for and supply of education (which also respond to these signals, albeit slowly) and migration at the bottom end of the skill distribution displaced by mobile work flowing to highly-skilled workers in developing areas and increasing local economic pressure on the less-skilled.

TERRA2000 is developing a synthetic model that integrates endogenously determined technological change and education with flows of trade, work, finance and workers.

2.3. Policy levers

TERRA2000 analyses three broad policy levers in connection with its Human Capital theme. These can be described as: adjustments to human capital *supply* (esp. education); adjustments to human capital *demand* (esp. migration of work and other changes connected with the transition to an Information Society); and improvements to the *matching of supply and demand* (esp. migration of workers). These alter productivity and economic competitiveness; returns to human capital investment and remuneration for work; economic dynamics; public finances; societal cohesion and the transition to a knowledge society. Three relevant policy levers are:

- Education and training: policies connected with formal and informal human capital formation. Information access is easy, cheap and global; knowledge access remains difficult and patchy. The analysis considers levels of formation, the roles of public and private bodies, skill transferability or flexibility and costs to students, taxpayers, employers, etc. It also takes account of ‘ownership’ of benefits (compensation patterns, taxation, IPR, etc.) – critically, the ‘embedding’ of returns to educational investment in the countries where education is provided and the implications for development, etc.

- Migration of workers: policies connected with immigration and emigration of workers with different skill sets. The analysis distinguishes economic and political migration, and their very different consequences for growth, social cohesion, etc.
- Migration of work: considers intranational (telework) and international (outsourcing, FDI, etc.) movement of the work to the workers, rather than the workers to the work.

3. Policy concerns relating to Human Capital

3.1. Observations

Technology, changing ‘relations of production,’ intangible capital and knowledge all help to shape GNKS employment, economic growth dynamics and transition to the GNKS. Knowledge is central to this – it has some public good characteristics and is associated with important network effects, in terms of both new knowledge creation and increasing knowledge intensity of all economic activity.

Intangible investment^{iv} in knowledge creation and human capital maintenance is increasingly important: by the 1960’s its market value began to outweigh that of tangible capital (infrastructure, equipment, inventories and natural resources)[3, 4]. Since the 1980’s it has grown about 3%/year; its composition differs strongly across OECD countries.

Accelerating production, accumulation and depreciation of knowledge reflects faster technological progress and emerging knowledge-based forms of organisation [5] – e.g. a ‘consultant culture’ of creative workers in loose networks rather than tight affiliation with their clients. Their external connections add value for clients, workers and society at large.

The increasing speed and intensity of innovation is seen in formal RTD, the proliferation of new goods and services (including ‘personalised products’), the emergence of experience-based learning environments and institutions as collaborative work gradually transforms Fordist production [12] and the growing role of consumers as sources of innovation [8]. ICT facilitates knowledge creation by an increasing range of knowledge producers working and learning together in public (or semi-public) spaces for information exchange, contributing to large, dispersed data systems and databases, and utilising new techniques for codifying, searching and transmitting knowledge.

Transition to the GNKS is reinforced by competition and the resulting ‘innovate or die’ imperative. *Networking* is important to this transition; the accuracy of communication depends on the ‘distance’ from sender to receiver and its impact reflects the extent to which it can cross ‘domains’ or groups. There are also economies of scale; efficient networks can capitalise on positive feedbacks and reduce levels of duplication, while broad peer-to-peer architectures allow new types of communication. From an economic point of view, different types of human capital are increasingly *complementary*.

GNKS jobs are increasingly knowledge-intensive – not just in high-technology sectors. Demand for ‘soft’ (interpersonal) skills may begin to recover as deindustrialisation proceeds and telework lets people from a variety of contexts participate in teams. Work is also moving away from centralised factories [2, 11]. Not all tasks can be performed virtually, but there are already big changes in the way we work. Certainly, employers and employees *can* choose among a greater range of models; *actual* choices have cultural, equity and environmental sustainability consequences.

3.2. Policy concerns

These observations point to emerging and persistent *welfare divides*^v (across and within skill levels and countries) locked into a mutually reinforcing relationship with *access*

divides in education, information, finance, etc. This section considers the underlying market failure, resulting movement of workers and/or work and the ‘paradox of access.’

Individual and social returns to human capital are changing strongly, and there is a role for policies to ‘correct’ the signals sent by human capital markets. These policies must consider the roles of public and private parties, the balance between hard and soft skills, the mix of training, education and certification provided by educational systems, and technological acceleration of knowledge depreciation and obsolescence.

Knowledge production and uptake is not evenly spread across countries and sectors. Adverse impacts can be seen e.g. in slow progress in dealing with ‘diseases of the poor’ - potentially very large returns are too remote and difficult to capture to motivate pharmaceutical companies without intervention. Such market failure has profound implications for sustainability of knowledge-based economic development.

