Chapter 7

Technology and Society

Considering that the title of this book is *From Need to Greed*, we shall define these concepts first, even at the risk of repetition. Need is the requirement for the availability of conditions and technologies that enable human life to exist at a basic subsistence level. Needs are satisfied by basic essentials, such as basic food, shelter, clothing and clean water. According to circumstances, the list may be extended to include cooking facilities and some kind of heating in cold climates. If we wish to be slightly more generous, we may include a requirement for basic education and health care. What we regard as basic varies with social development. What is basic now was extremely luxurious, indeed non-existent, in earlier times.

Greed, at the other extreme of the scale, drives our desire for possessions and material satisfactions well beyond what is necessary for survival. Purchases of luxuries are driven by greed. Thus purchases of expensive jewellery, meals in expensive restaurants, holidays in luxury hotels, ownership of yachts and luxury cars or private jets are all driven by greed. The desire for personal prestige and power can also be partially satisfied by purchases of luxury goods.

In the continuum of gradations between need and greed we may introduce the concept of want, which describes our desire to live comfortably above subsistence level and to indulge in a modicum of small luxuries. All three concepts, need, greed and want, are largely socially determined and vary from time to time and from place to place. In very rough general terms, wants are satisfied by the purchases of the middle classes that extend beyond the purchases of the poor, but fall behind the purchases of the rich. Obviously these definitions are purely indicative and not rigorous.

We distinguish between technologies that are driven by the need to survive and serve only our basic needs, and technologies that are driven by the desire for comfort and fun. Hence we say that although technology still satisfies our needs, its main focus has shifted to satisfying our greed and our wants. In order to survive as a producer of technology in a capitalist society, profits are of the essence and thus the term greed is here also used in a sense that describes a desire for profit. For lack of a better term we thus use the word greed with two slightly different meanings; the desire for excessive consumption and the desire for profit. The assertion made in this book that technology has gone well beyond fulfilling human needs, has two components. Producers of technology no longer answer the question what do people need; instead they ask what technology they can profitably sell to people. People, on the other hand, no longer buy only what they need in the strict sense of the word but buy to satisfy their wants or their desire for luxuries. The title from need to greed thus describes a fundamental change in behaviour of both producers and consumers of technology.

We next define society in the modern sense as an assembly of people living in proximity to each other in both space and time. People living close together inevitably interact with each other and need rules to avoid or regulate conflicts. They also need to organise the supply of goods and services they require both for survival and for pleasure. Quite apart from rules and organisation, individuals are strongly affected in their behaviour and their thinking by their interaction with other members of their society. Over the millennia of human existence, many forms of societies have evolved and indeed societies are continually evolving. Social organisation is complex and multi-faceted, possessing the following features in various forms:

1. A legal framework that is vital for the avoidance of conflict and, even more to the point, for not allowing conflicts to get out of hand. Thus we have rules of what is allowed or forbidden, rules how certain social trans-

actions are to be carried out and we have a system for adjudication in cases of conflict and for meting out punishment in cases of violation of the rules. The legal system consists of many sub-systems. In democracies, parliaments make the more important laws and many lesser organisations make lesser laws and rules. There is a bureaucracy to implement the laws and regulations, and to provide the infrastructure a modern society requires. We may distinguish between a social infrastructure, e.g. regulations and public administration, and a technological infrastructure.

2. Underpinning the society is a multi-layered educational system that provides educated citizens as carriers of the elusive system of customs, beliefs, assumptions and traditions which, taken together, define the characteristic features of a given society, often called its culture. Unfortunately the word culture is somewhat ambiguous, especially as the word describes the general ambience of a society but also its cultural activities, such as art, literature, music, science. I like to divide, somewhat controversially, this aspect of culture into high culture and popular culture and thus I distinguish, for example, popular music from classical music. Culture is an ambiguous concept that can be properly understood only in the context in which it is used. The educational system is also called upon to provide skilled people for work on the infinite number of tasks that need to be carried out in an advanced society, from bricklayer and carpenter to architect and structural engineer; from general medical practitioner to specialist surgeon, from school teacher to nursery nurse, from actor to musician and so forth to almost infinity.

3. For a society to function on a large scale it needs a substantial technical infrastructure. This consists of a system of transport and communications, a system of housing, a system of manufacturing all the multitude of artefacts that society requires (whether it needs them or not), a system of food production, a system of maintaining public order and a system of waging war (also known as defence). Of course all these systems require an elaborate organisation and, what is of the greatest interest to us, a huge variety of artefacts known as technological products and a huge variety of techniques for the manufacture of such products and for the maintenance and construction of the technological infrastructure.

As society evolves, so does its technology. We have argued elsewhere[1] that whereas technology develops unidirectionally, social structures and, first and foremost, the values held by society evolve in a haphazard, somewhat cyclical, manner. At the time of writing this last chapter of *From Need to Greed***,** in the spring of 2009, there is very little cause for rejoicing when surveying the social situation of large parts of global society. We have a combination of unrestrained capitalism that has driven itself into a catastrophic financial and economic crisis, causing much hardship and pain. At the same time we have severe environmental problems that are being tackled rather inadequately, allowing a serious degradation of the planet. On the other hand, we have vicious dictatorships and bloody strife in many countries. It is, of course, always possible to remain sanguine as to the future, but it is very hard to see the world in its current state as a just, fair and wonderful place. Nature is undisputedly wonderful, but human greed is busy destroying what remains of it. Surveying the state of human society and the state of the planet on a global scale does not warrant complacency.

This book deals with the role of technology in society over a long period of history. One of the most characteristic features of technology is its constant development and this means that the consideration of technological innovation is uppermost in our story. We attempt, however, to consider technological innovation not only as the outcome of the inner logic of technology, but also as the result of social forces influencing technological development. We have to think of technological change in a changing society. Technologists and their managers are permanently on the lookout for commercial opportunities. To say that technologies are developed only in response to needs is a smokescreen; the reality is that needs are developed in order to make new technologies profitable. The commercial principle that guides technology is the seeking out of opportunities for making money with the aid of technology. Technology is the most fundamental means for making profits, because technology is the means for making goods that can be sold at a profit. There are many ways of making money, but technology is the only one that also creates new real tangible material wealth.

Of course technology is still required to fulfil its original purpose; to sustain human life on earth. But whereas in the past technology was only able to provide a small population with the most essential needs, ena-

[1] 1995, Ernest Braun, *Futile Progress*, Earthscan, London

bling them to live short lives full of toil and hardship, modern technology sustains huge populations at varying levels of comfort. Whereas life in developed countries has, by and large, become extremely comfortable, nay luxurious, and the life-span now exceeds the biblical three score and ten, life for the majority of humans who live in less developed countries is still pretty hard and miserable. Life in modern Western cities requires an extremely high level of technology just to keep going. A modern city needs vast amounts of food to be distributed, it needs all forms of mechanical transport, water supplies, sewerage, electricity, heating, air conditioning, medical services, security services, and much else besides. Instead of making hopeless attempts at enumerating all the technologies required to sustain life in a city, we may subsume them all under the title *system of city technologies*. At a basic level, these technologies may justly claim that they provide only what people need, as without them life in cities would simply collapse.

Finding new uses for various materials can also create new wealth and economic growth. Metal ores had no value until metal smelting and the use of metals for the production of various artefacts were discovered. The value of precious stones or precious metals is not inherent in them – their value derives from their fashionable use in highly valued artefacts such as jewellery, but also in the value ascribed to them by rarity and convention. Finding new uses for materials or introducing new items from foreign lands is, as far as the economy and economic growth are concerned, as good as new technologies. A good example of the extreme value of a new use for a material is the case of oil. Oil was originally just dirty useless stuff. It began increasing in value when it became used as raw material for the production of various substances and its value truly exploded when motorcars, power stations, domestic heating systems and industrial machinery – to name but a few - developed an insatiable thirst for the stuff. Oil has become one of the most important trading items in the world and vast commercial empires are sustained by it. The process can, and does, also happen in reverse. When flint was no longer needed for the production of tools and weapons, it lost whatever economic or traditional value it had possessed.

Technological innovation creates new commercial opportunities and is therefore regarded as highly desirable. Because markets for technological products tend to saturate, technologists and their managers try to rekindle flagging sales by improving, changing, or replacing products when sales stagnate. Apart from rekindling saturating markets, technological innovation creates entirely new products that create entirely new markets. From the point of view of the economy a new service is almost as good as a new product, as long as a reasonable balance is maintained over a range of services and products. Generally speaking, new services are often connected with the use of new technologies. The introduction of the computer, for example, has brought in its wake a number of new services, such as computer programming, systems analysis, computer repairs, computer instruction, and so forth. The computer has also fundamentally changed other services, e.g. accountancy, banking, tax collecting and many more. Technologists and investors seek to find applications for new technologies wherever they might find them and it matters little to them whether they make a profit out of selling new products, or new production technologies, or new services.

Until quite recently services such as retailing used only very simple technologies. Weighing-scale and cash register were just about all the technology needed by retailers. The IT revolution changed all that. Self-service has largely replaced shop assistants. The goods are automatically pre-packed and labelled with bar codes and thus carry their own information on their weight, the unit price and the price of the package. At the till the label is automatically read and the total price of the goods in the shopping basket is worked out. At the same time the sales information is collected for purposes of stock-keeping and as a basis for the formulation of sales policy.

Many services have arisen out of the application of new technology. Indeed most major new technologies bring in their wake new services needed to use, service, and sell the new technologies. Older technologies, as the example of retail sales has shown, often deploy new technologies when these appear to provide advantages for their particular business. The development of Information Technologies followed its own trajectory and in the course of this development it became obvious that retail sales could use some of the new technologies, whereupon specific developments aimed at the retail trade took place. The sequence of events was that technology developed to a certain point and technologists then became aware of a possible new field of applications. This field was then further developed in conjunction with the newly targeted customers. At least some aspects

of IT have managed to conquer a great variety of markets and IT has become a universal tool for a great many human activities.

Numerous writers, considering technological innovation over the last few decades, have aimed mainly at classifying types of innovation and analysing ways and means of organizing innovation so as to accelerate its pace and improve it efficiency. Much of this kind of writing aimed to improve policies supporting technological innovation, but also policies for controlling unwanted effects of new and old technologies.

As an example of the classification of technological innovation we may take the taxonomy described by Freeman and Perez [2], who distinguish between four types of innovation:

1. Incremental innovation, i.e. the process of continuous improvement and development of products and processes;
2. Radical innovations, i.e. technological discontinuities which are usually the result of deliberate R&D;
3. Changes of technology systems, i.e. 'far-reaching changes in technology, affecting several branches of the economy, as well as giving rise to entirely new sectors';
4. Changes in techno-economic paradigm (technology revolutions).

This and similar taxonomies have a certain intellectual beauty, though they classify technological innovations a posteriori only. They are useful for obtaining a historical picture on the role of certain types of technologies in the overall scheme of technological development. However, it needs to be emphasized that items two to four of the above taxonomy do occur over a long period of time and really consist of a whole series of innovations. A single big leap forward is very rare, if it exists at all. Large steps in technological developments usually consist of a series of small steps and both the starting and finishing lines are set somewhat arbitrarily. Take the innovation "steam driven railways". Undoubtedly, an innovation of the highest order, indeed a change in a techno-economic paradigm. The leap from animal drawn carts and carriages, requiring only simple roads and not much organised infrastructure, though the effort of providing roadside inns and stables to facilitate long journeys should not be underestimated. Nevertheless, building railroad track, steam locomotives, carriages, and a supply and maintenance network requires a great deal more and the investments and economics of railways is of a different order to that of animal-drawn transport. But where did this innovation begin and where did it end? There certainly was no single idea or driving force behind it. Nobody sat down and decided to design a new transport system from scratch. What happened was that individual smaller innovations created the conditions that made the steam-driven railway system possible. Many things had to come together. First the steam engine, which itself was created in many small steps. The steam engine had to become light enough and small enough to be mounted on wheels. This "miniaturization" also required a number of small steps taken in order to allow a more widespread use of steam engines rather than specifically with railways in mind. This thought came somewhat later and required several crucial improvements to coal-fired steam boilers. Other innovations that fed into the stream that ended with the early railways were the improved manufacture of steel rails, the construction of stable tracks, the production of strong wheels and so forth. And what is the end point of this innovation? One possible answer is that we have not reached the end point yet. Railways are still improving and still experimenting and innovating, reaching greater speeds and less pollution. The railway connecting London to Paris and Brussels via the channel tunnel is certainly a very far cry from the early railways constructed by Stevenson or Trevithick and even from the tracks built by Brunel. We might agree to set the endpoint of the railway innovation at some arbitrary point when the building of track proceeded at pace and railways were run on a commercial scale. Or should we set the end point at the end of World War One, or World War Two? Or perhaps with the activities of Lord Beeching in 1963, who wrote a report that led to radical pruning of the huge British railway network to a more economic size, and thus set the point at which railway development in Britain reached its peak in the total length of track?[3]

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[2] Christopher Freeman and Carlota Perez, A taxonomy of innovations, pp. 45–47, in Giovanni Dosi et al., eds., , Technical Change and Economic Theory, 1988, Pinter Publishers, London & New York

[3] Between 1963 and 1975 the length of railway track in Britain was reduced from 28,000 to 17,000km

There are two points I am trying to make. First, the classification of an innovation depends to a considerable extent on the points chosen for the beginning and for the completion of a particular innovation, and both these points are fairly arbitrary. Secondly, most innovations, except the least radical and often trivial ones, require a large number of preconditions and consist of many innovative steps that, taken together, constitute a given innovation. Thus an innovation may be seen as the integral over time of many small contributing developments and many preconditions that are necessary before the innovation can proceed.

Many of the preconditions are technical, i.e. requirements of pre-existing technologies. Many conditions are social and consist essentially of a supply side, i.e. the availability of capital for investment in the innovation and of suitable labour that either has, or can acquire, the skills necessary for the development and application of the new technology. The demand side, as always, consists of the probable total demand for the innovation, in the case of railways this means total demand for freight and passenger transport that might be carried by rail. The demand forecast for an innovation is always a forecast and therefore largely a matter of faith backed by common sense.

We have stressed many times that an innovation is basically a coming together of a new technological possibility with a social demand. In other words, the new technology needs to arouse sufficient interest by a sufficient number of purchasers to part with sufficient cash to make the innovation economically viable. Thus the idea of an innovation will only come to fruition if the new technology meets sufficient demand, backed by purchasing power.

In the distant past technologies were created for the sole purpose of enabling humans to survive. Human inventiveness and human needs and wants led to constant improvements in technology and gradually enabled humans to tackle a greater variety of tasks of increasing complexity. Eventually, through a combination of technological logic and social desires, humans abandoned their nomadic hunting and gathering existence in favour of a settled way of life, supported by agriculture and animal husbandry. Sedentary societies became increasingly complex with the rise of wealth and the division of labour.

