

GLOBELICS
WORKING PAPER SERIES

**THE GLOBAL NETWORK FOR ECONOMICS OF LEARNING,
INNOVATION, AND COMPETENCE BUILDING SYSTEMS**



A Green and Socially
Equitable Direction for the
ICT Paradigm

Carlota Perez

Working Paper

No. 2014-01

ISSN: 2246-0616



A Green and Socially Equitable Direction for the ICT Paradigm

Chris Freeman Memorial Lecture GLOBELICS 2012, Hangzhou, P.R. China
Revised and updated March 2014

London School of Economics and Political Science, U.K. Tallinn
University of Technology, Estonia

Abstract

This paper takes up Chris Freeman's challenge of facing the environmental limits with science, technology and innovation in order to keep open the possibilities of the developing world along a sustainable "green" growth path. It analyses the differences between the energy intensive paradigm of mass production and consumerism in mid-20th Century and the potential shift to sustainability generally provided by the ICT revolution. It then focuses on the developing world and examines the changes in the global market context that are creating windows of opportunity for local innovation, social inclusion and green growth. It finally discusses the alliances and conditions for taking full advantage of the available transformative potential.

A GREEN AND SOCIALLY EQUITABLE DIRECTION FOR THE ICT PARADIGM

Carlota Perez

London School of Economics and Political Science, U.K.
Tallinn University of Technology, Estonia,

Chris Freeman Memorial Lecture
GLOBELICS 2012, Hangzhou, P.R. China

Revised and updated March 2014¹

1. Chris Freeman's challenge	2
2. The potential for environmental and social sustainability	3
The paradigm shift and the new context for production and innovation	3
The crisis and the need for an active State	5
The space of opportunity for a global positive-sum game	7
The technological potential and the tasks ahead	7
A possible route leading to an all inclusive golden age	9
Is ICT compatible with "green"?	11
Guiding production innovation - growth and the environment	12
3. The new power of the emerging and developing countries	13
The paradigm shift and the conditions for development:	14
How to understand the new possibilities for inclusion?	14
An example: a dual integrated strategy for natural resource producers	15
'Leapfrogging' and catching-up in the current world	16
4. A Global Green New Deal for the people and for the planet	17
A transformative alliance	17
Global converging actions	18
References.....	20

1 I thank Yap Xiao Shan and an anonymous referee for their help with comments and references but remain the sole responsible for omissions and shortcomings

1. Chris Freeman's challenge

When the MIT Report *Limits to Growth*² appeared in 1972, a very intense debate ensued. The report, prepared for the Club of Rome, showed with abundant data and the use of a simulation model that the world was heading for a catastrophe if it continued using energy and materials at the rate prevailing then. Many voices in support began advocating zero growth, while at the opposite extreme other voices were labeling the report as exaggeration or based on flawed information. The voice of SPRU, with Chris Freeman's leadership, was heard in a book titled *Thinking about the Future: A Critique of "The Limits to Growth"*.³ Without denying that the continuation of the prevailing trends in resource use would be catastrophic, it held that such problems were to be confronted with science, technology and innovation and that fostering these required global policies. In essence the book proposed not to stop growth but to reorient it. And one of the arguments against zero growth as an option was the responsibility to the people of the developing world.

Twenty years later, in 1992, five years before KYOTO, in his book *The Economics of Hope*, Freeman publishes the article "A green techno-economic paradigm for the world economy". In it he insists on the need for sustainability through reorienting the R&D system and through major institutional change. And he added that "because developing countries will increase consumption, we need radical change for absolute reduction... A global effort is needed, where a strong commitment from the developing countries is most important".⁴

Two more decades have passed and we have not yet acted on Chris Freeman's urging. Several meetings since Kyoto have yielded meager commitments and even less results. Although facing the environmental threats is present in the political, business and technological agendas, it is not clear that they will be confronted properly and in time to avoid the worst consequences. From the perspective of the developing world, facing Chris' challenge implies answering important questions: Does care for the environment hinder growth? Can we achieve global green growth through technological and institutional change? Is inclusive and participatory development possible? Can the emerging and developing countries take a leading role in the process?

Having had the privilege of sharing life and work with Chris for many years, I have felt particularly moved to do research in this direction. What follows is a summary of some of the avenues I have been exploring and some of the elements of a sustainable future they help us envisage.

Section 2 looks at the nature of the current moment in the diffusion of the information technology revolution and examines whether the installed technological potential, in contrast with that of the mass production revolution, can be guided towards sustainability worldwide. Section 3 focuses on the developing world and analyzes how new conditions may be opening more favorable windows of opportunity for development, enabling local innovation, social inclusion and green growth. Section 4 concludes looking at the possible transformative alliance and summarizing the conditions for attaining a global sustainable golden age with the ICT paradigm.

2 Meadows et al. 1972

3 Cole, Freeman, Jahoda and Pavitt 1973.

4 Freeman 1992

2. *The potential for environmental and social sustainability*

“The ICT paradigm can be shaped and steered in an environmentally friendly direction. This was not true of the previous paradigm which was based on mass production and the exploitation of cheap oil”

Freeman 1992, p. 203

A techno-economic paradigm (TEP) is a set of principles for the most efficient and adequate organizations and practices for using the potential of each technological revolution.⁵ It evolves and diffuses with each revolution making obsolete the practices and structures of the previous revolution and becoming the new 'common sense'. This makes a paradigm shift a painful process for all those that espoused the old common sense and led successful professional lives following it.

If we accept that the mass production paradigm established the environmentally harmful production and consumption patterns that still prevail, we need to identify what has changed that would help us modify those patterns. In other words, why can we be confident that the potential is there for achieving both sustainability and growth in the world economy?

The most important factor in favor of the reorientation is the replacement of the techno-economic paradigm or common sense best-practice for innovation. Another factor is that the economic crisis is prompting governments to act to stimulate the economy. Even though the austerity recipes still prevail in many OECD countries, income polarization and high unemployment rates are increasing the political pressure to favor stimulus instead. In this respect, those that are convinced of the threat of global warming are giving urgency to the sustainability direction. And, as far as the potential of the developing world, there has been a substantial change in the relationship between the emerging and the advanced countries, opening opportunities for self-guided development.

This section will discuss the new global potential and the following one will focus on the developing world.

The paradigm shift and the new context for production and innovation

The paradigm shift has changed the context for innovation. Until the 1970s Fordist Mass production and consumption saw energy and materials as too cheap to worry about⁶ and waste as a natural by-product of progress. Since then, with the ICT paradigm, flexible production patterns have opened a whole new range of possibilities in energy and materials saving as well as in new intangible products and services based on the low cost of information access, processing and transmission. Waste is now avoidable and can even become a source of wealth.⁷ This shift not only means that there are sustainable paths for innovation but also that innovating in the old direction means going backwards.

As with every previous technological revolution, the current techno-economic paradigm based on the potential of ICT has modified the economic space and the forms of competition. As a consequence of this modification we have observed three hyper-segmentations: To begin with, global corporations are hyper-segmented organizationally and geographically. Rather than the old pattern of commercial or assembly affiliates, they have been disaggregating their

5 Freeman-Perez 1988; Perez 2002 and 2010a

6 Rose (1974)

7 Murray 199?

value-networks and outsourcing activities across the world. In some case those activities are similar to those in the past –i.e. just final assembly or packaging or distribution– but in other cases they give rise to local high tech service companies or R&D activities⁸. This has led to segmented industrial structures with much narrower specializations and therefore with greater access for newcomers.