Worker migration in response to skill shortages or growing inequality may not be sustainable. It is inconceivable that one-way flows of skilled individuals could continue indefinitely; source countries would find ways to use self-produced human capital, the flow of applicable new knowledge would dry up or returns to (esp. public) education would drop, choking off investment. Moreover, such flows have not, to date, reduced either shortages or inequality. The alternative of *work migration* avoids some of these problems, but produces rebound effects on unskilled workers ‘at home.’ Resulting migration of unskilled workers produces cultural and social pressures that increasingly dominate the news and political debate, as instance at the recent Seville Summit^{vi}.

Work and workers are also coming together; interesting ‘creative clusters’ emerging around the world reflect the forces of networking and globalisation. Policy to ‘kick-start’ such clustering offers interesting possibilities both for European competitiveness and for management of side effects of other human capital policies.

Policy regarding knowledge ownership and dissemination is affected by the ‘paradox of access’ [6]. On one side, technological and economic advances are making it easier and more efficient to share knowledge and information (through telecommunications, enhanced search capabilities, teleworking, etc.). On the other side, this leads to attempts to limit access and create artificial scarcities via extended intellectual property rights, relation-specific learning, etc.

Finally, changing human capital formation and market dynamics affect the economy’s competitive health^{vii} and, potentially, the quality of knowledge production and use, so the impacts of human capital policy on market structure and information quality and deployment should be carefully considered.

4. Indicative Policy Analysis

The analysis sketched below uses the observations above to develop implications of two aspects of the GNKS (networking and complementarity) for human capital

4.1. Co-ordination and networking

In addition to the policies traditionally used to improve *supplies* of human capital matching (economic) uses to which it is put, attention has recently turned [10] to immaterialisation and other ways of making better use of available human capital, and to policies that improve labour market functioning. The following stylised example shows how the economy can get ‘trapped’ in an inefficient equilibrium and how networking affects the choice of policy to remedy the problem. Employers (row player) choose product specification level and workers (column player) choose skill levels; each receives the

indicated payoffs. We assume that $C > B$, $D > A$ and $D > C$. Bold outcomes are Nash equilibria (mutual best replies). The ‘Low’ (shaded) equilibrium represents a stylised *status quo of skill shortages and skilled unemployment* – it is inefficient relative to the ‘High’ equilibrium.

	Low skill	High skill
Low specification	(C, C)	(A, B)
High specification	(B, A)	(D, D)

It is obvious that policy to raise B (the opportunity cost of playing ‘High’ in a mismatched market) above C (e.g. by subsidising education or RTD) can eliminate the inefficient equilibrium. However, the required subsidy may be large; more interesting policy perspectives come from embedding this game in a *network* – in other words, by letting many parties interact with their network neighbours [7].

If behaviour evolves – for example, if random players get the chance to optimise against their neighbours (subject to random shocks), the efficient equilibrium will be stable if it is also *risk-dominant* in the sense that $C - B < D - A$. This holds for a range of network structures. Policy that increases b to ‘escape’ from the inefficient equilibrium has a lower required subsidy - the threshold value of B is $C + A - D$, which is less than the threshold (C) in the non-networked case. Alternatively, policy can be used to raise d relative to a, effectively raising the opportunity cost of playing ‘Low’ in a mismatched market. Further analysis has established conditions under which making the network structure itself endogenous (e.g. liberalising labour markets via the policy levers considered above) can stabilise the efficient outcome even when it is not risk dominant, speed convergence or destabilise the ‘bad’ equilibrium.

4.2. The problem of complementarity

Complementarity is sometimes regarded [9] as *the* defining characteristic of network goods and services. It is certainly typical of GNKS team working skills. Complementarity creates severe problems for competitive economic models - ‘winner-take-all’ equilibria, inefficient tradeoffs between compatibility and diversity and potential emergence of bottleneck market power among holders of globally scarce skills that are strongly complementary to others. It can even lead to non-existence or multiplicity of equilibria. Complementarity also complicates socially optimal pricing in monopoly or oligopoly settings. Optimal wages maximise a weighted sum of stakeholder returns (the Ramsey problem). With complementarities, socially optimal returns to some skills fall below their marginal cost of acquisition –thus they must be subsidised^{viii}.

More practically, the theory of multiple-unit auctions [1] or matching problems [13] exposes the economic and policy consequences of complementarity. This subsection briefly considers an application to^{ix}: i) hiring groups of experts from a network of consultants; ii) hiring groups of workers together (e.g. to staff a new plant or produce a new good or service); iii) bidding for groups of contracts by workers or expert networks; or iv) offering packages of skill training. In each model, buyers whose preferences or productivities may be unknown bid for *packages* of complementary and/or substitute objects.

