TECHNOLOGY GOVERNANCE

Working Papers in Technology Governance and Economic Dynamics no. 28

THE OTHER CANON FOUNDATION, NORWAY
TALLINN UNIVERSITY OF TECHNOLOGY, TALLINN

CONTACT: Rainer Kattel, kattel@staff.ttu.ee; Wolfgang Drechsler, drechsler@staff.ttu.ee; Erik S. Reinert, reinert@staff.ttu.ee

The financial crisis and the future of innovation: A view of technical change with the aid of history

Carlota Perez, Technological University of Tallinn, Estonia and universities of Cambridge and Sussex, U.K. www.carlotaperez.org

February 2010

This paper was prepared with funding from the Advisory Council for Science and Technology Policy of the Netherlands

This essay locates the current financial crisis and its consequences in a historical context. It briefly outlines the difference in patterns of innovation between the first two or three decades of each technological revolution –regularly ending in a major financial collapse– and the next two or three decades of diffusion, until maturity is reached. With this historical experience in mind, the essay discusses the opportunity space for innovation across the production spectrum taking into account the specificity of the Information and Communications Technology (ICT) paradigm and the increasing social and environmental pressures in the context of a global economy. Finally, there is a brief look at the sorts of institutional innovations that would be required to provide adequate finance to take full advantage of those opportunities.

Table of contents

INTRODUCTION: The mixed consequences of major bubble collapses 3
GREAT SURGES OF DEVELOPMENT: Two different periods in the propagation of technological revolutions and their paradigms 4
The Turning Point and the need for institutional innovation 6
Installation and Deployment: different drivers of innovation 8
THE NEW DIRECTIONS FOR INNOVATION: Sources of criteria for gleaning the trajectories of technical and social change 12
The hyper-segmentation of markets: differentiation and adaptability 13
The hyper-segmentation of production units: networks and specialisation 17
The shaping power of the energy and environmental challenges 20
The coming redesign of globalisation 21
The gestation of the next revolution 24
THE POLICY CHALLENGES: Taking the paradigm and the period transition into account 25
The implicit innovation policies 27
The direct policies: innovating in the financing of innovation 29
SKIEs, SMEs and networks 30
Recognising intangible value 32
Providing continuity of support along the life-cycle 33
The roles of R&D in the present and for the future 35
CONCLUSION 36
References 38

INTRODUCTION: The mixed consequences of major bubble collapses

Major bubbles in the market economy are complex processes with mixed consequences. The NASDAQ boom, the collapse of which brought a two year recession and permanently wiped out half the illusory value of the inflated technology stocks, facilitated enough over-investment in telecommunications and fibre optic cables to interconnect the global space digitally and bring hundreds of millions of people into Internet use.[1] The 2008 meltdown is having and will have a much deeper and more widespread negative impact on the global economy. The upside of that is made up of two very different consequences: One is the fact that from 2004 to 2007 there was a definite impulse to global growth. At the centre of it were the Asian economies, especially China and India, which through their lower costs for products and services increased the buying power of salaries in the already industrialised world and also gave a respite to the energy and materials exporting countries through a major increase in prices. This had as a counterpart, though, that the boost in consumption in the more advanced economies that facilitated this global growth was fed by the export surplus funds coming back from Asia. This inflated the housing bubbles that enabled growing consumer credit on the back of the asset price gains. The bursting of those bubbles has brought the whole network down and turned the positive feedback loop into a vicious downward spiral. Nevertheless, globalisation is a fact and the new emerging economies will change the shape of the world to come.

The other consequence of the bust, which could in some sense be defined as 'positive', is that by revealing all the crooked ways of the financial world during the boom, it has broken the myth of an ideal 'free market' and brought back the State into an active role in the economy. Such a come back is not limited to restraining the abuses of finance but extends to favouring the expansion of production and job creating activities over speculation and to spreading the benefits of growth more widely across society. This happened in the past after each of the major technology bubbles, with different intensity and in varying manners depending on the historical moment and on the specific technological revolution that underlay the boom. The most recent and strongest case of State intervention in these directions is, of course, the Welfare State and the Bretton Woods agreements and institutions, after the war and the long depressive years of the 1930s. The set of institutional innovations adopted then was very well adapted to the requirements of the mass production technologies of the time, which were able to bring consumer prices down to the level of workers' wages, as long as the market was large enough to reap the full economies of scale.

---

[1] The Internet really only began in 1994 but by 2000 there were already more than 300 million people using it. The estimate now is one and a half billion. From http://www.internetworldstats.com/stats.htm downloaded April 13, 2009

The current meltdown will require, after the initial rescue of finance, an equivalent set of institutional innovations at several levels: global, supranational, national, regional, local and community. The governance structure of societies is likely to experience changes as profound as those that turned the rigid pyramidal and strictly hierarchical and compartmented organizations of giant corporations into relatively flat, highly flexible and dynamic networks spanning the globe. Rather than strictly separate single-function departments with interaction only at the top, these nimble giants now count on innumerable single-purpose (though often multi-function) units that are small, agile, creative and empowered to pursue the defined objectives in their own chosen manner and to respond immediately and autonomously to changes in context or in clients' demands. A transformation of equivalent magnitude and direction is now in order for the State at all levels, though taking into account the difference in criteria, guiding principles and goals.

This essay begins by briefly summarizing the path followed by the operation of the market system in the process of installing and deploying successive technological revolutions and locating the current historical moment in that recurring sequence. A second section examines the sources of criteria to 'foresee' the directions of innovation in the next two or three decades and the final section discusses the policy challenges posed specifically by the need to foster the pursuing of those directions.

GREAT SURGES OF DEVELOPMENT: Two different periods in the propagation of technological revolutions and their paradigms

Technical change in the market economy is constant but not continuous; it takes place by massive surges of change. The current Information and Communications Technologies (ICT) revolution is the fifth such upheaval experienced by the capitalist system since the 'industrial revolution' at the end of the 18th Century. Each of these *great surges of development* (GSDs) has given rise to a whole set of new industries along with a set of new organisational principles and externalities of infrastructure and knowledge that enable the modernisation of practically all of the existing industries. The vehicle for this upgrading is a new *techno-economic paradigm* (TEP) or best-practice model, emerging from the practical implementation of the new technologies and embodying new and wide-ranging common sense criteria for the most efficient, effective and profitable products, processes, business organisations and market behaviours.

Table 1 indicates the five surges, with the industries and infrastructures that constitute the technological revolution that drives them and with a selection of the most salient common sense principles of each paradigm.

The assimilation of such profound changes by the economy and society is a very difficult process that must overcome both human resistance to change and institutional inertia. The success in achieving this becomes in

Table 1. Five Great Surges of Development: Main technologies, industries and infrastructures and prevailing techno-economic paradigm

Techno-logical revolution	2. New technologies and new or redefined industries	3. New or redefined infrastructures	Techno-economic paradigm 'Common-sense' innovation principles
FIRST: *The 'Industrial Revolution'*	Mechanized cotton industry Wrought iron Machinery	Canals and waterways Turnpike roads Water power (highly improved water wheels)	Factory production Mechanization Productivity/ time keeping and time saving Fluidity of movement (as ideal for machines with water-power and for transport through canals and other waterways) Local networks
SECOND: *Age of Steam and Railways*	Steam engines and machinery (made in iron; fuelled by coal) Iron and coal mining (now playing a central role in growth)* Railway construction Rolling stock production Steam power for many industries (including textiles)	Railways (Use of steam engine) Universal postal service Telegraph (mainly nationally along railway lines) Great ports, great depots and worldwide sailing ships City gas	Economies of agglomeration/ Industrial cities/ National markets Power centres with national networks Scale as progress Standard parts/ machine-made machines Energy where needed (steam) Interdependent movement (of machines and of means of transport)
THIRD: *Age of Steel, Electricity and Heavy Engineering*	Cheap steel (especially Bessemer) Full development of steam engine for steel ships Heavy chemistry and civil engineering Electrical equipment industry Copper and cables Canned and bottled food Paper and packaging	Worldwide shipping in rapid steel steamships (use of Suez Canal) Transcontinental railways (use of cheap steel rails and bolts in standard sizes) Great bridges and tunnels Worldwide Telegraph Telephone (mainly nationally) Electrical networks (for illumination and industrial use)	Giant structures (steel) Economies of scale of plant/ vertical integration Distributed power for industry (electricity) Science as a productive force Worldwide networks and empires (including cartels) Universal standardization Cost accounting for control and efficiency Great scale for world market power/ 'small' is successful, if local
FOURTH: *Age of Oil, the Automobile and Mass Production*	Mass-produced automobiles Cheap oil and oil fuels Petrochemicals (synthetics) Internal combustion engine for automobiles, transport, tractors, airplanes, war tanks and electricity Home electrical appliances Refrigerated and frozen foods	Networks of roads, highways, ports and airports Networks of oil ducts Universal electricity (industry and homes) Worldwide analogue telecommunications (telephone, telex and cablegram) wire and wireless	Mass production/mass markets Economies of scale (product and market volume)/ horizontal integration Standardization of products Energy intensity (oil based) Synthetic materials Functional specialization/ hierarchical pyramids Centralization/ metropolitan centressuburbanization National powers, world agreements and confrontations
FIFTH: *Age of Information and Telecommunications*	The information revolution: Cheap microelectronics Computers, software Telecommunications Control instruments Computer-aided biotechnology and new materials	World digital telecommunications (cable, fibre optics, radio and satellite) Internet/ Electronic mail and other e-services Multiple source, flexible use, electricity networks High-speed multi-modal physical transport links (by land, air and water)	Information-intensity (microelectronics-based ICT) Decentralized integration/ network structures Knowledge as capital / intangible value added Heterogeneity, diversity, adaptability Segmentation of markets/ proliferation of niches Economies of scope and specialization combined with scale Globalization/ interaction between the global and the local Inward and outward cooperation/ clusters Instant contact and action / instant global communications

Note: * These traditional industries acquire a new role and a new dynamism when serving as the material and the fuel of the world of railways and machinery

Source: Based on Perez (2002) pp. 14 and 18

turn an obstacle for the adoption of the next revolution, which tends to occur as soon as the potential of the previous one approaches exhaustion.[2]

It is due to these inertial forces that each great surge, rather than propagating smoothly, exhibits two very different periods of about two or three decades each. The first is the turbulent battle of the new against the old; a time of Schumpeterian creative destruction, of intense free market experimentation and exploration of all the possibilities of the new technologies. It is a time when financial capital joins forces with the new entrepreneurs to unseat the established giants and to dismantle the institutions that had facilitated their growth and expansion. This is the *Installation period*, which begins in the midst of a mature economy in decline and ends with a frenzied prosperity characterised by the triumph of the new paradigm, the emergence of new giants and the development and collapse of a major financial bubble. During this time, the short-term objectives of financial investors become prevalent and guide production investment and decisions through their control of the sources of funds and of stock market values.

