Surfing the Sixth Wave

By Stephen Aguilar-Millan

Introduction

Given a sufficiently long perspective, it is possible to identify a number of long-term trends in the development of technology. We like to view these as a succession of long waves of technological advancement, but, in reality, this imagery is deceptive. Whereas ocean waves will break and recede, waves of technology will do neither. Technological advancement is additive: New waves add to what has come before. This produces rich and layered strata of technology that result in a view of progress that is continuous. Although we might think of new waves of technological development as separate units, we also need to recognize the threads of continuity that are present.

Different disciplines bring different approaches to the long waves of technological development. For example, we all have heard of 'the information revolution', but what exactly does that mean? To a technologist, it might mean the process of coalescing by which a number of complementary technologies have allowed us to collapse time and space through the development of the Internet. Few would disagree with this view. However, to a futurist, the information revolution might represent something rather different. It could equally be seen as a process whereby a long wave of technology has been deployed to shape the society, the economy, and the politics of the modern world.

The difference between these two positions is that the technologist might look at the agent of change (the Internet), whilst the futurist might take a longer perspective to contextualise the change in terms of its impact (shaping the modern world). Both positions, though, see the chain of events as a process.

If we see technological development as a chain of events, where one innovation leads to another, then we can think of a long wave in systemic terms. This describes a pattern of developments that interact together to become a dominant technological paradigm. When we distil this paradigm into its essential core, we are left with a model describing the long waves of technological development.

The purpose of this piece is to consider the evidence that argues for the existence of long waves of technological development, describe the underlying model implicit in this evidence, and to consider how the wave diffuses itself over time and space. With this theoretical model to hand, we can then use it to provide a long term perspective on current events, and more importantly, use it to suggest how our immediate futures are likely to play out. We might then draw a number of tentative conclusions.

The Existence of the Long Waves

The possible existence of long waves in the economy was first drawn to our attention by Nicholas Kondratieff in the 1920s. Kondratieff noted that the economy appeared to follow long alternating cycles of relative activity and inactiv-

Stephen Aguilar-Millan is director of research at the European Futures Observatory, and a Director of The Greenways Partnership, a firm of consulting futurists, both based in the UK. He is the president of the Europe Chapter of the World Future Society and can be reached at stephena@eufo.org.

ity each lasting about 50 to 60 years. He did not make the key link between economic activity and technological development.[1] This was done by Joseph Schumpeter, who noted that periods of relatively high economic activity coincided with periods of rapid technological advance, and that periods of relative economic inactivity coincided with periods of relative technological stagnation.

But while Schumpeter made the key link between economic activity and technological development, he did not propose a model of causality to describe the relationship between the two.[2] This theoretical underpinning was provided much later by Carlota Perez, who has gone a long way in developing the fully functioning model that we shall describe later in this piece.[3] For the moment, however, we are getting ahead of ourselves and need to examine why it is that Kondratieff, Schumpeter, and Perez all believe that there are long waves of economic activity and technological development.

England was the first country to industrialize, beginning in the 1770s. The new knowledge gained from the scientific revolution was put to use in commercial applications as the country moved from being primarily agricultural to being the first manufacturing nation in the world. Between 1770 and 1800, it is estimated that UK GDP rose by 24%. This may not sound like much, but during the period 1700 to 1770, roughly three times as long, UK GDP only rose by 19%.[4]

The contribution made by the output of industry and commerce was significant. Between 1770 and 1800, this output rose by 94.4%—almost doubled. The emergence of this first wave of technological advance, based upon the use of canals to transport goods and of water as a source of power, provided the platform upon which later British economic strength developed. The eruption of this new wave was brought to an abrupt halt in 1797, when the financial bubble in canal financing that had been underway since 1793 suddenly burst.

The second wave of technological advance—the age of steam and rail—can also be traced to Britain, and dates from the 1820s. It is associated with the development of technologies around steam power, their use in transportation (especially railways), and in industrial organization (the development of the factory system). Between 1826 and 1846, the authorized capital of railway companies in Great Britain rose from £4 million to £207 million.[5] During this period, UK GDP rose by 79.7%, more than three times that achieved in the first wave of technological advance. Needless to say, the second wave as well ended in a financial crisis.[6] The railway panic of 1847 saw the end of speculation in railway shares and brought to a halt the rapid advance of the second wave.