Markets are also hyper-segmented by innovation, differentiation and adaptation into innumerable niches, so that all types of products present a kaleidoscope of options in the market, from the commodity segment to the multiple specialized or customized versions or, what Chris Anderson has called 'the long tail' of small quantities of innumerable different versions.⁹ The forms of competition and the conditions for success in each type of market are different and this opens innumerable possibilities for new entrants and for developing country producers and innovators, from natural resources, through manufacturing, to services (see figures 1 and 2). Thus, one can no longer identify 'industrialization' with manufacturing industry, but rather with innovative and technological capabilities in any activity.

Figure 1. Hyper-segmentation of markets in the ICT paradigm

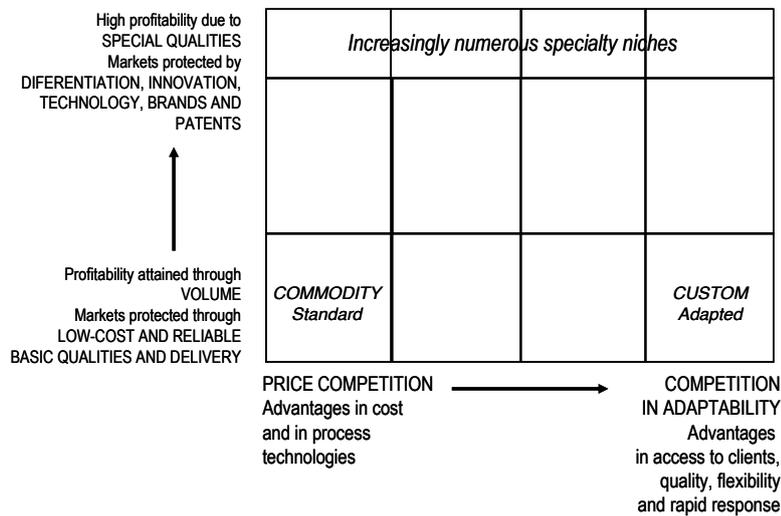
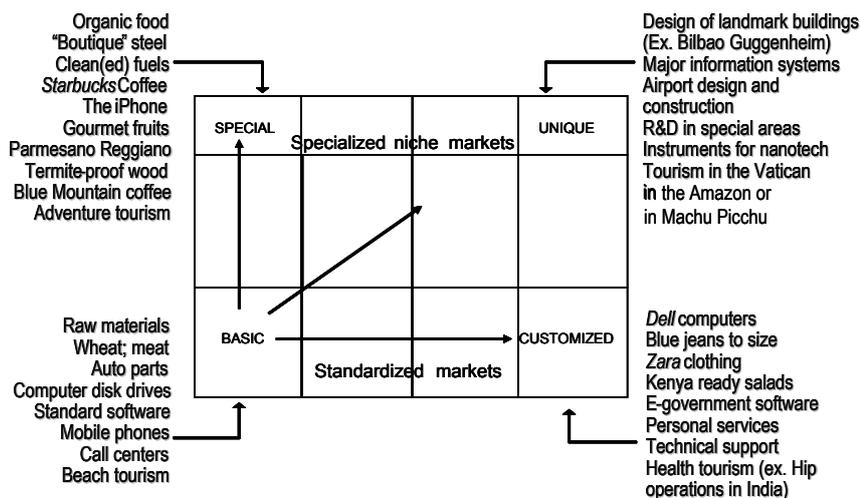


Figure 2. Some examples of market segmentation



Source: Perez 2010b

8 Ernst (2007); Ernst and Kim (2002)

9 Anderson (2006)

Finally, in contrast with the “one best way” and “one best product” of the Tayloristic past, products of several technological levels can coexist in the same economic space without competing each other away (e.g. Organic and high tech; ultra sophisticated and “frugal”, etc.). Equally, because of these differences, production scales are also varied and small companies with differentiated products can prosper next to the giants (or be profitably sold to them).

There are therefore multiple innovation and specialization routes for companies and countries. Depending on the choices made within that very wide range of segments, the adequate capabilities and policies to support them will be different. But whatever the choice, as always, intense learning efforts will be the key to success.¹⁰

The crisis and the need for an active State

The market economy is a system prone to crises and instability.¹¹ But not all crises are of the same nature. There is a particular type of bust after a major bubble that is strongly related to the diffusion of each technological revolution and has typically occurred midway along that path.¹² Such have been the canal panic of 1797 during the industrial revolution in England, the railway panic of 1847, the Baring crisis of 1890 (and others in the southern Hemisphere), the crash of 1929 in the middle of the mass production revolution, this time in the USA, and the double bubble (NASDAQ 2000 plus the 2007-08 credit crunch) midway along the current ICT revolution. The ensuing recessions have been of very different durations from as little as two years to as much as thirteen (in the case of the 1930s). What is important about these particular bubbles and crashes is that they prepare the conditions for the Golden Ages. The great British leap at the turn of the 19th Century, the Victorian Boom, the Belle Époque and the Post War Golden Age all followed such post-bubble recessions (figure 3).

Understanding the nature of the current crisis in that historical context lets us see how the possibility of a “green” direction for innovation and growth is there for the taking. As on previous occasions, this is a time when finance needs to be regulated and reoriented towards investment in the real economy. It is also a time when the State comes back actively with policies that stimulate demand in specific directions. The previous time, when the mass production potential was there to be shaped, the Welfare State, suburbanization and the Cold War created the necessary demand and production synergies for a period of dynamic growth and innovation. Unfettered free markets and government austerity may have worked for overcoming the recession of the 1980s (at a huge social cost), but they are totally inadequate for the current situation. From the point of view of the availability of innovation and expansion opportunities, the 2010s and the 1980s are very different.

10 Lundvall et al. (2002), Dore (1989)

11 Minsky (1982)

12 Perez 2002 and, for the particular double bubble that has occurred this time, see Perez 2009.

Figure 3 The historical record: bubble prosperities, recessions and golden ages

GREAT SURGE	Date Technologies Core country	INSTALLATION PERIOD	TURNING POINT	DEPLOYMENT PERIOD
		Bubble prosperity	Recessions	"Golden Age" prosperity
1 st	1771 The Industrial Revolution Britain	Canal mania	1793-97	Great British leap
2 nd	1829 Age of Steam and Railways Britain	Railway mania	1848-50	The Victorian Boom
3 rd	1875 Age of Steel and heavy Engineering Britain / USA Germany	London funded global market infrastructure build-up (Argentina, Australia, USA)	1890-95	Belle Époque (Europe) "Progressive Era" (USA)
4 th	1908 Age of Oil, Autos and Mass Production / USA	The roaring twenties in USA Autos, housing, radio, aviation, electricity	Europe 1929-33 USA 1929-43	Post-war Golden age
5 th	1971 The ICT Revolution USA	Emerging markets dotcom and Internet mania real estate and financial casino	2000 & 2007-08 -???	Sustainable global Golden Age?

↑
We are here

Source: Perez (2013) p. 11

The 1980s recessions and “lost decades” were due to the exhaustion of the prevailing mass production paradigm. Innovation trajectories had matured; productivity increases had diminishing returns; few new products could be added to existing product systems; markets for most industries were saturated; finance had ‘idle money’. The import substitution policies in the developing world --based on assembling mature products-- were already reaching saturation in terms of demand expansion possibilities. The information revolution was in its infancy and was not yet able to rejuvenate industry. 'Picking winners' was practically impossible, be it by the public or the private sector. The painful processes of destroying protective barriers and reducing government support opened the way to massive and painful “creative destruction” (often simply “destructive destruction” as Reinert puts it¹³). Governments retrenched and finance took over, operating in unfettered free markets. Gradually the big financial push helped the ICT revolution flourish (much of it riding on a wave of technologies developed by the US government¹⁴ or aided by its funding and procurement). Computers, the internet and the Japanese methods of production (ref?) provided a new paradigm that enabled the rejuvenation of the mature technologies, both through reorganization and through optimizing costs by means of outsourcing and off-shoring. By the late 1990s, spurred further by the internet, a whole new potential for growth had been installed or revitalized.