The second period brings to fruition all the potential opened up by the new technologies. It is the *Deployment* period when the new production giants serve as engines of growth. It is a time of 'creative construction' involving the expansion of both the new and the rejuvenated sectors and usually spreading the benefits of growth much more widely than during Installation. Production capital is then at the helm of investment decisions and finance adapts (or is induced to adapt) to serve those longer-term objectives and benefits from them.

The Turning Point and the need for institutional innovation

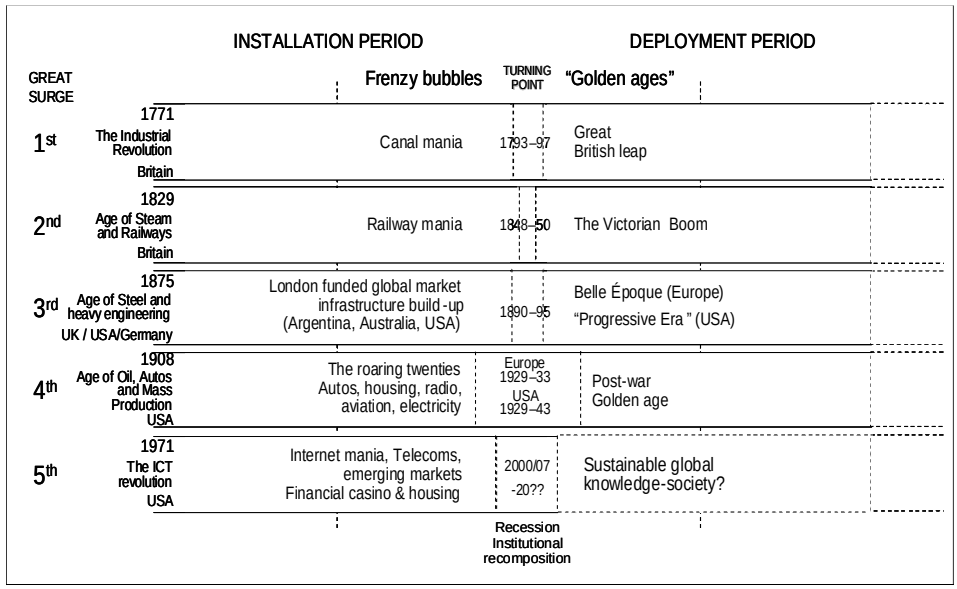
Such a shift in conditions and leadership does not happen easily or automatically. It requires a radical institutional recomposition (of which Bretton Woods and the Welfare State are the outstanding example) in order to modify radically the business context, favouring real production and employment creation over speculation and start reversing the income polarisation process that characterises installation periods. That redressing is important as much in the name of social justice as for overcoming demand constriction. These institutional changes tend to occur as a response to the intense political pressures that follow the recession or even depression and other socially painful consequences of the major bubble collapse at the end of Installation. At this transitional point, the role of the State in the economy is a determining factor and the capacity to innovate boldly in government policy is crucial.

---

[2] A complete discussion can be found in Perez (2002) and a briefer summary in Perez (2007). Readers familiar with the model presented there can skip this section.

The years between the bust and the unleashing of Deployment (from two years to as much as thirteen, as was the case in the 1930s) constitute the *Turning Point*, referring to the shift in conditions and leading role from one period to the other.

Figure 1. Two different prosperities and a break in each great surge of development



Based on Perez (2002) p. 78

Figure 1 presents the five surges in parallel, indicating the Installation bubbles, the dates of the Turning Point recessions, and the Golden Ages that characterise early deployment (leading later to maturity and the irruption of the next technological revolution).

In 2009 the world is going through the Turning Point and deciding the global and national context for the full Deployment of the ICT surge. Understanding the nature and direction of the changes required is a crucial input for designing institutional and policy innovation and increases the probability of taking best advantage of the new wealth creating potential of the new paradigm. The elements likely to define that orientation are (1) the need to switch from Installation to Deployment conditions, (2) the characteristics of the current ICT TEP and (3) the new forces likely to shape its application. The first can be gleaned by analysing the faraway past with the lens of historical recurrence; the other two by examining the trends of the past few decades with a 'paradigm lens'.

The rest of this section will look at what the switch to Deployment has regularly implied for conditioning innovation and its relationship to investment decisions. The section after that will discuss the specific directions that might be taken by innovation in this particular surge.

Installation and Deployment: different drivers of innovation

Distinguishing between innovation in the core new industries themselves and in the industries or activities that apply the new technologies to innovate is important for understanding the main differences between Installation and Deployment as regards the rhythm and direction of technical change. Installation is basically an experimental period for trying out in the market the innovation space opened by the technological revolution and defining the shape of the new industries, the new production and distribution methods, and the new consumption patterns. The extraordinary profits exhibited by some of the young companies lead to an increasingly biased allocation of funds towards these novel industries and in particular to the new infrastructures that are destined to provide the main externalities for the users of the emerging technologies.

At the peak of the boom of the second surge in 1847, investment in railways represented 55% of gross national fixed capital formation in the U.K.[3] During the first globalisation, at the end of the 19th Century, in the third surge, between 30 and 50% of British investment went overseas mainly to finance infrastructures, especially in the Southern hemisphere (Australia, Argentina, etc.) for counter-seasonal trade as well as in the strongly emerging countries of North America (US and Canada) that were building transcontinental routes for their mining and agricultural products.[4] In the US, during the whole of the recent Installation period, between 85 and 90% of venture capital went to ICT companies.[5] The high and growing valuations of telecom and Internet-related companies during the NASDAQ bubble facilitated the completion of a global fibre optic network that has become the foundation of the globalisation process.

This bias towards the new technologies enables the novel entrepreneurs to test their strength in the market and allows for the potential users –be they producers or consumers– to express their demand preferences. As a result, the new leaders emerge, the new industry structures are basically defined and the economy can count on a set of new and powerful engines of growth.

At the same time, the Installation period facilitates the emergence of the new paradigm. Even the funding granted to the traditional industries is usually biased towards modernisation assimilation of this new paradigm or preparing to take advantage of the new infrastructure. This is done through

---

3 Mitchell (1964)

4 Davis and Gallman (2001)

5 Gompers and Lerner (2001)

the incorporation of the new organisational models, the updating of equipment, the use of the new infrastructures, the change in product profile to fit the new consumption patterns and so on. As a result, by the time of the major bubble collapse, the whole of the economy is ready to innovate along the lines of the new paradigm or can adapt to do so; industry structures of both new and renewed industries have more or less defined their new borders and forms of competition and the techno-economic paradigm has been incorporated as common sense and as the common language of producers, engineers, bankers, investors, consumers and all the other agents active in the economy. Yet while the paradigm shift is basically complete, the institutional context is lagging.

In order to achieve this transformation, not only had the world of finance led the reallocation of funds towards the new technologies and practices, but it had also become an intense innovator in its own right, taking advantage of all the possibilities offered by the new technologies. This means that both –the real and the paper economy– produce good and bad innovations, successful and failing ones. The actors in the Deployment period, in a context shaped by government policy, will end up selecting those that survive and thrive and will also stimulate new ones adapted to their newly defined needs.

The deployment period is the time when the modernised companies across all sectors innovate using the power of the technologies of the revolution and of the new –by then, established– paradigm. It is a time of expansion, extension and multiplication of possibilities in the whole spectrum; it is also a time for social innovation in order to spread more widely across society the benefits of the vast wealth creating potential.

In sum, there is a changing of the innovation guard with the Turning Point. During Installation the innovation drivers are the new technological entrepreneurs and the financiers while the State has a service and facilitating role with a *laissez faire* attitude. During Deployment, the State comes back actively and serves as innovation driver together with production capital, which takes the helm of investment while financial capital serves as support.[6]

What this means in terms of financial innovation is that it moves from a 'supply push' behaviour to learning to respond to 'demand pull' from the

---

6 During the third surge deployment (the Belle Époque) finance remained at the helm but not from the stock market but from the boardrooms of the gigantic companies they supported. The core industries of that revolution required major investments up front: steel, heavy engineering (chemical, electrical, civil, naval), transcontinental railways, steamship companies and the major producers of raw materials and agriculture that were the main products of that first globalisation. So the likes of Morgan in the US and the German banks actually played the double role of production and financial capital. The case of the UK was different, but this is not a discussion for this essay.

production sector. And that is also what happens with the revolutionary industries. In this Deployment, ICT will also move towards fulfilling the demands of innovation across its user industries. Both companies and consumers are now savvy in terms of what ICT can provide and they have multiple ways of making known what their specific demands and expectations are. And the same can be said about governments, NGOs and other innovating organisations.

Although it is indeed possible to identify recurrence in history, it is crucial to recognise the uniqueness of each manifestation. In this sense, it is very important to note that the major bubble of the current surge occurred in two episodes: the Internet boom at the end of the 1990s, based on technological innovation, and the boom of 2003-08, based on financial innovation.[7] This peculiar separation of what in the past had been a single bubble has many implications, some of which have to do with the direction of innovation, others with the timing of certain recurring processes.

One of the typical consequences of each bubble bust is a comprehensible avoidance of risk in the particular objects of speculation that fed the boom. In the aftermath, investors tend to steer clear of mortgage-backed securities and any other synthetic instruments. Similarly, after 2000, investors had become wary of Internet and dot.com projects. Many private equity funds moved from venture capital to buying, transforming (or stripping) existing companies and reselling them; ICT entrepreneurs were more likely to aspire to a generous acquisition by Google or Cisco or Microsoft than to an IPO in the stock market, (although Google itself was one of the brilliant exceptions to this climate).

Thus, some of the phenomena that characterise the aftermath of major technology bubbles were already present during the casino boom of the 2000s. Some of the new innovation spaces that were made possible by the installation of the ICT technologies began to flourish, especially those that multiplied the uses of the Internet, those that responded to environmental concerns and those that aimed at alternative market segments. Even the ailing automobile industry can already boast multiple new directions, from the all-electric luxury Tesla, through various hybrid models,[8] to the Tata Nano aimed at lower income buyers. Silicon Valley itself has moved strongly towards clean-tech since 2000.