The third wave is generally dated during the 1870s, and is seen as the age of steel, electricity, and heavy engineering. It is associated with the development of the metallurgical technologies that allowed for transcontinental transport and communications. It is an era of the first steel-hulled ships, refrigeration, and the telegraph. By this time, Great Britain had lost its industrial dominance and been supplanted by Germany and the United States. This was the second era of globalization, and when the surge of innovation ended with the Long Depression of the 1890s, the impact was global in scale.

Peculiarly, the fourth wave is usually seen as having begun in the 1910s, about 10 years earlier than expected. It is associated with the development of the technologies of oil, automobiles, and mass production. This was an era when highways were built across North America and Europe, when air travel came into being, and the shape of modernity was developed. During this period, the United States became the dominant industrial force. The expansive part of the fourth wave came to an end with the great Depression of the 1930s.

The fifth wave started in the 1970s. It is the information revolution, and it has had a profound effect upon the social and economic structure of

the world over the past 40 years. This has seen the digitization of the economy and a revolution in global communications. It has also resulted in the third era of globalization. The "Dot Com Crash" of 2001 marked the end of the expansion of the fifth wave and brings us close to the present.

If our model is valid, then we can expect a sixth wave of technological advancement to commence developing sometime in this decade, and for it to fully take off in the 2020s. As we will consider in greater detail below, we anticipate that the focus of the sixth wave will be the technologies of scarcity, and that it will end, like all expansionary stages, with a financial crisis sometime in the 2040s. If we are right, then the five waves that we have seen so far all follow a similar pattern, which we can apply to what we would expect to happen during the sixth wave. This familiar pattern is the model of a long wave of technology, to which we now turn.

A Model of a Long Wave

The five long waves that we have seen so far all follow a similar pattern. The wave starts with an Installation Phase of about 20 to 30 years, where the technology fully evolves and is refined into something like a mature product. The Installation Phase consists of two stages: the Eruption Stage and the Frenzy Stage. As the name suggests, the Frenzy Stage usually results in an unsustainable financial bubble, the bursting of which—called the Crisis of Maturity—marks the end of the Installation Phase. The Crisis of Maturity normally lasts seven to 10 years, and it sets the scene for the Deployment Phase as the technology matures.

The Deployment Phase likewise has two stages: the Synergy Stage, which is something of a golden age for the technology involved; and the Maturity Stage, where the technology starts to become all pervasive. It is at that point that we need to look for the early development of the subsequent wave. It is worth considering each of these stages in turn.

The Eruption Stage normally starts with a "Big Bang" of some sort. In the case of the fifth wave, the Big Bang is normally identified as the invention of the Intel 4004 microprocessor in 1971. During the Eruption Stage of the Installation Phase, the core technology becomes further refined and normally incorporates several complementary technologies that provide a synergy with its main use. For example, there is a huge leap between the Intel 4004 microprocessor of 1971 and the Internet as we know it 40 years later. That leap contains decades of refinement of processing capacity, both in terms of speed and memory; the development of screen technology away from cathode ray tubes to LCD flat screens; the development of telephony away from copper-based cable to wireless, fibre-optic, high-speed broadband; and the development of keyboard technologies that allow for touch-screen data entry.

Although a wonderful new technological paradigm is in development, the technology of the previous wave is still dominant. The core of the new wave is still too new and immature to be fully understood. For example, although substantial advances were being made in microelectronics (the fifth wave) in the 1970s, that decade was still dominated by the mature technologies of automobiles and mass production (the fourth wave). As the new technology evolves and matures, it obtains a higher return on investment than is enjoyed by the more mature technologies, thus attracting additional investment funding.

The attraction of additional investment funding marks the move away from the Eruption Stage to the Frenzy Stage of the Installation Period. It is during this period that the technology becomes less off-beat and more mainstream. If we think back to the late 1970s and the early 1980s, we can recall being aware that something was changing, even if we couldn't precisely say what it was. Personal gadgets were getting smaller (the Sony Walkman dates from 1978), desktop computers

were starting to appear in offices, and the deregulation of telecommunications (British Telecom was privatized in 1984) made inter-continental communications cheaper, faster, and of far better quality.