When humans embarked upon the path of agricultural production and urban life, gaps appeared in the technological system that supported the new way of life and thus new needs arose that had to be satisfied by new technology and new organisational measures. Large settlements developed in regions of high agricultural productivity and interdependence between agricultural production and urban markets developed. The operation of this system required improvements in agricultural techniques in order to supply a growing number of non-agricultural workers with food. It also required the establishment of a system of transport into the towns and a system of storage of food for a sizeable population. The distribution of food required some form of organisation: it could be traded, which required markets and money, or some kind of tally system, or it could be distributed by some authority, and that necessitated a suitable organisation and a written accounting system. It is a fundamental property of all technological systems that in the course of their development gaps arise that need to be filled by new technologies and/or new organisational measures to guarantee the smooth functioning of the system.

Nomadic hunters and gatherers own very little. The concept of wealth became established as a result of the rise of agriculture and the sedentary lifestyle. The most important early form of wealth was ownership of land, but this was soon supplemented by forms of wealth created by technology. Indeed from very early on technology became a vital factor in the creation of wealth, and the pursuit of wealth soon became a driving force for the creation of new technologies. Technological artefacts became embodiments of wealth. This is particularly true for the ownership of dwellings, from the modest family home to the luxurious palace or public building. Domestic implements, furniture, and ornaments also soon claimed their place amongst objects of value. Whereas the farmer attempts to own as much land, and as many farm animals and farming implements as possible, the urban dweller attempts to own as large a house as possible and furnish this with the best furniture, domestic implements and ornaments.

The most vital change in the human condition, brought about by the introduction of agriculture, was the change from a nomadic to a sedentary way of life and the establishment of permanent settlements, many of which later grew into towns. The rise of agriculture and its consequences are a prime example of the intimate interweaving of social and technological factors. We may say that agriculture was a logical development of

technology, and society found it convenient to adapt to its use. But we might also say, with equal justification, that society found it convenient to become sedentary and developed the technology to enable it to achieve this aim. I do not think that this chicken-and-egg argument can be resolved. We have to accept that social and technological factors form an inseparable pair, and that the fabric of society is a weave of human and technological factors that cannot be neatly separated into weft and warp, social and technological.

The second vital change in the human condition, also a consequence of the establishment of permanent settlements, was the emergence of social organisation, including the establishment of religious cults. No doubt early nomadic tribes had some rudimentary social structure, but nothing as complex and tangible as sedentary populations. It is probable that some form of animistic beliefs emerged very early in human existence. The incomprehensibility of death and the many puzzling and frightening aspects of nature probably led humans to believe in spirits – perhaps the spirits of the deceased – that may intervene in human affairs. We cannot know what hunters and gatherers thought, but we do know that Neolithic people built large edifices and complex burial places that provide plausible evidence for organised religion. The large monuments also provide evidence for social organisation, probably cooperation at regional level, for the enormous amount of planning and work that these edifices required could not have been accomplished without leadership of some kind and without labour coming from far and wide. The need for religious or social cult was strong enough to lead to its physical embodiment in the shape of massive works, such as Stonehenge and many similar ancient monuments. Technology began to serve non-material needs that were deemed desirable, in addition to supporting physical survival. It would be wrong to argue that society placed orders for monuments, and technology fulfilled them. The need was primarily social rather than material, and there was interplay between the need and technological capabilities, a kind of bargaining between social and technological forces, which led to decisions on what technology could provide and on the degree that this would satisfy the social need. We do not know the mechanisms by which such bargains were struck, but struck they were.

Toward the end of the Neolithic period technological skills had developed to a degree of complexity that required specialist craftsmen. In earlier days, the people who used the tools also produced them, later on there were specialist producers at work. Some trade in certain high quality raw materials and in technological products had begun to develop quite early on. It was not yet a trade in which the traders accumulated wealth, but a trade that enriched local facilities and caused an exchange of ideas and knowledge over some considerable distances. The precondition for both specialisation and trade was, of course, that agriculture was able to produce more food than the farmers and their families consumed themselves. Agricultural surplus is a prime condition for the existence of non-farming occupations.

As societies became more extensive and more complex, the non-farming occupations that arose included rulers, administrators, priests, specialist technologists, traders and, soon enough, soldiers. The accumulation of wealth by some, and the formalisation of religion, led to social differentiation and to the exercise of power by an elite. The elite was associated or allied with priests; earthly and supernatural powers became firm allies. It is easier to exercise power over fellow humans if the claim to power appears to be backed by divine authority. Relatively conspicuous consumption by the elite enhanced their prestige and their power.

Civilizations, from ancient times to this day, have two faces: the military, conquering, cruel face; and the face of organised society, the rule of law and high artistic achievement. When we speak of civilizations, we should remember the two meanings of the word: on the one hand civilized peaceful behaviour with high artistic and technical achievements, and on the other hand power, warfare and cruelty. War became a normal aspect of the life of states and has remained so to this day. Whereas technology originally served the purpose of physical survival, and thus the maintenance of human life, technology later accepted the task of serving the purposes of war and thus contributes massively to the extinction of life. Ever since the early civilizations, the task of producing weapons and armaments has been one of the major preoccupations of technology, and never more so than in most recent times. Undoubtedly early tribes fought neighbouring tribes to some extent, but truly organised warfare and organised armies belong to a period of major cities.

Once the concept of wealth was established in people's minds, the pursuit of wealth inevitably followed and this pursuit took on many forms, such as trade, conquest, slavery and exploitation of fellow humans. As technology developed, its production became the domain of the skilled craftsman who had several possibilities of

acquiring wealth, even if his income often sufficed only for a modest living. The skilled technologist could sell his skilled labour to those who needed it, or he could sell products of his labour in the form of traded goods such as furniture, domestic utensils, tools, carts, or weapons. As soon as the avenue to wealth via technology had been created, technologists began to think of new possibilities for increased revenues. The first thing that comes to mind is, of course, the creation of opportunities for new income by the creation of new technologies. Thus the relationship between technological innovation and the creation of wealth became established quite early on, when technologists were simple craftsmen working in small-scale workshops, long before the establishment of capitalism as a form of social organisation. Farmers, on the other hand, could increase their income either by acquiring more land, or by increasing the efficiency of their production by means of improved technologies.

We may ask what modern society requires of its technology. The requirements may be summarised into five categories.

1. Technology needs to sustain the life of the huge population living on the planet today. This task includes the provision of a basic supply of a multitude of goods, including clean water, food, clothing and shelter, but also the provision and maintenance of the essential physical infrastructure needed by modern societies, e.g. for transport by road, rail, water and air, for communications, public administration, health care and education.
2. Technology is called upon to make a major contribution to economic growth by increasing productivity in the production of goods and the provision of services, and by bringing new technologies onto the market, thus extending the range of goods available for consumption and increasing wealth.
3. Modern technology can and must reduce human drudgery. Modern machines largely eliminate the need for excessively hard physical labour. Beyond that, technology provides physical comfort in comfortable housing, the provision of hot water, heating, air conditioning, and good clothing.
4. Technology needs to provide the material means to safeguard the internal and external security of modern states.
5. Technology needs to find solutions to societal problems as and when they arise. Examples are problems of environmental pollution and climate change, or threats to human health, e.g. by malaria or aids.

The above are the functions society expects its technology to fulfil to a greater or lesser degree. The producers of technology, on the other hand, expect to make profits from technology. They make profits on condition that their goods find buyers willing to pay a price that allows the producer a profit margin.

It is interesting to ask whether technological development obeys some fundamental laws, or rules, and, if so, what these laws might be. We may define six such laws:

1. **As technology develops, it expands its capability for the satisfaction of an increasing range of human wants**. The wants generally increase from essential needs for mere survival towards wants that tend toward the unnecessary and luxurious. Necessity is, however, at least in part determined by social structure and custom.
2. **As a technology develops in the course of its life, its performance, measurable by an individually defined factor of performance, improves**. The steam engine, for example, improved to produce greater power with reduced size and lower fuel consumption.
3. **Technological development is irreversible and always proceeds in the directions given by the first and second laws**.[4] Technological progress means the satisfaction of an increasing range of human wants and an improved performance of technological devices. Change in the opposite direction does not occur. It is arguable, however, that some qualities of products, such as durability and appearance, may deteriorate as a result of progress.

[4] The termination of supersonic passenger flights appears to contradict this law, but Concorde was a politically created blind alley in technological development and the advantage of its great speed was outweighed by many disadvantages.

4. **Technology progresses into technological systems with increasingly complex interdependencies**. The interdependencies occur in the means of production, in the input of parts and in the actual use of the new technologies.
5. **The introduction of new technology often involves painful adjustments.** These occur in society, particularly because of the obsolescence of some skills, the displacement of labour and of some products by others.
6. **No technology that goes against the interests of the ruling elite is ever accepted**. At present, labour saving technologies are readily accepted. Technologies that would increase the labour content of a product are unlikely to be accepted. It needs to be said, however, that sometimes the introduction of a technology has unintended and unforeseen consequences and these may, occasionally, be detrimental to the interests of the ruling elite. It also needs to be said that consequences of a technology are usually equivocal and that there may be some benefits and some disadvantages for all concerned. Nonetheless, the above law is generally valid, though there may be occasional exceptions from it. At present the ruling elites appear to be willing to accept that the preservation of the environment is in their interest and therefore there is hope that so-called green technologies will prevail.

The first and second laws simply state that as technologists and their managers and investors seek opportunities to sell technological devices and products, they must be constantly on the lookout for unsatisfied potential demands. This can be done in two ways: either by offering technologies that fulfil entirely unfulfilled potential wishes, (this leads to the first law), or by making improvements to existing technologies, thus kindling new demands for the improved product (this leads to the second law). The SMS (short message service) for mobile telephones is an example that combines both laws. It represents an entirely new product that satisfies a previously non-existent demand, and it represents an improvement in the performance of mobile 'phones. The strategy of the innovators has worked; SMS is becoming increasingly popular, though nobody could argue that it is vital to the survival of individual humans or the human race.

The third law results from the fact that comfort is addictive. Nobody who has used a washing machine would voluntarily go back to washing by hand. Nobody who has used a mechanical digger would want to go back to pick and shovel. And despite the somewhat problematic nature of computers, not many people who have used a word processor would go back to a typewriter.

The fourth law will be discussed later; suffice it for now to mention a contemporary example. The modern desk-top computer is part of a system, comprising, among other items, the following: semiconductor electronics (so-called chips), other electronic components, visual display units, various memory devices, printers, keyboards, audio systems, system software, applications software, the telephone network, the Internet with its service providers, and maintenance and repair services.

We have discussed some of the momentous social upheavals, caused by the introduction of new technologies, especially during the industrial revolution. Much social change was brought about in more recent times by the introduction of computers and automation. The huge factories with tens of thousands of workers are a thing of the past. This is perhaps why old-fashioned socialism, based mainly on the teaching of Marx, is a thing of the past. The proletariat that Marx had in mind no longer exists, which is not to say that there is a lack of underprivileged people even in the rich countries. The modern workforce in manufacturing industry is very much smaller than in the past and many of the highest skills required have moved away from the shop floor into management. Both these trends illustrate the 5th as well as the 6th law, as management forms part of the ruling elite and much prefers to manage a small workforce rather than a huge army of potentially unruly workers. The moderately skilled worker on the factory floor has largely given way to unskilled operators of automatic machinery on the one hand, and very highly skilled machine setters and maintenance workers. All operations are thoroughly planned and designed and many of the previous skills have been incorporated into computer software.

Among the social effects of doubtful benefit we might mention urban sprawl, the demise of the small shop, and an increase in road casualties as results of motorised transport. We might mention the demise of the small farmer as a result of mechanisation of farming, or the demise of thousands of typists as a result of the introduc-

tion of computers in administration. We might mention the predominance of large-scale commercial operations as a result of massive savings in mass production, in mass purchasing and in mass marketing. All these trends result from automation, mechanisation, and computerisation and are supported by political upheavals that support neo-liberal policies and globalisation.

As the centuries went by and the range of available technologies became near infinite, the link between the creation of new technologies and the creation of wealth became ever stronger. Though undoubtedly technology still serves our vital needs and enables humans to survive in vast numbers, the main focus of technological endeavour has shifted away from the satisfaction of needs to the search for new opportunities for the creation of income and wealth. Technological innovation aims to create new sources of income, and thus has become a major source of economic growth. Because economic growth is a coveted goal of almost all contemporary societies, and technological innovation is seen as a principal contributor toward economic growth, technological innovation has become a favoured child of society.

As our real needs can now be more than satisfied in Western societies, but the desire for growing wealth apparently can never be satiated, technological innovation is pursued with undiminished fervour with the goal of making money. The desire to make money is the principal driving force behind all contemporary technological activities. This is not surprising in a capitalist society in which the desire for making money is the principal driving force behind all economic and most other activities. Technology is not exempt from the fundamental principle of capitalist society.

Even necessities can be provided at very different levels. If we look at a modern Western household and speculate how much of its equipment is truly necessary and how much simply makes life more pleasant, we invariably reach the conclusion that the modern household is equipped well beyond its essential needs. Not only do we own more equipment than we need, but much of it is substantially more elaborate than it need be. Yet those who cannot afford modern household equipment feel severely deprived and relatively poor.[5]

Profits and wealth can be made out of a great variety of activities. They are, for example, made out of trade, even though the trader does not produce material goods. Trade is essential for the distribution of goods and, as far as the economy as a whole is concerned, the source of profits is often seen as immaterial, though I regard this view as fallacious. Some argue that as long as money is made and circulated, the economy benefits. However, real material wealth is only created by technology, including agriculture, and no amount of trading could keep an economy going without material goods being produced – though not necessarily in the domestic economy. It is also hard to imagine how economic growth could be achieved by trade alone, unless new goods can be brought into the economy from somewhere. New goods are produced by technological means – including agriculture and forestry – either in the domestic economy or are brought in by traders from foreign lands.

The economy of a country provides and distributes a great variety of goods, largely produced by technology. Of no less importance, however, is the fact that the economy provides employment. The importance of employment is twofold: it provides income for the employed, or self-employed, person and it provides the person with a place in society and a sense of being useful. An unemployed person is deprived of a large part of his/her income and is deprived of the company of fellow workers. The companionship of workmates is of great importance to most workers and the private social life of many people is enhanced by, sometimes dependent on, contact with fellow workers. The unemployed find it hard to structure their day. Why should I get out of bed and how should I fill all these long vacuous hours before I can go back to sleep? Last, but not least, the unemployed lose their sense of self-worth. Nobody needs me, I contribute nothing to the world, I am useless and worthless.

Work and employment are the most valuable things that technology both provides and takes away. We should do all we can to maintain employment as one of the most valuable goods. In the relentless pursuit of profits managers should do all they can to keep their workforce in employment and use redundancy only as a very last resort. Unfortunately managers often do not see things quite this way.