---

[7] For a full discussion see Perez (2009)

[8] Though Toyota's efforts at energy efficiency and oil avoidance date from 1977, the first generation of Prius hybrids arrived in the US in 2000. At that time, oil prices were still very low but by 2008 the various automakers had launched more than 30 different models to compete in the hybrid market.

The other process typical of the aftermath of technology bubbles that was already taking place during the second boom is the restructuring of one industry after another and the definition of new boundaries through mergers and acquisitions. This was very much facilitated by the easy credit that characterised the second boom. The process is far from being completed –indeed, it is never really final. There are still many industries in search of a stable structure with complementary profitable strategies, between industry leaders and followers, between vertical, horizontal or diagonal integration, between giants and medium and small firms, between global and local players. The airline industry, for instance, is still very much in flux and trying to cope with an uncertain future.

The historical tendency, as conditions switch from Installation to Deployment, has been to moderate ferocious survival competition and to tend to establish some form of oligopoly that will restrict competition to certain variables and will allow long-term investment in technology or expansion, risking neither the anger of an impatient stock market nor a price war with competitors.

As will be discussed below, though, the hyper-segmentation of markets and the flexibility of ICT is likely to change the way of defining industries and the markets in which they compete, in order to focus on the demand sectors rather than on the supply ones. Sports & leisure, clean-tech, health, third age, education, etc. are already more useful for identifying the real competitors than textile, shoes, clothing, food, etc. This might have consequences for the space to be occupied by eventual oligopolies. Such sectoral redefinitions have occurred with every paradigm shift and the trace is kept –with delay– in the changes of statistical categories across history. Since such changes take time and occur as a result of trial and error strategies and competition, they can only be recognised in the statistics when they have already become the norm in practice. But being alert to these processes is crucial both for companies and for governments, because they provide important signals for innovation and growth paths.

All these transformations in industrial and market structures are very relevant for understanding the likely direction of innovation in the next couple of decades. During Installation, the engineers are best placed for seeing where innovation is likely to go. Technological trajectories of individual products and of whole systems indicate a logic of improvement that is an essential part of the paradigm and serves to guide progress in each area. But with Deployment comes a fundamental shift of focus. Rather than looking at the potential of technologies, the focus switches to the opportunities defined by markets and by growth possibilities. Thus, in technical and business innovation also, decision-making behaviour moves from ‘supply push’ to ‘demand pull’. Therefore, modern policies for supporting innovation need

also to understand the shift and to incorporate knowledge about changing market and business structures into policy design.

THE NEW DIRECTIONS FOR INNOVATION: Sources of criteria for gleaning the trajectories of technical and social change

Each techno-economic paradigm emerges through a trial and error process while experimenting and learning to use the new technologies and their infrastructures. Moving from the giant IBM computers of the 1960s-70s to the personal computer of the 1980s to the laptops and blackberries of the 2000s has not only meant that 'smaller and more individual is better' but also that networks are the more adequate organisational structure to take advantage of the ICT technologies. Giant organisations –through the mediation of Internet– can now grow much larger than before but as relatively flat networks gaining all the flexibility and agility of small companies; small organisations in turn can gain the advantages of scale by joining with others to form dynamic networks.

The flexibility of computer-aided design and equipment has liberated manufacturing from the need to pursue identical products. It is now possible to make model changes and to have a mixed product profile with high productivity, even as production volume of this varied and changing mix is several times greater than was possible under the mass production paradigm. The resulting hyper-segmented markets, catering to more and more market niches, have made it possible for innumerable small firms to offer highly specialised products or services with high profitability. It has also encouraged global firms to decomponentise their activities across the value network and to out-source them locally, to other countries or at-a-distance through Internet. This has transformed the relationship between users and suppliers from arms-length to collaborative and has allowed the valuing of expertise, creativity, human capital and other knowledge and experience inputs, which were previously shrouded in the impersonal workings of the old hierarchical pyramids.

Another major transformation is the new value placed on intangibles and human capital. Whereas in the previous four surges technology was usually embodied in tangible equipment or manufactured products, the area of intangible products, from services to information itself is now an increasing part of value added, of investment and naturally of innovation. The fact that the notion of *human capital* is replacing that of *human resources* is itself a signal of the deep change that has already occurred and is likely to intensify in the Deployment period. That will not only gradually transform the composition of world production, but will require significant innovation efforts in both finance and policy to deal with an unaccustomed form of value, when it comes to determining its price and/or treating it as collateral.

Thus, when there is a massive change in the prevailing technologies, there is an associated transformation not only in production and consumption patterns but also in the forms of organisation and competition, in the structure of markets and in the way the fabric of the economy is woven. Let us examine some of the consequences of this paradigm and their implications for the shaping of markets and company structures and consequently for influencing the direction of innovation.

The hyper-segmentation of markets: differentiation and adaptability

Variety and differentiation in all industries and services distinguishes the flexible production logic of the ICT paradigm from the homogenising logic of mass production. Rather than the traditional three-tier structure –of big, medium and small; luxury, middle income and low income– characterising markets, there is now a hyper-segmented structure, broken in kaleidoscopic fashion to cater to every difference in needs or preferences, counting on the versatility and modularity of information technology at every stage of the process from design, through production to marketing and distribution.

Two complementary processes have been occurring spurred by information technology. On the one hand, all basic products can be produced in enormous volumes (several times what was considered 'mass production' in the past) with very high productivity. Together with the impact of low cost Asian labour, this has led to such an impressive deflation in the prices of standard manufactured goods –especially those related to ICT– that they can be considered 'commodities'. Price competition has become the characteristic of these basic goods and they tend increasingly to be marketed and distributed by supermarkets like Wal-Mart and Tesco.

At the same time, there has been a growing differentiation away from the commodity segments to multiple specialised niches and to what has been called 'mass customisation',[9] adapting commodity components to the preferences of the clients. Both processes have been enabled by the power of information technology to reduce the costs of design, of flexible production (changing models and product mix) and the capacity to market and distribute relatively small quantities to targeted audiences. Both processes reduce the vulnerability of the producers to excess competition and provide much greater profit margins.

Figure 2 maps the hyper segmentation of markets in both dimensions and figure 3 gives some illustrative examples from various sectors. It should be noted that the clear separation between raw materials, manufacturing and services, or primary, secondary and tertiary sectors is less and less a valid

[9] The term was introduced by Davis (1987)

or useful classification. It is particularly obsolete when distinguishing between the more or less advanced and more or less profitable industries or segments. It could easily be more profitable and require more sophistication and expertise to offer a specialised service or a niche material than to produce standard mobile phones or hard drives.

An implication of this way of defining new market segments is the hyper-segmentation of the technologies that are present in the market at the same time. During the mass production surge, it was common for less productive technologies to be competed right out of the market. Once you could produce the perfect red and plump tomato without spots and all the same size at a relatively low price, you excluded from the market all producers of organic, varied-sized tomatoes with blemishes. Today, they are both sold in the same super-market in different shelves and the 'ugly' ones command premium prices. And in that same super-market, there will be shelves for diabetics and for people suffering from various allergies. In the previous surge, when a section of a copper mine had too low a tenor to justify extracting the ore with advanced technology, it was left unused. However, developments in biotechnology have allowed productive mining of low grade ores through bacterial leaching methods. These methods can now coexist in the same mine, in the same company or handled by different ones. Many software packages are offered in a simple version for free (for occasional users and testing) while the professional version is sold at a profitable price. Even more surprising is the coexistence of the open-source movement with the fully paid software in many of the same product areas. This variety in supply is likely to expand and become the norm in all cases where the market segments targeted can be clearly defined and where the distribution channels are capable of handling small quantities of varied products.

Figure 2. Market segmentation and its differing conditions from raw materials to all manufacturing and services

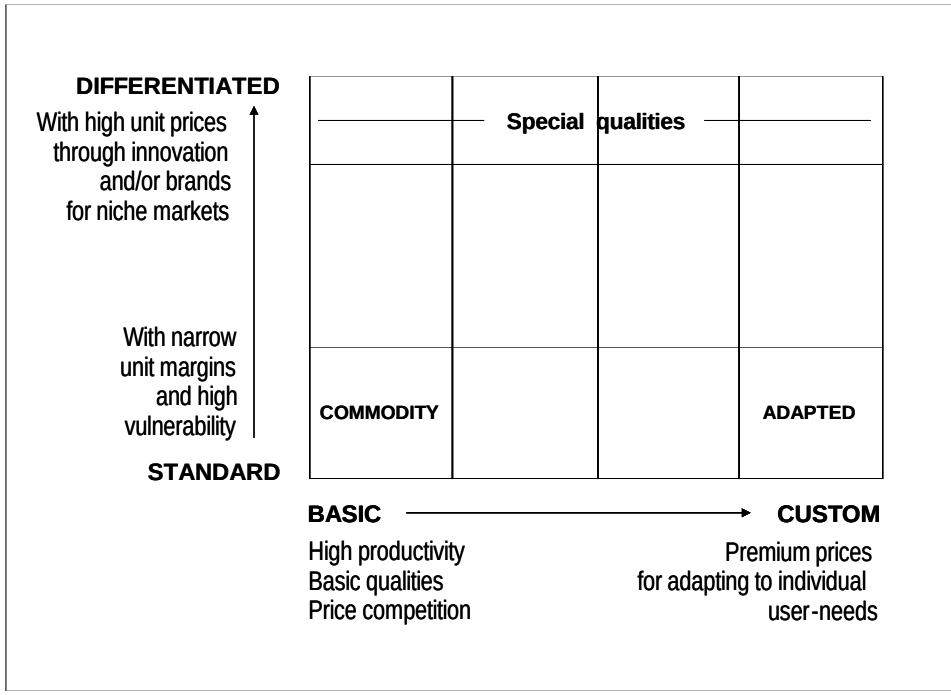
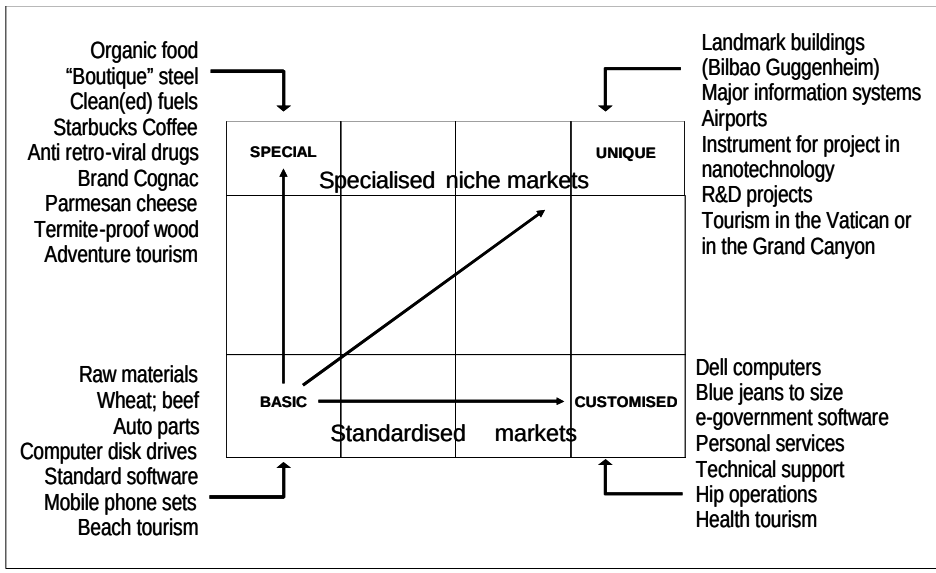