It is at this point that the real economy and the financial economy start to become detached from each other. As profits grow, and as investment in the new wave of technologies become more fashionable, the valuation of companies in the financial economy become divorced from their fundamental valuations in the real economy. The financial bubble continues to inflate until it becomes apparent that the earnings enjoyed in the real economy cannot support the valuations created in the financial economy. At that point, the bubble bursts, and the Crisis of Maturity is upon us.

It is easy to argue that the "Dot Com Crash" of 2001 started the Crisis of Maturity for the fifth wave. It had quite a similar profile to the Great Crash of 1929 (which started the Crisis of Maturity of the fourth wave), and the Railway Panic of 1847 (which started the Crisis of Maturity of the second wave, and which was well described by Charles Dickens[7]). It is during this period that valuations of the financial economy start to realign with what the earnings in the real economy can sustain.

A great deal of wealth is lost in this phase—a period of creative destruction, according to the Schumpeter model—but it does represent an essential rebalancing of the economy in favour of the new technology and away from the old technologies. We would argue that we are currently at the end of the Crisis of Maturity of the fifth wave. The old companies of the fourth wave—the automobile firms, airlines, and industrial conglomerates—are now going the way of the dinosaur companies of previous waves. This is making space for the new companies of the fifth wave as they begin the process of maturing.

As the economy moves out of the Crisis of Maturity, economic recovery incorporates the new technologies as these start to be more widely deployed. This is the second part of the wave: the Deployment Phase. The Deployment Phase begins with a Synergy Stage during which larger companies begin to assimilate the new technologies. The process of coalescence and consolidation sees a falling away of profit margins, which is more than compensated for by the expansion of the sales base. The Synergy Stage is often seen as the golden age of the technology.

That would imply that we are about to see the golden age of the Information Revolution, something akin to the Great Victorian Boom of the 1850s and 1860s, or the Belle Epoch of the 1900s. Whether or not this will be a particularly prosperous time remains to be seen, as the golden age of the fifth wave could follow the path of the first wave—a golden age with very little general prosperity.

The key to the Deployment Phase is that the pace of technological innovation slows. During the Synergy Stage, momentum is maintained through the consolidation of technologies and companies associated with the technology. However, that process has its limits, and when these are reached, the final Maturity Stage commences. Once the technology reaches full maturity, returns diminish—possibly even turning negative—as commoditization begins. The key to financial success in the Maturity Stage is cost control and capturing market share. Customers are likely to become very price-sensitive as the technology becomes ubiquitous. As this happens, the economy comes off the boil, and the scene is now set for the eruption of the subsequent wave.

How the Wave Diffuses

The model described in the previous section abstracts itself away from both time and space, in that it doesn't say where and when these processes might occur. Before we apply this model to the world in which we live, where time and space *do*

matter, we ought to consider the issue of diffusion through time and space.

Not all places experience each wave in equal proportions at the same point in time. There are remote parts of the world which have yet to experience the first wave, let alone any others. The more remote parts of Papua New Guinea spring to mind here. Equally, not each wave is necessarily experienced sequentially. For example, one could argue that some parts of India are experiencing the fifth wave—the information revolution—while the nation as a whole has yet to fully experience the third wave (the age of electricity) or fourth wave (the age of mass production), being stuck in the second wave (the age of steam and railways). The point I am making is that the diffusion of the various waves of technology is far more complicated than the basic model suggests.

Each wave tends to have a single epicentre. For example, we could well argue that the epicentre of the fifth wave was Silicon Valley in the United States. We could equally argue that the epicentre of the first wave was in northern England, and so on for each successive wave. It is not uncommon for the core technologies of the wave to be developed at various locations before fusing together and erupting into the Installation Phase.

There is, however, commonly a geographical coalescence of that preliminary work in one single area before the Eruption Stage becomes evident. Generally, a cluster of similarly occupied agents of a given technology forms—that is, individuals, companies, and public authorities—and these interact with each other, normally in a commercially competitive framework, to provide the boost that is required to achieve liftoff for the technology. For example, in the first wave, not only were the majority of the technological agents located in northern England; they were also connected through religious and family ties, which gave a form of social cohesion to the industrial community that they formed.[8]

