THE FORTHCOMING INFORMATION REVOLUTION:
ITS IMPACT ON SOCIETY AND FIRMS

by

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The impact of the industrial revolutions on all aspects of our society, work and life has, undoubtedly, been substantial. Will all the talk about the information revolution produce similar, far-reaching changes? By examining analogous inventions of the industrial and information revolutions, this paper argues that the latter is on target and that by around the year 2015 it will be at about the same stage of development as the industrial revolution is today. This would mean extensive changes which will affect the way we shop, obtain services, work, educate and entertain ourselves. Furthermore, the impact of information technology on firms and management will be considerable, resulting in flat, horizontal organizations and an intensified competitive market place that spans our entire planet as people will be capable of buying goods and obtaining services from anywhere in the world by using computer networks like Internet.
THE FORTHCOMING INFORMATION REVOLUTION:
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Spyros Makridakis
Research Professor, INSEAD

During the last three decades, numerous predictions have been made about the forthcoming
information revolution and its impact on society and firms.\(^{1}\) As is often the case, the speed
and the potential benefits of such a revolution have been exaggerated.\(^{2}\) By now, computers
should have been capable of speaking fluently and understanding natural languages, doing
automatic translations between such languages, reading handwritten text and being world
chess champions, while expert systems and robots should be in widespread use. Although
there have been considerable improvements in computer power and affordability, the major
use of computers is still limited to word processing, spreadsheets, graphics, data storage and
retrieval, and electronic data processing. There are even those who argue that the huge
investments in computers and other office equipment have not improved white-collar
productivity\(^{3}\) which remained stagnant between 1960 and the early 1980s and has increased
little since then.\(^{4}\) A major concern is, therefore, whether Computers and Communications
(C&C), the major components of the information revolution, will ever be capable of
delivering their promises of creating a revolution whose impact and consequences will be of
equal significance to those of the agricultural and industrial ones. This paper examines this
concern first by comparing the information revolution to the industrial one, exploring the
similarities and differences between the two, while considering major employment shifts over
time; second, it discusses what is already available in C&C and what is bound to become
technologically possible in the near and longer term future; third, it speculates about the future
environment when the information revolution, around the year 2015, will be at about the same
stage of development as the industrial revolution is today. Finally, the paper explores the
implications of the information revolution on society and firms, and discusses the major
changes that will take place when C&C allow the possibility of shopping, obtaining services,
educating ourselves, working, and having practically unlimited choices of entertainment in one's own home.

The Human Ability to Foresee the Magnitude of Technological Change

We, humans, have not been good at predicting the use, or practical value of new technologies. This is what Say, the famous French economist, wrote in 1828 about the possibility of cars as substitutes for horses:

"Nevertheless ... no machine will ever be able to perform what even the worst horses can - the service of carrying people and goods through the bustle and throng of a great city."

Even as late as the end of the last century, when cars were actually being produced, and less than a decade before Henry Ford mass produced his model-T, neither their potential value nor their widespread ownership was obvious. In an 1899 book entitled *La fin du cheval* (*The Demise of the Horse*) its author fiercely argued that the end of the horse was near, but he predicted that bicycles, rather than cars, were about to substitute horses. In the numerous illustrations made throughout the book by the futurist A. Robida, few cars are shown while bicycles abound. The same is true in a series of illustrations made in 1900 to commemorate the beginning of the new century by depicting examples of life in the year 2000. One of these illustrations shows a major boulevard in Paris where not a single car is circulating.

Say's objections were as valid in 1900 as they were in 1828. Cars were still dangerous, unreliable and terribly expensive (in 1900 it took four and a half years of a skilled worker's wage to buy a car in France). Moreover, there were few roads where a car could be used at speeds that were hardly faster than those of horses. Yet, less than ten years later cars were being mass produced and less than three decades afterwards more than half of the families in the USA owned a car. Needless to say, cars have profoundly affected all aspects of our lives by providing us with personal mobility and the freedom to choose where to live and work, do
our shopping or, in general, go whenever we wish to do so. Will the same thing happen with C&C or will their impact, if any, be minimal, having exaggerated their importance?