The situation in the 2010s is, therefore, almost the opposite of the 1980s. The new ICT paradigm is installed and capable of enabling innovation in multiple directions and across all sectors, as long as demand is forthcoming and synergies can be had. Finance got used to the casino mode of quick and easy gains and will not invest in the real economy unless short-term profits are assured. Control of investment and innovation has to go back to production. Rather than retrench, the State needs to become proactive. It is up to governments to reorient finance

13 Reinert 2007 and 2012 p.190

14 Mazzucato 2013

and to create conditions for dynamic demand and for synergy in consensus directions to stimulate innovation and investment.¹⁵

A new global economy has evolved and continues to be shaped by the policies and strategies of global corporations and governments. A global sustainable golden age is possible, but it has to be consciously guided and supported. Markets alone will not do it. And it is useless to make sacrifices (or to print masses of money through QE) in order to save the banks. Healthy banks in a languid economy will just be fuel for the—now global—financial casino.

The space of opportunity for a global positive-sum game

One of the main consequences of the diffusion of the ICT paradigm has been the globalization of the economy. The Internet makes trade in intangibles indifferent to distance and frontiers; it allows corporations operating globally to easily manage a complex worldwide network of a size several times what was possible in mass production times; and it enables the monitoring of increasing flows of global trade across land, sea and air. National markets and national policies or strategies must now take into account the global stage. Whereas the previous golden age was limited to the countries of the advanced world, a golden age shaped by the current paradigm would necessarily tend to be global.

Can the characteristics of a possible global golden age be gleaned? First we must examine the nature of the paradigm and the range of opportunities it offers for innovation and growth. We could call that “the supply opportunity space”. Then we need to explore the context in order to identify the sources of demand dynamism that can be stimulated or created or what we could call “the demand opportunity space”.

The technological potential and the tasks ahead

An analysis of the current situation observes on the supply side a vast range of possibilities for innovation *within* the ICT industries as well as across all sectors *with the aid of* ICT. The former ranges from the innumerable apps for smart phones and social media, through big data and the 'internet of things', to 3-D printing and robotics, while the potential for innovations using ICT and its paradigm cover practically the whole economy. The power of information technology can enable almost any industry to make its own revolution: the world of medicine, the world of materials or that of biology, the creative industries, the flourishing of all services --personal, collective and technical--transport, energy, buildings, nanotechnology, agriculture, logistics, education, entertainment and so on.

All these changes can cater to a diversity of lifestyles, from various luxury ones at the top, through several preferences across the middle ranges to the frugal innovations that can enable the poor to take the first steps unto the ladder to a better life. They define a vast technological supply potential, which—as with previous golden ages—can only be profitably exploited in those directions where it encounters sufficient demand.

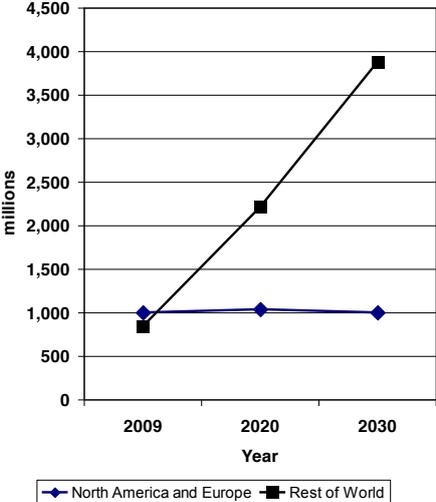
A basic source of demand is the diffusion of ICT itself. The more universal the access the greater the demand will be for ICT products and services and for those that incorporate it. This is analogous to the spread of electricity for the mass production paradigm. In this case, there is the additional advantage of educating the users both as producers and as consumers and in many cases as innovators. Access to internet defines the boundaries of the knowledge society and of the global market.

15 Perez 2002, Ch. 11

Another potentially massive source of increasing demand is global development. A recent estimate by Hara Kahmis (2010) of the OECD sees the consuming classes¹⁶ outside North America and Europe going from the current billion to nearly four billion in 2030 (Fig. 4) and from around 28% of global consumption to 64%.

This tripling of potential demand in less than twenty years makes unnecessary the planned obsolescence strategy, applied by most companies from the 1960s, in order to artificially increase demand in the saturated markets of the advanced world. The adequate strategies now need to fulfill the aspirations of the new three billion consumers while facing a single planet with limited resources. They would also have to overcome the socially unacceptable unemployment levels and income polarization that currently characterize the advanced countries.

Figure 4 - Growth of global middle class consumers - Forecast to 2030



Source: Kharas 2010

Thus, the world faces three simultaneous and inter-related problems, The threat of 'secular stagnation' in the advanced countries¹⁷, the limits to further growth in the emerging countries and the need to fulfill the development aspirations of the countries pulling up from behind.

It soon becomes clear that to effectively cater to that new demand, supply cannot be based on the “American Way of Life”. There are not enough resources on the planet to maintain the consumerist lifestyles and to expand the high-waste society that characterized the 20th Century. We are once again confronting the Meadows 'Limits to growth'. In fact, the current environmental problems stem directly from those decades of energy and materials-intensive production and consumption patterns, and of their continuation beyond their useful life.

On the other hand, the potential rise of hundreds of millions of people in the developing world out of poverty and into consumption and a comfortable life puts into question the zero growth strategy originally proposed by the Meadows team and reaffirmed since then by many academics¹⁸ and by several environmental organizations. Surely, the realistic answer is the

16 Kharas defines the consuming classes as those with daily expenditures of between 10 and 100 PPP dollars per person.

17 Larry Summers (2013) recently revived a debate on the risk of 'secular stagnation' that had been initiated by Alvin Hansen in 1938. The interpretation of the present situation in the advanced world as risking secular stagnation with low investment and high unemployment is becoming increasingly common, it is sometimes blamed on technology, sometimes on globalization, although making the parallel with the 1930s tends to be avoided.

18 Daly 2008, Jackson 2009, Mosley 2010

one given by Chris Freeman forty years ago: science and technology guided in the right direction, in other words, aimed at 'green growth'.

Full global development is only conceivable if it is pursued in a sustainable way. 'Green growth' across the globe would require a very clear redirection of innovation towards a massive increase in the productivity of resources –through closed cycle, durability and recycling– and a very significant rise in the proportion of services and other intangibles in production and consumption.