Many policy makers around the world have learned this lesson, and have directed policy towards attracting and nurturing a technology cluster in their jurisdiction. We think of Palo Alto as being such a market-based technology hub. However, this is not the only model, and we could point to Sophia Antipolis in France as an example of a world-class technology hub that the public sector created and nurtured. In both cases, the technological community has been encouraged to locate in that area, to their mutual benefit and the benefit of the hosting public authority.[9]

In many respects, this defines the Eruption Stage of the Installation Phase. It is a process where a number of nebulous technological communities struggle to become the dominant paradigm for the emerging technology. They do so through the formation of industrial clusters based around the emerging technology. These clusters are the epicentres of the various technological waves. Eventually, one cluster will come to dominate all others, for whatever reason, and will shape the emerging technological paradigm. As it does so, others look to follow its example.

When this happens, we start to move from the Eruption Stage to the Frenzy Stage of the Installation Phase. We have reached a point where locations do not wish to compete with the epicentre of the newly emerging paradigm, but to copy it. For example, in the fifth wave, after Silicon Valley in California had established itself as the epicentre for the emerging technological paradigm, a host of imitators arose around the world. We had "Silicon Alley" in New York, "Silicon Fen" in eastern England, "Silicon Roundabout" in London, and so on. All of these were pale imitations of the original Silicon Valley. However, they did serve to diffuse the technology in their various localities.

Normally, the process of diffusion of the technology happens at a much faster pace than the development of the technology. After all, the trial-and-error aspect of developing the technology need not recur. However, the diffusion process does have

to travel much further, depending upon the degree to which the new technology gains acceptance and the degree to which it is perceived as revolutionary. There is an argument that, in modern times, the process of diffusion has occurred at a more rapid rate owing to the degree to which the global economy is presently more integrated than in earlier periods in history. There is something to this argument, as long as it is not taken to the extreme. In our modern word, we forget the revolutionary impact of refrigeration combined with steamships upon the global food supply chain. This was a major advance within the third wave.

As we would expect, the impact of the new waves is felt first in the more developed areas of the world. This is because those parts of the world have an infrastructure legacy onto which the new technologies can be overlaid. For example, one could argue that the thing that prevents India—and to a degree, China, as well—from experiencing the fourth wave (the age of the automobile and mass production)—is the lack of a road infrastructure suitable for the motor car and for lorry-borne freight. Until this infrastructure is put in place, the development of those areas affected will be held back.

The direction of policy is to free the area from such an obstacle. When this happens, the resulting process of catch-up can be very rapid, and the results startling. It would appear that an economic miracle is occurring over a short period of time, whereas what is actually happening is a rapid process of catching up.

For example, in the case of Japan, the process of catch-up occurred between 1960 and 1975. As Japan caught up with the third and fourth waves, it experienced growth in GDP of not less than 5% a year, and even as high as 12% in some years (the average was 10% a year). It appeared as a miracle. However, by the mid-1970s, the process of catch-up was slowing down. Japan had caught up. Between 1975 and 1990, Japan experienced growth of 3%-5% a year (the average was 4% a year).[10]

The process of diffusion normally comes to an abrupt halt caused by the Crisis of Maturity. The history of the second wave provides an interesting case study on the diffusion of a technology. The epicentre for rail technology was England. In 1847, at the peak of the Frenzy Stage, there were 6,455 miles of rail under construction. Then the financial bubble burst in 1848. By 1857, only 1,004 miles of rail were under construction.[11] In England, this was a maturing technology.

In France, Germany, and the United States, this was a technology yet to be deployed. Peak rail growth occurred in France and Germany in the 1850s. In the United States, it was the 1870s and 1880s. While the crash of 1848 brought the Frenzy Stage in England to an abrupt halt, it didn't stop the Frenzy Stage elsewhere. At that point in time, the global financial markets were not very mature and not very sophisticated compared to today, which meant that financial contagion in one economy did not necessarily spread to all economies. Trade may have been affected, but trade only counted for a small part of GDP at that time.

The Crisis of Maturity may see a sharp downturn in economic activity that could last for up to a decade. Yet sooner or later recovery, gets under way, and the technology enters its Maturity Phase. The first part of the Maturity Phase is the Synergy Stage, where the technology is replicated as far and as widely as possible. In some respects, this represents a process of imitation rather than innovation. The Crisis of maturity has destroyed so much capital that funds for innovation are a lot harder to access. However, funding to grow a proven technology is available, and the replication of the technology grows either by companies imitating what has been successful elsewhere (other motor manufacturers follow the Ford method of organization), or by the original companies relocating (e.g., Ford moves to Europe).

