

*'Modern technology is not just a collection of more or less independent means of production. Rather it is becoming an open language for the creation of structures and functions in the economy. Slowly, at a pace measured in decades, we are shifting from technologies that produced fixed physical outputs to technologies whose main character is that they can be combined and configured endlessly for fresh purposes.'*

(W. Brian Arthur, The nature of technology)

*'Comme dirait Douglas Rushkoff: "Il n'y a rien au tournant. Pas de limite à atteindre, pas d'horizon événementiel à franchir ou de moment d'innovation à espérer. Le changement s'est déjà produit ..."*

(Antoine Chainas, Versus)

*'Gegen Krisen kann keiner was!*

*Unverrückbar über uns*

*Stehen die Gesetze der Wirtschaft, unbekannte*

*Wiederkehren in furchtbaren Zyklen*

*Katastrophen der Natur.'*

(Bertolt Brecht, Die heilige Johanna der Schlachthöfe)

*'We tend to "tunnel" while looking into the future, making it business as usual, Black Swan-free, when in fact there is nothing usual about the future.'*

(Nassim Nicholas Taleb, The Black Swan, the impact of the highly improbable)

## **Long waves of innovation as turning points?**

### **Paul Drewe**

*Marchetti's version of the long-wave theory of economic development has been chosen as point of departure, not as definitive answer to our question. There are four major issues to be elucidated: the content of a next cycle; the explanation and promotion of innovation; the time horizon and the geography of innovation. At the end of the day – as many uncertainties prevail and persist – one can only resort to the management of these uncertainties.*

### **1. Marchetti's long waves: a point of departure**

*'When we cross over into a new region of time, ... the immediate past is usually a poor guide to the future, and we need to look for corresponding episodes in the more distant past.'* (Boulding, 1985: 19). That is why the study of long waves in economic development can be of importance.

*'Humanity ... seems to behave like an interconnected system learning toward an*

*objective at an extremely stable rate.'*

It is this rather abstract working hypothesis which has guided Marchetti (1980) in his attempt to reconstruct three historical innovation (invention) cycles using so-called Volterra-Lotka equations of the form:

$$\log (F/1-F) = at + b$$

with  $F$  representing the cumulative number of innovations (inventions),  $t$  referring to time, and  $a$  and  $b$  being parameters to be estimated. Take for example the 1921 wave.

The innovation cycle starts in 1921 (midpoint). It comprises 41 basic innovations among which penicillin, the radio, television, and the jet engine. Basic innovations are product innovations that start a new industry, based on related discoveries or inventions. Television, for example, was invented in 1907. It started a new industry in 1936. In 1937, half of the basic innovations had been introduced (this is referred to as the innovation center point). It took 23 years for the fraction of the total set of basic innovations implemented to increase from 10% to 90%. The same holds for the set of corresponding inventions.

The 1802 and 1857 cycles are reconstructed in the same way. They, too, resemble Kondratiev cycles with the time difference between innovation centers being 50 odd years.

Marchetti may be outspoken as a long-wave theorist, especially when compared to authors who even doubt whether the long waves exist at all. But he certainly does not stand alone as his basic argument is backed up by both theory and empirical evidence. Here are some examples.

Marchetti belongs to those long-wave theorists who consider innovation as crucial with regard to long waves or as their main cause like Schumpeter, Mensch, among others. More specifically, additional evidence is provided by the hypothesis of the life cycle of industry along a S-curve: market penetration and saturation is the cornerstoner of Marchetti's reasoning. Indeed, a series of correspondences can be identified between stages of the life cycles of technologies, products and firms or industries. Marchetti's approach is also in agreement with the (competitive) substitution model of technological change, whether applied to materials' substitution (e.g. synthetic versus natural fibers), the diffusion of the automobile or the substitution of transport infrastructures. Finally, there appears to exist a link between innovation cycles and primary energy cycles. As shown in Illustration 1, the midpoint of the innovation wave coincides both with the coal peak (saturation point or maximum market penetration) and the introduction of natural gas a new primary energy source.