Figure 3. Some examples of products in different market segments



Based on Perez (2006) p. 45

Another consequence of the hyper-segmentation of markets is what was mentioned before about how the traditional supply-defined sectors, such as textiles, shoes, etc., are gradually being fragmented and rehashed into demand-defined agglomerations of specialised firms. A textile company that makes canvas for sailing boats and awnings would belong to the Sports and Leisure sector, as would Adidas. Yet the one that makes sheets and curtains for hospitals would be in the Health sector together with those who make special shoes for diabetics or invalids. Already pharmaceutical outlets such as Walgreens and Locatel are encompassing the whole range of health products from aspirin and cosmetics to wheelchairs, medical instruments and home care services.

In practice, the choice of a successful direction of innovation for each entrepreneur is likely to be influenced both by the company's own capabilities and by the networks to which it belongs (or can belong), including suppliers, competitors and clients. The Israelis, for instance, have highly developed and dense networks in the health sector, involving medical services, high-level science and technology research, innovation in diagnostics and equipment and production of all sorts of medical supplies. The network synergies are very great as are the externalities for any new producer in that area. The advantages include the local interaction with knowledgeable potential users and the possibility of learning to confront highly specialised competitors.[10] Of course, specialised innovators can also be connected to global networks where some of the synergy advantages also apply.

A final aspect to mention in relation to segmentation is related to the spaces of innovation opened by the possibility of catering to the differences in national, religious, educational and other cultural identities within a country or region. There are also age segments, such as the growing 'third age' markets of some of the advanced countries, and income segments, such as the 'bottom of the pyramid' markets in most developing countries. The mobile phone industry, for instance, has learned to replace the wired telecom services in the poor and relatively isolated villages of the world and in the shanty towns of the large cities.

All this suggests that the evaluation of innovation projects in relation to feasibility may well benefit from information about network externalities, segment definition, depth of knowledge and experience of the entrepreneur and other such aspects not customarily taken into account in the forms to fill out at the bank or the government agency (though they are in part typical of VC fund evaluation). The uncertainty of innovation can never be elimi-

---

[10] User-producer interactions are a central feature of what has been conceptualised by Freeman (1987) and Lundvall (1988) as *national systems of innovation*.

nated, no matter how much the projector or the banker may construct net present value models, but serious assessment of qualitative information relevant to networks and market conditions may be of great help for a higher success rate.

The hyper-segmentation of production units: networks and specialisation

Networks are the key structure in this paradigm; isolated firms do not fare well in an ICT-shaped world. Arm's length relationships with suppliers, clients and competitors, as in the mass production paradigm, no longer yield the best results and can endanger the survival of the company. This fact is at the heart of the strategy of every modern *global corporation* (GC).[11] It is also at the root of the success of the clustering strategies all over the world and of the various programmes undertaken by governments and international agencies to promote diverse forms of association for cost sharing or joint world marketing or training, as well as the formation of stable clusters or consortia.

There are multiple types of network and an even greater variety of possible roles in them. The global corporations themselves are often a network that coordinates the action of different networks. The specialised clusters find ways of sharing costs and externalities while maintaining the individuality of each participant, and so on. The question is in what ways network structures tend to shape the direction of innovation and entrepreneurship.

A basic principle applied by corporations when disaggregating all their activities into separable components is distinguishing between core competences and complementary ones.[12] The guiding idea is that the core competences are what gives the strength and the competitive edge as well as the long-term value to the company, while the other activities can in principle be outsourced without jeopardising the future. Yet, this notion of outsourcing is not about separating innovating activities from non-innovating ones. On the contrary, it is about deciding who will innovate in each area. When outsourcing the production of batteries or the fault detecting service

---

[11] The use of the term global corporation (GC) rather than multinational corporation (MNC) conveys a fundamental conceptual and practical difference. The MNC had a headquarters and subsidiaries in other countries that were often a smaller version of the head company or of a whole department of it (perhaps a production or a sales unit); the GC is a single complex planetary organisation with fuzzy borders It coordinates a widespread network of semi-autonomous or specialised units in various locations each with many types of close or loose links with multiple suppliers of goods and services, on site or at-a-distance. Depending on their nature, the units tend to adapt to the country or region where they operate and frequently conduct R&D or engineering to cater to the specificity of that location. For a view of the GC as a federation of semi-independent units see Mourdoukoutas (1999)

[12] The concept of core competencies was introduced by Prahalad and Hamel (1992)

or the custom software, for instance, the assumption is that by giving the job to specialists in each case you expect them to concentrate on innovating in that area with much greater expertise and success than an internal department could have done. In addition, the other clients of the specialists and the other members of their network, will provide extra information that would not have been available to the internal department. The final result is that the whole network becomes an innovating machine with each part maximising its contribution and improving the whole at a much faster rate.

This practice of global corporations has very important consequences for the fabric of the economy. It induces the proliferation of *small knowledge intensive enterprises* (SKIEs) which are active innovators at the same time as they serve as a sort of technical infrastructure for attracting further user investment. The denser the fabric of SKIEs in an economy the greater will be the externalities for growth and competitiveness of the user firms. In addition, SKIEs themselves, in whatever field, are typically intense users of ICT services and of highly skilled human capital. They are also natural networkers with universities and other sources of information within and outside the country of operation. Finally, they are likely to participate in export markets, either through global corporations for whom they are suppliers or through their own efforts. That makes them key actors in the deployment of the knowledge society in each country.

A major consequence of this is a radical redefinition of the role of SMEs. Without ignoring the importance of the traditional small and medium firms, it would seem that the treatment of SKIEs and the catering to their support requirements, being fundamentally different from those of SMEs, will demand a different set of policies.

Next to SKIEs (and with some overlap) we find the creative industries and services, the proliferation of which is also a natural consequence of the ICT paradigm. These industries comprise a whole range of activities from software design, through architecture or advertising, through all forms of art. Each of them has been radically expanded and modified –at least, potentially– by computer-aided design and by the possibility (to a certain extent) of trading and distributing digitally. This transforms the economics and the market potential of all these industries and turns them into an important component of the domestic product of any country.[13]

Relating to art, there is another aspect worthy of note. Obviously, the various art forms have always been part of the cultural scene, but they have

---

13 See Freeman, A (2008)

also been influenced by the appearance of new technologies. Lower cost printing in the Victorian boom facilitated the wide diffusion of newspapers, cartoons and novel reading; photography and colour printing encouraged the posters of the Belle Époque and probably influenced the impressionists while radio, recorded music, the movies (and then the 'talkies') and television created major new inter-related industries in the fourth surge. They also massified art and divided it into high- and low-brow; for the masses and for the elite. Yet throughout those changes, however spectacular, the essence remained the same: the artist was on one side and the public on the other. What the ICT paradigm does is to blur that difference for a whole range of activities; blogging makes everyone into a writer or a journalist, uTube into a film maker, Second-Life into an active novelist (Japanese *karaoke* into a singer) and so on. There is also the massive participation in the Open Source movement as software designers and there are already several corporate web-sites and other enticements that encourage people to give ideas and even offer new products to some of the major companies for some sort of reward.[14] All of this opens the channels that can make creativity an integral part of the quality of life and that allow the fusion of consumption and production in important aspects of personal experience. Just as leisure is more and more outdoor sport and physical activity rather than the passive TV watching of the fourth surge, so the enjoyment of creativity is becoming more of an active endeavour.[15]

Just as it was said above that a thick web of specialised services increases the competitiveness of a locality, so it can be said that fostering this sort of creative-productive-consumption increases the value of human capital. Young people that participate intensively in such activities will be tomorrow's innovative entrepreneurs.

Finally, there is the world of face-to-face personal services that can include everything that requires direct human interaction from local tourism, through chiropractors to much training and education. They also include many NGOs which perform community services or protect weaker individuals in the community. All of these are likely to proliferate as induced activities during deployment, to absorb some of the managers and workers displaced by globalisation, to complement digital services (delivery of tangible internet purchases, for instance) and to enhance the quality of life in the knowledge economy. Since relatively few of these are likely to require R&D-based innovation, it is easy to dismiss them as just standard businesses to fund through the banks and not included in innovation policy. There is how-

---

14 See Von Hippel (1988 and 2007) and Franke et al. (2006)

15 This phenomenon can become a non-trivial contributor to overcoming the consumerist mode of satisfaction that so strongly characterised the mass production times.

ever a whole range of business-model and organisational innovations to be fostered in these sorts of services, the importance of which becomes greater the more advanced the economy. That is because they are stable employment creators (face-to-face services cannot be off-shored) and because they are possibly those that would most directly influence the quality of life in any particular locality.

Although some of the companies in the creative and face-to-face categories may be SKIEs (and even GCs), it is important also to recognise the role played by the SMEs in these sectors in increasing *social innovativeness*. To enable their proliferation and support their success could do more to 'boost the entrepreneurial spirit' than many apparently more targeted attempts.

Thus, the hyper segmentation of markets, technologies and activities, is giving rise to an emphasis on the small business unit, be it as a direct part of a GC, as an independent or semi-independent supplier, as a start-up that can some day become a giant, as a franchisee, a member of a specialised cluster, a local provider of services or an independent expert unit in interaction with other global players in that particular niche. This not only implies giving particular importance to fulfilling the needs of SME innovation but truly paying particular attention to the different types of small companies and their specific requirements. This is part of what will be discussed in the final section.