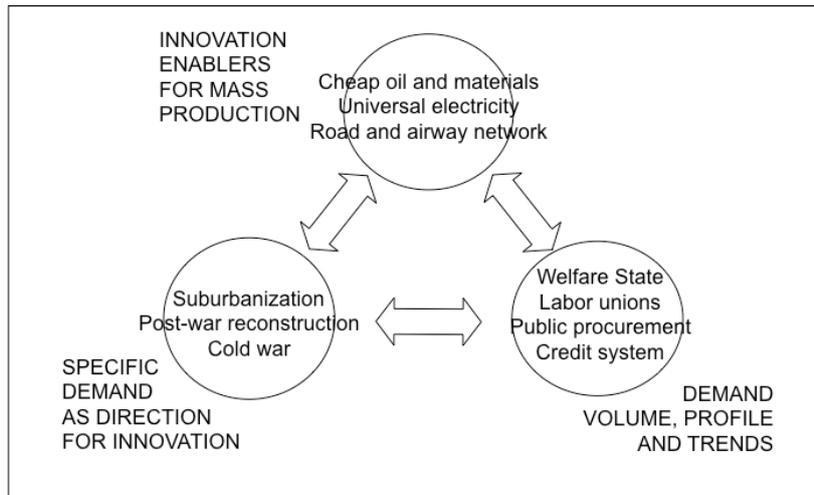
A possible route leading to an all inclusive golden age

History shows (and the advertising industry knows) that massive shifts in consumption patterns cannot be based on guilt, fear or self-denial, but on desire and aspiration. What needs to change in the green direction is the notion of the 'good life', both in the advanced world and among the newcomers. This is not as unlikely as it seems at first glance. Every golden age in history has seen a redefinition of the luxury life. The austere styles of the Victorian boom were replaced by the baroque cosmopolitanism of the Belle Époque and that, in turn, was replaced by the comfort maximizing 'American way of Life'. It is likely that a health-seeking, nature-loving lifestyle could evolve in the next few decades. Already obesity is being shunned, while exercise and gourmet food are seen as luxury living; solar panels and electric cars are signs of wealth; 'retro' furniture and clothing have become fashionable and minimalist design is seen as the most elegant. Admittedly the shift is slow but the direction is being signaled and historical experience tells us that there are 'tipping points' that mark a sharp acceleration in diffusion trends.

If we look at the post-war golden age from the perspective of the 1930s, we can find equivalent incredulity when faced with the possibility of massive worker ownership of houses full of electrical appliances and with a car at the door; of full employment through the multiplication of jobs in services, in government and in construction to replace those lost through mass production in manufacturing and mechanization in agriculture. All this was brought about by institutional innovations along the lines proposed by Keynes, with government management of the economy through a massive taxation system that funded the two main sources of demand: that of consumption supported by the Welfare State and that of military procurement. Suburbia and the Cold War, both guided innovation and upheld the constant growth of demand.

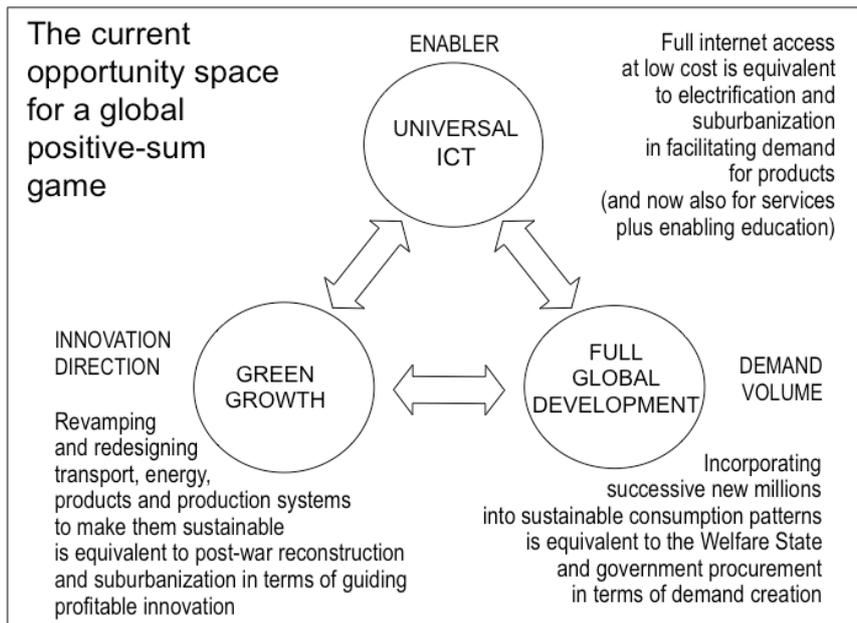
It is with hindsight that we can see the innovation potential installed during the roaring twenties and waiting in the wings in the 1930s. It required a major world war to reveal the amazing possibilities, which were later to be fully unleashed for civilian purposes. As shown in figure 5, the combination of factors driving full deployment in the 'West' included the facilitators (low cost oil, roads and electricity); the demand pull factors (Welfare State, official labor unions, consumer credit and mortgage support) and the innovation direction (suburbia, Marshall Plan, Cold War). The various elements were provided in different proportions in each 'First World' country.

Figure 5 The technical and institutional drivers of the Post War Golden Age



A global sustainable golden age would now be possible with a combination of universal ICT, full global development and 'green' growth. (See figure 6). The role of enabler would now be played by universal access to cheap internet and the innovation potential of ICT. Demand volume for both consumer and equipment goods would come from the spread of production and income growth across the globe and, in order to make it feasible, policies to tilt the playing field in favor of green growth would provide the direction for profitable innovation. Such measures would probably be different in the old advanced countries, the emerging ones and the countries coming up from behind, but the end result could be a positive sum game, protecting the planet, encouraging investment and innovation and increasing the quality of life for all.

Figure 6: Potential drivers of the demand opportunity space for building a global sustainable golden age with the ICT revolution



There might be other combinations of supply and demand opportunities to take advantage of the technological potential waiting in the wings. Perhaps a more restricted globalization with a cyber-militaristic orientation led by the financial world, is one of the possible routes, maintaining income polarization and favoring war and power blocks rather than global trade and social inclusion. History shows that the space of the possible provided by every paradigm is very wide. The previous mass production technologies enabled systems as diverse as Soviet socialism, Nazi-fascism and Keynesian democracies in the advanced world, and a great variety of forms of State Developmentalism in the relatively marginalized 'Third World'. This time instead of different systems confronting each other to the point of war, the variety could be in the nodes and sub-systems of a single global network. What seems advantageous about the proposed combination is that it sustains a positive sum game between business and society within each country, among the advanced, emerging and developing countries and between humanity and the planet.

Is ICT compatible with “green”?

The particular trajectory followed by a technological revolution is not endogenously determined only. All that a technological potential can do is set the stage for the social actors to take their decisions and shape the favored direction from within the new range of the viable. The specific context in which a revolution diffuses has a determining influence in the direction taken. Having emerged in a world strongly shaped by mass production, ICT companies have also adopted the planned obsolescence strategy of inducing consumers to dispose of products frequently, instead of upgrading the software or replacing some parts. Equally, they have continued the energy-intensive path that has long characterized product usage. Both these trends kept from the old paradigm were intensified by the low price of energy at the precise time when the ICT companies were defining their growth strategies in the late 1990s. The price of oil was then, in real terms, less than before the energy crisis of the mid-1970s. This lowered the cost of materials too, making it easier to be wasteful. In addition, the possibility of outsourcing production to countries with extremely low-cost labor in Asia was enhanced by the decreasing cost of transport, however long the distance. These context conditions have basically disappeared and a certain amount of reversal of the high-energy frequent-obsolescence trends may be expected.

Ironically, ICT has been the central instrument for energy and materials saving in most other industries. Of course, there is still a long way to go to achieve maximum results in the green direction. The potential of ICT is largely unrealized. Digital controls and computer aided design and production can reduce energy consumption, materials use, emission of pollutants, etc. It can aid the redesign of materials to make them more closely specified to their use, therefore allowing less material per unit of product. It can also help streamline products, processes and logistics. With the appropriate software it is possible to coordinate and optimize combinations of disparate technologies, of transport routes and means as well as value chains and all sorts of networks to minimize energy use and reach other green goals. Innovation in ICT can replace products with services, much travel can be reduced with telecommunications, so can paper use with electronic tablets and so on. Both these trends have been wrongly predicted several times but may now be on their way to fulfillment, especially if relative costs change to foster them.