As the Maturity Phase progresses, the emphasis is less on invention and innovation, and more on increasing market share. This spreads

the technology into tertiary and quaternary markets. In our own time, it gives rise to the peculiarity of high-performance cars being sold in countries that don't have the roads on which to drive them. In this case, the secret to the successful longevity of the technology is the ability to lower costs. If cost is lowered sufficiently, then the technology will become ubiquitous and all pervasive as it rests in the Maturity Stage of the Maturity Phase. This is the point, for example, when most communities in the world have access to a TV or a mobile phone. This is the maximum point of diffusion, beyond which lies the incorporation of the technology into subsequent technologies.

Where Are We Now?

In many ways, the usefulness of futuring is its ability to help us to contextualize the present into a longer inter-temporal story. If we have the right context, then we will be able to anticipate the future with much greater confidence. At the moment, we are suffering a severe downturn in economic activity, most of the developed world has an enormous debt overhang, we face the prospect of acute resource scarcity as population growth encounters "Peak-Just-About-Everything," and the prospect of disruptive climate change hovers over us. It is at this point that it becomes comforting to know that our model, based upon our previous experiences, can explain this and shows us a way out of our present situation.

We are of the opinion that, in 2012, we are currently coming out of the Crisis of Maturity of the fifth wave of technology. The crisis started with the financial recession of 2001 and continued along to the downturn that we are currently experiencing. Exactly when we should date that is a matter of conjecture, but we prefer the collapse of Lehman Brothers in 2008. In many respects, that marked the turning point because it abruptly halted the Frenzy Stage of the fifth wave. We are now moving into the Maturity Phase of the fifth wave.

Much of this decade and the next will be dominated by the unravelling of the indebtedness in which many companies, households, and nations now find themselves. In this environment, the funds available for further invention and innovation in the fifth wave are likely to be quite restricted. We may see the occasional flurry of activity in the latest hot thing (the floatation of Facebook springs to mind here), because the Frenzy Stage will continue to spill into the Synergy Stage, but, as times goes on, these bouts of frenzy will become less frequent.

The key to growing a technology will be to replicate it into markets in which it currently has little standing—Africa springs to mind as having enormous potential in this decade—but only by bringing down the cost to the consumer and enhancing the functionality of that technology.

For example, we often ask our interns whom they think will be the largest bank in Africa in 2020. It is a trick question because we feel that the largest bank in Africa in 2020 will be a company that isn't a bank today. A company such as Vodaphone, which owns the M-Pesa mobile phone payments system, is a far better candidate than any of the current banks. This gives an idea about how an existing technology—mobile phones—can be spread into relatively under-developed markets, such as Africa, to disrupt and transform existing business models.

At some point in the decade after this one, the tempo will change to where smarter phones are less attractive than cheaper phones. We can liken it to the point in the 1980s where cars stopped being "sexy" and started to become "efficient." This will mark the point at which the fifth wave moves from the Synergy Stage to the Maturity Stage, and mobile connected devices will become ubiquitous.

This ubiquity will not be felt equally across the globe at the same time. We can expect Europe, North America, and the more highly developed parts of East Asia to experience it first. Within

this timeframe, the key uncertainty is whether or not China has completed the process of technology catch-up. If it has, then it will act as a key driver of volume in the market. If it hasn't, then it will drive the market to solutions that highlight value over elegance.

As the fifth wave heads towards volume over innovation, the world economy will start to hit the constraints placed by finite resources on this process. Resources are set to become the limiting factor. We have already experienced a glimpse of this future in recent years. The spiking of oil prices at over $140 per barrel in 2008 was, in our opinion, a foretaste of the future. At the same time, the prices for a wide range of commodities—both hard commodities (e.g., copper, nickel, iron, etc.) and soft commodities (e.g., wheat, rice, cocoa, etc.)—also spiked in price. These price spikes were driven by demand. While the fifth wave rolls out across the globe, the supply of resources remains relatively fixed. Thus demand is set to grow significantly, particularly in the newly emerging nations. It is quite likely that growing resource scarcity will provide the impetus for the sixth wave to form.