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[5] We distinguish between absolute and relative poverty. Somebody absolutely poor suffers real deprivation and may suffer from hunger and cold; somebody relatively poor simply cannot afford all the goods and services that most people enjoy.

Over many years, and particularly between 1950 and the present day, employment patterns have changed dramatically[6]. Whereas in 1900 agriculture provided about 11% of UK employment, the share of agriculture in employment had fallen to about 2% by 2000. During the same period the share of employment in manufacturing industry fell from 28% to 14%. Employment in services increased from 34% in 1901 to 75% in 2000.

The causes for these dramatic changes are not hard to find. Undoubtedly the main cause was technological change. Technology changes as a result of both internal forces, such as curiosity research, ambition, and, first and foremost, the constant thriving for profit. Some technological change is caused by interactions between technology and society. Thus social forces can also be causal factors in technological change. The trend to the nuclear family and the trend toward equal rights for women are closely related to the introduction of modern household machinery, as is the trend away from employment of domestic servants. Technology in these situations is not the cause of change, but plays the role of an enabling factor. How the relationships work in detail will not here be investigated. In oversimplified terms we may say that domestic machinery has freed women from much domestic drudgery and has encouraged middle-class households to manage with only casual part-time hired labour. The relationship between the trend toward the nuclear family and technology is complex and beyond the scope of this book. Emancipation of women and enhanced mobility no doubt play key roles.

The technological changes that brought about diminishing employment in agriculture and, to a lesser extent, in manufacturing industry are, in a nutshell, mechanisation, followed by automation. When sowing by hand was replaced by machinery and the horse-drawn plough gave way to the plough pulled by tractor, and when harvesting was no longer carried out with the scythe followed by laborious threshing, and when all these operations were replaced by combine harvesters requiring only a fraction of the labour used previously, it is not surprising that the total labour force required by agriculture shrank to a fraction of the previous force. With a workforce in agriculture, forestry and fishing of only 2% of the total UK workforce, the contribution of these activities to GDP is also about 2% of total GDP.

A further factor that contributed to greater efficiency in agriculture, meaning the creation of greater value with less labour input, is plant and animal breeding in the widest sense. Thus modern farm animals produce far more of whatever they are supposed to produce with the same inputs of labour and materials. Modern plant crops produce greater yields per unit area. Tree felling and the preparation of timber products has been largely mechanised and thus less labour is needed for the same output. Fishing has also increased its productivity with the calamitous result of over-fishing and the threat of extinction for many species of fish.

Work in agriculture has fundamentally changed. Gone are the days of extremely hard labour with pick and shovel and scythe and horse-drawn plough. The farmer or farm labourer now works with sophisticated machines, the cow-shed is often automated, and the computer plays a central role in farm management. Brawn has given way to brain.

The changes in manufacturing industry are every bit as dramatic as those in agriculture. Not only has total output of British manufacturing industry, particularly of British-owned manufacturing industry, declined by a huge amount in favour of foreign-owned industry and of imports, but industrial productivity has also increased owing to mechanisation and automation. Some branches of industry have declined dramatically. Coal mining has almost disappeared, ship building has declined, general engineering has declined, the British-owned motor industry has disappeared and total output of British industry is much diminished, with the gap being filled by imports.

Gone are the days of factories employing thousands of workers on a single site and gone are the days of whole villages and regions living on coal-mining[7]. In the fifties and sixties a production line in an automobile factory employed hundreds of workers each placing a part onto the car being produced and screwing, riveting or welding it on by hand. It looked very much as parodied in Charlie Chaplin's *Modern Times,* whereas a modern automobile production line is operated largely by robots and other automated machinery. Work is almost

[6] See e.g. March 2003, Craig Lindsay, A century of labour market change:1900 to 2000, Labour Market Trends, pp. 133–144

[7] Between 1917 and 1927 over a million coal miners were employed in British collieries. In 1947 the National Coal Board took over the management of 958 collieries employing 703,900 miners. In 2001/02 only fifteen deep mines remained employing just over 6000 miners. In addition there were 20 opencast mines in Britain.

as monotonous as before, but physically less demanding and much more effective. Similarly, coal is no longer hewn out of a coal-face by pick-axe or hand-held pneumatic drill and then shovelled onto a conveyor belt to a railroad, where it was loaded by hand onto wagons and transported to the lifting gear. A modern mine operates with huge automated machinery that enables a handful of workers to produce vast amounts of coal. The work is far less strenuous and less dangerous than in the past and, of course, much more efficient in terms of input of labour. On the other hand, narrow coal seams cannot be mined by modern methods and production has to be concentrated on relatively few favourable spots. The trade-off is that mining is no longer a hazardous and back-breaking occupation, which surely is a very good thing. The major costs in mining are no longer labour costs; capital costs are now dominant.

Coal has acquired a bad name as an environmental pollutant. There is no doubt that burning fossil fuels, such as coal, inevitably produces carbon dioxide, the gas that is regarded as the main cause of global warming. Concern about the increasing use of coal in China and India is widespread. However, modern research has developed methods whereby the burning of coal on a large scale, as for example in electricity generation, need not be environmentally harmful. It is possible to collect the carbon dioxide produced in the combustion process and bury it deep underground or in disused oil and gas fields in the ocean-bed. The method is known as carbon capture and storage (CCS) and Norwegian experience has shown it to be practicable and effective.[8] These methods are not fully developed yet and are still expensive, but they look very promising and might enable many countries to use their ample coal reserves for the generation of electricity without causing harm to the environment. The highly problematic and controversial nuclear option is by no means the only option for generating electricity without causing global warming. There are all the possibilities of using renewable energies, but there is also a possibility of building and operating clean coal-based electricity generating plant. Opponents of coal argue that such plants would be expensive. In view of the fact that the cost of nuclear power stations is somewhat indeterminate and almost certainly much higher than its proponents admit, coal is very likely to be rather competitive and using coal might be a sensible use of rich domestic resources in many countries, including Great Britain and the US.

The shrinking agricultural and industrial sectors made room for the expansion of public and private services. Employment in the service sector has risen to 75% of all employment and the contribution of services to GDP has risen to 66%. Public services have expanded considerably, despite the new-found religion of privatization. Social services and the National Health Service have become major employers, and education has expanded markedly. In total, government expenditure as a proportion of GDP has gone up to around 40%.

There is nothing wrong in principle with an expanded service sector. However, some services are more useful than others. The British service sector became dominated by financial services that appeared to make a large contribution to GDP, and while there was an abundance of financial advisers, it was hard to get a plumber. Worse still, the financial services sector appears to have operated a series of scams and its huge profits were made by conjuring tricks producing money out of thin air. Now that the sector has virtually collapsed and its fat cats are licking their wounds[9] instead of carting off their unjust rewards by the lorry-load, the real economy is being dragged down with the collapsing financial institutions and governments have no option but to produce rescue packages financed by issuing new money or government bonds (gilts), more or less eagerly bought by the wary public at home and abroad. When the going gets tough, the majority of even the most enthusiastic free marketers remember the theories of John Maynard Keynes, calling for government expenditure in times of a market slump and begin to appreciate the need to set bounds to the absolute freedom of markets. The call for more and better regulation comes from many quarters and it is to be hoped that the wild excesses of the banks will be curbed and some honesty and sense will be brought back into the financial sector.

It is often argued that services are as good as manufacturing to sustain an economy. This may be true for a small country in a special situation, such as having a thriving tourist industry or exceptionally profitable financial services. Countries such as Liechtenstein, the Cayman Islands and the British Channel Islands come to mind as examples. During the Thatcher years it was argued that the City of London is the greatest British asset

[8] See e.g. The Observer, 15. February 2009, pp. 18–19

[9] It would appear that some of the fat cats are managing to embark upon one of their legendary spare lives

and it was thought that letting British industry decline does not matter. There were always those who regarded these policies as misguided, but just how very badly misguided they were, is now becoming crystal clear.

An economy relying in large part on honest services, such as medical services, education, social services, catering, transport, and craft services such as plumbing, joinery or hairdressing, alongside some industry, could probably work reasonably well. An economy relying heavily on financial services, to the exclusion of almost all else, blatantly cannot and this is the reason why Britain is being hit so very hard by the current world financial crisis. The banks could benefit the economy at large if they fulfilled their basic function of providing credit where credit was needed and if loans were made with due regard to the ability of the borrowers to pay interest and repay the loans; in other words, if banks acted with proper diligence and honesty. When banks and other financial institutions marketed loans quite recklessly, pushing hapless people into purchasing everything from houses to cars and consumer goods on the never-never, a huge bubble of debt grew ever larger until it reached bursting point. What is now known as sub-prime lending was in fact reckless lending that was bound to end in disaster. Disaster did indeed strike in due course, in late 2008. At the time of writing, in early 2009, the disaster is in full swing. The total credit market debt as a percentage of the total economy (GDP) in the USA stood at about 160 in the year 1980; by the year 2006 this ratio had increased to about 330.[10] This, it would seem, is far too high for a healthy economy and eventually many citizens were forced into default and, in the worst cases, lost their homes.

It now turns out that banks can not only make large profits, but can also accumulate losses of magnitudes that exceed by far the imagination of most people. Making a loss in business is always regrettable, but not necessarily reprehensible; making astronomical losses from reckless lending to private individuals and businesses is more than reprehensible. In the eyes of the law-abiding citizen it is regarded as a result of criminal activity, even if no laws were actually broken. Unfortunately *due care* is not a law that bankers appear to be bound by. The banks have caused untold misery to a lot of people and are now being bailed out by governments that can ill afford to raise such huge sums of money, especially as some of the promises to insure banks against losses are equivalent to throwing money down a bottomless pit. It seems likely that some of the finance now raised by governments will never be paid back, as governments are entitled simply to create money via their central banks and pump it into the economy. In sum total the present operations of governments, necessary as they are, will cause considerable future budgetary problems.

The behaviour of investment bankers has in no small measure contributed to the mistrust of ordinary people toward those in authority in general and bankers in particular. It is unclear whether the behaviour of banks is just a facet of unfettered capitalism that has caused a lack of trust toward business, authorities, politicians and everything else, or whether banks act in a powerful world of their own. I think that a free market economy can only function properly if it adheres to strict rules; a totally free market, especially a totally free global financial market, leads to excesses that cause first a loss of faith and eventually lead to total calamity.

Central banks are different from all other banks, as they are supposed to create money, act as lenders of last resort by lending to banks at the interest rate that they fix from time to time, and try to control inflation. In recent years and months, the control of retail prices in the major economies was reasonably successful. Indeed free markets in consumer goods are frequently reasonably stable of their own accord. Markets for labour, land, housing and capital are, on the other hand, inherently unstable. Unfortunately this is not accepted by classical economic theory and central banks have not attempted to stabilise prices for such goods[11]. As a result of such lack of attention, there has been a veritable explosion of house prices and of share prices on the stock exchange. A majority of the money in circulation in such markets comes from credit and thus the credit in most highly developed economies has expanded beyond reasonable limits. Indeed a credit bubble formed and this bubble has now burst. Much credit was extended without due care and the stock exchange prices, also driven up by credit and by complex machinations, burst together with the credit bubble.

The old-fashioned banker was mostly honest and modest, content to safeguard the funds deposited by savers and making loans to customers who could, by and large, be trusted to pay interest and repay the loan. From

[10] Data from Ned Davis, Inc., 2007

[11] 2008, George Cooper, The Origin of Financial Crises, Harriman House, Petersfield, UK.

the earliest days of banking, when gold was the common currency, bankers lent out more than the deposits they were holding. Experience taught them that they needed to hold only a fraction of total loans as a reserve for those customers who wished to withdraw their deposits. Thus a risk of a run on the bank was always present, but the degree of allowable risk was based on experience and no elaborate risk assessment calculations were required. The replacement of gold by paper money made no difference; so-called fractional lending remained the norm. It is a large leap from the relatively simple banking to modern banking and financial institutions. We now have a multitude of financial institutions covering a multitude of financial services. Some might say that we now satisfy a multitude of financial needs, but I regard many of these so-called needs as commercial, frequently unsound, offerings rather than true needs.

The major financial institutions are the stock exchange, commercial banks, investment banks, insurance companies and specialist mortgage lenders. In reality many institutions combine several of these activities. We may regard all financial services and transactions as information services and should not be surprised that modern information and communication technologies have become indispensible, and indeed dominant, in the financial sector of modern economies. The introduction of the computer and of computer experts has fundamentally changed financial activities. Bankers became bolder in their taking of risks because they thought that with the aid of computers and sophisticated mathematical models they could fully understand and control the risks they were taking, and remained convinced that those who dare will win. In other words, bankers began taking great controlled risks, producing large profits. In reality you cannot control risks; at best you can calculate the probabilities of certain events happening. Investment bankers became highly inventive in producing new risky and profitable financial instruments, far removed from the original simple practices of bankers. The mathematical theories on which some novel financial instruments are based became highly complex and demanded highly skilled computer experts. The financial transactions enacted by investment banks became very close to those of a casino. Investors were not sold shares in real tangible businesses; they were sold odds on future prices of commodities or shares. Thus the financial sector became almost totally divorced from the real economy. Although shares dealt on the stock exchange still represent a slice of ownership of real businesses, the values assigned to shares are based on expectations, and have little or nothing to do with the real worth of these businesses. Worse still, the new financial instruments, so-called derivatives, represent nothing real at all; they are sophisticated bets based on sophisticated computations.

Another important effect of modern technologies on the financial sector is the interdependence between institutions all over the globe. Banks and other financial institutions are inextricably linked by a web of mutual investments, credits and management. Because the use of modern computer and communications technologies (Information Technologies) makes global transactions practically instantaneous, the global financial networks have become virtual organisms with huge financial flows connecting the different parts. In the ten years between 1995 and 2005 gross flows of financial capital between countries have almost trebled to reach 16% of world GDP.[12] Because of these linkages, the failure of one large institution is likely to cause failures in further institutions and the whole financial system becomes unstable.

As the current credit crisis has shown, the problems of the financial sector very quickly affect the real economy. Though so many financial transactions are unrelated to the real economy, nevertheless the real economy is vitally affected by problems in the financial sector. For business of almost any kind to thrive, it needs frequent favourable credits from the banks; for the housing market to thrive, it needs reasonably priced and freely available mortgages. For the consumer sector to thrive, consumers need credit for large purchases. Unhappily in the recent past prices of houses rose dramatically and mortgages were given to people unable to meet payments of interest and repayments of capital. Equally unfortunately, consumers bought too much on credit. To compound the difficulties many financial transactions, such as the purchase of shares on the stock market, were also transacted on credit. Thus a bubble of credit grew and eventually burst, when too many borrowers of all kinds became unable to meet their obligations.