In relation to reducing its own energy use, the ICT industry is exploring the possibility of shifting to direct current USB-based equipment and is engaged in other major research

projects such as using the so-called 'tunnel FETs' that could in theory achieve a hundred-fold power reduction.¹⁹

But the technologically feasible is only realized when facing a good demand opportunity space. Social values, policies, regulations, taxes, costs and relative prices will be the ultimate drivers of the speed and depth of the shift

Guiding production innovation - growth and the environment

Environmentally friendly production and consumption patterns can simultaneously save the planet, recover employment in the advanced world and promote full global development. Green growth may be the only realistic strategy to achieve those goals today.

How can we define green growth and development? The UN Environmental Program (UNEP 2010) has defined a green economy as: "one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. In its simplest expression, a green economy can be thought of as one which is low carbon, resource efficient and socially inclusive."

We are thus referring to a growth process that guarantees an increasing quality of life for growing proportions of the world's population through an environmentally sustainable economy. It is not just about avoiding global warming; it is also about sharing and preserving scarce natural resources and overcoming poverty.

It would involve, among other aims:

- Less energy and materials per unit of production, transport and consumption, involving a massive increase in the productivity of resources,²⁰
- Strongly increasing the proportion of renewable sources in energy and materials use with a clear focus on conservation²¹.
- Maximum recycling and imaginative uses of waste: Circular economy²²; cradle to cradle²³, Zero waste²⁴, etc.
- Durability of products (with originator responsible for disposal)²⁵ plus dynamic second-hand, third, fourth and Nth-hand markets –perhaps with a rental model– creating jobs for widespread maintenance and upgrading.
- Revamping all existing infrastructure to make it durable and energy efficient
- Increasing proportion of services in lifestyles, so that intangibles grow much faster than tangible products in GDP thanks to maximum use of ICT and greater emphasis on health, creative activities and quality of life.
- Etc., etc.

19 Ionescu and Riel 2011

20 The Ellen MacArthur Foundation (EMF) in its 2014 Report estimates that circularity in manufacturing could yield net materials cost savings of up to US\$ 630 billion/year in the EU alone.

21 Wilson and Grubler 2011 estimated that between 1974 and 2008, the countries of the IEA (International Energy Agency) countries have achieved 59% of their carbon emissions reduction through energy conservation in use, and 19% through incorporating renewable sources. By contrast, only 9% of the energy R&D budget is attributable to each of those goals, while the 82% of R&D costs went into nuclear, fossil fuels and others. (See Table 3, p.180)

22 EMF 2012

23 McDonough and Braungart 2002

24 Murray 2002

25 As in the EU WEE Directive for the disposal of electrical and electronic equipment

Green growth would be both a redirection of innovation in design, production, logistics and marketing strategies and a radical redefinition of the good life.

As mentioned before, each technological revolution has led to a shift in lifestyle and each style becomes 'the good life' shaping the desires of the majority and guiding innovation trajectories. However, the shift is unlikely to be attained by markets alone. Government policies and various institutions of civil society must converge to change the incentive system and guide demand and market actions in the desired directions. A technological revolution and its techno-economic paradigm can only set the stage and provide the wide range of the possible. It is up to us to determine the direction of change.

*“A TEP is driven not by predetermined natural forces ('natural trajectories')
but by economic and social institutions and actors”*

Freeman 1992, p. 198

Can we, then, achieve global green growth through technological and institutional change? From all of the above it would seem that the answer is positive. However, its realization will depend the outcome of the confrontations, negotiations and agreements of the socio-political forces.

Today, the technological potential is available; there are possible sources of demand dynamism and we are at the right historical moment. It is up to us to seize the opportunity to construct a socially and environmentally sustainable world.

The questions about the role of the developing countries remain: Should the developing world wait and see what the advanced world does? Is inclusive and participatory development possible? Can the emerging and developing countries take a leading role in the process?

3. The new power of the emerging and developing countries

*“A green techno-economic paradigm would need to get strong support from public opinion
... and most important... a strong commitment of Third World countries
“...even though their specific patterns of production and consumption would undoubtedly
differ from those of the United States.”*

Freeman 1992, p. 191 and 209

What has changed?

The first thing to note is that the term 'Third World' is no longer applicable. Its disappearance expresses, on the one hand, the end of the Cold War and the incorporation of most of the old 'Second World' to the global market economy and, on the other, the emergence of the BRICs and the gradual and uneven rise of the rest. South Korea can now be counted among the developed countries, while China, though still ruled by a communist party, is poised to become the world's largest market economy with the fastest growing domestic consumer demand. Those momentous transformations have occurred in the short space of barely more than two decades.

What are the conditions that have been driving those changes in the old 'Thirds World'? In the first place, the new information and communications technologies (ICT) have enabled the globalization of the economy and, through it, have created new favorable conditions for

technological acquisition, autonomous innovation, catching-up, “leapfrogging” and original pathways in countries that saw themselves—and were, in practice—technologically dependent on the First or Second worlds. In addition, the techno-economic paradigm change has opened opportunities for inclusion that were not available with the previous technologies. Finally, the high prices of raw materials have opened new prospects for innovation in the resource-rich developing world and for materials and energy saving among consumers.

The paradigm shift and the conditions for development:

In the times shaped by the mass production paradigm, there was a need for unlimited availability of cheap energy and natural resources; a need for homogenous markets (the 'American Way of life' for all); relatively high incomes in order to count on the workers as consumers and the concentration of manufacturing plants in order to achieve economies of scale. This led to an international division of production that disadvantaged countries producing energy or raw materials. The notion of 'dependency' originated in observing that model of subordination²⁶.

By contrast, the flexible production paradigm based on the characteristics of ICT, needs to count on cheap microelectronics and cheap telecommunications. ICT-enabled products can use less of relatively more expensive energy and materials; there can be a great diversity of scales in production and markets. The resulting hyper-segmentation of markets, activities and technologies suggests that rather than aiming at homogenization, business can find an advantage in variety of market demand and of lifestyles.

All that variety and flexibility seems to be leading to an international division of production that opens multiple opportunities for technological development in all sectors and all countries and to a much greater inter-country differentiation than was typical of the old 'Third World'. Much depends on the previous conditions and the capacity of the leadership. The ample diversity of routes and results was shown by Oyeyinka and Rasiah (2009) looking at the evolution of the hardware sector in seven countries of Asia and Africa as well as at innovation in both modern and traditional sectors.²⁷

Of equal importance is the potential to move from the illusory trickle-down effect for alleviating poverty to the potential for proper social inclusion by enabling wealth creation from the grassroots up. Small units, traditional technologies and special niche products can coexist with those of the most powerful companies in the current diversified markets. The success of Fair Trade is a clear example²⁸ and so are the many niche market successes.²⁹

How to understand the new possibilities for inclusion?

There are three areas where change opens the possibility of incorporating the poor: consumption, production and identity.

26 The Dependency school in the 1960s and 1970s held that underdevelopment was not about lagging along a similar path as the developed countries but about playing a dependent role in relation to the advanced world and necessary to it. See Cardoso and Faletto 1971 in the 1979 updated English version.

27 Rasiah 2012

28 Bowes 2010

29 Since the mid-1990s the OECD had already seen the potential of using niche markets for rural development (OECD 1995)

In consumption, the new paradigm enables directly catering to the needs of the excluded, from 'frugal innovation'³⁰ to infinite adaptability to specific conditions and limitations.

In terms of wealth creation, production can now take place in every corner of each territory thanks to the hyper-segmentation of markets, the transport and trade of small quantities, the coexistence of multiple technologies in the same market, the outsourcing practices of the global corporations, the clustering arrangements of similar companies, the new value placed on the hand-made & traditional, and so on.

Regarding identity, the new flexible production and trade conditions open vast opportunities for diversity in production and consumption patterns; this allows rescuing cultural and religious identities, valuing traditions and creating original combinations of high tech with low tech; and reaching very high quality of life in the countryside, reducing the urge to migrate to the slums in the cities.