Where Are We Heading?

The role of price inflation in spurring technological change is often overlooked. The case of the fifth wave is instructive here. The fourth wave—The age of oil, automobiles, and mass production—had the effect of raising income and living standards in the United Kingdom from the 1950s onwards. And yet, the benefits of those rising living standards were not enjoyed fully across all of society. The middle class did quite well in the 1950s and 1960s, but the British working class didn't quite share that enrichment. This was the basis of the UK trade-union militancy in the late 1960s and 1970s. During this period, a massive wealth transfer occurred in the country from the middle class—particularly the rentier middle class—to the working class through the means of wage inflation.

However, the process of wage inflation was ultimately self-defeating. As the cost of labor increased, so the incentive for organizations to use labor-saving devices also increased. This provided a major boost to the forming fifth wave. We now conceive of the fifth wave as an age of information and telecommunications, while forgetting that the first instance of the fifth wave was in the form of robotics and industrial automation. The economic downturn of the early 1980s led to a shakeout of blue collar employment as a result of industrial automation. However, the fifth wave continued by facilitating the automation of work that was traditionally office based. Hence the downturn of the early 1990s was the first shakeout of white-collar employment. Labor had become sufficiently expensive, and machinery had become sufficiently productive, to change the nature of employment.

We can reasonably expect a similar process to happen in the decade after this one. As the debt overhang of the fifth wave starts to be rebalanced, the financial economy will start to become more realigned with the real economy. This realignment is the basis upon which recovery will occur. As it does, we can reasonably expect the imbalance between the supply of global resources and the demand for them to begin to push up their price. This supply-led inflation is significant because it will be the stimulus for the sixth wave.

In the face of a long trend of rising prices for a key input, organizations can react in a number of ways. To begin with, they can ration the use of that resource. However, this is a solution that only makes sense in the shortest of terms. A response in the medium term would be to find a way to absorb those rising input costs, possibly by passing them on in the form of higher prices. This is the familiar price spiral that leads to a more general inflation. Beyond this, organizations could try to find an alternative supply of that resource, which is much of the logic behind China's recent acquisition of resources on a global scale. Finally, the

organization could adopt a technology that uses less of that resource per unit of output. This is what we call the "Technology of Scarcity," and is what we believe will be the impetus for the sixth wave of technology.

There are many dimensions to this sixth wave. For example, current motoring technology places before us the prospect of cars that deliver 120 miles per gallon by 2020. Sixth-wave technologies would look way beyond that to cars that can deliver 200 miles per gallon and more. Alternatively, global demand for food is set to increase by 50% by 2030, but our ability to meet this demand is bounded by the availability of water. Sixth-wave technologies would be set to focus upon the development of drought-resistant, water-retentive crop strains that have the impact of increasing crop yields dramatically. What is common to the technologies of the sixth wave is the issue of sustainability.

At present, the dominant paradigm for the sixth wave has yet to emerge. While no single technology is dominant, we can reasonably expect it to represent a combination and fusion of four current technologies: nanotechnology, biotechnology, information technology, and cognition technology.[12] We can expect the profile of the dominant technology to be small, organic, information rich, and smart. At the moment, the sixth wave is at the pre-eruption stage, where funding and developments in each of these four categories is discrete. When the categories start to interplay with each other, the technology will have started to move to the Eruption Stage of the Growth Phase. We expect this to occur at some point in the decade after this one.

Exactly where the epicentre of the technology will be is hard to see at the moment. The two competing locations at present are Europe, which probably has the edge right now; and North America, which has the capacity to catch up with Europe very quickly and to overtake it. There is an outside possibility that East Asia could also act as an epicentre for the sixth wave, but we don't see this as a realistic possibility at this point in time. For us, East Asia is likely to be too preoccupied with catching up with Europe and North America—especially in terms of infrastructure development—to be able to take the lead.

This matters greatly because the epicentre of the technology will define the nature and organizational structure of the sixth wave. For example, the language of the Internet is English mainly because Silicon Valley was the epicentre of the fifth wave. It is governed through U.S. institutions and reflects American views on the freedom of speech and individual liberty. Had the epicentre of the fifth wave been elsewhere, say France, then we would have today a very different Internet to the one we currently see. This is why public policy around the world is attempting to steer the sixth wave into their jurisdiction. The authority that contains the epicentre will be able to dominate the business environment for two to three generations.