In recent months a number of investment schemes, some of them of very large dimensions, turned out to have been fraudulent. Many bona fide investors have lost their money and these fraudulent operations have not

[12] www.theage.com.au/news/business/globalmoney flow soars.....28.01.2009

exactly enhanced the reputation of financial institutions. Yet again it has been shown that excessive greed and "wonderful opportunities" have presented bankers and their likes with "irresistible temptations". It is clear that inherent honesty and decency is in inadequate supply in financial circles and that it is vitally necessary to supervise and regulate their activities much more closely and carefully. Where honesty and morality fail, the law has to step in.

Bankers have caused a substantial loss of trust and this deficient trust is a very serious deficit indeed. Society cannot function properly without an adequate measure of trust. We need to trust our institutions, and, at a more basic level, we need to trust all people we interact with, whether in commercial or social intercourse. Unfortunately practically no modern society is achieving a perfect degree of trust because all societies contain criminals of various kinds. But the present loss of trust in most of our institutions, and in many leading figures in our society, affects us all and isolates and alienates us from our society. To be fair, it is not only the fault of the bankers. It is also the excessive speed of change, including technological and commercial change. How can we trust products that change all the time and that we cannot adequately test before buying them? How can we trust firms that are in continual flux by being taken over or merging with other firms? How can we trust institutions that are continually reformed and never settle into a proper working mode? Perhaps President Obama was right when he emphasized the need for change in the USA, but we can have too much change and we have a great need for continuity and for trust in existing institutions and procedures.[13]

In some services it is difficult, if not impossible, to replace human workers by the deployment of technical means. Nursing, teaching, care for the young or the elderly are examples of services that are inevitably labour intensive. Because productivity in such services is low, they are expensive to run, difficult to staff and difficult to finance. This is highly problematic, because such services embody the very essence of being humane and civilised. The care of the old and the young, education and health are the Cinderella of capitalist technological societies. Care for the natural environment is another of the forgotten children of such societies, although it is possible to make profits from the introduction of new technologies that combat environmental degradation. The creation and introduction of environmentally friendly technologies could produce very many opportunities for profitable investment and for employment. Out of the many possibilities, suffice it to mention improved insulation for houses, more efficient motor cars, better public transport, better methods for recycling and cleaner electricity generation.

Change is, and always has been, an essential characteristic of human society. Changes in technology – technological innovation – differ in some respects from general social change in that it is more unidirectional and more rapid. Technological innovation is deliberate and, because of the prevalent faith in its economic benefits, it is regarded as highly desirable. The desirability of innovation seems to have been transferred from the sphere of technology to most other spheres of life. It so happens that technology, by implication, makes all novelty desirable. We may speculate whether the acute search for novelty in technology has influenced the general desire of contemporary society to seek new ways in every endeavour. Indeed novelty has largely replaced criteria of quality; if it is novel it must be good. This quest for novelty often leads to absurdities, especially in the arts and in the media, but also in education and other fields.

Video techniques allow all kinds of tricks, such as overlapping semi-transparent pictures, and rapid sequences of images that confuse the viewer and make no sense. Opera and drama have been infected by a relentless search for novelty of staging that often flies in the face of a sensible and sensitive interpretation of the intentions of the original playwrights or composers.

It may be that technology is to blame for some of the new-fangled ideas because using new technology makes it possible to tread entirely new paths. But quite apart from the fact that technology has made some things possible that previously were not feasible, technology seems to have infected all our thinking with the desire for novelty even in spheres where quality, rather than novelty, should be the measure of things. No doubt the application of new technologies opens up new possibilities that should be used, but they should be used with the guidance of criteria other than novelty. Not everything that can be done should be done. Whereas technological innovation, with all its aberrations, makes at least some economic sense, the general elevation of

[13] The dangers of rapid technological change are discussed in 1995, Ernest Braun, *Futile Progress*, Earthscan, London

innovation per se as an attribute of value makes, in my view, no sense whatsoever. The arts and, to some extent politics, are particularly affected by a pathological desire for novelty, forgetting all else in the quest for originality. Alas, novelty cannot be a substitute for quality!

One of the most fundamental laws of technological progress states that all technological development is unidirectional in the sense that all new devices, replacing older technology, show improvements in performance. They may be more efficient, more convenient to use, more accurate, perform tasks that the preceding technology was unable to perform, or be "better" in some other way. More recent developments of technology cast doubt on the universal validity of this law. We find some changes in the design of various consumer technologies of very questionable value. Unfortunately the law does not hold absolutely, some designers indulge in useless gimmicks to induce purchasers to buy their goods. Take, for example, recent developments in small digital cameras. They no longer provide viewfinders and use a screen instead. As a result, it is impossible to use them in strong light – no more photographs of kids in the sunshine. They are less convenient to use than older models and this lack of convenience is not balanced by any other improvement. This development is the result of an attempt to create a new fashion in cameras, and by creating a new fashion, making older models obsolete in order to create new markets. The new cameras are as unreliable and as short-lived as their immediate predecessors. Perhaps manufacturers deliberately make small digital cameras difficult to use in order to enhance sales of more expensive digital single lens reflex cameras.

There is a general assumption, and frequent assertion, that all technology is created to satisfy some human need. We can, of course, define need in such ways as to make this dictum true, but that would lead to logical absurdities and would turn the relationship between human need and technology on its head. The example of a recent technology that most definitely was not developed in response to any reasonably defined need is the introduction of very small cheap motorcycles, unsuitable as road transport and intended to make money out of selling these lethal machines to teenagers or children. They are quite fast and unsafe and can be bought by children from their pocket money or by indulgent and ill-advised parents. The "need" they satisfy is to have fun through speed, noise, and danger and the "need" to impress the peer-group through misunderstood manliness. These machines cause injuries, and even fatalities, and are a nuisance to all those unfortunate enough to be near the scene of their activities. To my mind, it is an irresponsible development and fulfils a need only if we pervert the meaning of the word and designate everything people buy as a need. This is precisely what uncritical supporters of free market economics do. It must be admitted that as far as economists are concerned there is no other option than to regard all purchases as needs because neither statistics nor economic theories are able to distinguish between necessary and foolish purchases. Economists have no option but to regard all purchases by consumers as satisfying needs, from the macroeconomic viewpoint it is not possible to differentiate between purchases according to the motivation of the buyer.

Increases in productivity, i.e. more products produced with the same input of labour and other factors of production, can also lead to economic growth, provided the savings in labour lead to increased production rather than to unemployment. Unemployment is not only a great waste of human resources and a drain on state finances[14], it is also a personal tragedy for those willing to work and unable to find employment or create income from self-employment or other legal activities. The unemployed lose their main link to society, become socially isolated and find it hard to structure their time in any satisfactory way. They suffer all this in addition to suffering financial hardship.

There is one special case in the provision of goods and services: the provision by the state. In most countries the state, or its agents, provide essential infrastructure, such as roads, sewage, street lighting and cleansing and, until very recently, electricity, gas, telecommunications, postal services, railways, ports, and airports. In many countries the ideology of privatising as many as possible of these infrastructural services has become dominant and they are now often provided by private enterprise under some form of state supervision. Thus the providers of many essential services now use technology in the pursuit of profits, rather than for the exclusive purpose of providing essential public services or public infrastructure.

[14] In those states where unemployment benefit is a right paid by the state

A case in which the division between private and public provision has long been problematic and controversial is the provision of health services. In recent times medical technology has made very large strides and this has caused the cost of providing up-to-date medical services to rise very rapidly. There is a lot of money to be made out of innovative medical technology and, as a result, the provision of full medical services for whole populations, without discrimination between rich and poor, has become problematic. Of course not only medical technology has advanced, but the pharmaceutical industry has also not stood still. There are many new drugs on the market and many of them are extremely expensive because, so the industry claims, research into new drugs has become complex and costly.

Finally, we must mention the armed services, including both internal and external security services. Virtually all states provide these services out of the public purse, though private enterprise provides some supplementary services. Innovation in arms and armaments and other military technologies is very rapid and the cost of armed services is high. Industry that supplies the armed services often makes very large profits, thus technology is here again seen to be in pursuit of profits. Yet it needs to be said that governments put pressure on industry to produce improved weapons and weapons systems, as superior weapons can provide a decisive advantage in modern warfare. The arms race favours the richer nations and often beggars the poorer ones, and the arms industry and arms dealers make profits out of all clients, rich and poor. As we live in a world perverted and primitive enough to settle its disputes and pursue its political aims by the use of arms, we may say that the need for arms is a real social need. I regard this as extremely unfortunate and regrettable, but cannot deny it. The use of the most sophisticated weapons in the pursuit of the most primitive of human activities – warfare – is the most disgraceful absurdity of our time.

The tradition of warfare is at least as old as the oldest civilizations, and possibly older. The early civilizations began a tradition that is still alive: the tradition of warfare with the purpose of increasing wealth and power of the aggressor at the expense of other people. All ancient states kept armies and used them to attack neighbours near and far with the aim of plunder, of acquiring slaves, of exacting tribute, of expanding their territory and of self aggrandisement. We speak of great empires and great rulers, more often than not meaning their military might, their cruelty, their wealth, and their successful military campaigns. The word "great" is here used in a perverted Pickwickian sense. Unfortunately the connection between technology and warfare has always been, and still is, extremely close; they are, indeed, inseparable twins.

Technology in all its aspects has become an essential economic activity. We spend a lot of effort on introducing new and improved manufacturing technology in order to streamline the production of goods, we constantly attempt to introduce new or improved products in order to stimulate flagging markets, and we constantly strive to improve technologies used in services and in administration in order to improve some services and streamline administration. As technology has become a central economic activity, it should not surprise us that the measure of all economic activity – money – is also the measure of all activities relating to technology.

It is true, of course, that the vast numbers of people, and the complex societies they live in, could not be sustained without the extensive use of technology. But it is equally true that most contemporary technological innovations aim primarily at making money rather than at improving our lot.

All producers of technology depend on selling their goods, in other words on customer demand in the strictly economic sense. Demand is what people buy. The causes of demand, i.e. the reason why people buy certain goods or services, may be ordered into several categories. We have mentioned purchases by private individuals and divided these into purchases by different social groups. We now turn to purchases by organisations.

1. *Purchases by social organisations*. Government in all its forms is a major buyer of many goods and services. In recent times many government functions have been privatised, but in these cases private firms simply fulfil roles previously fulfilled by Government. The trend continues and some writers call the phenomenon of a government that has passed many of its functions to private enterprise a 'hollow government[15]. From the point of view of the Neo-Conservatives the hollow state is highly desirable, to less radical right-wingers and, of course, to left-wingers, such a state is a horror vision. Government buys directly or by proxy of private firms major and minor equipment for its armed forces, for its transport networks, for the police, for

[15] See Naomi Klein, (2007), The Shock Doctrine, p. 294

public administration and so forth. No matter who the purchaser is, a functioning state needs large inputs of goods, many of the high technology products, and many services. Indeed public administration may be viewed as a service. Though many of its functions are performed by civil servants, quite a few functions are bought in, even in a state in which privatization has not been driven ad absurdum.

2. *Purchases by industry and business*. A very large amount of buying and selling, of supplying and consuming, takes place between commercial organisations. If we take the car industry as an example, we find that the motor manufacturer mostly carries out the assembly of parts supplied by a whole host of suppliers. The car manufacturer coordinates all the functions necessary for the production of cars, buys in the parts and often even the designs, assembles the cars and sells them to the public. Thus the manufacturer may be regarded as a large scale purchaser of products and services that he assembles and markets, where marketing is in itself a major function.

One of the outstanding characteristics of technology is that it consists mostly of systems[16]. There are two kinds of technological systems. On the one hand, we may speak of, say, a system of domestic technologies consisting of washing machines, dishwashers, cookers, vacuum cleaners and so forth. Each of these machines is relatively self-contained, though all depend on external inputs. The dishwasher, for example, requires various ancillary inputs such as running water and an electricity supply, salt, rinsing aid, and special detergents. It also requires adequate drainage, and we may call this assembly of the dishwasher with its inputs and outputs a sub-system of the household machinery system. When we speak of a system of household machinery, we mean an assembly of machines and devices that help us run a household; yet we do not mean a system of interdependent technologies. We may run a washing machine on its own, without necessarily deploying any other household machinery, but not without some external inputs, such as detergent. As an aside we note that most household machinery merely performs tasks that we can perform without machinery, merely by the labour of our hands, aided by simple tools. We can wash dishes and clothes without machinery, we can brush and beat carpets, we can cook on an open fire. Household machinery is typical of the class of technologies that make life easier and save labour, yet has no capabilities entirely without the range of human abilities.

The concept of even such loose systems – more assemblies of machinery rather than systems – is helpful in the search for spotting marketing opportunities for new technologies. The potential innovator surveys the "system household" and seeks gaps in the provision of technical aids, as well as improvements in existing machinery and gadgets. The search for new opportunities is facilitated by the system nature of technology, even in cases where the system is only a loosely interconnected one. Each generation of domestic machinery is a little better than its predecessors and gaps in the mechanisation of the household are quickly filled. More recently a whole new system of domestic communications, electronic data processing and entertainment has been added to the common range of household equipment and more is being added all the time. The complete system of household technology consists of domestic machinery, household electronics, and furniture and furnishings, not to mention the dwelling itself with its sub-systems such as heating, water supplies, electricity supplies, roofs, insulation and so on.

Many technological systems are much more close-knit. The number of examples is well nigh infinite. We shall describe one or two examples, but only after describing such systems in general. A technological system consists of one or several interdependent devices that require for their production and their use a number of additional technological inputs and the fulfilment of some technical and social preconditions. Take as an example the ubiquitous computer. In practical terms, the computer could not be developed without some mathematical analysis and without the availability of semiconductor electronic devices[17]. These devices were initially developed as replacements for cumbersome electronic elements known as tubes or valves, without initially thinking of computers as their eventual main field of application. Indeed the computer could not have become the universally applied tool without the prior development of integrated circuits, making it possible to gradu-

[16] There are many definitions and many kinds of systems. For our purpose a system is a functionally related group of elements that perform some specified function.

[17] For a description of the initial history of solid state electronic devices, so-called chips, see e.g. 1982, E. Braun & S. Macdonald, *Revolution in Miniature*, 2nd ed., Cambridge University Press, Cambridge

ally increase the computing power and computing speed by giving individual chips enormous computing, switching and memory capacities. To do all this, a large array of technological developments were necessary. The development is not, of course, finished and both individual chips and computer systems are still becoming increasingly powerful.

We cannot possibly enumerate all the items and sub-systems that go into the making of a computer and shall mention only a few essential ones. To make modern computer chips it was necessary to develop the art of purifying materials, especially silicon, and the art of growing large near-perfect single crystals of this material. To manufacture chips from the crystals they have to be sliced and so-called doping materials have to be incorporated in very precise patterns on a very small scale. For this purpose masking, etching and diffusion or ion bombardment techniques were developed and, of equal importance, highly sophisticated masks had to be produced photographically to define the areas into which diffusion should take place.