Long-wave theories seem to work for the past, that is they can at least be reconstructed empirically. But what about the future? Is it possible to 'extrapolate', the coming cycle, say, the next Kondratiev? *What* could be its content? *How* does the innovation process work? *When* will it happen, and *where* will it happen?

## **2. What? The content of a next cycle**

Based on the observed historical regularities, Marchetti ventures to construct the forthcoming cycle which he assumes to have started in 1980. As to the kind of

basic innovations to be expected, there are at least some (more or less) likely candidates, i.e. innovations related to:

- information management and manipulation, including genetic engineering and its impact on new, very sophisticated as well as base chemistry (judged as obvious by Marchetti)
- management of new energy sources such as nuclear energy ('less obvious') changing to chemicals and synthetic fuels affecting the fueling of airplanes and cars
- food and agriculture (such as landless farming).

The Economist (1999) has sketched the fifth cycle, currently on its way, marked by digital networks, software, and new media. The preceding fourth cycle was dominated by petrochemicals, electronics, and aviation. So far the journalists.

What do the experts have to say about forthcoming innovations? Musso, Ponthou, Seulliet (2005, 2007) have reconstructed the history of more than 150 successful innovations. As to the future they name five families of technological products and services: intelligent houses; nomad or mobile technological objects such as ubiquitous computing; 'electronic clothing'; robotica; emotional informatics (including 'affective computing').

There are also six promising domains of innovation, identified by leading futurologists (Weissenberger-Eibl et al, 2010): solar energy (to reduce dioxide emissions); information technology (flexible screens); textiles ('intelligent clothes'); robotica; mobility (the electric car); nanotechnology.

More down to earth, the EU publishes regularly the results of European Research (*research\*eu*) in areas such as biology & medicine, energy, environment, IT & telecommunications, and industrial technologies. A closer look at the research results will tell whether we are already dealing here with innovations or only with inventions.

Then, however, Marchetti's question remains: why are some (few) inventions developing into innovations while others (most) do not?

Therefore it is time to look at the *how* of the coming cycle, a question 'blackboxed' by Marchetti.

Platt once wrote 'The solution of social problems lags behind technology because we have not organized the same sharp search for new ideas' (Platt, 1966: 132). Social problems, especially persistent ones, ask for new ideas or social innovations. The latter are not necessarily commercially successful.

At the outset, Indian entrepreneurs have found a way to create profitable innovations with few resources that help people in a sustainable manner (Pralhad & Mashelkar, 2010). Today, the so-called Ghandi innovations also hold for highly developed branches. There are three types of Ghandi innovations: use of existing technologies to revolutionize business models; combination and refinement of existing technologies and competences; purchase or development

of completely new technologies and competences. New competences have, for example, been created in the field of mobile-radio services and deep-sea drilling. IT services, health care and the treatment of herpes are examples of revolutionized business models. Emergency care is a mixed case. In the cases of mobile-radio services and IT services, technologies and competences have been purchased. With the treatment of herpes and Tata Nano car production they have been newly developed. Purchase and development hold for both deep-sea drilling and emergency care.

(Note that Marchetti did not even consider improvements of the process of production or of the quality of products as innovations).

What a next cycle may bring in social innovations, is difficult to tell. If the Indian model is going to spread, there may be more social innovations (but this already related to the geography of innovation; more about it later). Anywhere, once the need for social innovations has been widely recognized, this may already constitute a turning point. How can, for example, Europe attain a smart, sustainable and inclusive growth (see European Commission, 2010) without major social innovations?

## **How? Explaining and promoting innovation**

How to explain and foster innovation? It can be approached from two angles: from theoretical that is hypothetical relationships between presumed enabling factors and innovation – or – starting from real-world innovations, trying to reconstruct empirically the innovation process (Drewe, 2010a). The latter is a bottom-up approach: from business firms to the urban and regional context in which they operate and to the national or supranational frameworks of innovation policy. Hence the issues connected to innovation can be decided empirically such as the (relative) weight of frequently quoted critical success factors:

- universities and education
- R&D expenditures, private and public
- venture capital
- ICT
- local and transterritorial networks
- national and European framework conditions

and so forth.