There is a certainty concerning both computers and telecommunications: their costs are decreasing exponentially while their speed is increasing exponentially. Moreover, it is highly likely that these trends will continue in the future with critical implications for how information is stored, retrieved, processed, communicated and used, as well as the type of tasks that computers will be capable of performing more productively than humans. As machines substituted, supplemented and amplified practically all routine manual tasks previously done through the use of human muscles, computers will similarly substitute, supplement and amplify almost all standardized mental tasks currently performed by humans using their brain. If present trends continue, computers will, in the not too distant future, be able to read handwritten text without major mistakes, understand and speak a limited vocabulary of natural languages and by the beginning of the next century acquire some elementary vision. In the longer term, 2010 to 2020, they will be capable of reading and speaking and probably "seeing". This means they will be able to perform, in conjunction to machines, practically all repetitive manual tasks and the great majority of standardized mental ones currently performed by people, while also helping to substantially increase the productivity of all mental tasks performed by humans, even those requiring high levels of skills and/or creativity. The consequence will be another major shift in employment, considerable changes, both societal and organizational, and new skills required to succeed either in life or in business. The implications of the changes involved are enormous.

**Employment Shifts: The Analogy between the Industrial and Information Revolutions**

Figures 1 and 2 show the percentage of the labor force employed in agriculture, manufacturing and services in the UK and the USA since reliable data have been available. The employment shift from agriculture to manufacturing that started with the industrial revolution reached its peak in the 1950s and consequently started declining, with services increasing as the percentage employed in both agriculture and manufacturing has been
% OF LABOR FORCE IN AGRICULTURE, MANUFACTURING AND SERVICES: UK

FIGURE 1

% OF LABOR FORCE IN AGRICULTURE, MANUFACTURING AND SERVICES: USA

FIGURE 2

% CONTRIBUTION TO GNP OF AGRICULTURE, MANUFACTURING AND SERVICES: UK

FIGURE 3

% CONTRIBUTION TO GNP OF AGRICULTURE, MANUFACTURING AND SERVICES: USA

FIGURE 4
declining. Figures 3 and 4 show the percentage contribution of each of the three sectors to the overall GDP of the UK and the USA. Interestingly, this percentage contribution of agriculture and manufacturing has remained constant, or slightly decreased, even though employment in these two sectors has been diminishing substantially. This means that the relative productivity in agriculture and manufacturing is on the rise (actual productivity is also increasing at a faster pace as the real output of both of these sectors is rising too). The relative contribution of services, on the other hand, has been declining relative to agriculture and manufacturing while the actual productivity, according to some authors\(^{12}\) has been stagnant for the last two decades.

The fact that white-collar productivity has not been increasing, at least as fast as manufacturing, in spite of the huge investments made in computers and other office equipment\(^{13}\), has raised concern as to whether or not C&C will be capable of providing the substantial productivity improvements required so that the expected benefits of the information revolution will be harnessed. Evidence from an analogy between the major inventions of industrial and information revolutions indicates that the latter is on target.

Newcomen developed the first workable steam engine in 1707. It took more than 200 years before Henry Ford used such an invention for the practical purpose of building a useful car that the majority of people would be willing to and could actually afford to buy. Furthermore, it took another half a century before cars could substantially change our mode of life by permitting people to decide, among other things, where they would live (in relation to their place of work) and where to do their shopping. Similarly, it took more than 90 years between the time electricity was invented and its use by firms to substantially improve factory productivity. At the beginning of our century it took more than 20 years before the considerable investments in electricity paid off.\(^{14}\) It cannot be expected, therefore, that computers will produce immediate results. After all, they were invented about half a century ago and they are still used mainly for doing more efficiently tasks done without computers beforehand (the same was true of engines before 1910 and electricity before the mid 1920s).
Thus, the fact that investments in C&C have not as yet produced substantial returns does not mean that they will not do so in the future.

Table 1 shows analogous events concerning major inventions in machines and computers. These analogies can be justified by relating major discoveries of the industrial revolution to corresponding ones of the information one. Analogies in inventions of the industrial and information revolutions like the steam engine and the mainframe computer, electricity and time sharing, the internal combustion engine and the microprocessor, cars and personal computers, and so forth, can be justified on logical grounds because of their similarities. Consequently such inventions allow us to predict, through analogies, forthcoming developments of the information revolution. If the analogies displayed in Table 1 are valid, we will be entering by the end of this century, or the beginning of the next, into a period where major productivity improvements from the computer revolution will be achieved. Recent evidence indicates that productivity improvements due to investments in information technology may have started to pay off. If the analogies continue, by 2015 the information revolution should provide firms with as many improvements in productivity as those achieved by the industrial revolution until today.