Even the most sophisticated computer chips would be useless unless the art of programming computers had been developed to a very high degree of sophistication and efficiency. A computer has to be able to store its programmes, as well as a large amount of external and internal data. So we need different memory devices, and we also need devices to allow the input and output of data. Finally, we need to be able to print or transmit the outputs from the computer. This requires the development of visual output devices, such as cathode ray tubes or liquid crystal arrays, and the availability of fast printers.

This very sketchy and incomplete enumeration of the various technical sub-systems that go into a computer system should suffice to illustrate the essential nature of computer technology as a technological system, consisting of much varied hardware and a great deal of software.

Complex as all this is, it is not enough to make computers operational on the vast scale on which they currently operate. To make this happen, some social conditions had to be fulfilled. The principal social ingredient that had to be provided was a trained workforce able to produce, operate, program, service, repair and sell computers. The very first computers were designed by mathematicians and the first chips were produced primarily by physicists and chemists. The pioneers in every new field have to acquire their knowledge by trial and error and are essentially self-taught. These early experts then train the many new experts required, until a whole system of training and qualifications is established and a proper job-market develops.

The most crucial and essential condition for the establishment of a new technological system is the willingness of entrepreneurs to invest money in new ventures. Production facilities have to be built and a market in the new devices needs to become established. Both the risks and the potential gains are very large while the first uncertain steps on the path of a new technology are taken. In the case of semiconductors and computers the public purse helped to take some of the risk out of the enterprise. The military eagerly bought the new devices at prices that few civilians were prepared to pay. At a somewhat later stage, governments provided all kinds of help to the emerging technology because they became convinced that the economic future of their respective countries was at risk unless their country mastered and established the new technology at an early stage.

Finally, the computer had to find acceptance by a large number of people in a large number of applications. The technology had to become easy enough to use by only moderately trained people and its advantages had to be large enough to outweigh its disadvantages. This is a universal rule for the diffusion of new technology. People are always reluctant to change their accustomed ways and to throw overboard their skills and their experience. New technology has to offer considerable advantages to overcome the natural reluctance of people to change their ways; or so one would think. The most recent social climate, the'Zeitgeist', helps to overcome these natural human and organisational tendencies. The current Zeitgeist makes much of the value of progress and of modernity, whereas being old-fashioned has almost become a term of abuse. To be modern, progressive, 'with it' are desirable attributes, whereas being conservative, unadventurous, and reluctant to accept change are regarded as wholly undesirable attitudes. The ode on progress is sung by all and sundry, is heard from every rooftop and, of course, from all the political, cultural and – last but certainly not least – commercial establishments and the media. Old is out, novelty is king. Progress is the supreme goal. And, because technical progress is so much easier to achieve and to measure compared to social progress, technical progress has become virtually synonymous with progress as such. I regard this as unfortunate, because we could well do with social progress. Technical sophistication is no substitute for what has been called "the good society".

Taking technology as a whole, it is correct to say that it consists of an assembly of technological systems of various sizes, various degrees of complexity, various degrees of interdependence and various degrees of utility. All that has been said about household technology or computer technology as examples of technological systems could be said with equal validity for systems such as railways, road transport, aircraft, machine tools, textiles and clothing, and many more. Modern technology encompasses so many systems and sub-systems that any enumeration would be tedious and boring; suffice it to say that the totality of technology may be divided into a large number of systems, sub-systems and, within these, individual technologies. Each of these systems serves a particular group of purposes. These can vary from extending human capabilities beyond their natural limits (e. g. flying), or simply to ease the burden of physical labour and/or to accelerate the performance of tasks that are within human capabilities, albeit aided by simple hand-tools or implements, (e.g. digging, washing clothes).

Many complex novel technologies are troubled by unreliability. Actually it is the consumer who is troubled by malfunctions and breakdowns of many apparently wonderful gadgets. And, because there is an enormous discrepancy between the productivity of factory systems of production and repair workshops, repairs to malfunctioning gadget are comparatively very expensive and often hardly worthwhile. Quite a few relatively new but malfunctioning products are thrown away rather than repaired – we have become a throwaway society in many respects. This leads to waste of materials and to a good deal of frustration.

Some technological innovations are so radical that they form the beginning of an entirely new technological system. It is difficult, often impossible, to foresee the development of a radically new system when the radical innovation is still in its infancy. Examples are easy to find. The invention and introduction of the automobile started a radically different system of road transport and a very large new industry. In its further consequences the automobile caused fundamental changes in the way we live. If we consider the technological system "automobile", we need to consider the manufacture of thousands of individual parts that go into the assembly of a motorcar and the process of planning, designing, assembling and selling motor vehicles. We further need to consider the system of roads and all their ancillary features, such as the production of tarmac, traffic lights, bridges, tunnels, and so forth. And, of course, the system of producing and delivering fuel. The introduction of motor vehicles has brought in its wake a whole range of new legislation and regulation, including driving licences, compulsory motor insurance, vehicle inspections and vehicle licences. The automobile revolution has changed the face of towns and we may claim, without fear of exaggeration, that it has changed the face of the earth as well as the structure of society.

Major social change follows in the wake of major new technological systems. We have discussed briefly how the motorcar has changed the life of individuals, has contributed to change in family structures, in retail shopping, in town planning, in patterns of consumption and in environmental hazards. We should add a brief reminder that the widespread use of the automobile has also influenced global politics. Oil has gained fundamental importance in our economies and the politics of oil exploration and marketing has become a major factor in international relations and politics. Although no politician has admitted it, there is a widespread belief that the recent war in Iraq was fought primarily in order to secure Iraqi oil supplies for the USA and Western oil companies.

The most radical single innovation that contributed substantially to the rise of the computer to a major technological system was the humble transistor invented in 1948 as the forerunner of semiconductor electronics. Semiconductor electronics became a major industry in its own right and is at the heart of all modern computers.

The widespread use of computers has caused manifold changes in society. We have mentioned that the combination of data processing and communications technologies has enabled huge multinational corporations and financial institutions to be effectively controlled. This, in conjunction with modern transport technologies, has led to the phenomenon of globalisation, i.e. to the dominance of relatively small numbers of international corporations over most of our economic activities.

It is virtually impossible to know from the outset that a particular technology will lead to a huge system with enormous social repercussions. At the beginning of a radical new technology the scale of things to come is always underestimated. When the first automobiles came on the market, it was thought that they would serve

only as toys for the rich. Nobody envisaged the automobile at first as a means of mass transport and nobody imagined that the automobile industry would grow into one of the largest and most important industries in the developed world. The same happened with the first computers, with the telephone, with solid-state electronics, and so forth.

The radical innovation that becomes the forebear of a new technological system must have the potential of substantial utility and of capturing large markets. It will either replace older technologies (e.g. the automobile replacing the cart and horse), or fulfil some task that no other technology had fulfilled before (e. g. the aeroplane or the computer).

The new technological system may arise out of a single invention, but generally it will use older technologies in addition to the new invention for its early implementation. In the further course of its development the radical new technology will draw on numerous further new inventions for its eventual development into a new system. As soon as the potential of the new system becomes apparent to investors, there will be a rush of new investment that, generally speaking, will overshoot the mark. Once the potential of a new technology is realised, many old and newly founded firms endeavour to produce the new technology and try to reap above average profits from the novelty. Sometimes this pays off, but generally speaking many of those who chase after the novelty fall by the wayside and may not even recoup their investment.

The birth of a new technological system conjures up the image of a river. Even the largest river starts from small sources. It grows into a brook and on its way absorbs tributaries and thus swells into a river. Eventually it may become a major waterway with profound effects on the landscape and on the population that lives near it.

The large-scale application of a new technological system is invariably associated with radical social changes. Apart from the usual changes in occupations, it may affect the geographic distribution of populations, trade flows, and the very essence of personal and family life-styles. If we compare human society as it was roughly a century ago with human society today, we observe huge differences and note that many of them were caused, directly or indirectly, by road transport in general and the automobile in particular. Similarly, telecommunications had a profound effect upon society, as did air transport, television and the ubiquitous computer.

One of the properties of technological systems is that they can be both perfected and expanded by additional innovations. Once a new system starts on its course, numerous potential innovators look at every aspect of it in search of new opportunities to make profits. These may arise out of possible improvements in the manufacturing process of the new technology or of improvements in its performance. They may also arise by expanding the system to perform tasks that were not originally foreseen or envisaged.

Generally speaking, technologists and industrialists are always on the lookout for innovations that they might persuade the public to buy. The existence of a relatively new technological system that can be both improved and expanded is a great help to their endeavour as it focuses their search for innovative potential. Indeed occasionally an innovation is positively demanded by industry and we speak, rightly, of demand-driven innovations. This is the case when a new device or system shows a definite weakness, if there is an identified missing or weak link in the system. In early computers, even when solid-state electronics had overcome the greatest weakness of unreliability and large power consumption of thermionic valves, there were weaknesses in memory devices and in printers. On the other hand, when it comes to expanding the capabilities of technological systems, the innovations are more likely to be of the technology-push type, though with relatively easily foreseeable market chances. When large expensive computers had established themselves, it did not require great foresight, nor did it involve great risks, to attempt to market smaller and cheaper computers. Similarly, it is fairly clear that increasing the capacity of memories and increasing the speed of computers would be accepted by a market always keen on cheaper models and improved performance of virtually all technological devices.

The humble telephone provides some good examples of the ways in which a nascent technology can be gradually improved and expanded. The first crude telephones were sold in very small numbers to businesses and the exchange (central office) was technically very simple, with human operators plugging cables into and out of junction boxes. In due course the quality of reception improved and automatic exchanges were invented. Both these improvements required a great deal of development effort and many additional inventions and in-

novations. The telephone found it difficult at first to become widely accepted both because the quality of speech reproduction was poor but also, more importantly, because its usefulness was limited when the number of subscribers was small. In due course more telephone cables were laid and the number of subscribers increased. To lay cables and build exchanges was an obvious path for investors and innovators to take.

With global expansion of the telephone network the pace of development accelerated. Transmission became better, individual telephones were of better quality and more streamlined design, and it became possible even for long distance calls to be connected automatically. When everybody could dial everybody else throughout the world, the development of the stationary telephone had more or less reached its limit. However, soon the function of the telephone was supplemented by data transmission and the race was on for faster reliable transmission of increasing quantities of digital data. With this change the voice transmission tended to become digital as well, although the process of digitalization is not complete yet.

There was another possible way of expanding demand for telephones. Why have a telephone only in the office and in the home, when it became technically possible to have a telephone wherever you went. The mobile 'phone was brought onto a market that never knew it needed it, but accepted it with alacrity. The mobile telephone went from strength to strength and entrepreneurial firms soon added data transmission, access to the Internet and built-in digital cameras to mobile 'phone devices. At the moment industry is trying to sell TV reception on mobile 'phones, but whether the public will buy that is an open question.

Before the telecommunications industry could reach its present state, numerous technical inventions had to be made; from the humble magnet in a traditional telephone to sophisticated cell technology in the modern mobile 'phone. Thus the system was complemented and improved throughout its life, as well as expanded into performing additional tasks, not previously thought of.

The system nature of technologies provides valuable guidance to would-be innovators. The filling in of gaps in a system, the improvement of performance of certain parts of a system and of the system as a whole, and, finally, expansions of the system into previously uncharted territory all offer opportunities for innovators. The decisions what to buy and what not to buy are left to the market, i.e. to purchasing decisions by managers in the case of manufacturing technology and to purchasing decisions by individual consumers in case of consumer goods and services. Thus the market reigns supreme, as contemporary economic and political theory demand.

In reality, however, the market is distorted by all kinds of mechanisms. First and foremost, large firms create monopolies or oligopolies that dictate not only prices but also technological trends and the pace of technological change. It is obvious that industry marches more or less in unison. Major change in technological systems occurs more or less synchronously throughout an industry. Secondly, the actual market is not determined by genuine demand but by artificially created demands. A vast and sophisticated public relations and marketing apparatus invests enormous sums of money, manpower and ingenuity in telling people what they want to buy. To integrate a digital camera into a mobile telephone might seem like an exotic whim, but once the idea is pushed hard enough by the advertisers, it advances from whim to apparent necessity. A mobile 'phone without a camera suddenly becomes old-fashioned and obsolete. I suppose the combined device can be marginally useful to a few people who might take on-the-spot pictures of, say, real estate to send back to their offices. But does it offer any real utility to the youngster who would not be seen without it? The role of fashion in purchasing decisions cannot be overestimated. The me-too factor is as strong in the ownership of technological devices as in the ownership of anything else.

What happens when social needs have no champion? What happens about the urgent needs for technology that safeguards the natural environment? If governments are not prepared to look after the environment and provide the cash and the incentives needed to produce environmentally benign technologies, who else will? The task is too large for voluntary organisations and can only be very inadequately broken down into private purchasing or behavioural decisions. Governments are there to safeguard the public good and it should therefore be mandatory for governments to protect the environment. Many governments do little more than pay lip service to the task; and only some really try to do something substantial. Some governments of the greatest environmental polluters do not even pay lip service to the need for environmental protection and hide behind the convenient theory that the market knows best; the market will do all that is necessary. This is both logically

and practically a nonsense and means that if humans want to bring about their own destruction, so be it. Humans do not really deliberately wish to destroy the planet but are unable to prevent it unless their major social institutions, such as governments, take over this task. National governments and international governmental institutions provide the only possibility of taking a technological path toward a sustainable future. It is often argued that the necessary measures are too expensive. They are not. All that is required is the development of environmentally benign technologies. Such technologies can provide ready markets for the right entrepreneurs. Governments merely need to prime the pump and, in some fields of technology, e.g. energy, provide the right regulations and, occasionally, finance major schemes such as tidal power stations. Waging war to acquire energy resources is no substitute for developing alternative energies and energy conservation schemes.

Currently the all electric automobile is being hailed as the saviour from carbon dioxide pollution and hence the answer to all worries about climate change. The argument is based on a very obvious fallacy. The proposed system consists of a battery and an electric motor. The battery will supply the electric current for the motor that will drive the car. The battery[18] will be charged from the normal electricity supply grid. But how will the electric power in the grid be produced? If it is produced from fossil fuel, then the carbon dioxide pollution is simply shifted from the internal combustion engine in the car to the power station feeding the grid. [19]I find it hard to believe that the proponents of the electric vehicle are unaware of this problem; it is too obvious. I suspect that the idea behind the all electric car is being pushed by the nuclear lobby because nuclear power generation, with all its risks and problems, does not cause carbon dioxide pollution. The hybrid electric car is a different proposition because here the battery would be charged by an internal combustion engine that also drives the car under certain circumstances. The alternative of using so-called fuel cells in which hydrogen is used to produce electricity for driving the vehicle is a promising proposition, perhaps the most promising, but still some way from becoming useful in practice. The problem of providing a network of hydrogen fuelling stations is rather formidable. The hydrogen could be produced in places with an abundance of solar energy and transported to where it is needed.