One may also detect that serendipity has played an important part in the innovation process (Van Andel & Bourcier, 2009).

The approach, however, does not answer two of the questions that have intrigued Marchetti and which have been left unanswered by him:

- What causes innovation *waves*?
- Why do basic innovations come in *bunches*?

To answer these questions one must refer to a more encompassing long-wave theory such as the one that guides Gordon in his work as a consultant (<<http://www.thelongwaveanalyst.ca>> ). Gordon divides each cycle into four seasons (translated from Schmidt, 2010):

*Kondratiev Spring:* after a phase of debt reduction, the economy reawakens. The mood is optimistic, but credit (both supply and demand) is handled with care. Credits are mainly provided for investment.

*Kondratiev Summer:* credits expand, inflation sets in, and raw materials become scarce which often leads to distributional conflicts.

*Kondratiev Autumn:* the stringency of raw materials comes to an end. The paper value of bonds, shares and real estate is rising. Consumer and public debt, however, is exploding.

*Kondratiev Winter:* the time has come for debt reduction. Stock exchanges crash and deflation sets in. Cash becomes more important than shares. Massive bankruptcies make that the economies enter a phase of deflation.

According to Gordon, its '*winter time*' now. The existing financial system goes bankrupt. A small slot remains in which new solutions can compete with old paradigms. Even without the seasonal metaphor, Gordon's approach allows to embed innovation in a broader economic, in particular financial context. Innovation waves and bunches of basic innovations like Bandini, 'must wait until spring'.

## **When – The time horizon of the next wave**

When will the next cycle happen? Are we any good in predicting it?

*'All together I think the idea of 55 year cycles in the behavior of our society is one of the most penetrating and useful in organizing social and economic facts. Together with the innovation-diffusion concept that we are currently using, it provides a most crisp and internally consistent description of human affairs'* (Marchetti, 1988: 7).

If, according to Marchetti, the forthcoming long wave has started in 1980, then we are going to end up in 2035. With Gordon, a new upward swing is about to start in 2020-2025.

These time horizons are challenged by those who claim that they are either

shorter or longer.

The Economist (1999) argues that the long waves of industrial innovation are becoming shorter, say, 30-40 years, thanks to increased R&D efforts. On the other hand, the historian Morris 'shows that over a period of 10,000 years one civilization after another has hit a "hard ceiling" of social development before falling apart, unable to control the forces its success has unleashed' (Economist, 2010 introducing Morris' latest book). What he calls the five horsemen of apocalypse (climate change, famine, migration, disease and state failure) played an important part in this. Morris expects that 'Western "rule" will end early in the next century'. 'There is, on the other hand, 'a real possibility that we fail to negotiate even the next 50 years without triggering environmental catastrophe, global pandemics or nuclear war' (Economist, 2010). But somehow one gets the impression that Morris' patterns of history are like a 'hammer', that is a tool treating the future as a 'nail'.

Morris' book is entitled 'Why the West rules for now' (Morris, 2010). This brings us to the where of the next wave.

## **Where or the geography of innovation**

Marchetti completely ignores the geography of innovation.

Why do innovations do or do not happen in certain countries, regions or cities? Some are leading, some are average, some are catching up just losing ground. A sound bite, often used today, is 'the world is not flat'. For a detailed analysis of development disparities at international, national and local scales see The World Bank (2009).

Innovations need to be identified, first of all, at the level of individual business firms. One can then aggregate them at regional, urban or national levels. This is where the geography of innovation comes in. Economists use macro, meso and micro levels of analysis. The parameters of macroeconomic models may be mistaken for explanations of the behavior of companies (or of consumers for that matter), committing a fallacy of disaggregation. Or this behavior can be mistaken as representative of macroeconomic phenomena which is a fallacy of aggregation. One could even say that the aggregate that we call national economy is, at least to some extent, a construct whereas the 'real' economy is happening in cities and regions. If this is the case, where do nations or, say, the European Union come in? It depends on whether they can act as motors of innovations at firm, regional and city levels, creating effective framework conditions, including financial support. What about the impact of the National Knowledge Commission

India (or India's science and technology policy for that matter), a generous R&D budget in China, national innovation platforms made in Finland, 'Europe 2020' and the like?