The shaping power of the energy and environmental challenges

The fabrication and consumption patterns of the mass production surge were strongly shaped by the abundant supply of cheap energy (in the form of oil derivatives) and cheap materials (petro-chemical plastics and energy-intensive aluminium, steel, cardboard, etc.). The consumerist style of satisfaction established by the 'American Way of Life' was based on that cost structure and on the cost advantages of economies of scale.

The IC technologies with their low cost provision of information and communication have slowly been modifying production and life-styles in the direction of taking advantage of less expensive intangible values. It is part of the capabilities provided by ICT to be able to make products smaller, with no materials waste, serving multiple uses (thus potentially replacing, say, three products by one), monitoring energy use and several other environmentally friendly possibilities.

The fact that companies have not yet sufficiently taken advantage of these possibilities needs an explanation. There were two main circumstances that facilitated the conservation of the energy- and materials- intensive mass

production strategies of the previous paradigm: the opening of the ex-socialist countries to the market economy and the very low cost of oil in the 1990s. Both of these happened precisely when the ICT industries were defining their strategies. This made it possible to take advantage of cheap energy and cheap labour to continue along the path of non-durability and planned obsolescence (quick discarding of physical products to be replaced by the next model) and to ignore the costs of global transport (which were coming down with increasing scale and cheaper energy).

This began to change when energy and primary commodity prices shot-up brusquely, changing the relative costs of labour, transport and materials. The current recession, by restricting production and world trade has made those prices collapse again. Nevertheless, one can expect them to rise once more when Deployment takes off. It is true that the extremely high prices of oil and other materials at the peak of the boom were due in a certain proportion to financial speculation with 'futures', but the basic fundamentals have to do with limited –and more costly– supply not being able to keep up with the pace of increasing demand as globalisation continues.[16] Thus the pressure for materials and energy conservation and for the introduction of alternative energies due to the high price of oil can be expected to come back.

However, that is only one of the forces that are likely to shape the way in which the ICT paradigm is to be deployed. The likelihood of overcoming the 'mass production syndrome' and exploiting the 'green' potential of ICT stems from the conjunction of three powerful sets of trends: (1) the limits of supply in energy, materials, food and water, (2) the increasingly convincing threat of global warming and (3) the various geopolitical tensions that endanger globalisation (tensions with the oil and gas exporting countries, economic and political migratory pressures and the diverse forms of violence both within each country and in the form of international terrorism). These forces will act as selection mechanisms for the direction of innovation within the range of the possible and –most importantly– may also be expected to reshape the current patterns of globalisation.

The coming redesign of globalisation

There is a fundamental tension in the logistics of globalisation. While the infrastructure for coordination, administration, interactions, decision making, financial transactions and other information-based operations are processed and 'transported' by ever faster and more powerful 5th paradigm

16 See for example Tertzakian (2006)

ICT, all the tangible elements of production are still being transported by 3rd and 4th paradigm technologies (ships, airplanes, trains and trucks) that however much they are modernised and upgraded by 5th paradigm technologies, are increasingly confronting inevitable limits.

The most important limit is perhaps their contribution to global warming. All those transport vehicles are moved by oil-based fuels. If one takes the full carbon footprint of a product assembled in China, it comprises bringing the raw materials from a faraway country, probably by ship, moving it to the materials processing region and then to the manufacturing one – probably by truck, perhaps by train– doing the same with the cardboard and plastic (themselves highly energy-intensive) to package the product safely for long journeys, moving the product again to the port or airport and on to the ships or planes that will take them to the shores or airports of the consumer countries, where once more they will be put on trucks or trains to reach the central depots and from there to the final destinations at the stores.

If a carbon tax of one form or another were to be imposed, it would soon change the economics of the current pattern of globalisation by making business weigh both the cost of labour and that of transport in their decisions. Even without taxing, the inevitable rise in the cost of energy and materials when the recovery comes will gradually change the relative cost structure.

There are also other limits that are augmenting the cost of transport, one is the restricted size of the Panama canal (built a century ago); the other is the piracy threat on the route to the Suez Canal. Both are likely to take several years to be overcome and, in the meantime, they both increase the time, the length and the cost (including insurance) of the voyages that would now have to be made around the respective continents.

All of this means that the obvious economies of the current path of globalisation, based on very cheap labour in Asia and decreasing costs of transport, are destined to change. The multiple decisions made by the globalisers and by the various governments are bound to end up in a completely different pattern that might combine the faraway production of somewhat higher value lower-volume products with a greater use of nearer locations (Eastern Europe and Northern Africa for Europe; Mexico and Latin America for the US) to produce heavier and higher volume products as well as the return of some production to the advanced world, some of it as near as possible to consumers as may perhaps be the case of hydroponic vegetables and other light perishable items around the cities. It could be that processing materials *in situ* near the point of extraction of the ore may become the more cost-effective way of reducing the total cost, by transporting

lighter and more valuable cargo, directly to the manufacturers of the final products.

These relocations are likely to be accompanied by a strong drive to overcome those limits through innovation. Apart from the obvious pressure to develop alternative forms of energy and methods of energy conservation in transport and carbon capture, there will gradually be more and more interest in alternative materials and materials-saving methods, other means of transport, new forms of packaging, cost-effective logistics, etc.

Global warming, especially if the natural catastrophes can be ascribed to it, is also increasing the cost of risk insurance and threatening to weigh heavily on government budgets and hence would increase the pressure for regulation, carbon trade or taxes, intensifying the feed-back loop.

Apart from the impact on transportation and the shape of globalisation, there might be an even more fundamental change in the offing. The environmental limits may result in a gradual but radical transformation of consumption patterns. The change in the proportion of needs satisfied with intangibles rather than with products may intensify, but especially, a trend towards maximum quality and durability of physical products, minimising energy consumption, maximising modularity for refurbishing and recycling, preferring the 'healthy' alternatives in food and leisure, etc.

This implies the complementary shift in production and marketing strategies. Without globalisation and the incorporation of additional millions of consumers every year, that change of strategy would be impossible. When limits to market growth were being reached in the 1960s and early 1970s, 'planned obsolescence' and constant fashion change became the way to keep production rhythms in saturated markets with low demographics, making the same people buy the same products over and over again. When globalisation resumes at a brisk pace –and if investment prone policies are set up in all countries– incorporating new consumers can be an alternative and highly profitable strategy.

For the moment that sounds utopian and unrealistic. But it is just the global version of what sounded utopian in the 1930s. Saying then that the way to increase markets for automobiles, refrigerators and houses was to incorporate the great majorities (including the low-skilled workers) into consumption would have been deemed unrealistic. Yet it was achieved by raising wages with productivity increases and by setting up a Welfare State that subsidised mortgages; helped keep monthly payments going with unemployment insurance; covered all or part of the costs of health and education, freeing incomes for consumption, etc. Today that seems absolutely normal.

What cannot be done, because we do not have seven planets, is to incorporate all the inhabitants of China and India into the 'American Way of Life'. Neither can the advanced world expect to stop them from aspiring to 'the good life'. It is only by redefining the good life from the top that the aspirations of the rest of the world can be reoriented and made feasible and this redefinition will increasingly be imposed on the world as the response to environmental limits.

In any case, the rising costs of materials and energy and the restrictions of supply will put pressure on markets to increase the efforts to find and develop alternative energies and materials, new modes of transport (including urban design that reduces or eliminates the need for transport), recycling and recovery of all effluents in the processing industries and other innovative means of coping.

Social pressure on the other hand, facing the threat of global warming, is already creating dynamic and profitable markets for environmentally friendly products, 'green' alternatives, 'organic' agriculture and clean-tech in general, while gradually accepting the change in lifestyles. All this opens market opportunities for testing the new directions.

Whether the deployment period will see the world gradually leaving behind 'conspicuous consumption' to embrace durability, recycling, high quality and eco-friendliness is yet to be seen, but much is going to depend on the political will of governments to regulate in order to tilt the playing field in that direction and on the understanding that 'going green' is probably the best hope for innovative dynamism, investment, jobs and growth in the advanced world and for making possible a sustainable global golden age.

The gestation of the next revolution

The historical experience with previous revolutions shows that the various components that will eventually come together to transform the production landscape of the next surge develop gradually under the previous paradigm. At first, there can be little or no connection between them and they are more likely to grow in association with the industries of the prevailing paradigm. Transistors were mainly used to make radios portable while typewriters and calculators were still mechanical machines that gradually incorporated electricity. At that time, even if they may have used transistors, control instruments were still analogue and had needle – rather than digital– displays. Telephones and computers had little in common in the 1960s. The same had happened with the steam engines in the first surge. While horses pulled the barges along the canals, steam engines were stationary and helped operate the locks.

Using the lens of recurrence, one can foresee that biotechnology and/or nanotechnology are likely to produce the breakthroughs that might lead to the next revolution. Both these technologies are still very expensive and relatively restricted in their impact but their promise is extremely wide-ranging.

The results of R&D and innovation efforts in these industries can lead to successful companies and products, but perhaps the most important goal when supporting their development is ensuring a good positioning for the future, through being part of the global networks woven around them and through accumulating the sort of knowledge that could be crucial in order to guarantee a place in the front ranks early in the next surge.

THE POLICY CHALLENGES: Taking the paradigm and the period transition into account

As in previous cases, one of the consequences of the financial crisis is the breakdown of the quasi-religious faith in the virtues of unrestrained free markets and the re-entry of the State into the economic scene as a valid actor. In the early aftermath of the bust, the basic roles that are expected of government refer to regulation, bailouts and economic stimulus in different proportions depending on the country. However difficult, though, it is probably wise to begin the fundamental redesign of the economic space and the regulatory framework to clearly favour real investment and discourage casino behaviour in the financial world. Institutional restructuring is what would really unleash a healthy period of prosperity, fundamentally different from that of bubble times. Whether and how such a redesign is done on the national and supranational levels, the likelihood of a successful outcome is much greater if the debate is on the table from early on and if enough concrete and viable proposals and innovative solutions are there when the decision makers are ready to act.

Regarding finance, the new architecture will probably require global institutions with power of enforcement due to the borderless nature of financial flows and operations. Refusing supranational supervision and a standardised regulatory 'floor' may seem like protecting sovereignty but is in fact surrendering it to the power of supranational finance.