Technologists strive to produce new or improved technologies in order to re-kindle demand in often saturated markets. Two fundamental features of the interaction between humans and their technologies help to make never-ending innovation possible. The first feature is human greed in general, and the desire to buy more and more products of technology in particular. The second feature is an obsessive desire of humans to follow the latest fashionable trend, to keep up with the Joneses, to be up-to-date. Once a new technology gets a foothold on the market and establishes a new fashionable trend, there is no looking back. People want to have the latest and manufacturers make sure that the latest replaces the established as soon and as often as possible. Yesterday's latest cry of technology is today declared obsolete and somewhat pathetic compared to the very latest technology. New technology is, in a very real sense, addictive. Many people have a craving for the latest technological products. They regard it as shameful to use any mobile 'phone that is not up to the latest standard; they cannot be without the latest in music recording and playing technology; they must have the latest washing machine, cooker, or whatever. This addiction is, of course, aided and abetted by the advertising and marketing fraternity and ably supported by the media.

Each new technology does, of course, have some advantages over its predecessor. The advantage may, however, be quite small and inessential, yet clever marketing will kindle a general desire to own this latest product rather than stick with the older one. Some innovations are merely stylistic, but we should not underestimate the influence and power of fashion well beyond the field of clothing. Fashion dictates much design of consumer articles and, in particular, domestic styles in decorations, furniture, tableware, and even gardens. Fashion also dictates our taste in the exterior appearance of technological products such as motorcars, buildings, computers, TV sets and many more. More importantly, some small improvements in technology become fashionable and kindle the desire to purchase the novelties. Take, for example, the introduction of central locking or electric window winders in motorcars. Admittedly they offer small improvements in comfort, but their irresistibility

[18] The most promising candidate for a suitable battery is a lithium–ion battery, though this is not entirely unproblematic. If the use of such batteries becomes widespread, lithium will become a valuable commodity.

[19] Admittedly a power plant produces energy somewhat more efficiently than a small internal combustion engine, so a small advantage can be achieved by the electric car.

mainly shows the power of fashion. Soon after the introduction of these items it became impossible to sell new cars not equipped with these new goodies.

Some improvements within the system 'motorcar' are more important and make more serious contributions to the safety of cars. Items such as ABS (preventing the blocking of wheels) and electronic stability programmes probably make valuable contributions toward car safety. Air conditioning, especially in its automated form, certainly makes a valuable contribution to comfort but, alas, uses up some energy.

The nature of technology as an assembly of systems, and the nature of humans to want the most fashionable product, makes life a little easier for the innovator. The task is nevertheless difficult and risky. There is a long way from idea to prototype, from prototype to marketable product, and from there to large-scale production. The road is long, full of obstacles and unexpected problems, and requires a great deal of money and perseverance. The vital question of whether or not the new technology will be profitable remains unanswered till a very advanced stage of the innovation process.

We have said that technologies are addictive and this is true in more ways than one. Once somebody has owned a car, he or she does not want to be without one. The addiction is reinforced by social adaptation to the motorcar. Public transport is usually neglected because it struggles to achieve economic viability in the face of competition from motorcars. Thus relying on public transport is often inconvenient and this inconvenience increases the attraction of car ownership. The car is still addictively attractive, despite all its environmentally negative impacts, despite the horrible carnage it causes on the roads, and despite the frequent gridlock it causes on the roads. From the point of view of society, the motorcar is a disaster; yet the illusion of power and freedom that it provides to individuals makes it irresistible.

Other technologies have proved equally addictive. Anybody who has ever owned a domestic washing machine is most reluctant to make do without it. The washing machine provides independence and frees people from real drudgery. Anybody who has ever owned a television receiver is most reluctant to abandon it. The addiction to television is very powerful and of socially dubious value; though a detailed discussion goes well beyond the scope of this book. I mention it only as an example of the addictive power that technology can have.

The natural inclination of most humans to want the latest technologies is, of course, reinforced by the manufacturers and their marketing departments. The consumer was compelled to change from long-playing records to compact discs by the simple expedient of virtually stopping the production of the older records and record players once the compact disc had more or less established itself on the market. The same is happening with video tape recorders that have become virtually unobtainable because they are being replaced by DVD recorders. The change of analogue TV broadcasts to digital broadcasts takes a little longer because the necessary investments are very large and because TV services have the status of quasi public services. The change will, however, be forced on the public by the same simple device of discontinuing analogue services and replacing them by digital services within the next very few years. People will have the option of not having TV at all or to avail themselves of digital terrestrial services, digital satellite services, or digital cable services. So embedded in our society has television become that very few people will forego it altogether, the overwhelming majority will choose some combination of the new service possibilities and will buy the requisite hardware to receive the digital programmes.

The pressure to purchase the latest medical equipment is somewhat different. There is a constant stream of innovations, with existing medical equipment being improved for greater effectiveness, greater accuracy and greater user comfort. In addition to improvements to current equipment, new machinery is added all the time to the range of diagnostic, surgical and therapeutic devices. Some innovations may be of marginal utility and some may not be strictly useful at all, but on the whole, equipment is constantly improving and expanding the range of applications. Providers of medical services are obviously under great pressure to ensure that their equipment is up to the latest standard. Many parts of medical provision are competitive and must therefore be able to boast of the best available equipment. Other parts are under public control and purchases are controlled by the public purse, but even these are under political pressure to provide the best possible service. Hovering in the background are the lawyers trying to threaten medical practitioners with legal action if there is even the slightest whiff of negligence. Using antiquated equipment is a weakness that medics do not dare to show, thus playing into the hands of sales departments for medical equipment.

Many small technical gadgets, including personal computers and amateur cameras, have to be replaced frequently because they develop faults. Repairs are inordinately expensive compared to new goods because industrial production is extremely efficient, whereas repairs are labour intensive and cannot be streamlined in the same way as production. The consumer often purchases new equipment to replace faulty items because the cost of repairs is exorbitant compared to the cost of buying new. An additional problem is unavailability of spare parts for older equipment and the incompatibility of old equipment with new accessories, or vice versa. Incompatibilities of all kinds and rapid obsolescence affect mainly computers and other electronic equipment.

From the point of view of manufacturers, rapid obsolescence, expensive repairs, and unavailability of spare parts for older equipment are viewed as blessings. Manufacturers, particularly motor manufacturers, used to push obsolescence to absurd levels. Under public pressure they were forced to increase the longevity of their products and these have now reached fairly reasonable levels. Household machinery still has too short a lifespan and computers age at a ridiculously rapid rate. It is argued that computers are a relatively new technology that is still undergoing rapid improvements. This may be so, but, on the other hand, ordinary consumers hardly benefit from the sophistication and power of the most recent machines and would be happier if their older computers lasted longer.

The rapid development of medical technologies poses substantial problems of funding medical services and also extremely controversial and difficult ethical problems that do not lend themselves to rational analysis. The problems I am referring to may be put in a nutshell: should medical technology be used to prolong life, of whatever quality, at all cost and under all circumstances. In my view it is very doubtful whether hopelessly sick people suffering total incapacity should be kept in a state of some kind of animation by the use of elaborate machinery. These are very problematic issues and solutions can only be found on an individual basis. There can be no universal answer to the question of what kind of life is worth living and should therefore be sustained. Nevertheless, the question needs to be asked from case to case and cannot simply be rejected as an inadmissible one.

There is a second ethical question associated with high tech and high cost medicine:

If financial means are not available to offer every available treatment to every sufferer from severe disease – as is the case in publicly funded health care – how do we ration funds? What criteria should be used? The degree of suffering; the age of the patient; his or her family responsibilities; his or her social importance? In this connection we might also question the right of the rich to buy themselves every kind of medical provision, even if the provision itself is scarce. There may not be enough specialists or enough machines to treat everybody; do the wealthy in this situation have the right to preferential treatment?

A thorough discussion of these complex controversial issues is well beyond the scope of this book. The reason I raised the issues is to show how deeply technology affects our lives. Indeed even the most searching questions about the meaning and value of life, on the face of it entirely unrelated to technology, need to be discussed in conjunction with the use of contemporary technology.

So far we have discussed technology mainly from the point of view of the consumer. We now turn to the manufacturer. The criteria applying to purchases of process or manufacturing technology are entirely different from those applying to consumer technologies. The main pressure on the manufacturer is the pressure of competition. This forces the manufacturer to do essentially two things: a) to produce technological innovations to keep ahead of the competition and to reap extra profits on innovative technologies, and b) to keep the cost of production as low as possible.

Although technological innovation is expensive and risky, it is, at least in high tech industries, mandatory. Only by innovation can any manufacturer gain substantial advantages over the competition and, of equal importance, innovative technology in its early stages can often command premium prices on the market and thus help to repay the considerable costs incurred in producing the innovation.

As technologies mature, the pressure on prices intensifies because more often then not an overcapacity develops because of over-investment in a new promising technology, and because markets tend to saturate once the technology is mature. Price competition becomes severe under these circumstances. The manufacturer is therefore forced to reduce costs in order to maintain a profit margin. The first thing that can be done to reduce costs is to improve the production technology. This means investing in better machinery and equipment that

can improve the quality of the output, reduce the number of rejects, and reduce the requirement for labour. The product can be designed for ease of manufacture, thus improving the overall efficiency of the process. Apart from improving the design of the product and improving the manufacturing technology, thus causing savings in materials and energy, the manufacturer must use possible savings in one of the greatest cost factors: labour. Labour can be saved by better production technology and also by better organisation of the whole process of production, including items such as layout of the factory, stock-keeping, streamlining the delivery of parts, choosing efficient suppliers for parts and services, and so forth. The unhappy outcome of all this drive for efficiency is a reduction in the workforce while maintaining the level of production and sales.

Another method of reducing costs is to reduce the wage-bill. In the most advanced countries this is difficult to do because of old-established rights of workers and strong trade unions. As unemployment grows, however, so the pressure on wages and privileges of workers increases and effective wages can be reduced. The threat of moving production to lower wage countries is another effective means of reducing domestic wages, but the actual move of production to low wage countries produces the ultimate savings in labour costs. It is a well-established practice of Western companies to shift production to Asian or east European countries where wages are low and the work force is well educated, well disciplined and docile. The individual firm may benefit from such a move, but the economy of wealthy countries suffers. Unemployment rises, purchasing power declines and the sense of well-being declines. People need work and this need is greater and more fundamental than the need for ever-cheaper goods. And not everybody can make their living from providing those ubiquitous financial services. In any case, recent events have shown the vulnerability and insanity of much that is going on in the world of finance.

The firms using all these various cost cutting methods may prosper and the consumer may benefit from reduced prices of goods. However all these measures cause reductions in employment in the wealthy countries and indeed unemployment has become endemic in most of them. This is a very unfortunate development, as the unemployed suffer not only considerable financial hardship but also severe social and psychological problems. In a very real sense the unemployed are outcasts and their potential as constructive and valuable citizens is lost to society, much as their potential for work and their potential as consumers are lost to the economy.

Work has become a commodity in short supply and work is the one thing people need more than various fanciful goods. However, governments find it very hard to ensure full employment. This is not surprising in economies that are run on purely capitalist principles in which governments have very few possibilities of intervening in the economy. They use various programmes ranging from training to underpinning some employment schemes, and they reduce workers rights, but the effect of all these schemes is marginal and cannot solve the root-cause of unemployment. The root-cause is that production efficiency is very high and that there is too much production capacity for any sustainable market demand. Innovations help to keep firms and the economy going, but most economic growth now is so-called jobless growth. This means that production can rise without employing additional labour. This is a consequence of highly automated production machinery and of increased administrative efficiency owing to the use of computers.

There are alternative means of reducing the pressure of competition and thus the pressure on employment in the rich economies. One alternative is the introduction of various trade restrictions, such as monopolies or cartels. Because of the current fervent belief of most governments in the virtues of free trade, these measures are now much more difficult to use, though very few people will claim that they play no role in contemporary economies. With so many huge global firms exerting their considerable power over markets, it is hard to believe that competition and free trade work to such enormous benefit to the consumer as our politicians would have us believe. Considering the effects of Western trade policies upon developing countries, the faith in the benevolence of free trade, as defined by Western governments and the World Trade Organisation, is even harder to sustain.

Unemployment has become endemic in developed countries and catastrophic in developing countries. Reluctantly, we must leave developing countries out of our discussion – their huge problems do not fit into the framework of this book. Most economists in the Western world believe that the endemic unemployment problem would disappear if our industries became even more efficient, if our labour costs, especially costs such as social, pension, and health insurance, could be reduced and if labour became more flexible (read less demand-

ing) and better qualified. All these measures might, just might, have a positive effect upon the supply side of the economy, i.e. upon manufacturers and service providers. On the other hand, workers who are less well secured in case of unemployment, sickness and old age would lose some of their propensity to spend. If wages were lowered as well, it is hard to see how the more efficient supply side, with an even greater production of goods and services, could find consumers willing and able to buy all these additional outputs. Improving the supply, without a corresponding increase in demand, is futile.

There are demands that remain unfulfilled despite unemployment and spare capacities in many industries. The unfulfilled demands are of two kinds:

First, there is a great deal of unsatisfied demand for various labour intensive services, such as health services, public transport, education, care for the elderly, sick and disabled, and so forth. The problem with these services is that by their very nature they are expensive and it is hard to see how they could be delivered with increased efficiency. Those in need of the services generally cannot pay their full costs. Hence the public purse is required to face the bill and the public purse cannot, or will not, stretch to covering the full potential demand. Solving this problem would create massive employment and create a more humane society. At the moment, it is hard to see how this might happen in this profit-oriented society.

Secondly, there is considerable potential demand for environmentally benign and sustainable technologies. They range from very simple measures, such as more intelligent flushing systems for toilets to save water, to the highly complex and expensive projects for sustainable non-polluting energy supplies, to technically feasible but socially complex measures to reduce pollution from motorcars and lorries.

Energy supplies are a highly controversial topic. The positions range from that of the US, the greatest energy guzzler and polluter of them all, whose government simply does not want to know about measures to reduce greenhouse gases[20] or measures to curtail the use of nuclear energy, to that of the German Government that is committed to phasing out nuclear energy. France, on the other hand, is fully committed to nuclear energy, whereas the British Government has announced yet another review of energy options with the likely outcome that a new generation of nuclear power stations will be built. The nuclear option is advocated by many as the best option for large-scale electricity production because, unlike thermal power stations, it produces no greenhouse gases, in particular no carbon dioxide. Opponents of nuclear energy point out that it is expensive, that the future of Uranium supplies is uncertain, and, most importantly, that the radioactive waste produced by such power stations needs to be disposed of safely for a thousand years and that this is fraught with dangers and difficulties. They also point out that the power stations themselves might be prone to dangerous breakdowns, accidents and leaks of radioactive materials and might be vulnerable to terrorist attacks. Supporters of nuclear energy think that all the problems can be solved and that nuclear energy is the environmentally most benign and also the most economic solution to rising energy requirements.