China and India are expected to be the principal players in the next cycle in the field of health care, solar technology, bionics, nano machines, space stations and so forth (Schmidt, 2010).

Increasingly, the *where* of the next cycle is linked to processes at world level in terms of the geography of world power. Mahbubani (2008) writes about 'the irresistible shift of global power to the East'. He also sketches three scenarios for this:

- *'The March to Modernity'* (which he considers as both 'happy' and probable)
- *'Retreat into Fortresses'* (less happy, less likely)
- *'Western Triumphalism'* (most unlikely)

What is at stake here is global leadership and the new principles of global order: democracy, rule of law, social justice, partnership and pragmatism. Note that the implementation of these principles constituted major social innovations taking precedence over technological innovations in the next cycle.

The discussion involves the position of the US and of Europe and their mutual relationship. Can they improve their position through cooperation or does a *Chacun pour soi* rule? The Atlantic Community rather seems to be a wild-goose chase between, on one side, a *'Sarah Palin for President'* scenario and the question *'Quo Vadis Herman van Rompuy?'* (Drewe, 2010b) on the other.

After the failure of the Lisbon strategy, the EU has launched 'a strategy for smart, sustainable and inclusive growth'. But the Commission has to admit that the future is uncertain by sketching three scenarios for Europe by 2020 (European Commission, 2010: 7):

- *Sustainable recovery*: Europe is able to make a full return to earlier growth path and raise its potential to go beyond
- *Sluggish recovery*: Europe will have suffered a permanent loss in wealth and start growing again from the eroded basis
- *Lost decade*: Europe will have suffered a permanent loss in wealth and potential for further growth

Only the *'sustainable recovery'* scenario rhymes with a next wave of innovation. It requires what Verhofstadt (2006) has called five missions for

a new Europe: a

- European social and economic strategy
- new European technology wave
- European space of freedom, security and justice
- European diplomacy
- European army

This calls for a '*vision commune*' in order to produce a turning point. See the Spinelli manifesto: <<http://www.europeecologie.eu>>

However, Europe today, at least for the time being, has rather embarked on a 'National preference' scenario (Drewe, 2006; Crozet & Musso, 2003).

### **Conclusion: plea for an uncertainty management**

The long waves of innovation offer interesting avenues of thought concerning content (what?), innovation process (how?), time horizon (when?), and geography of innovation (where?). But all this is not really conclusive. Major uncertainties prevail and persist. It is time to rediscover the management of uncertainty, an approach that goes back to spatial planning in the UK in the early 1970s (see for example Friend, Power & Yewlett, 1974).

The authors distinguish three types of uncertainty:

- *uncertainties about the operating environment*
- *uncertainties about related choices*
- *uncertainties of policies*

One might also add a fourth type: *uncertainties about means*.

Once the uncertainties have been diagnosed, there are two options:

- they can be *reduced*
- or they must be *accepted*

Reductions depend on the type of uncertainty:

- more research or investigatory activities in the case of uncertainties about the operating environment ]; these activities should include scenario building (Drewe, 2006); as far as economic research, leave alone economic predictions, the mainstream, neoclassical economics can hardly show the way when it comes to reduce uncertainty (Keene, 2008)
- policy clarifying activities when clearer objectives or policies are needed, for example, as far as the European Union is concerned, a *vision commune*
- a more strategic view or coordinated approach: after exploring a problem in a wider context, this can lead to partnerships (see e.g. Mahbubian)
- more means, financial and others (in the case of *Europe 2020*, the

considerable budgets research, stimulation of companies, and regional development – hitherto separated – must be coordinated, focused on innovation

But not all uncertainties can be reduced. Some must simply be accepted. However, instead of doing nothing and running the risks, one can strive for built-in flexibility of the decisionmaking process and the policy decisions themselves.

*'Change is caused by lazy, greedy, frightened people looking for easier, more profitable and safer ways of doing things. And they rarely know what they are doing'* (Economist, 2010).

This 'Morris Theorem' invites defeatism as far as turning points are concerned. Let us rather try to manage the uncertainties here and now.

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