There are less than 20 years between now and the year 2015, by which time the information revolution should be in full swing. The information revolution is not too different today to when Henry Ford achieved substantial productivity improvements between 1914 and 1915 (close to 90%) by implementing the moving production line in his factories. Ford's innovation was to use mechanical power in a brand new way by moving work to a worker placed in a fixed position and forcing a uniform pace of output which allowed the mass production of the Model-T car. Ford exploited the possibilities of the available technology of his time to the maximum. His bet paid off, opening up a huge market and a high growth industry. His success was based on three aspects: (a) using available technology in novel ways to substantially reduce production costs and therefore prices (the price of the Model-T was reduced by 2/3 between 1908 and 1914), (b) providing a product which was user-friendly
<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>FROM STEAM ENGINES TO UNATTENDED FACTORIES AND FROM THE ENIAC COMPUTER TO EXPERT SYSTEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MECHANICAL POWER</td>
<td>COMPUTER POWER</td>
</tr>
<tr>
<td>1712 Newcomen's Steam Engine</td>
<td>1946 ENIAC Computer</td>
</tr>
<tr>
<td>1784 Watt's Double Action Steam Engine</td>
<td>1950s IBM's Business Computers</td>
</tr>
<tr>
<td>1830 Electricity</td>
<td>1971 Time Sharing</td>
</tr>
<tr>
<td>1876 Otto's Internal Combustion Engine</td>
<td>1973 Microprocessor</td>
</tr>
<tr>
<td>1914 Continuous Production Line</td>
<td>1970s Electronic Data Processing (EDP)</td>
</tr>
<tr>
<td>1890 Cars</td>
<td>1977 Apple's Computer</td>
</tr>
<tr>
<td>1901 Electricity in Homes</td>
<td>1980s Computers with Modems</td>
</tr>
<tr>
<td>1919 &quot; in 1/3 of &quot; Widespread Use of:</td>
<td>1993 Personal Computer in 1/3 of Homes</td>
</tr>
<tr>
<td>1950s Electrical Appliances</td>
<td>Widespread Use of:</td>
</tr>
<tr>
<td>1960s Cars</td>
<td>200? Computers/Communications</td>
</tr>
<tr>
<td>1970s Long Distance Telephones</td>
<td>200? Tele-Services/Shopping</td>
</tr>
<tr>
<td>200? Unattended Factories</td>
<td>200? Tele-Work</td>
</tr>
<tr>
<td>200? Expert Systems</td>
<td></td>
</tr>
</tbody>
</table>
and easy to repair, and (c) choosing a product (the car as a form of personal transportation) whose potential demand extended to all households, or even every single adult and which greatly increased people's freedom of choice to go where they wanted whenever they wished to do so.

Where do C&C technologies stand today with respect to their ability to be used in brand new ways, substantially reduce costs and prices, while opening up new markets extending to all households or even individuals? What is clear is that the equivalent of Ford's production line has not been invented as yet, but its invention is, in my view, around the corner. It is about to come through the digitalization of sound (including voice and music) and image which will permit the marriage of computers and telecommunications. The possibilities are limitless when the right products (hardware, software and groupware) become popular, user-friendly and cheap enough for households, not just businesses, to acquire and use. Most importantly C&C will increase people's freedom of choice as much as the car did, if not more.

State of the Art in C&C and Forthcoming Multimedia Applications

In addition to data which has been transformed in digital form, i.e., in zeros and ones, since computers were first introduced, the digitalization of sound and images allows their storage, retrieval, and/or processing in exactly the same way as data. Once this capability has been fully achieved, and once the technology becomes both user-friendly and affordable, it will allow for multimedia interaction(s) between sources and users, including the simultaneous interaction among many users/sources located anywhere in the world. Such interaction can include data, sound, and/or image permitting rich and instantaneous communications. The consequences are enormous. A single computer can, in addition to its traditional tasks, also become a terminal capable of being used interactively for the following:
- Picturephone and teleconferencing among users who can simultaneously see and talk or send written messages, including data, graphs or documents, to each other.
- Television and videos on demand from any source located anywhere in the world to be watched, rented or bought wherever a customer wishes.
- Music (sound and videos) on demand from any source to any customer/place.
- Access to shopping by directly connecting to a manufacturer's computer and putting in customized orders directly. Alternatively the connection can be made in a warehouse/shop where the products can be seen, examined and even, in the case of clothes or shoes, worn by a computer model of oneself. Direct shopping would avoid intermediaries and allow for lower costs while getting an instantaneous and personalized/customized service.
- Access to banking and other financial services by connecting directly to appropriate computers carrying out the requested transaction.
- Airline, hotel and car reservations made directly from a personal computer rather than by telephone.
- Medical advice, including diagnosis, offered through specialized equipment which can monitor and/or measure relevant bodily information allowing the computer to make instant diagnosis or, in case of doubt, pass it to a doctor for finalizing it and telling the patient what needs to be done.
- Access to all (other) types of services that can be located anywhere in the world.
- Video games (individually or with others) on demand from any source to any customer(s)/place(s).
- Other games (e.g., gambling, chess etc.) on demand from any source(s) to any customer/place.
- Virtual reality simulations (e.g., flying an airbus plane, or piloting a submarine or guiding a spaceship). As professional pilots are already trained using computer-driven simulators, which are as realistic as flying the real plane, they can be extended to anyone with a computer.
- News, sports and weather reports, as well as any other TV program which can be customized for individual users and even be seen interactively by allowing the user to determine the speed or content of what is being watched.
- Access to data banks, libraries and museums located anywhere in the world from one's personal computer and easy retrieval or viewing of whatever a user is interested in.