At the same time, national level financial policies are going to be crucial for the medium-term future of any country. It is not merely a question of financial health but essentially of pro-production bias. The motto of 'don't work for money, let money work for you', so popular in recent time, needs to sound completely unrealistic in a world where economic policies, be they regulatory, fiscal, monetary or whatever, resolutely favour working for money –and making abundant profits– through innovation, investment and job creation in the real economy.

The come-back of what could be considered 'industrial policy'(in this paradigm, increasingly a question of technology and innovation policy) can be expected and probably needs to be recognised and accepted as essential for a full recovery and for a better performance in a globalised world. The intense debates about the demise of the national state that were so common during the Installation period have moved on to discussing what the government should do for the economy. In practice, globalisation has proceeded with greater success wherever the State has been actively defining its preferences, enhancing the advantages and creating the enabling mechanisms.

The Chinese government has been exercising industrial policy with great success and with the quiet acceptance of both the participating companies and their governments. At first salaries were kept low and the currency devalued in order to attract labour-intensive manufacturing industries, destined for export markets. The foreign companies accepted all sorts of government conditionings, including the obligation to transfer technology to local personnel and the lack of effective patent protection, in order to reap the cost benefits for a few years. The government has now radically modified its policies to strongly favour clean-tech industries and energy saving technologies.[17] Since they have an official procedure for evaluating and approving every single investment in terms of technology and location, they are once more steering production according to their national interest.

This is not necessarily a model to follow in an advanced and fully capitalist country, in fact, in this paradigm it would make much more sense to construct a consensus vision between government, business and society to make the actions of all the agents converge in agreed directions. What the Chinese case shows is that in the fastest growing country during the *laissez faire* period, it was not the free market that decided what and where to produce, but a set of official guidelines and some government offices approving or disapproving each project. Like Saint-Exupery's king in *The Little Prince*, who suggested waiting towards the end of the night—when conditions were more favourable—before asking him to order the sun to rise, the most effective conditioning policies are those that (1) are rooted in the specific advantages and interests of the country or locality in question,

---

[17] See the Chinese government site on the new strategy, published Dec. 2008, downloaded April 13, 2009 http://www.fdi.gov.cn/pub/FDI_EN/News/Focus/Subject/wzzgxe/wzfzjj/t20081204_99876.htm. It basically decided that foreign capital will be encouraged 'to go to sectors like high-tech, energy conservation and environment protection, high-end manufacturing, modern services and modern agriculture, especially new energy development and application: it is also directed to original innovation, integrated innovation, and re-innovation by means of technological introduction, digestion and absorption, as a way to promote the industrial restructuring… [and to] set strict limits on transferring resource-extensive industries with high consumption and high pollution to China'

(2) aim at the dynamic technological opportunities of the time and (3) establish a positive-sum game with the strategies and interests of the decision agents—be they foreign or domestic companies.

Understanding the forces shaping such opportunities and interests is an important input for policy design (as well as for business strategies). Examining them was the purpose of the previous section. Let us now explore the specific area of government policies to facilitate the financing of innovation.

The implicit innovation policies

The explicit policies that directly fund research or innovation projects can be a relatively small proportion of the set of policies that influence technology and innovation across society. Most government decisions, including those that seem far from technology, have an influence on markets and technical change. During the unquestioned reign of the free market in the early 2000s, the invasion of Iraq tilted the playing field in the US in favour of military technologies (which the end of the Cold War had diminished in importance) and by influencing the supply of oil, unwittingly contributed to the rise in prices, which in turn changed the conditions in the energy markets and revived interest in energy saving technologies (which had been dormant since the low prices in the late 1990s). So, there is no vacuum where "free" markets operate unhindered. There is every reason to suppose that tilting the conditions for competition in the market in a socially agreed direction is likely to yield better results than either bureaucratic decisions or an illusory even playing field.

From the discussion above, there is every reason to suppose that strict environmental regulation (possibly enhanced at first by favourable tax treatment or subsidies) could be much more effective for stimulating innovation and investment in 'green-tech' and 'clean-tech' than any amount of project money for entrepreneurs in the area. Equally, finding a way of guaranteeing that oil prices will not go below a certain threshold can be a stronger incentive for investing and innovating in alternative energies than any amount of grants or subsidised loans.

The obligation to recycle a growing proportion of an industry's products moves companies to innovate in materials, in assembly and disassembly processes, and in the products themselves in ways that may give them a competitive edge in global markets, while creating jobs and improving the local environment. Of course, in some cases, being ahead of the pack in what is going to be a trend is an advantage (if it indeed becomes generalised), in others, the ideal is for regulation to encompass as many coun-

tries as possible so that global trade doesn't have to face a variety of conditions that make compliance costly.

Another way of tilting the playing field towards innovation is through facilitating access to infrastructure. Full provision of optical fibre to the home would not only be a policy to widen Internet access to all citizens (thus a form of income redistribution). It would also increase the conditions for innovativeness across society –in or with ICT– and multiply the possible consumers of many services and products. One of the central tasks of the famous Tennessee Valley Authority in the New Deal of the 1930s was to construct a hydroelectric dam to provide all the inhabitants of the valley with electricity. That radically changed the consumption and production possibilities for the population of the region.

The provision of government demand for tested new products that do not yet have enough market scale is another way of facilitating innovation and accelerating the path along the productivity curve. Using solar energy for schools or electric cars for the postal service (if it is public) or other similar decisions can create enough of a local market to even foster competition and rapid learning for eventual export. Another useful route for making it possible for important innovations to converge upon a coherent market and be tested are the equivalent of "man-on-the-moon" projects such as zero-waste, zero-carbon footprint cities or other such demanding goals.

Hypothecated taxes are also ways of creating demand. A tax on CO2 emissions that is destined for funding the development or purchase of clean-tech alternatives is a self-feeding mechanism for innovation in that area, or a tax on automobiles destined for public transport innovation.

Finally and most importantly, under conditions of deployment, if both tax policy and regulation induce the financial world to move away from short-term speculation and capital gains and to focus once more on funding investment in the real economy, we can expect the private sector to come up with new financial instruments that respond to the specific expansion and innovation needs of the economy as it revives. If conditions are such that the main source of financial gain –be they dividends, interest or service fees– are the profits of the production sectors, investors and financiers are likely to turn to innovation as one of the most lucrative options.

Sometimes the innovations in the private sector require complementary actions on the public side. An obvious example from the previous surge is consumer credit. It began with the automobile companies themselves in order to expand their markets to people that could only pay by monthly instalments, it went on to be offered by other durable goods producers and

finally by the banks. Equivalent developments happened in the housing market. These private innovations were accompanied by public ones such as unemployment insurance, which guaranteed that payments could continue to be met, the legislation that enabled savings and loan associations and mortgage support (the now notorious Fannie Mae, in the US, was set up by Roosevelt's New Deal in the 1930s) to facilitate a regular increase in the number of households buying durable goods.

Essentially then, attention to what is shaping market conditions and taking consensus decisions to tilt the field in directions that will stimulate market expansion in innovative directions may sometimes be more effective than simply making funding available for innovation, however intelligently this is done. Not taking account of this can make business and government act in diverging directions and risks seeing different government departments work at cross purposes, hindering the possible positive results.

The direct policies: innovating in the financing of innovation

The safest way to approach the financing of innovation in the deployment period is to assume that the instruments that worked in the installation period may now be inadequate. Many of the debates of the time may be obsolete, many of the empirical proofs for one position or another may be dated (and the same analysis conducted five years from now is likely to yield different results). Just as business strategies are fundamentally dynamic and shaped by a changing context, so government policies need to take into account the fundamental shift in business climate and, in the case that occupies us, the change in the direction of innovation. It is advisable then to re-examine all existing instruments and policies putting special attention on what might have been shaped by the specific conditions of the time.

The context may change quite radically even in very short periods. The abundance of private equity going into venture capital funds and facilitating start-ups, innovation and multi-million dollar IPOs in the technology boom of the late 1990s pretty nearly dried up in the easy-credit boom of the 2003-08, when private equity turned massively to leveraged buy-outs of existing companies and in some cases to hedge funds.

Neither set of conditions is likely to hold in the next decade. The opportunities for innovation are manifold, both in existing companies and for new ones, if the potential installed in the territory (and in the minds) by ICTs and their organisational paradigm finds a favourable financial and regulatory atmosphere in which to flourish.

But innovating within a paradigm is much easier and less risky than doing so using the paradigm in another sector. This was learned by the venture

capitalists in the 1990s when they tried to apply the same criteria and expectations to innovators in biotech as to those in ICT; both sides ended up frustrated and disappointed. When technologies are in their gestation period they are groping and their trajectories are far from defined; suppliers are not yet adequate or sufficient; markets are uncertain and time lags are very common. In the particular case of biotech, given the bias towards the human health sector, the regulation on medical trials and the difficulties for government approval lead to very protracted processes, often lasting more than ten years.

Even without having to confront the specific hurdles of medical biotech, a good proportion of the range of innovations open across sectors in the coming deployment will also be exploring unknown territories and facing significant levels of uncertainty. New and custom materials, alternative energies, new forms of transport, waste disposal and recycling, carbon capture, water purification, alternative food sources (or significant productivity increases), metal and materials recovery and the many other solutions to environmental limits do not yet have clearly defined trajectories and are likely to make unpredictable breakthroughs in unpredictable time periods. Some will be more dependent on S&T research, others in solving engineering problems, still others in a business model that will make them cost-effective and so on.

A large set of innovative opportunities is in the area of small knowledge intensive enterprises (SKIEs), where the intangible nature of the products and of the human capital involved presents complex issues for the traditional methods of the financial system.

It is probable that only a combination of multiple forms of public and private support in the different stages of the process –depending on the type and size of company, the type of innovation and the target markets– will be required to optimise the innovative capabilities in any country or region. Observation, experience and intense interaction with the actors involved, identifying the hurdles to remove as well as the type of direct or complementary help needed at each turn, may be the most effective route for reaching a set of satisfactory instruments.

Some of the issues requiring particular attention are the increasing importance of small innovative firms, the question of intangible value, the need for continuity of support and the role of R&D.

SKIEs, SMEs and networks

There are at least two major consequences of the fact that the global corporations and the large firms increasingly achieve flexibility and higher com-

petitiveness by outsourcing a significant part of the peripheral and of the highly specialised (non-core) activities. This practice is bound to result in much greater proportions of (1) the working population receiving irregular incomes and (2) the part of the economy without a cushion to withstand downturns. These problems directly affect general economic policy and the social security model while they indirectly condition innovation policy.