Opponents of nuclear energy generally argue that there are plenty of non-nuclear possibilities to produce energy in environmentally benign and sustainable ways and also that our profligate use of energy could easily be curbed by suitable technological and social measures. Let us start with options for energy production. The order in which I list them is not necessarily their order in importance, as this is hard to gauge as yet. I start with the bio-fuel option, in which fuel is produced from agricultural crops of various kinds, beginning with fast growing woods and ending with rapeseed or sugar beet. Almost any plant and much organic waste can be converted into fuel by suitable fermentation processes. The fuel can be burned in conventional ways and the burning process does, of course, produce some carbon dioxide. However, as the plant uses dioxide from the air to grow, the net input of dioxide into the atmosphere is zero when burning fuel produced from plants. We may argue that bio-fuel is one way of using solar energy, because the plant uses solar energy to grow. The major objection to bio-fuel is that it uses agricultural facilities and soil that might otherwise be used for growing food, and thus drives food prices up beyond the reach of the poor. There can be no objection to the production of bio-fuel from waste. There are other ways of using solar energy, the ultimate source of most energy on earth. We can install solar panels of two kinds: either panels similar to central heating radiators that use the heat of the sun to heat water, mainly for domestic hot water systems; or we can use solar panels that convert the light

[20] This situation appears to be changing with a new President and a new administration having taken office recently.

from the sun directly into electric power. This, at the moment, is suitable for small-scale energy production, but is very useful for isolated places needing small amounts of electric power and is being technically improved all the time. We can also use solar energy much more indirectly, by using wind power or wave power. Both these technologies are used currently on a reasonably large scale. Some people object to the use of wind energy, claiming that it is unsightly, noisy and disturbs birds in their flight. Beauty lies in the eye of the beholder, the noise is not obtrusive and the degree of disturbance to birds is largely unknown. Another way of using wind power is to install devices that ride the ocean waves and translate their movement into rotary motion that drives an electric generator.

The next source of energy is not the sun but, rather indirectly, the moon. We can use tidal flow to produce energy either by simply inserting underwater turbines into the flowing tidal water, or, on a much larger scale, by building a barrage and thus capturing, in suitable estuaries, very large flows of water and, thus, produce large amounts of electric power in more or less conventional hydro-electric power stations. Some such schemes are in operation in Europe; in Britain a commission investigated the possibility of building a barrage across the Severn Estuary near Bristol. So far, the scheme has not been realised on account of the high cost involved and, less significantly, because of objections that local wildlife might be disturbed.

Finally, there is the hydrogen option. Hydrogen can be produced from natural gas, but that defeats the object of preserving the dwindling resources of gas. Hydrogen can also be produced from water; simply by splitting the two atoms of hydrogen from the atom of oxygen (water consists of H_2O). This can be done by electrolysis, which uses electric energy. The electrolysis needs to be powered by "clean electricity", that is electricity produced without carbon dioxide emissions. Hydrogen can be used as a mobile fuel with the attractive property that its sole product of combustion is water. The production, storage and transportation of hydrogen pose considerable problems. It appears likely that countries with plenty of sunshine will export this energy in one form or another; perhaps in the form of hydrogen or perhaps in the form of electric power.

Apart from the various possibilities of producing energy, we can also be less profligate in our use of energy. Houses can be better insulated; cars can be more efficient and need not travel so fast; public transport is more efficient in its use of energy than private personal transport, industrial production can be made more energy-efficient, and we need not use so much packaging. The fuel consumption of motor vehicles rises very sharply with increased speed of travel. Decreasing the speed of travel saves precious fuel and thus reduces costs and, of equal importance, it saves lives because it reduces the number and severity of accidents. We can save water and thus preserve a valuable resource, and thus also save energy used in pumping, cleaning and heating it.

Whether we speak of alternative sources of energy or of energy savings, in all cases there is scope for technological innovation with all its benefits of producing new employment. Recently there has been talk of collecting carbon dioxide as it escapes from chimneystacks and pumping it into some kind of storage facility. This would reduce the amount of carbon dioxide that enters the atmosphere, and may thereby reduce a further increase in the concentration of greenhouse gases, and thus avoid acceleration in climate change. Old oil wells or coalmines are among the storage possibilities being discussed. For some countries it may well be worthwhile to continue the production of coal and the operation of coal-fired power stations. They would need to make sure that the waste gases are thoroughly cleaned and consider the possibility of storing carbon dioxide, which is an unavoidable product of the burning of coal and other fossil fuels. The days of coal may not be over yet.

Whatever we might do about producing alternative energy, we certainly cannot get by without decreasing our energy consumption. There is not enough potential for the development of alternative energy sources to feed our profligate use of energy. We must save in order to make a real impact on the greenhouse effect and the potentially disastrous human-made fast climate change.

There would be considerable scope for work on environmental improvement and on redesign of technologies to make them environmentally more benign. Unfortunately the public purse is not very generous at the moment and environmental projects are starved of cash. To design products for environmental compatibility is not generally regarded as worthwhile, because the public is not inclined to spend money on such improvements unless they offer individual advantages in addition to the societal advantage of environmental compatibility. Perhaps entrepreneurs should be a little more inventive and offer environmentally benign technologies that do benefit the individual purchaser. Solar panels, for example, can reduce the energy bill of households. They are

rather expensive, but in countries where government supported the technology in its infancy, thus bringing down the price, they find a ready market. House insulation is another technology that reduces household bills. Advanced central heating boilers and installations, with suitable electronic controls, are other examples. As the market for so-called hybrid cars shows, the public is not disinclined to purchase vehicles with very low fuel consumption if they become available at the right price and the right levels of comfort. Unhappily, at the same time as people buy frugal cars, they also buy ludicrous gas-guzzlers with engines that could propel a tank and acceleration and top speed suitable for racing cars rather than road vehicles. This development is, I think, one that calls for regulatory action that would remove such anti-social monsters from public roads. Automobile manufacturers will produce anything that provides them with profits and thus the frugal very small car lives side by side with extreme luxury cars or extremely fast so-called sports cars.

All kinds of socially desirable services are difficult to finance. At the moment discussions about the financing of retirement are en-vogue, whereas discussions on the financing of care for the elderly and the disabled do not feature quite so prominently in our media. Yet it is hard to finance such services because they are very labour intensive. With the demise of the extended family the elderly often end up in institutions. Neither the state nor private individuals find it easy to finance these institutions. They often run on a shoestring and provide inferior quality care, and yet they stretch private finance to the limit.

The situation of public transport is much the same. It seems almost impossible to run railway or bus services at a profit. The main reason for this is competition from private cars, but also very high costs of the necessary investment. So many problems of congestion in cities and of excessive pollution and excessive fuel-consumption would be eased if more transport of passengers in cities, and of goods between cities, could be shifted from motorcars and lorries to trains and buses.

Another socially desirable range of services that are difficult to finance are education in general and infant education in particular. The long fought for equality of women and equality of occupational opportunities for women, hinges on care for infants and toddlers. There is no known or conceivable technological "fix" for this problem despite a well-established social need. Not only is technology unable to take over from qualified people to look after children; it cannot even reduce the cost of such services. Except in horror visions, it requires humans to look after the human young. The cost of high quality care for young children is very high and this is a huge burden, especially for single parents. An important social problem that has no technological answer. The only feasible answers are social.

It is a shameful sign of our times that one of the pillars of civilization; the provision of a secure environment – has been badly eroded. We now need more security services than ever before and technology finds considerable scope in aiding the provision of security. Metal detectors are widely deployed, especially at airports, to detect firearms and explosive devices[21]. Security cameras are in widespread use to deter criminals and to help catching them. Biometric data augment the well-established use of fingerprints, and computers are able to check and verify such data at great speed. Biometric data can be used in place of simple passwords or simple keys. Many countries are planning to use such data in identity documents, including passports.

The disposal of waste has become a major headache and a variety of technologies are being developed to help solve this problem. One of the more modern approaches to waste management is recycling. This requires the sorting of waste into components that can be recycled and does not, of course, get rid of all the waste. The main items that can be recycled are metals, glass, paper, various plastic materials, and some textiles. Apart from this type of recycling we can also use garden and kitchen waste to produce compost and thus reduce the total amount of waste that needs to be disposed of and produce a valuable material for the garden that replaces some chemical fertilizers. The waste that remains after all that needs to be either buried or incinerated. In both cases it is helpful to remove toxic materials first and in more advanced waste disposal schemes items such as batteries, waste oil, paint and pharmaceuticals are disposed of separately. Incinerators can be used for district heating, but their design and safe operation are somewhat problematic. Burying waste can be useful as landfill, but suitable sites are difficult to find.

[21] The metal detector cannot, of course, detect explosives; it can only detect metal parts of a bomb. Sniffer dogs, on the other hand, can detect explosives and drugs.

There are many ingenious ways of dealing with problems of waste. Automobiles are now designed so that many recyclable or problematic components can be removed with relative ease, while the rests can be compressed for ease of storage and transport, and the steel can be recycled. The recycling of steel, glass and paper are old-established techniques, but currently more recycling techniques are being developed in response to awareness of the need to preserve materials and energy and also because landfill sites are scarce and the dangers of seepage of toxic materials are acute.

It is often claimed that the use of the computer has increased the efficiency of services by leaps and bounds. It is also claimed that the computer has enabled new types of services to be introduced. Both these claims imply that the computer has strengthened and expanded the service sector in the economy and has thus contributed to economic growth.

The above statements beg two questions. First, what does efficiency in the provision of services mean? It is easy enough to measure some kind of efficiency for services that are bought and sold in a market. In this case efficiency means the ratio of outputs to inputs, both measured in monetary terms. This kind of formal measurement has no meaning in terms of the quality of the service or its social desirability, it merely means that by putting in a certain amount of capital, labour, energy, and so forth a service of such and such a monetary value can be sold. A very large number, probably a majority, of services are not sold directly in a market but are either provided by public bodies or are so complex and multifarious that the overall efficiency or profitability cannot be ascribed to any particular aspect of the service in any meaningful manner. The efficiency of public services is very hard to measure, and what measures are used are largely arbitrary and subject to political influence. Politicians love to claim that they, unlike their opponents, can increase the efficiency of public services, but none of them can ever provide a precise answer on how they will do it or how they will meaningfully measure it. They all say they will cut waste, but what is wasteful lies, more often than not, in the eye of the beholder. Is it wasteful to provide a home help to old ladies and allow the help to chat a little with her lonely old client? Is it wasteful to plant annual flowers in borders of shopping centres or parking places? Is it wasteful to provide pedestrian zones in city centres? There is no end to possible questions, but a dearth of sensible answers. The truth is that the quantity and quality of public services are not defined and, hence, the efficiency of providing them cannot be defined either. Undoubtedly some rational measures can be taken to run a given service at lower cost in undiminished quality. But these sorts of measures are very limited and usually fully exhausted. Generally speaking, when costs need to be cut, either some services are cut or their quality is reduced.

This brings us to a discussion of quality of services. There are as many measures of quality as there are services; the general rule is horses for courses. Take, for example, a passenger transport service. What the customer wants to see is comfort, punctuality, frequency, reasonable costs, transparency of tariffs, ease of booking, ease of access, ready availability of information, assistance with luggage, and possibly some more. The computer can help with some of these aspects of quality, but the computer can also be misused to cut costs and diminish the quality of the service. The internet can provide useful information about timetables and tariffs of transport services. Alas, most websites are badly designed and difficult to use and hardly any can answer obvious questions such as: what is the best time to travel if I want the cheapest available fare? Not everybody has access to the internet and not everybody can handle websites. Telephone services will therefore remain indispensable for a long time to come and need to be adequately staffed. Some travel tickets are sold over the internet and the actual process of using the ticket to check in can be a nightmare. The choice between overstretched staff and long queues on the one hand, or difficult to understand and to follow procedures for self-check-in, is the choice between a rock and a hard place. How idyllic were the times when nice people sold you the ticket that was best for you and told you what to do next! Did these people really have had to be replaced by horrid machines? Even cashiers are being replaced by horrid self-service cash points. How idyllic were the times when one could speak to a shop manager or a sales assistant and obtain sensible answers to sensible questions, whereas now one speaks to somebody in a remote call centre who only knows as much as the computer he or she is facing. And that is, generally speaking, not a lot.

Some services, we might call them high-tech services, use highly complex machinery to provide the actual service and, in addition, use computers in their administration and their logistics. We consider two examples: a hospital and an airline. The technologies that are fundamental to these services are medical technologies on

the one hand and airliners on the other. Both these technologies are immensely complex and their application requires many technical and organisational ancillaries and a lot of highly trained staff. In both cases the computer is ubiquitous throughout the basic technology and throughout the service.

Computer applications fall into two groups: the computer as an administrative/organisational tool and the computer as a technical component of some machinery. Examples are not hard to find. In the case of a hospital we can think of computer tomography that has a computer as a central component, and we can think of patient records as a use of the computer for administrative tasks. In the case of an airline we can think of numerous computer systems used to control the jet engines or the auto-pilots, and we can think of computers used for passenger reservations.

Almost all contemporary services use the computer for at least one category of application. The only exceptions are services organised on a very small scale, one man or woman businesses providing services such a gardening, domestic cleaning, hairdressing and the like. We tend to overlook and underestimate these services, yet they contribute a great deal to the quality of life of many people and provide a source of income to many others. In my view, we could do with many more of these types of services and could readily dispense with many glamorous "financial services" that provide excellent income to their practitioners and often poor value to their clients.

Whether through the influence of computers or not, we have become obsessed with measurement. We want numerical values for everything and then construct comparative tables, league tables, graphs, targets and percentages of the attainment of targets. Most of these figures, tables and graphs mean very little, but we cannot employ thousands of computers and thousands of graduates of business schools in public administration and in business and yet escape this particular penchant. Computers are good at it and business schools love it because it endows them with a kind of scientific respectability.

There are two fundamental difficulties with this kind of thing. Excessive measurement, often of items that cannot be meaningfully measured, and excessive setting of numerical targets, leads to distorted values and to futile goals. It leads to the pursuit of false gods and to misallocations of resources.

The second fundamental problem with the excessive worship of measuring rationality is that it is juxtaposed with irrationality. Whereas it is perfectly feasible to think and act rationally even in the absence of measured data; we now seem to think that the only alternative to measurement is irrationality. Even if such sentiments are rarely clearly enunciated, they are often applied in practice.

Unfettered competition and excessive reliance on advertising and the media has led to a loss of confidence. The modern citizen feels constantly cheated. Cheated by politicians, cheated by advertisers, cheated by the media, cheated by business and cheated by bankers.