Moreover, as wireless telecommunications will be possible, the above list of capabilities can be accessed from anywhere in the world without the need of regular telephone lines. This is considerably more than the E-mail capability of computers which allows sending written messages to others, or the groupware (e.g., Lotus' Notes) programs which facilitate written communication as well as the sharing of information among people having access to such a program. The Internet provides at present a glimpse of the new, brave world of multimedia C&C even though there are still many problems to solve and dangers to be conquered.
A high degree of interactivity and high added value coupled with a low cost are opening up huge possibilities which will, I believe, become the centerpieces of the information revolution. This is more so as personal, wireless telephones (or telecommunication devices) are spreading at a fast pace as they are becoming progressively cheaper and more powerful. The current battle shaping the telecommunications and entertainment industries and the building up of information superhighways will further increase the demand for multimedia computers and decrease their costs, in particular as competition in this high growth area is becoming fierce. Multimedia computers which can also be connected to the information superhighways are bound to become as popular and as easy to use as telephones are today. They will fundamentally change the way people interact, shop, get services, entertain and educate themselves, and work. It will be the equivalent of combining the telephone, the television and the car in one device that would allow simultaneous and unlimited access to information, data, sound and images, together with the freedom of choice of being anywhere, anytime.

Computers, Communications and Superautomation: Implications for Society

As computers become more powerful, smaller, and cheaper, so will robots and other machinery which use computers for their functioning. By the beginning of the next century, unattended factories run by computers and using robots will be common; by 2015, when computers will be capable of "seeing" and exhibiting some elementary intelligence, they will be widespread. This means that manufacturing employment (see Figures 1 and 2) will continue declining, and by 2015 it will probably be, in advanced industrialized, or better "informatized" countries, at about the same level as agricultural employment is today, i.e. a couple of percentage points. This will leave services to employ close to 95% of the working population in most "informatized" countries. Consequently it is the service sector where the highest need to improve productivity will arise. However, higher productivity in the service sector, including white-collar office work, will further decrease traditional employment and would require new sources for generating work for those becoming unemployed through the widespread use of C&C and superautomation.
By 2015 there will be little need for people to do repetitive manual or mental tasks. The former will be automated using machines and robots while the latter will be performed through appropriate computer programs and expert systems. Machine and computer-based automation have and will continue to increase human productivity which allows firms to reduce the real costs of goods or services and pass part of the savings on to consumers, in terms of decreases in real prices, part to a firm's employees, in terms of increases in real wages, and part to shareholders, in terms of higher dividends and retained earnings. Productivity improvements have and will continue to be indispensable in increasing people's buying power, under the combined impact of lower real prices and higher real income, and in raising their standards of living. Today, people from advanced, industrialized countries spend a progressively lower percentage of their income on food, and other necessities, and a larger amount on housing, entertainment and medical care (see Figure 5). In addition they work less (see Figure 6), having, therefore, more time free for leisure activities.

Ironically the drive towards improved productivity and greater standards of living requires automation to substitute expensive workers with machines and computers so that firms can continue to decrease costs and therefore prices. This is particularly necessary because of competition from developing countries where labor costs are a small fraction of those in developed ones. Advanced countries must, therefore, concentrate on products and services which add high value and allow their firms to pay the high wages and additional benefits their citizens are accustomed to. The more advanced the country, the higher its standards of living and the lesser the need for low-level, unskilled jobs which are either automated or exported to developing countries. Moreover, as developing countries compete with advanced ones and enter industries which provide standardized products or services, the pressure increases for advanced countries to move upwards in the products or services they provide. In this continuous spiral, technological innovation, creativity and entrepreneurship become essential factors in staying competitive and creating employment to substitute for that lost through automation or exportation to low cost countries.
PERSONAL CONSUMPTION EXPENDITURE

FIGURE 5

% of Total

- Food
- Housing
- Transportation
- Medical Care
- Entertainment

ANNUAL HOURS OF WORK

FIGURE 6

PERSONAL CONSUMPTION EXPENDITURE

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ANNUAL HOURS OF WORK

FIGURE 6
The price for high living standards becomes, therefore, the pressure to automate and continuously improve productivity by eliminating repetitive and routine jobs. This in turn requires a well-educated workforce capable of using their heads, instead of their hands, to add extra value for the high income they receive. Consequently, to improve their productivity such a workforce will have to use C&C to a maximum to improve their effectiveness and efficiency and continue increasing the living standards of their advanced nations. We may be moving, therefore, towards a dichotomy of high and low skills and jobs, the former grouped around tasks that can add high extra value and the latter around providing personal services to those enjoying the high skills/pay jobs but who have little free time.