But the existence of the inclusion possibilities does not guarantee that they will be realized in practice. If there is an area where public policy is absolutely indispensable it is in relation to poverty. Information, education, funding and coordinating access to markets will all be necessary to make these possibilities fructify. And policies can (and should) aim at quality in all three areas of inclusion.³¹

An example: a dual integrated strategy for natural resource producers

Combining the new possibilities for inclusion, for innovative networks and for market segmentation, I have proposed a dual strategy for natural-resource-rich countries in Latin America.³² It would involve, on the one hand, constantly upgraded production networks in the processing industries around natural resources, acting as engines of growth and producing advanced competitive technologies for global markets. On the other hand, multiple interconnected specialized 'local' economies leading to the differentiated development of each part of the territory. This would be based on identifying or promoting the local productive vocation and providing educational, technical and business support for grass-roots initiatives.

The natural resource sector, with a strong and innovative network up and downstream, would be highly dynamic in terms of technology and market targeting.³³ Innovations in equipment, in inputs, in specialized materials adapted to specific uses and with required qualities would diversify the export mix while increasing its value. The increase of local downstream processing would be pursued with the help of changing cost advantages and well directed negotiations. The objective of this sector would be growth and the generation of foreign exchange and tax revenue.

The objective of the bottom-up half of the strategy would be to raise the quality of life of all the inhabitants. With this in mind, both the choice of products and the organization of production would be geared to respecting local identities, climate and other conditions.

In between, there would be an active State supporting each of the groups with adequate and different strategies and instruments; facilitating and promoting local initiative, providing

³⁰ Bhatti 2012

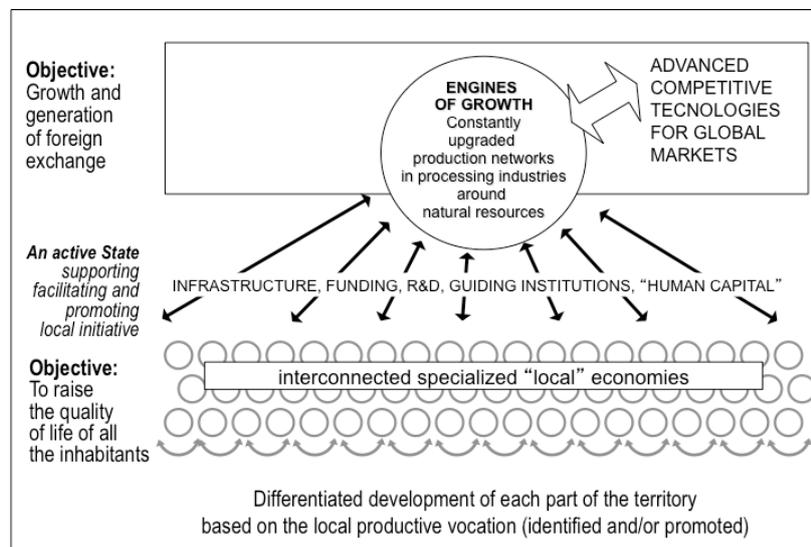
³¹ UN Human Development Report 2011

³² Perez 2010

³³ An argument for the possibility of technologically dynamic networks around natural resources in the developing world is found in Marin et al. 2013 and Perez et al. 2014. The Globelics working paper that is the source of both is Marin et al. 2010

infrastructure, funding, R&D, negotiating power, guiding institutions, “human capital” and whatever else is required and viable (see Figure 8).

Figure 8 - A dual integrated model for development in natural resource producing countries
(A proposal for Latin America)



Of course, for natural resource producers, the “green” orientation, both in their own practices and in those of their clients, is particularly relevant. Being in the eye of the storm, environmental problems and demand trends have to be taken seriously into account when defining the direction of innovation.

‘Leapfrogging’ and catching-up in the current world³⁴

Today, we have living proof that the old condition of dependency is no longer the main reality. Ambitious visions such as the one proposed above have indeed become possible, often supported on foreign technology and investment, always with a strong role of the State, guiding, regulating, funding and educating.³⁵ South Korea and China are prime country examples of catching-up and perhaps of eventual forging ahead. The direct leap to mobile phones and alternative energies (common in Africa) are instances of technological leapfrogging. We have witnessed the rise of powerful innovating firms and market leaders in emerging countries, such as Brazil, China and India, which have several global companies. Biotechnology innovations are being made in several developing countries.³⁶

As to the behavior of the global corporations, enclave practices are increasingly being abandoned in favor of upgrading local participation. De Beers has been developing local skills in the processing of diamonds in Botswana³⁷; BHP Billiton is funding a program in Chile³⁸ to increase the number and quality of local knowledge intensive service suppliers for copper mining and so on.

34 Perez-Soete (1988)

35 Wade (1990)

36 Marin et al. (2010)

37 Marciano et al (2006); Warhurst (2008)

38 Urzua (2012)

At different rhythms, developing country companies are moving from simple supply contracts to making alliances, providing R&D, improving technologies, learning from the advanced world and innovating on their own.³⁹

A paradigm shift is indeed a deep modification of conditions and possibilities and it is more likely that companies and countries take full advantage of them when the new situation is fully recognized. For the developed world, the paradigm shift requires retrofitting and abandoning past habits; for the developing world it is a choice between copying the 20th century or directly moving on to the 21st.

4. A Global Green New Deal⁴⁰ for the people and for the planet

“There are powerful constraining forces in our societies which channel, promote and limit the main directions of technical advance”

“Changes of the necessary magnitude require a substantial long-term policy embracing environmental, social and technological objectives.

The ICT techno-economic paradigm can be adapted to these objectives, given the political will.”

Freeman 1992, p. 203 and 208

A transformative alliance

It is gradually being recognized that sustainability may be an effective route to world economic recovery. Both the World Bank (2011) and the OECD (2011) have argued that 'green' and 'growth' are a viable combination towards the future. Several researchers have shown how an environmentally sustainable route can lead to solving the lack of employment and consumer demand⁴¹. And yet, there is still a reluctance in political and economic circles to seeing 'green' not as a hindrance to economic recovery but as the solution. Thus, the political will that Chris Freeman required is not yet there.

In the process of analyzing the conditions for such political will, when it comes to the green transformation, Hubert Schmitz (2013) has proposed reaching a 'transformative alliance' among all those who, though having different goals, could nevertheless reach them best through innovating in a green direction. He notes that most efforts up to now have been focused on global scale decisions reached by public entities of the advanced world in order to avert climate change (see the "top-down" column in Table 1).

Table 1 - A potential set of alliances for accelerating the green transformation

Approach	Top Down			Bottom Up
Level	Global	National		Local
Location	North	Rising Powers		South
Actor	Public	Private		Civic
Motive	Climate Change	Energy Security	Competitiveness	Green Jobs

Source: Schmitz 2013 (our emphasis in column 1)

39 Ernst and Kim 2002. See also Hobday 2003.

40 The term was proposed in a 2009 report for the UN by E.B. Barbier. It combines policies for world economic recovery, for a sustainable environment and poverty reduction. See also Barbier 2010.