Europe currently has the lead because the European Union first developed a vision and a strategy to capture the sixth wave—the much-derided Lisbon Strategy. From that, it developed a policy framework designed to steer the development of science and technology onto the sixth wave. This has resulted in a number of painful and costly changes to the way in which business operates in Europe, the latest of which is the air transport industry becoming part of the Emission Trading Scheme for carbon emissions. It currently has a 10-year lead over the United States, but the United States could catch up with Europe's lead and overtake it, given sufficient political will. A start has been made under the Obama administration, but that process of catch-up may not survive a change of administration in 2013.

At present, the recession has put to one side the development of the sixth wave. The development does continue, but at a much subdued pace. As the global economy moves into recovery later

this decade, that pace will pick up. Commodity price inflation will be a key trigger for the quickening of the pace of invention and the subsequent diffusion of the new technologies. Sustainable innovation will be the key to profitability within this paradigm, and experience suggests that it will be taken up with relish.[13] Eventually, as the sixth wave moves from the Eruption Stage to the Frenzy Stage sometime in the 2030s, we can expect the financial economy to become detached from the real economy—yet again—resulting in the Crisis of Maturity of the sixth wave, sometime in the 2040s.

Conclusions

In this piece, we hope to have shown that there is a longer-term context to our current economic predicament. By adopting a model of long-term waves of technology, we can understand how a long wave develops and diffuses. The usefulness of this approach is not only its ability to help us understand our current position, but also to help guide us in our thinking about how the future might unfold for us. This is useful conceptually, but also in terms of developing timelines for the future and thinking about *where* the future will occur. In our opinion, that is absolutely crucial to the formation of policy.

Policy directed at the future is all about finding a point where time and space coincide with longer term trends, and then organizing efforts to achieve that congruence. To do this, policy makers need a conceptual framework of the future. It is our belief that the concept of long waves of technology does this, and as such, deserves attention.

The model we have described alerts us to the possibility of a lessening pace in the information revolution in the coming decade, the possibility of resource-led price inflation towards the end of this decade, and investment opportunities in the technologies of scarcity in the decade beyond this. We hope that this information may be of benefit to those organizations upon whom we all rely. Indeed, all of our futures depend upon it.

References

1. For an introduction to Kondratieff Cycles (also spelled Kondratiev), see *The Kondratiev Cycle: A Generational Interpretation* by Michael A Alexander (Universe 2001).
2. See *Capitalism, Socialism, and Democracy* by Joseph A. Schumpeter (Pober Publishing 2010) for the key idea of 'creative destruction.' A more interesting compilation of readings can be found in *The Economics And Sociology Of Capitalism* by Joseph A. Schumpeter, Ed. Richard Swedberg (Princeton 1991).
3. See *Technological Revolutions And Financial Capital: The Dynamics Of Bubbles And Golden Ages* by Carlota Perez (Edward Elgar Publishing 2003).
4. Data is obtained from *British Economic Growth 1688-1959* by Phyllis Deane and W. A. Cole (Cambridge 1969). The growth figures are derived from Table 19 on page 78.
5. Deane and Cole, op. cit. Table 59 on page 231.
6. Deane and Cole, op. cit. Table 37 on page 166.
7. See *Hard Times* by Charles Dickens (Penguin 1995) for an account of the economic collapse following the railway boom in England.
8. See *Religion And The Rise Of Capitalism* by R. H. Tawney (Pelican 1975) for an account of the significance of a socially cohesive group in launching a new technological paradigm.
9. See *The Competitive Advantage Of Nations* by Michael Porter (MacMillan 1990), which is regarded as the standard textbook for the development of industrial clusters.
10. Source: The European Futures Observatory, using World Bank and IMF historical data.
11. Deane and Cole, op. cit. Table 60 on page 232.
12. See *The Extreme Future* by James Canton (Plume 2007) for a good exposition of how the NBIC technologies are developing off each other.
13. See *Sustainable Innovation* by Dorothea Seebode (Philips Research 2006) for an interesting example of how one corporate giant plans to capture this wave. Alternatively, see *The Sixth Kondratieff—Long Wave Of Prosperity* (Allianz Global Investors 2010) as an example of how innovation funding is being channelled in this direction.