Table 2 shows the cumulative effect of growth in the Index of Industrial Production (IIP), real GNP and real prices, as well as the buying power and population, including those over and under 65 years old, from 1890 to 1990. In addition, it extrapolates the historical trends of these variables assuming that real prices will continue to decrease by 1% a year, per capita IIP increasing by 2.8% and real per capita GNP by 1.8% while the population growth of developing countries will follow the same pattern as that of developed ones. By the year 2015 per capita industrial production will double together with buying power. By the year 2090 they will have both increased about sixteen-fold. If we assume that real prices will decrease, on average, by 2%, instead of 1%, a year (a more realistic assumption) then buying power will double by the year 2008 and will increase close to 46 times by the year 2090. Full material abundance will create huge opportunities but also problems and challenges. As the production of standardized products or the offering of standardized services will be robotized and/or computerized, their supply will exceed demand in practically all areas. In particular, the growths in demand will be slowing down as people, at least in industrialized countries, will already possess everything they want and population will be reaching a standstill. The major growth markets will, therefore, have to be found in developing countries whose population will continue to grow (Figure 7) and whose citizens do not have and will demand the material possessions enjoyed by people in advanced countries. However, in order to
TABLE 2

THE CUMULATIVE EFFECT OF GROWTH RATES: Prices = -1%, Per Capita IIP=2.8%, GNP=1.8%
(Assuming that the growth of the population of developing countries will follow the same pattern as that of developed ones)

<table>
<thead>
<tr>
<th></th>
<th>1890</th>
<th>1990</th>
<th>2000</th>
<th>2015</th>
<th>2050</th>
<th>2090</th>
</tr>
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<tbody>
<tr>
<td>IIP (Index of Industrial Production)</td>
<td>6</td>
<td>100</td>
<td>132</td>
<td>200</td>
<td>524</td>
<td>1582</td>
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<tr>
<td>Real GNP</td>
<td>17</td>
<td>100</td>
<td>120</td>
<td>156</td>
<td>292</td>
<td>595</td>
</tr>
<tr>
<td>Real Prices</td>
<td>270</td>
<td>100</td>
<td>90</td>
<td>78</td>
<td>55</td>
<td>37</td>
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<td>Buying Power</td>
<td>6</td>
<td>100</td>
<td>133</td>
<td>200</td>
<td>530</td>
<td>1608</td>
</tr>
<tr>
<td>Earth Population</td>
<td>30</td>
<td>100</td>
<td>120</td>
<td>145</td>
<td>240</td>
<td>250</td>
</tr>
<tr>
<td>Older 65:Developed</td>
<td>4%</td>
<td>12%</td>
<td>14%</td>
<td>17%</td>
<td>24%</td>
<td>24%</td>
</tr>
<tr>
<td>Older 65:Developing</td>
<td>2%</td>
<td>4%</td>
<td>5%</td>
<td>6%</td>
<td>14%</td>
<td>21%</td>
</tr>
</tbody>
</table>

THE CUMULATIVE EFFECT OF GROWTH RATES: Prices = -2%, Per Capita IIP=2.8%, GNP=1.8%
(Assuming that the growth of the population of developing countries will follow the same pattern as that of developed ones)

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<td>82</td>
<td>60</td>
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<td>13</td>
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<tr>
<td>Buying Power</td>
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<td>100</td>
<td>146</td>
<td>260</td>
<td>973</td>
<td>4577</td>
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<td>120</td>
<td>145</td>
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<td>6%</td>
<td>14%</td>
<td>21%</td>
</tr>
</tbody>
</table>
FIGURE 7
WORLD POPULATION

Billions: 1.7  2.5  5.3  8.3  12.2 Billions

100%
75%
50%
25%
0%

Africa
Rest
India
China
Europe, North America, Ex-USSR

1900  1950  1990  2025  2060

7%  12%  24.6%  24.6%  24.6%
30%  16%  15.5%  15.5%  15.5%
4%  22%  9%  7.7%  7.7%

Year of Asia

stimulate demand, the income of developing countries must increase, encouraging governments and firms in advanced countries to help them do so and in the process raising the standards of living of developing nations.