We cannot blame the loss of confidence entirely on technology. There are many causes, but in many of them technology plays at least some role. The dominance of multi-national firms and very large business firms has caused considerable unease among the citizens and the faith in the integrity of such firms is at a very low ebb, to put it mildly. Technology plays a role in so far as without information and communication technologies such firms could not operate and could not have achieved their dominant positions. We may view technology as merely an enabling factor that allowed certain tendencies to become reality. But we may also think of technology as providing opportunities, ideas, and temptations on the line that anything that can be done shall be done, as long as it provides benefits to some skilful and well-placed players.

We have completely lost such faith as we ever had in the integrity of our politicians. We cannot blame technology for this, but must at least suspect that the media have something to do with it and the modern media are certainly creatures of technology. Politicians who are exposed to the daily gaze of the public on television find it hard, if not impossible, to retain any credibility. Too obvious are the twists and turns and implausibility of their arguments, too obvious their cavalier attitude to facts and the truth, too obvious their blatant attempts to ingratiate themselves to the public by saying anything that their public relations consultants think will go down well. Indeed it has in some cases become hard to distinguish between public relations and politics or policies and, as a result, the public feels constantly cheated.

There are more direct influences of technology that cause loss of confidence in citizens. First and foremost it is the loss of personal contact. We are no longer personally connected to large parts of our society; our con-

nection is now via an intermediary and the intermediary is a machine – the computer. We can no longer telephone our suppliers directly; we have to go through a call centre and although we nominally speak to humans, in effect we speak to a computer. The human operator merely puts into human language what he or she reads off the computer screen. The feeling of the citizen is that he or she is dealing with a vast anonymous impenetrable organisation. It is the situation described by Kafka in his novel "The Castle" all those years ago. The difference is that Kafka described an impenetrable alien and undemocratic bureaucracy, whereas we are now dealing with supposedly friendly democratic institutions corrupted by the computer into something alien.

A blatant example of the generation of mistrust, with technology acting as a facilitator for mischievous and criminal human behaviour, is internet criminality. It ranges from the considerable nuisance, and often severe damage, caused by viruses and worms and whatever else these constructs of sick brains are called that infest the Internet, to downright theft perpetrated on the Internet, and includes criminal child pornography. The latter is made more dangerous by chat rooms and similar institutions that enable adult criminals to pose as youngsters who "innocently" wish to meet other youngsters. The Internet makes it easy to assume a false identity with criminal intent. The Internet thief is a very different animal from the common and garden burglar; the Internet criminal only needs good knowledge of computers and some ingenuity to manipulate other people's money for his or her own benefit. For protection against such criminals locks or burglar alarms or fierce guard dogs are of no use. What is required are ingenious security programmes that are constantly being improved. The old race between criminals and security devices is now being run between computer programmes. The police too has had to adapt to the new situation and needs computer experts to fight computer crime.

Another matter that causes uncertainty and ambiguity toward technology is the frequent malfunction and unreliability of many high-tech products. Manufacturers drive the technology to its limits and rush out new products before their development and testing is completed. They do this in an attempt to be first, or at least among the first, to bring out products with novel features onto the market because such products can be sold at premium prices and because high-tech firms lay great store by their image as being innovative. The image of pioneer is worth a great deal to them. The reverse side of the coin is the disappointment of many purchasers that their shiny and wonderful new equipment is nowhere near as wonderful as the marketing departments claim and, much worse, that equipment often fails entirely after a very short period, usually just after the expiry of the guarantee. And because manufacturing is very efficient, whereas repair work is labour intensive, repairs are inordinately expensive. All this adds to an atmosphere of frustration and mistrust; obviously things are not what they are supposed to be.

These comments apply to almost all high-tech sold to the ordinary consumer and the only beneficiary from the unreliability of products are various insurance companies who offer insurance against failure; albeit at a very high cost. The consumer is ambiguous; on the one hand he or she is attracted to the new apparently wonderful products, on the other hand their unreliability engenders a general feeling of being cheated. And this feeling goes well beyond high-tech products and permeates many aspects of the individual's relations with society.

Some technologies are socially more desirable than others. The practical application of this simple and uncontroversial statement poses two difficult problems. First, who decides and articulates the social desirability or undesirability of the consequences of a technology? Secondly, how are we to know beforehand what consequences will flow from the future application of a new technology? Technology Assessment attempts to answer the second question in order to inform the decision making process and, hopefully, achieve better decisions[22].

The answer to the first question depends on who sponsors the technology in question. Large-scale publicly funded or supported projects must be decided upon by due political process. What this process is depends on the particular governance of a particular country, but the decision on major public technological projects is, for better or for worse, an essentially political decision. Whatever we may think of a particular system of governance, the government of a country is the ultimate guardian of the public interest and must decide whether a particular technological project is or is not in the public interest. The actual decision-making process may involve a variety of mechanisms, including the setting up of a commission of enquiry, public debate, debate

[22] See e.g. Ernest Braun, (1998), Technology in Context, London, Routledge

among interested parties, parliamentary debate, specific research projects aimed at informing the debate, and so forth.

Technological projects sponsored by private firms are a matter for the firm to decide and the decision will be based mainly on an assessment of the earnings potential of the project. The firm will ask whether the project is within its capabilities, whether it will enhance the reputation and the growth potential of the firm and so forth, but the expectation of profit - the so-called bottom line - will be the decisive consideration. The firm will give some consideration to the social and environmental consequences of the proposed technology. It will do this in order to ensure that the proposed technology conforms to all applicable existing and foreseen regulations and standards. These considerations are mandatory; no firm can afford to ignore existing and legally enforceable regulations or standards. For a variety of reasons, the firm may add further social considerations. It may do so because its management is enlightened and committed to environmental protection or some other social ideal, or it may do so because it wishes to gain the goodwill of an enlightened public.

Many major projects undertaken by private firms are supported in various ways by governments, be it by direct subsidies, advance purchases, R&D in government laboratories, tax concessions, or other means. Whenever government is involved in a technological project, it ought to be up to government to perform the necessary technology assessment or, at least, make sure that the commercial partners in the project have carried out a satisfactory assessment.

The main question the manufacturer asks before introducing a technology, having made sure that it conforms to all standards and regulations, is whether it will sell and bring in a profit. An enlightened manufacturer often attempts to advertise his wares by showing that their performance is better than regulations require, that the product is indeed beneficial to the environment and is safer than safe. One of the ways to make products more desirable for environmentally aware consumers is to show that they consume little energy and that they can be recycled at the end of a long useful life.

In these neo-liberal days 'regulation' has become a dirty word. But sensible regulation is vital to the functioning of society and to the functioning of technological systems within society. The controversy should not be so much whether a degree of regulation is necessary, but what constitutes sensible regulation. To answer this question in individual cases is one aspect of technology assessment.

Regulation of technology has essentially three aims: 1. To ensure the safety of the users of the technology. This includes, for example, regulations about the safety of electrical appliances both in regard of preventing electrocution and of avoiding fire hazards. 2. To ensure that the environmental damage of the technology is limited to whatever standard is agreed by the lawmakers. This includes, for example, regulations about permissible levels of harmful emissions from motorcars or from factory chimneys. 3. To limit the danger and inconvenience a technology might cause to others. This includes traffic regulations and the allocation of wavelengths in the electromagnetic spectrum to different users of wireless communications. Regulations may change with new technologies and new scientific discoveries, but also in the light of public awareness and of political developments.

One form of regulation consists of the setting of standards for products by special institutions set up for this purpose. Standards have the dual role of ensuring the safety and functionality of certain technologies and, no less important, the interchangeability of products. If, for example, every manufacturer were to produce a different electric plug, the users would have no guarantee that the appliance they bought could be plugged into the sockets in their home. If a product complies with the standards applicable to it, the customer has an assurance that the product will perform its functions to a satisfactory degree and will not interfere unreasonably with other users or the general public.

We come to the second question asked above: how are we to know beforehand what consequences will flow from the future application of a technology? In the strictest sense, we must admit that we cannot know the future effects of a technology, indeed that we cannot know much about most aspects of the future. We need not be so strict, however, and may be able to achieve useful insights by trying to foresee the consequences in the fullest possible way, rather than simply trusting to luck or a highly partisan forecast by a committed proponent of a technology. The future is always uncertain, but by systematically trying to foresee the consequences of our

actions we improve our chances to achieve our goals and to avoid various pitfalls. Humans are planners, they expend much effort on planning the future, and Technology Assessment is a method for improving the planning of technology.

An enlightened manufacturer attempts to foresee, during the early stages of R&D, as many effects of the new technology as possible in order to use the technology to best advantage and to be spared unpleasant surprises. Similarly, a public authority, embarking upon a technological project, seeks to foresee all the consequences that will flow from the implementation of the project. Much has been written about the methodology for TA, but beyond a very general universal methodology, it is necessary to devise the TA to suit the particular project in mind. "Horses for courses" is an appropriate rule for TA.

The general methodology helps to set out the problem in a systematic way. In summary, we may say that each technology assessment should consist of four basic steps: 1. deciding the scope of the investigation; 2. describing the technology involved, including rival and complementary technologies; 3. attempting to foresee the impacts of the technology or technologies, showing both positive and negative effects and identifying the affected parties; 4. looking at options for policies to be adopted with respect to the introduction of the technology and possible ways of promoting, directing or regulating it. This formulation is clearly more appropriate to public bodies than to commercial firms, but in essence the process of TA is the same for whoever plans to introduce a technology.

Several remarks need to be made. First, it needs to be emphasized that TA is an interdisciplinary activity. It requires technical expertise, as well as social, legal, economic and commercial knowledge. Thus the TA investigators must consult with as many experts and, of equal importance, with as many potentially affected parties, as appropriate for the particular assessment.

Secondly, it is difficult to know in advance what scope of assessment might be necessary. If, to take an historic example, we had been given the task of assessing the impact of the earliest semiconductor devices, the rectifier and the transistor, we might have come up with purely technical effects, such as compactness and low power consumption of future electronic devices; the need for retraining of electronic engineers, and possibly the need for developing new manufacturing techniques, but not much else. Nobody could possibly have foreseen the revolutionary developments in electronic devices, the huge expansion in computing and computers, the change from analogue to digital electronics, and all the vast gamut of changes in technology and in society that followed in the wake of the earliest steps in semiconductor electronics. This is truly an amazing story of the humble acorn growing into a mighty tree.[23] It requires a good deal of lateral thinking to know in advance what scope of TA should be attempted. And, most important, a single TA will often not suffice; the process needs to be repeated as the story unfolds, as new technologies emerge, as new knowledge accrues, and as the first impacts are beginning to be felt. Once a technology has gone too far, once it has become entrenched, it becomes very difficult to do anything about modifying its social effects[24]. We only need to think of the motorcar, or of the computer, or telecommunications, or the railways, or aviation, to see what is meant.

Finally, the activity of technology assessment is an advisory activity. Its aim is to inform decision makers, to warn them of risks and make them aware of opportunities. Whether in the public arena or in private firms and whatever the specific set-up, decisions on technology (as on any other matter) should be taken with the aid of the best possible information. Better informed decisions are likely to be better decisions in the sense that undesirable consequences may be avoided and positive opportunities may be taken[25]. On the other hand, we must acknowledge, albeit with regret, that despite all information decisions are often faulty and that no amount of objective information has the power to override irrational forces, prejudice and self interest. Even well established facts, let alone uncertain projections and controversial theories, are not necessarily the most important consideration in a decision. The power of science is limited in two senses. First, much knowledge that would

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[23] For a discussion of the influence of cybernetics on R&D see Michael Nentwich, *Cyberscience*, 2003.

[24] David Collingridge, (1980), The Social Control of Technology, Open University Press, Milton Keynes, discusses thie problem in detail

[25] Nassim Nicholas Taleb argues in his book *The Black Swan* (2008), Penguin Books, that forecasting is useless because the really important outcomes are determined by unforeseeable events and circumstances

help decision makers is simply either unavailable or insufficiently well founded to be truly helpful. Secondly, inconvenient facts are often ignored by decision makers upholding their own interests or prejudices.

One factor that relegates the eminently sensible activity of Technology Assessment to a minor role is the globalisation of the economy and of technology. If a technological trend starts anywhere on earth, the rest of the world will follow it almost without question for fear of missing the boat and falling behind in the fiercely competitive quest for profit. Nevertheless, if the activity of TA is carried out with international cooperation it can still be very useful.

Because technological innovation is believed to stimulate the economy and to bestow competitive advantages upon countries, most governments try to stimulate technological innovation in a variety of ways. First and foremost, the public purse supports basic science, also known as curiosity driven science. This may be seen as a general cultural activity with the aim of knowing more about the world we live in; knowledge for the sake of knowledge, as a value in its own right. It may, however, also be seen as providing the fundamental knowledge on which future technologies may be based. We no longer believe that the distinctions between pure and applied knowledge are entirely clear-cut. Governments hope that their support for a purely cultural activity will, one day, yield economically useful knowledge. Governments do, of course, support applied research and technological development and, sometimes, even lend support during the early stages of the introduction and marketing of new technologies. The last of these may take the form of government purchases, or government sponsorships of conferences and seminars, or government help for pioneering early buyers of the new technology. Government also finances what we might call a research and information infrastructure, in the form of research institutes, research libraries, the patent system, learned societies, and a multi- layered education system. Government provides a variety of tax incentives for research and development and for technological innovation. And, last but not least, government itself – particularly its armed forces – is a major purchaser of innovative technology.

Before lending support to a new technology, government must make sure that the technology will bestow real benefits and will not cause harmful side effects. To do this, government or its agents usually perform a Technology Assessment or a series of assessments in various forms. Although it is not possible to foresee all effects of a technology in its infancy or, harder still, during its embryonic state, the attempt is nevertheless well worth the effort because it can also help to shape the technology to some extent in order to improve its utility and reduce its ill effects. What represents utility and what is an ill effect is, of course, debatable and must be subject to a political process. The TA can provide useful, careful and balanced information to feed into the decision process. Technology Assessments should inform both the regulation of technology and support for technological innovation by public authorities.

Currently, for example, there is a lively debate about the utility and the hazards of genetic engineering in all its aspects and ramifications, including genetically modified food. If we are to believe certain commentators, we might be at the beginning of a development that looks to me like a horror scenario[26]. Careful and numerous Technology Assessments will be needed before and during the process of lending public support to these developments and legislating in this highly controversial area. I hope that the Technology Assessments will stimulate and inform a public debate that will influence the political decision makers. Too much is at stake to leave the matter in the hands of scientists, ill qualified to make moral or political judgements. Too much is at stake to leave the matter to the lay public, uninformed in matters of science and technology. Too much is at stake to leave the matter to the discretion of politicians, driven by their own sets of interests. The future is too important to be left to the sole discretion of any of these groups and should be in the hands of scientists and engineers, technology assessors and social scientists, the general public and politicians, each contributing their shares and acting in cooperation.

Technology is inescapable; we cannot survive without it. We must make sure that it is used for the good of all humans and to help us take care of our planet.

26 See e.g. Pierre Baldi, (2001), The Shattered Self, MIT Press

Further Reading for this Chapter

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