The standard ‘solution’ is a *Vickery auction* [14]: bidders submit prices for all possible packages and the auctioneer picks the most profitable way of selling all the objects. By selling to the highest bidders for each part of the package at the lowest price they could have bid while still winning the object^x, the mechanism assures that honest bidding is a *dominant strategy* - each bidder will bid honestly – no matter what the other bidders do. If the goods in the package are substitutes^{xi}, we get the full-information market outcome. However, if there are complementary skills, a number of problems arise. The following matrices show the payoff to the bidder (employer) for various combinations of skills:

Example 1: The standard solution may not pay off

Employer	Skill 1	Skill 2	Both skills
A	€0	€0	€2
B	€2	€0	€0
C	€0	€2	€0

With a Vickery auction, employer B will hire Skill 1 and employer C will hire Skill 2; each will pay €0. Note also that if B and C merge, increasing their payoff to having both skills from €4 (€2+€2) to €5 via merger efficiencies, they will now have to pay €2 to beat the (truthful) bid of employer A. The net payoff is only €3, which will deter this socially efficient merger. Complementarity can distort technological progress for the same reason.

Example 2: The standard solution is vulnerable to cheating

Employer	Skill 1	Skill 2	Both skills
A	€0	€0	€2
B	€½	€½	€1
Ba	€2	€0	€0
Bb	€0	€2	€0

If employer A faces an honest employer B, he'll get both skills at a cost of €1. However, if employer B masquerades as Ba *and* Bb, each of his 'subsidiaries' will win the skill he bids for at a cost of €0.

In addition, budget constraints may destroy the dominant strategy property, and may involve employers paying different amounts for identical skill sets, even when their bids were the same. It may also be extremely time-consuming to formulate (and process) bids for all possible packages, as the standard solution requires.

An adaptation of a mechanism defined by Ausubel and Milgrom [1] produces an ascending proxy auction alternative: Employers choose any list of skill packages, and instruct a representative as to the value they place on each package. In each round, the proxy raises (by the minimum allowable amount) the offer to every package where he is not the current high bidder and where winning that package in addition to the others he is currently winning will raise his principal's valuation. This mechanism meets all the above objections, has additional desirable theoretical properties *and* describes experimental behaviour more accurately. It provides better incentives for skill acquisition, is less vulnerable to collusion and generates higher equilibrium returns. Moreover, the truthful bidding that characterises the equilibrium facilitates the exchange and aggregation of information about the value of human capital in a way that present labour market outcomes cannot.

The real value of the mechanism comes in application. In the GNKS, electronic labour exchanges are already beginning to displace conventional labour markets. They do not seem to perform well in providing fair and efficient returns across complementary skills – growing income divides among skills around the world provide ample evidence. This mechanism can be robustly implemented in the Internet environment: the necessary computational power is easily available to seller(s), and the computational burden on buyers is reduced to valuing those packages in which they are really interested.

5. Conclusions

This paper has described the approach taken by TERRA2000 to understanding the role of human capital in the GNKS and its policy implications, developed a framework for considering these issues and provided an overview of current trends and developments of policy concern. It has also used simple game-theoretic tools to analyse specific aspects of the situation revealed by the empirical observation, and to indicate the role for policy in

addressing difficulties with current arrangements. Preliminary indications are that networking *can* simplify policy responses to human capital market failure, that the way people connect is as important as the number of people connected, and that innovative mechanisms can be used to improve the functioning of human capital markets. The next steps being taken are to flesh out the theoretical models, test them against available data and scenario analysis using the TERRA2000 tools and data, and to refine the policy analysis.

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ⁱ Terra2000 combines paradigmatic models of abstract phenomena with dominant relations models of important aggregate linkages and trends and more detailed integrated policy models.

ⁱⁱ Results of detailed scenario analyses will be presented during the conference.

ⁱⁱⁱ This refers to Schumpeter's view of the economy as driven by 'creative destruction' – the continual succession of better or more attractive goods and services produced in more efficient ways.

^{iv} OECD measures knowledge production by investment in RTD, public education and software.

^v The 'transatlantic consensus' (term due to Sachs) notes widening *income* inequality in 'market dominant' economies (e.g. US, UK) and the widening *employment* inequality in 'social market' economies (e.g. continental Europe).

^{vi} European Council, "Presidency Conclusions, Seville," <http://ue.eu.int/pressData/en/ec/71212.pdf>.

^{vii} In the economic senses of allocational and productive efficiency and minimising the distributional distortions of information rents

^{viii} Conventional arguments for educational subsidy use social value or universal-service considerations.

^{ix} Each of these has been worked out, and is available on request.

^x This second-price sealed bid auction is equivalent to an ascending open auction; the price stops rising when the second-highest bidder drops out.

^{xi} In other words, if having more of one skill *decreases* the marginal productivity of the other skill.