As consumption and material possessions increase, however, so will pollution, including waste disposal, and its impact on the environment. Given the continuous increase in industrial production and people's buying power, such problems will become exaggerated, in particular since the population of the earth will exceed 12 billion by the middle of the next century. Thus the need to deal with pollution, and its related problems, as well as overcongestion and overconsumption will be astute, requiring a huge effort to deal with them. For instance, it is doubtful that the climatic equilibrium of earth can be sustained if the population of developing countries starts consuming the same per capita energy as people in the USA. Thus, achieving sustainability without reducing the standards of living will probably become the biggest challenge facing humans in the next 100 years. These major problems of pollution and overcrowding, and the challenge of sustainability can create many opportunities for the firms that will find effective ways of solving them.

The New High Growth Technologies

Table 3 lists the five most important technologies of the industrial revolution. Each of them contributed significantly to changing the way people lived, and the organization, management and running of firms. Electricity brought mechanical power everywhere, whether in factories or homes, and allowed the effective use of power tools. Batteries allowed using mechanical power, even when electrical plugs were not available. Electrical appliances, in particular those for home use, freed women from household work, thus giving them the opportunity of entering the labor market. Cars provided people with mobility and unlimited freedom to go wherever they wanted and whenever they wanted in comfort. Cars permitted people to move from cities, where the majority of the jobs were located, to the suburbs, and go shopping far away from their homes in search of bargains. Telephones allowed people to talk to relatives or friends, get information or services, or do business from their homes or offices. As long
distance calls have become cheaper and cheaper, communications over telephone wires have become more and more popular, affecting both customers and firms. Cellular and wireless telephones have allowed the possibility of keeping in touch from wherever one may be located. Television, finally, brought entertainment to every home and reduced the need to physically go out. Satellite and Cable TV increased the choice of programs while VCRs permitted additional freedom of what to watch.

Table 3: Five Inventions that have Contributed to the Most Significant Changes in our Lives

- Electricity
  - Batteries

- Electrical Appliances
  - Programmable, Rechargeable

- Automobiles
  - Greater Choice, Better Quality

- Telephones
  - Cordless, Mobile

- Television
  - Remote Control, Cable, VCR

The five technologies shown in Table 3 have achieved practically 100% penetration rate in most developed countries. The obvious reason is that people want them and are willing to pay to obtain them. It is interesting to consider the five industrial revolution technologies shown in Table 3 and their correspondence in terms of C&C as they will influence the pace and impact of the information revolution.

Electricity: Computer networks will bring computer power to everywhere for anyone who wishes to use it. In addition to desktops, portable notebook or smaller size computers can be used as terminals allowing unlimited access to networks. Existing networks of networks such as internet are used by many millions of users in all parts of the world. At present they are
mainly used for text and data transmissions but eventually they will also be used on a grand scale for multimedia communications between and among people as well as unlimited access to information and its processing. Groupware such as Lotus' Notes will further facilitate interactions among people working in the same company or belonging to a common group in ways that will allow them to improve their decision making power and their ability to work together, more efficiently and effectively, as a team.

**Electrical Appliances:** Software and groupware will become as easy to use and provide as much value as electrical appliances have already done, in ways that are not clear yet, as the value of electrical appliances was not obvious 100 or even 50 years ago. Moreover, software and groupware will proliferate and become exceedingly cheap and user-friendly, and as widespread as refrigerators or ovens are today. Moreover, they could be used anywhere or at any time they could be useful as part of a network or stored in one's own computer.

**Automobiles:** Of the five technologies of the industrial revolution shown in Table 3, cars are the most problematic. Their success has clogged up roads, made parking in popular places impossible and has increased air pollution. Computers and Communications can provide an alternative to cars by permitting people to work, shop or obtain services, and entertain themselves anywhere they wish, including in their own homes, thus reducing the need for automobile travel. Most interestingly, their freedom of choice in terms of where they work, shop, obtain services or get their entertainment needs not to be limited by geographical proximity (the reach can be truly global) or weather conditions.

**Telephones:** Computers through multimedia can augment the two-way voice communication of the standard telephone. They can permit multiple connections, and allow interactivity between and among users. As sound and images, in addition to data, are becoming digital, and as common standards are established, teleconferencing over personal computers will become affordable and as popular, by the beginning of the next century, as telephones are today.
Television: Information superhighways running over fiberoptic, cable networks, and/or satellites will be competing with regular telephone networks and will be allowing multimedia interactions as well as bringing any kind of messages, information, music and/or images (books, magazines, newspapers, teaching material, television, etc.) to any home. The possibilities are limitless, not only for entertainment, but also for all kinds of related leisure activities, from reading a rare book to viewing the entire works of Picasso from different museums around the world, from watching a theater play in London to being given a personalized tour of the Acropolis in Athens. In addition, entertainment can become more personalized and interactive including the possibility of competitive games or virtual reality simulations played among players who are not located physically at the same place. Large, high definition TV screens connected to computers can be used for high definition viewing while TV cables can be utilized to get access to global networks that include all kinds of services that provide among others entertainment, sports and shopping.