41 See for example Ashford et al. 2012

However, there are many groups acting bottom-up in a local context (see right hand column) who are counting on the green direction to solve the unemployment problems in the developing world—and increasingly also in the cities and communities of the developed world. He also notes that the greatest R&D efforts in advanced green technologies are being made in the BRICs and in South Korea. China, for instance, dedicates 33.4% of its stimulus budget to such investment and South Korea 95%⁴² The traditional advanced countries are trailing behind with 'green' representing between 10 and 20% of stimulus expenditure. Yet, the goals of the emerging countries, as Schmitz points out are less about sustainability than about energy security and competitiveness (see central column in table 1). This also suggests that it might be easier for countries not so strongly tied to past investment in the old technologies⁴³ to follow the new paths and even become leaders in some of the green technologies.⁴⁴

The notion of an alliance following convergent routes with diverse objectives makes the transformation seem more feasible. It also fits more closely with the historical patterns. The Post-War Golden Age in the advanced countries of the West was based on the convergence of interests between the labor unions wanting a better standard of living and the mass production companies wanting to sell them houses, cars, electrical appliances, refrigerated food and disposable plastics. The high salaries, the high taxes and the Welfare State, which were unacceptable to business in the 1930s, became normal after the war, when they guaranteed government procurement and consumer demand growth.

Global converging actions

The complexity of the current transition is far from being understood by the leadership, especially that of the advanced countries. It is no longer a question of national policies only. The economy, the availability of natural resources and the threat of climate change are now clearly of a global nature. For all countries, understanding this as well as the character of the historical moment is crucial. In the developing world the first step to a successful strategy could be recognizing the new innovation potential and the advantages of not having a legacy to “retrofit” or abandon. The second could be discovering that countries and companies can negotiate better conditions with global corporations by knowing their interests, those of their competitors and the goals you want to attain.⁴⁵

For the advanced countries, accepting that there is no return to 'business as usual' could be the basis for success in implementing growth and job creating strategies. It is not enough to save the banks for the economy to regain dynamism. The available innovation potential is not of the same nature as that of a technological revolution. While the ICT innovations naturally clustered and created synergies for each other in the market and among the supplier base, the potential available now is much more disperse across industries and will only be profitable if the synergies are consciously created by inducing investment and innovation in convergent directions. Jobs will not come to the advanced world through expecting finance to fund them with free competition in the current global context.

42 Barbier (2010b) p.7

43 Perez and Soete (1988)

44 Mathews (2014)

45 Perez (2001)

As after the 1930s, governments everywhere must strongly tilt the playing field and actively shape and create new markets.⁴⁶ Given the global nature of the ICT based economy, it is likely that countries will have to specialize or respecialize by innovating or promoting innovation in areas where they have static or dynamic advantages, or where they can provide important local markets or a natural endowment or an accumulated skill base. Health, sports and leisure, creative industries, third age, extreme climate and many others can be chosen as specializations and all local industries can innovate to converge onto those directions. As discussed above, natural resource producers can aim at differentiated materials and customized equipment. Countries with very large populations to lift out of poverty may include frugal innovations among their areas of concentration and so on. But whatever the demand spaces chosen, the global convergence on the 'green' direction is what will make it possible to achieve enough synergies for full global development with limited resources.

The potential is there for a sustainable global golden age, but all that a technological revolution can do is set the space of the possible in wealth creation. As Chris Freeman emphasized, it is up to the socio-political forces to shape the direction in which that space will be used and how its fruits can be distributed.

The technologically feasible is largely mapped out; dynamism will depend on income distribution for reshaping demand and on policies that define and support a synergistic direction for innovation. This is a time for institutional innovation as bold and imaginative as the one displayed after the war to set up the Welfare State and as consistent with the nature and potential of this paradigm as the previous one was with the character and potential of mass production.

That paradigm required massive demand for identical products and therefore homogenizing lifestyles and providing enough income for the workers to act as middle-class consumers in the advanced markets. It also required increasing quantities of energy and raw materials at low cost, which underlay the profound differences between core and periphery. The resulting Golden Ages in the nations of the First World did not include the developing world.

The current flexible production paradigm based on ICT, could lead to a global rise in the quality of life. It is already doing so, although very unevenly. It could also lead to different sustainable 'glocal' lifestyles, based on mass customization. These new technologies do not thrive in homogeneity but in diversity. The narrow profit margins on very high volume manufacturing of identical products lead producers to differentiation and customization in search of greater profits. This time, development may occur gradually across all countries, leading to a possible sustainable global golden age.

After the major bubble collapse we are at the precise moment when a strong and active State needs to construct an ambitious consensus vision to move towards development on as green a path as possible. That is the best route to social inclusion; it is within the technological potential; it is the safest route to development and is even likely to define the most dynamic export markets of the future

Does it all sound utopian? Don't forget that in the 1930s it sounded utopian to say that blue collar workers (then massively unemployed) would live 'middle class' lives in their own suburban homes or that most colonies would gain independence, sometimes even without war. And in the 1960s no one would have believed that the hippie organic foods and natural materials would become the luxury items in supermarkets and shops.

46 Mazzucato (2013) shows the crucial importance of mission oriented R&D in green technologies, by showing how much State funding went into the ICT revolution, as well as into biotech and nanotech.

The best of the viable futures have to be conceived and constructed boldly. Once you identify the seeds, it is important to plant and harvest them!

References

- Anderson, C. (2006) *The Long Tail*. New York: Hyperion
- Ashford, N.A., Hall, R.P. and Ashford, R.H. (2012) "The crisis in employment and consumer demand: Reconciliation with environmental sustainability". *Environmental Innovation and Societal Transitions*. 2 (2012) 1–22
- Barbier, E. B. (2010a) "Global Governance: The G20 and A Global Green New Deal", *Economics: The Open-Access, Open-Assessment E-Journal*, 4(2): 1-35.
- Barbier, E.B. (2010b). *A Global Green New Deal: Rethinking the Economic Recovery*. Cambridge, UK: Cambridge University Press.
- Bhatti, Y.A. (2012) "What is Frugal, What is Innovation? Towards a Theory of Frugal Innovation" (February 1, 2012). Available at SSRN: <http://ssrn.com/abstract=2005910> or <http://dx.doi.org/10.2139/ssrn.2005910>
- Bowes, J. ed. (2010) *The Fair Trade Revolution*, London: Pluto Press
- Cardoso, F.H. and Faletto, E. (1971:1979) *Dependency and Development in Latin America*. English translation. Berkeley, London: University of California Press
- Cole, HSD., Freeman, C., Jahoda, M. and Pavitt, KLR. (eds.). (1973) *Thinking about the Future: A Critique of "The Limits to Growth"*. London: Chatto & Windus for Sussex University Press.
- Daly, H. (2008) *A Steady-State Economy*. Sustainable Development Commission, UK. Downloaded 23/03/2014 http://www.sd-commission.org.uk/data/files/publications/Herman_Daly_thinkpiece.pdf
- Ronald Dore (1989) "Latecomers' problems" in *The European Journal of Development Research*, 1:1, 100-107
- Dosi G., Freeman C., Nelson R.R., Silverberg G. and Soete L. (eds.). (1988), *Technical Change and Economic Theory*, London: Pinter.
- Ellen MacArthur Foundation (2014) *Towards the Circular Economy Vol 3*. London: EMF
- Ernst, D. (2007) "Innovation Offshoring: Root Causes of Asia's Rise and Policy Implications" in Palacio, J. ed. *Multinational Corporations and the Emerging Network Economy in the Pacific Rim*, Cheltham, UK: Routledge.
- Ernst, D. and Kim, L (2002) "Global Production Networks, Knowledge Diffusion and Local Capability Formation". *Research Policy* 31, 1417-1428
- Freeman, C. (ed.). (1992) "A Green Techno-Economic Paradigm for the World Economy" in *The Economics of Hope: Essays on Technical Change, Economic Growth and the Environment*. London: Pinter Publishers. pp. 190-211.
- Freeman, C. and Perez, C. (1988) "Structural Crises of Adjustment: Business Cycles and Investment Behaviour" in Dosi et al. (eds.). *Technical Change and Economic Theory*. London, Pinter. pp. 38–66.
- Gutman, G., Lavarello, P. and Grossi, J. (2007). "Networking and alliances in the diffusion of biotechnology in emerging countries. The agro-food systems in Argentina". Paper presented on VI International PENSA Conference Sustainable Agri-Food and Bionergy Chains/Networks Economic and Management. October 24-26, University of São Paulo, Brazil.
- Hansen, A. (1938) *Full Recovery or Stagnation?* New York: W. W. Norton,
- Heck, S., Rogers, M. and Paul Carroll (Contributor) (2014) *Resource Revolution: How to Capture the Biggest Business Opportunity in a Century*. New Harvest
- Hobday, M. (2003) "Innovation in Asian Industrialization: A Gerschenkronian Perspective". *Oxford Development Studies*, 31:3, 293-314
- Ionescu, Adrian M., and Riel, Heike, (2011) "Tunnel field-effect transistors as energy-efficient electronic switches", *Nature* 479, 329–337