It is no longer realistic to apply the classic unemployment insurance model as a one-size-fits-all recipe. It will probably be convenient to think about a series of different schemes for different conditions. Free-lancers, whether in cleaning or in highly sophisticated new materials design, have irregular income all year and will need some sort of income stabilising system, providing automatic credit in short-falls and automatic interest in surplus months. Innovation in banking and insurance should be able to cover most of this and the public sector could provide some social security compensation when necessary (combined with adaptation of the tax system).

This is relevant to small firms in general, because they tend to apply the part-time employment model for high demand periods. But it is particularly relevant to SKIEs (and therefore to innovative firms) because they generally have a very uneven flow of income through irregular contracts. A much higher proportion of small units in the economy, taking care of a greater share of employment as well as of profits and national product, will require similar stabilising instruments to those discussed above and possibly new insurance schemes tailored to those special needs.

A characteristic of SKIEs is the very high ratio of working to fixed capital. Given their knowledge intensive nature, their main "fixed" investment is in human capital and their working capital is mainly the relatively high salaries of their highly qualified staff. With the exception of companies specialising in biotech or nanotech or special materials, which may need high precision equipment, the other high cost is usually also intangible. It is the specialised software and the information services that they need to acquire to perform their job. Not meeting any of those payments can mean losing irreplaceable personnel or cutting-off the lifeline services. Giving the contracts as guarantee for working capital loans does not always work in these cases, except when it is a question of delayed payment, not of a truly irregular flow of contracts. The frequently used solution of making personnel become partners, paid irregularly according to the work coming in, merely shifts the burden to the individual persons and to society without changing its nature.

Innovative firms suffer from that problem in various ways. Specialised suppliers of GCs are expected to constantly do minor improvements and sometimes more significant ones. It can be that the user company is a partner in

the innovation and jointly funds it with the supplier (it can also be a group of users) or that the supplier takes the initiative and seeks the funds. There are also suppliers whose speciality is to do development work i.e. they are innovators under contract. All those cases and many other situations can involve periods of no receipts at all (depending on the funding or contract arrangements) and also the risk of unpredictable delays. Of course, SKIEs are high profit companies and under normal circumstances would have reserves for these situations. But new forms of insurance and running lines of credit will need to appear as the number of companies with these characteristics grows.

It might be interesting to look at the network as the possible route to solving many of these new (or intensified) needs of small companies. There is already a tendency of similar companies to flock together to gain advantages of scale for certain activities that can be funded jointly such as training courses, international marketing, specialised software development, etc. The idea of collective insurance of groups of companies –in a sector or in a region– or even networks of networks, in order to increase the volume and reduce the risk premium could be an adequate direction to explore.

Recognising intangible value

Naturally, the most vulnerable of all SKIEs and innovative companies are the start-ups. In the absence of venture capital, they are also the least likely to be able to obtain loans from banks, given the intangible nature of what they can usually offer as collateral. That is one of the reasons why individual "angels" and venture capital funds are the most appropriate providers of funds in those circumstances. They are often as knowledgeable as the innovators in the field of endeavour and can evaluate the likelihood of technological success and the capabilities of the project leaders. They can also complement the entrepreneurial capabilities and judge the market risk and the likely returns. It would, however, be legitimate to doubt the survival capacity and the profitability of small VC companies, once we are past the "easy" innovation space related to the technological revolution as well as the frenzied stock market promising multi-million dollar IPOs. It could be that those than are larger and can cast the net more widely are more likely to have the waiting capacity; perhaps having specialised units in large banks would serve to balance out the risks within the organisation. But policy innovations may be needed for stimulating venture capital and/or providing some other forms of direct or indirect support for innovators.

Another way to look at innovator entrepreneurs, their risky projects and their intangible collateral, is to consider pools of possible innovators and to provide collective collateral. One could think of imitating the practices of the

Industrial Districts or Northern Italy, with their collective guarantees to banks for the loans that are taken out by their members (and are recognised as serious and reliable by the approval of the association).

Maybe prestigious universities can harbour pools of innovators connected with their research and back their fund applications with an agreement with the VCs, a collective insurance and a stake in the successful companies. It could also be a joint-fund managed by the university, the alumni and a partner bank.

Whichever solutions prove to be practical, as knowledge capital becomes more prevalent, society will have to find a way of evaluating and recognising it. A good practice that would contribute to this would be to require of public companies –in the disclosure rules– that they inform about all intangible capital, calculating its value and its contribution. This would eventually establish norms of assessment and would gradually create conditions for judging the value of intangibles in the stock market and in banks.

Providing continuity of support along the life-cycle

It is true that innovation requires patient capital; it is equally true that it needs continuity of support. Although it has been shown that the linear model of innovation is not valid, that the continuous flow from science to technology to engineering to innovation only holds in a few cases, there is indeed a sort of "linear model" from innovation to stable success. The sequence followed by the venture capitalists –from seed money, along various stages, through to the IPO– does reveal the changing nature of the support needed to nurture inventions through the innovative introduction in the market, the production and distribution learning, the company growth process and the final entry into the world of established companies.[18]

Each one of those stages is of a different nature, requires different skills and contains different risks of failure. The various funding and support mechanisms, be they public or private or mixed, need to provide the appropriate type of service for each stage (in some cases those stages can also diverge depending on the sector). This is generally acknowledged and incorporated into the policy design of VCs and government agencies. What does not always happen is the "chaining" of the support stages, including the switch from public to private.

In the case of VCs, the constant evaluation of the project's progress allows continuous decisions about further outlays and about the type of comple-

[18] Gompers and Lerner (2004)

mentary skills required at each stage. When the company is ready to stand on it own feet and has a promising future, it is prepared for an IPO by experts in these processes and the costs are also covered. Perhaps patents have been acquired and their cost funded; perhaps other legal support has been provided.

Support from government is often "coordinated" by the innovator, who applies to the appropriate national or international agency at each stage, not always benefitting from the automatic referral from one agency to the other. Worse, still, when the entrepreneur "graduates" from government support to private loans or perhaps the possibility of a stock market offering, there might be no way of profiting from the successful completion of all the previous stages through an automatic recommendation from those who nurtured the process. One could imagine the advantages of networking across financial agents. There could be information sharing across agencies to speed up processes and at the end an agreement with a group of banks to send them an evaluation of the completed projects. This could unleash an active interest –and a sort of competition between banks– for financing the budding companies (a sort of IPO, not bidding up the stock but bidding down the interest rates and improving the conditions).

There is, of course, an overlap between the support offered to traditional SMEs and that offered to SKIEs, especially to innovative start-ups. Yet, it could be important to either expand the existing services or introduce new ones in order to further cater to the special needs of more knowledge intensive firms. Legal (and financial) support for copyright and patent protection, for instance, is likely to be a growing need, but others will be appearing and may warrant separate attention.

A final thought on continuity is about rewarding success with trust. Just as banks have credit ratings that facilitate the approval of loans for reliable creditors; funding agencies could automatically approve the next project of a company that successfully completed the previous. The forms to fill out could be much simpler and the evaluation and approval process much quicker. Naturally, if that project fails the entrepreneur would go back to the end of the queue. But such a system would relieve some of the pressure from the funding agencies, would stimulate serial innovation (the fear of going through long bureaucratic hurdles again can discourage promising companies from going ahead with the next project) and would reward responsibility and good judgment in the companies involved.

Of course, the very nature of knowledge intensive services makes it possible for these companies to expand into global networks and to eventually become global corporations. It is to be assumed that private finance would

be able to easily handle the needs of such processes. It would be wise, however, to be alert and remove any hurdles along the way.

The roles of R&D in the present and for the future

There are multiple questions to examine in relation to the most appropriate way to facilitate the financing of R&D in this particular deployment period. This essay will cover only those aspects that should be examined in the light of the current paradigm and of the switch in business conditions from installation to deployment.

Global corporations are now conducting R&D across the globe, wherever they find advantages in capabilities and costs, as well as possibilities for interacting with knowledgeable potential users or benefitting from local university research. This trend is likely to continue. Governments in high cost advanced countries can influence all these elements through their education, research and specialisation policies. Establishing a consensus process to define these policies—especially those that imply some form of concentration of resources to create powerful poles of attraction—may build advantages for the country in maintaining local R&D and in attracting more. Trusting free markets to do the job may be a regrettable choice.

Another trend to reconsider is the insistence on getting university researchers to find an interested industry user in order to have the project approved. This can continue to be appropriate for a certain proportion of research. It was in part necessary during installation in order to reconnect research with the real world and to inject novelty into an economy that had to abandon the old paradigm and incorporate the new. But in the next couple of decades we are likely to see three major directions of innovation with different connections between industry and university research.

One is the continuation of the development of the world of ICT products and infrastructure. Much of this is being funded by the new giants themselves in their own laboratories or in those they have endowed in universities. The start-ups in this area are not likely to require scientific inputs but are mainly engineering and are done by the innovators themselves.

Another is the flourishing of innovation across all sectors, in particular, but not only, the whole range of technologies that will cater to environmental requirements and constraints as well as those that cater to the 'bottom of the pyramid'. Those multiple areas will certainly require research results and solutions and much collaboration between universities and industry as well as much government support, directly and indirectly. However, since many research directions are uncertain and there can be serendipitous discover-

ies, it would be unwise to insist on a direct industry interest in all possible research projects.

The third area is the gestation of radical new technologies. It includes biotechnology, nanotechnology, bio-electronics, custom materials, etc. It is not easy to draw any clear limits, as it is obviously connected with both the previous groupings. But it is useful to distinguish it because it needs to be seen as insurance for the future rather than as an input to short term innovation and growth. Some products and technologies will indeed find immediate use, often in connection with some of the fast growing industries in ICT or in the pro-environment efforts; others can be isolated success stories as IBM was in the 1950s and 60s, but they are basically a sort of investment in the future. They are essentially a bet. Advances in particular aspects of those radical new technologies can locate a country at the heart of the breakthroughs that will define the next technological revolution. Nobody can predict which these breakthroughs will be or which technologies will define the next paradigm. But if history is a guide, those technologies are already in gestation around us and the biological and materials sciences seem poised to play that role.

This suggests that a reasonable proportion of R&D should be completely free. What today's companies see as interesting and probably profitable are technologies that are within the known trajectories and following the current paradigm. Insuring the future is preparing to nurture tomorrow's companies.