The technological possibility of multimedia global networks using computers and large, high definition TVs as terminals are already possible, although there are still technical problems to be solved while costs and prices must come down considerably for their widespread use. If established trends in C&C continue, there is no doubt that multimedia applications will spread as fast as the telephone, making the emergence of a tele-society possible.

The big question is whether or not people will opt for using multimedia technologies on a grand scale and prefer to shop and obtain services, work, entertain themselves and communicate through tele means rather than physically. This question divides experts and excites many people. On the one hand, there are those who say that a tele-society is dehumanizing and it will never be accepted. They argue that people are social animals. They like to go out, meet others, touch what they intend to buy and judge its quality and value by seeing it. They point to the growth of department and specialty stores and the weak performance of catalogue and mail order outfits. Moreover, they cite surveys where three out
of four people teleworking from home are not satisfied and would rather be in an office with their co-workers. On the other hand, there are those who point to the amount of time people spend watching TV, teenagers talking on the telephone, even though their friends are often down the road, or the high percentage of services completed over the telephone, computers or by post. Nowadays very few people go physically to a stockbroker to buy or sell shares, to an insurance firm's office to get a policy, or to some office to pay a bill. Moreover, the proponents of tele-society highlight the growth in mail sales of computers, or other standardized products, and the large number of self-employed people who work from their own homes.

The answer of whether or not people will prefer tele versus physical shopping, services or entertainment depends upon the value and cost, or inconvenience of each alternative, where the social pleasure of physical interaction is one of the factors that is added to value. For instance, the majority of people prefer to stay at home and watch TV or a video rather than go to the movies while a considerable minority prefers the physical aspects of going out, even when it rains and when they have to queue before going into the movie theater. Similarly, some people hate shopping and avoid it at all costs while others love it and will not buy anything unless they can see, touch and try it. Until now, however, the prices and costs of the various alternatives have been compatible. Moreover, buying through telemmeans (e.g., homeshopping via TV channels or catalogues) has been inconvenient in that buyers cannot physically examine their choices and have fewer choices than going to a store. Most importantly there are few price differences between physical and teleshopping.

If teleshopping is done directly from the manufacturer, prices can be substantially lower as all intermediaries will be avoided. Moreover, if the buying can be done through the manufacturer of one's choice, no matter where in the world it may be located, the choices available will be practically infinite. Furthermore, high definition, color screens can provide as good a sense about what one buys as being physically there. In addition, consumer reports done by independent, non-profit organizations can be readily available to facilitate one's
choice. Finally, products (such as clothing or cars) can be custom-made to one's individualized order. Lower prices, larger choice, and customization will increase the attractiveness of teleshopping and decrease or eliminate its present day inconveniences, thus opening up new possibilities that can fundamentally change the traditional distribution system.

Whatever is true for products is even more so for services. Once a multimedia computer terminal is connected to a network that provides access to service firms around the world, there are no constraints or limits to teleservices. These services can extend beyond traditional ones to education or medical diagnosis and prescriptions through telemeans (e.g., a doctor can do the testing while in his office and a patient at his home, or a student can have a lecture delivered at his home). Again the possibilities are limitless as the cost of such services decreases and the disadvantages of obtaining them are being reduced.

Television is already widely popular, so its extension to tele-entertainment will cause fewer problems than the previous four C&C technologies. Videos on demand, music records, games, theater plays, concerts, ballets, operas, or any sports event can be televised and shown to an audience of any size according to demand. C&C networks will allow for practically unlimited choices and a high degree of interactivity and personalization of what one chooses to watch, or play individually or with others. Moreover, entertainment can move into additional directions (such as virtual reality) not fully understood or explored as yet.