- Jackson, T. (2009) *Prosperity without Growth*. London: Earthscan
- Kaplinsky, R. (2011) "Schumacher meets Schumpeter: Appropriate technology below the radar". *Research Policy* 40 (2011) 193–203
- Kharas, H (2010) "The Emerging Middle Class in Developing Countries". *OECD Working paper* No. 285
- Lundvall, B-A, Johnson, B, Andersen E.S. and Dalum, B (2002) "National systems of production, innovation and competence building". *Research Policy* 31, 213–231
- Marciano, S., Porter, M. and Warhurst, A. (2006) *De Beers : Addressing the New Competitiveness Challenges*. Boston: Harvard Business School Publishing.
- Marin, A., Navas-Aleman, L. and Perez C. (2013) "Natural Resource Industries as a Platform for the Development of Knowledge Intensive Industries" in *Tijdschrift voor Economische en Sociale Geografie (Journal of Economic and Social Geography)*.
- Marin, A., Navas-Aleman, L. and Perez C. (2010) "The possible dynamic role of natural resource-based networks in Latin American development strategies". Globelics Working Paper 43-1, April. downloadable at: http://umconference.um.edu.my/upload/43-1/papers/292%20AnabelMarin_LizbethNavas-Aleman_CarlotaPerez.pdf (621kb)
- Mathews, J. (2013) "The renewable energy technologies surge: a new techno-economic paradigm in the making?". *Futures* 46, 10-22
- Mazzucato, M (2013) *The Entrepreneurial State: Debunking Public vs. Private sector Myths*. London: Anthem
- Meadows, D.H., Meadows, D.L., Randers, J. and Behrens_III, W.W. (1972) *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind*. New York: Universe Books.
- Minsky, H. P. (1982) "The Financial Instability Hypothesis" in Kindleberger and Lafargue (eds.), *Financial Crises: Theory, History and Policy*, London, New York: Cambridge University Press. pp. 13-39.
- Morris, M., Kaplinsky, R., & Kaplan, D. (2011). Commodities and linkages: Industrialization in sub Saharan Africa. (MMCP Discussion Paper No. 13). Cape Town, South Africa and Milton Keynes, UK: University of Cape Town and the Open University.
- Mosley, G., (2010), *Steady State; Alternatives to Endless Growth*, Sydney: Envirobook
- Murray, R. (2000) "The Socio-Economic Dimensions of Recycling Policy" in: F.Radermaker (ed), *The Consumption of Recycled Products: European Policy and Local Stakes*, Brussels.
- Murray, R. (1998) *Re-Inventing Waste*, Environment Agency & LPAC
- Murray, R. (1999) *Creating Wealth from Waste*. London: Demos
- Murray, R. (2002) *Zero Waste*. London: Greenpeace
- OECD (1995) *Niche markets as a rural development strategy*. OECD Issue 52
- Oyeyinka, O.O. and Rasiah, R. (2009) *Uneven paths to Development: Information Hardware Innovation Systems in Asia and Africa*, Edward Elgar, Cheltenham
- Perez C. (2001) "Technological change and opportunities for Development as a Moving Target", *Cepal Review* 75, 109-130.
- Perez, C. (1985) "Microelectronics, Long Waves and World Structural Change: New Perspectives for Developing Countries" *World Development* 13 (3), 441-463
- Perez, C. (2002) *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages*. Cheltenham: Edward Elgar.
- Perez, C. (2010a) "Technological Revolutions and Techno-Economic Paradigms", *Cambridge Journal of Economics*, Vol. 34, No.1, pp. 185-202.
- Perez, C. (2010b) "Technological Dynamism and Social Inclusion in Latin America: A Resource-based Production Development Strategy", *CEPAL Review*, No. 100, April, pp. 121-141.
- Perez, C. (2013) "Unleashing a golden age after the financial collapse: Drawing lessons from history", *Environmental Innovation and Societal Transitions*. 6, 9– 23

- Perez, C. and Soete, L. (1988) "Catching up in Technology: Entry Barriers and Windows of Opportunity" Dosi et al. (eds.). *Technical Change and Economic Theory*. London, Pinter. pp. 458-479.
- Perez, C., Marin, A and Navas-Aleman, L. (forthcoming 2014) "The possible dynamic role of natural resource-based networks in Latin American development strategies" In Dutrénit, G. and J. Sutz (eds), *Innovation Systems For Inclusive Development: The Latin American Experience*, Cheltenham: Edward Elgar.
- Rasiah, R., (2012) "Learning and Innovation in the Electronics and Garment Industries in Malaysia", Aman E. and Cantwell J. (eds), *Innovative Firms*, Oxford: Oxford University Press.
- Reinert, E.S. (2007) *How Rich Countries got Rich ,,,and Why Poor Countries Stay Poor*. London: Constable
- Reinert, E.S. (2012) "Neo-classical Economics: A Trail of Economic Destruction since the 1970s", *Real-world Economics Review*, No. 60 (20. June 2012). Downloaded 23-03-2014 from: <http://www.paecon.net/PAERReview/issue60/Reinert60.pdf>
- Rose, S. (1974) "The Far-Reaching Consequences of High-Priced Oil". *Fortune*, March 106-11 and 191-6
- Schmitz, H. and Becker, B. (2013) "From Sustainable Development to the Green Transformation -A Rough Guide". *Grey Literature*, IDS. March 8.
- Summers, L. (1913) "Remarks" IMF Annual Research Conference, November 8th. Downloaded 25-03-2014 from: <http://www.fulcrumasset.com/files/summersstagnation.pdf>
- UN Human Development Report (2011) *Sustainability and Equity: a better future for all*. UN Development Programme, New York, NY.
- Urzua, O. (2012) "Emergence and Development of Knowledge-Intensive Mining Services (KIMS)", *The Other Canon Foundation and Tallinn University of Technology Working Papers in Technology Governance and Economic Dynamics* (No. 41).
- Wade, R. (1990) *Governing the Market: Economic Tehory and the Role of Government in East Asian Industrialization*. Princeton: Princeton University Press
- Walker, M. and Jourdan, P. (2003). "Resource-based sustainable development: an alternative approach to industrialization in South Africa". *Minerals and Energy*, Vol. 18, No. 3, pp. 25-43.
- Warhurst, A. (2008). "How Botswana Leverages Growth". *Business Week*, April 30. Downloaded 19-07-2009 from: [/www.businessweek.com/globalbiz/content/apr2008/gb20080430_874526.htm](http://www.businessweek.com/globalbiz/content/apr2008/gb20080430_874526.htm)
- Wilson, C. and Grubler, A (2011) "Lessons from the history of technological change for clean energy scenarios and policies". *Natural Resources Forum*, 35, 165-184