CONCLUSION

Recent experience in shifting business climates suggests that adequate support for innovation may crucially depend on understanding the changing context, the varying conditions for competition, the nature of the guiding paradigm and the moving opportunity spaces available. This paper has endeavoured to discuss those aspects in order to provide criteria to better gear the design of policy instruments to promote innovation in the coming years.

If history is a guide, the global financial meltdown of 2007-08 marks a period transition from a world guided by financial criteria to a world guided by production, growth and welfare criteria. It also signals the return of the State as an active participant in guiding the economy. It is a decisive moment when institutional innovation crucially defines the conditions faced by the markets in the coming decades. The capacity of a new global and national regulatory framework to induce finance out of short-term speculation and towards concentrating on the real economy will determine the shape and the extent to which a global sustainable golden age can flourish.

The potential is already installed for vast innovation across all sectors using the power of information and communications technologies (ICT) and that of their organisational paradigm, which has become the shared logic –the 'common sense'– for most successful business practice. Sharing and understanding this logic is crucial for adequate government policies.

The hyper-segmentation of markets, technologies and activities that increasingly characterises the innovation space gives growing importance to small companies, in particular to knowledge intensive services. Together with the speed, band-width, low cost and coverage of the communications infrastructure, the density and the quality of the service networks have an important role in defining territorial competitiveness.

Energy and the environment are strongly signalling the direction in which that installed potential will be developed. Under the previous mass production paradigm the aspiration of suburban living became a focusing device for innovation across the economy –from construction, through electrical appliances, to refrigerated foods. Similarly, the ideal of healthy and eco-friendly lifestyles is gradually taking shape as the focusing device for wide-ranging innovations in the coming decades.

Tilting market conditions in favour of "green" innovation and in support of small knowledge intensive business units is an essential part of the range of required policy innovations.

In finance, in particular, both the private and the public sector will need to modify or create new instruments in order to tailor them to the nature of the changing needs of innovators. Viewing networks as valid interlocutors, recognising and learning to assess intangible value, providing adequate and continuous life-cycle support and strengthening local R&D for present and future needs is in the national interest of each country and in that of the business community located on that territory.

In a context of global competition, where the conditions of each national space define what investment is attracted, kept or rejected, it is particularly important to guarantee the coherence in all instruments of economic policy. Neither technology nor innovation policy can be truly effective if the general policy framework does not converge towards the same vision. The Deployment period of the ICT surge can deliver a highly productive and innovative society in a global context, guaranteeing environmental sustainability and increasing social well being and satisfaction for all.

Once the market and the State are no longer seen as alternatives in a dichotomy but as natural allies in a shared prosperity goal it becomes possible to construct a consensus vision. Such an agreement, based on understanding the nature of the opportunities and the national specificities, is the best guarantee that all actors in business, society and government will converge towards the best possible outcome.

References

Davis, Lance and Gallman Robert (2001) *Evolving Financial Markets and International Capital Flows: Britain, the Americas and Australia 1865-1914*, Cambridge: Cambridge University Press

Davis, S. (1987: 1996) *Future Perfect*, Harlow, England: Addison-Wesley

Dosi, G. et al. (eds.) (1988) *Technical Change and Economic Theory*, London and New York: Pinter and Columbia University Press

Franke, N. et al. (2006) "Finding commercially attractive user innovations: A test of lead-user theory", *Journal of Product Innovation Management*, Vol. 23, pp. 301-315

Freeman, A. (2008) "Culture, creativity and innovation in the internet age", MPRA No. 9007, http://mpra.ub.uni-muenchen.de/9007/1/MPRA_paper_9007.pdf

Freeman, C. (1987), *Technology Policy and Economic Performance: Lessons from Japan*, London: Pinter

Gompers, P. and J. Lerner (2001) *The Money of Invention: How Venture Capital Creates New Wealth*, Boston: Harvard Business School Press

Gompers, P. and J. Lerner (2004) *The Venture Capital Cycle*, Cambridge Mass.: MIT Press

Lundvall, Bengt Ake (1988), "Innovation as an interactive process: from user-producer interaction to the national system of innovation", Ch. 17, pp. 349-69 in Dosi et al. (eds.)

Mourdoukoutas, P. (1999) *The Global Corporation*, Sta. Barbara, CA: Quorum

Mitchell, B.R. (1964) 'The coming of the railway and United Kingdom economic growth', *The Journal of Economic History*, Vol. 24, No. 3, September, pp. 315-336

Perez, Carlota (2002) *Technological Revolutions and Financial Capital: the Dynamics of Bubbles and Golden Ages*, Cheltenham: Elgar

Perez, Carlota (2006) "Re-specialisation and the deployment of the ICT

paradigm: An essay on the challenges of globalisation" in *The Future of the Information Society in Europe: Contributions to the Debate*, IPTS-European Comission, EUR 22353 EN, Ch. 2, pp. 27-56

Perez, Carlota (2007) "Finance and technical change: a long-term view" in Hanusch, Horst and Andreas Pyka (eds.) *Elgar companion to Neo-Schumpeterian Economics*, Cheltenham: Elgar, Ch. 49, pp. 775-99

Perez, Carlota (2009) "The double bubble of the turn of the century: technological roots and structural consequences", *Cambridge Journal of Economics*, Vol. 33, No. 4, pp. 779–805

Hamel, G and Prahalad, C.K (1990) "The core competence of the corporation", *Harvard Business Review*, Vol. 68, May-June, pp. 79-91

Tertzakian, P. (2006) *A Thousand Barrels a Second*, New York et al.: McGraw-Hill

Von Hippel, E. (1988) *The Sources of Innovation*, New York: Oxford University Press

Von Hippel, E. (2007) "Horizontal innovation networks by and for users", *Industrial and Corporate Change*, Vol. 16, No.2

Working Papers in Technology Governance and Economic Dynamics

The Other Canon Foundation, Norway, and the Technology Governance program at Tallinn University of Technology (TUT), Estonia, have launched a new working papers series, entitled "Working Papers in Technology Governance and Economic Dynamics". In the context denoted by the title series, it will publish original research papers, both practical and theoretical, both narrative and analytical, in the area denoted by such concepts as uneven economic growth, techno-economic paradigms, the history and theory of economic policy, innovation strategies, and the public management of innovation, but also generally in the wider fields of industrial policy, development, technology, institutions, finance, public policy, and economic and financial history and theory.

The idea is to offer a venue for quickly presenting interesting papers – scholarly articles, especially as preprints, lectures, essays in a form that may be developed further later on – in a high-quality, nicely formatted version, free of charge: all working papers are downloadable for free from http://hum.ttu.ee/tg as soon as they appear, and you may also order a free subscription by e-mail attachment directly from the same website.

The first nine working papers are already available from the website.
They are

1. Erik S. Reinert, *Evolutionary Economics, Classical Development Economics, and the History of Economic Policy: A Plea for Theorizing by Inclusion.*
2. Richard R. Nelson, *Economic Development from the Perspective of Evolutionary Economic Theory.*
3. Erik S. Reinert, *Development and Social Goals: Balancing Aid and Development to Prevent 'Welfare Colonialism'.*
4. Jan Kregel and Leonardo Burlamaqui, *Finance, Competition, Instability, and Development Microfoundations and Financial Scaffolding of the Economy.*
5. Erik S. Reinert, *European Integration, Innovations and Uneven Economic Growth: Challenges and Problems of EU 2005.*
6. Leonardo Burlamaqui, *How Should Competition Policies and Intellectual Property Issues Interact in a Globalised World? A Schumpeterian Perspective*
7. Paolo Crestanello and Giuseppe Tattara, *Connections and Competences in the Governance of the Value Chain. How Industrial Countries Keep their Competitive Power*

8. Sophus A. Reinert, *Darwin and the Body Politic: Schäffle, Veblen, and the Shift of Biological Metaphor in Economics*
9. Antonio Serra, *Breve Trattato / A Short Treatise (1613)* (available only in hardcopy and by request).
10. Joseph L. Love, *The Latin American Contribution to Center-Periphery Perspectives: History and Prospect*
11. Ronald Dore, *Shareholder capitalism comes to Japan*
12. Per Högselius, *Learning to Destroy. Case studies of creative destruction management in the new Europe*
13. Gabriel Yoguel, Analía Erbes, Verónica Robert, and José Borello, *Diffusion and appropriation of knowledge in different organizational structures*
14. Erik S. Reinert and Rainer Kattel, *European Eastern Enlargement as Europe's Attempted Economic Suicide?*
15. Carlota Perez, *Great Surges of development and alternative forms of globalization*
16. Erik S. Reinert, Iulie Aslaksen, Inger Marie G. Eira, Svein Mathiesen, Hugo Reinert & Ellen Inga Turi, *Adapting to Climate Change in Reindeer Herding: The Nation-State as Problem and Solution*
17. Lawrence King, Patrick Hamm, *The Governance Grenade: Mass Privatization, State Capacity and Economic Development in Postcommunist and Reforming Communist Societies*
18. Reinert, Erik S., Yves Ekoué Amaïzo and Rainer Kattel. *The Economics of Failed, Failing and Fragile States: Productive Structure as the Missing Link*
19. Carlota Perez, *The New Technologies: An Integrated View*
20. Carlota Perez, *Technological revolutions and techno-economic paradigms*
21. Rainer Kattel, Jan A. Kregel, Erik S. Reinert, *The Relevance of Ragnar Nurkse and Classical Development Economics*
22. Erik S. Reinert, *Financial Crises, Persistent Poverty, and the Terrible Simplifiers in Economics: A Turning Point Towards a New "1848 Moment"*
23. Rainer Kattel, Erik S. Reinert and Margit Suurna, *Industrial Restructuring and Innovation Policy in Central and Eastern Europe since 1990*
24. Erkki Karo and Rainer Kattel, *The Copying Paradox: Why Converging Policies but Diverging Capacities for Development in Eastern European Innovation Systems?*

25. Erik S. Reinert, *Emulation versus Comparative Advantage: Competing and Complementary Principles in the History of Economic Policy*
26. Erik S. Reinert, *Capitalist Dynamics: A Technical Note*
27. Martin Doornbos, *Failing States or Failing Models?: Accounting for the Incidence of State Collapse*
28. Carlota Perez, *The financial crisis and the future of innovation: A view of technical change with the aid of history*

The working paper series is edited by Rainer Kattel (kattel@staff.ttu.ee), Wolfgang Drechsler (drechsler@staff.ttu.ee), and Erik S. Reinert (reinert@staff.ttu.ee), who all of them will be happy to receive submissions, suggestions or referrals.