Telework is another technological possibility that invokes strong positive and negative reactions. Some people believe that going to work allows for personal interaction among co-workers, making friends, participating in meetings and making personal contacts with customers and suppliers. Others point out the long time it takes to commute to and from work, the inefficiency of meetings, and the high cost of individual offices that are occupied but a small percentage of time by their occupants. With teleconferencing, computer conducted meetings can be held more efficiently without the need of physical presence.
Moreover, data and information can also be displayed, minutes kept, action steps verified and various decisions and their implications viewed and debated. The disadvantage of reduced physical interaction can be corrected, or even turned into an advantage, by using offices as clubs where people meet for breakfast or lunch and maximize their interpersonal interaction rather than locking themselves inside an office with a secretary acting as a barrier. Equally important, when the cost of telework becomes considerably less than traditional work in offices, it will be hard to continue it as new firms using telework will be at a competitive advantage over traditional ones that use a lot of office space to conduct their business.

**Firms and Management: From the Industrial to the Information Revolution**

The industrial revolution fundamentally affected all aspects of business firms and their management, as firms became bigger and more efficient and their professional managers, separated from their owners, developed along functional lines. Business firms became instrumental in increasing productivity, fueling economic growth, creating employment and, in general, raising the standards of living of the countries in which they operated. By exploiting the advantages of C&C, as well as superautomation, firms will continue to improve productivity, create employment and generate wealth. However, the firms of the 21st century will have few resemblances with their counterparts of the 20th century in much the same way as 19th century firms and their 20th century counterparts. The biggest change, which has already occurred and which is bound to continue, owns its origin to the very success of industrial firms in increasing productivity, cutting costs, and in general supplying products and services at a rate that has exceeded that of the increases in demand, at least in industrialized countries. This success has created overcapacity and increased competition, and has forced firms to continuously improve themselves in order to survive. With C&C the competition and pressure to reduce prices and profit margins is likely to continue, if not intensifying, bringing far reaching changes in the business environment and firms themselves.
The Decline of Large, Industrial Firms

Figure 8 shows the real sales and Figure 9 the real profits of Fortune's 500 industrial firms since data became available in 1954. Between 1954 and 1979 sales grew, on average, by 5.4% a year, well above real GNP which grew by about 3.3% during the same period. Similarly, real profits grew by 4.2% during the same period, higher than the 2.9% growth in real total corporate profits. The above average sales and profits of the 500 largest industrial firms indicates the importance of economies of scale and scope\textsuperscript{28} that brought such results. Things reverse themselves, however, starting in the late 1970s, as sales started declining and profits plunging both in absolute (Figures 8 and 9) and relative terms (Figure 10). Similarly, in 1968 profit margins started declining after having been, on average, steady at about 6.1% of sales (Figure 11). In 1991 and 1992 profit margins were less than half their 1968 level of 6.1% (see Figure 11). Thus, it seems that in a short period of time, economies of scale and scope seemed to provide no advantages to large firms, reversing a trend that had established itself since the beginning of the industrial revolution and which had become the holy grail of modern management.

A similar pattern can be seen in the number of people employed by Fortune's 500 firms (Figure 12) which increased on average by 3.8% a year, well above the growth of the civilian labor force which was 1.9% until 1969, then it slowed down to 0.8% between 1969 and 1979 while it has declined on average by 2.4% a year since then. Figure 13 shows the employment of Fortune's firms as a percentage of the total civilian employment and indicates a reversal in the relative growth too. After reaching 1.9% of the labor force in 1969 the percentage of people employed by Fortune's 500 firms dropped to less than 1% (a little more than half the 1969 level) in 1993. The largest industrial USA firms not only saw their sales and profits decline, but they also downsized, firing rather than hiring employees, while becoming less important in terms of the sales, profits, or employment opportunities in comparison to other firms in the USA economy.
Figures 8 to 13 indicate the end of the industrial revolution era. Its most prominent members, the largest industrial firms of the most capitalistic of all countries, declined, in both absolute and relative terms, while their collective participation in generating profits and their contribution as an employment source also diminished. Yet the productivity of these large, industrial firms has continued to climb at a constant pace between 1954 and 1993 as real sales per employee increased by an average of 2% a year during that period while profits per employee also increased albeit at the smaller rate of 0.5% a year, fluctuating more widely, however, since 1969, than they did before. Although it is not possible to separate cause and effects, the decrease in real sales and real profits that follow cannot be unrelated to the slowdown and decline in the growth of employment that started about a decade earlier.

Increased Competition: Past and Present
During the last two decades the competition in the business environment has intensified, posing new challenges and bringing new threats to firms. This section looks at such competition and its probable changes as the information revolution gets under way.

Overcapacity: The fact that the prices of most industrialized products have been declining in real terms and that profit margins have also been decreasing (see Figure 11) indicates that supply is higher than demand. Overcapacity fuels competition and forces prices and profit margins downward as producers attempt to sell their goods in a buyer's market. Before the industrial revolution, people could afford few material possessions as their buying power was low. However, during the last 200 years, as real prices have been declining and real income rising, the demand for goods and services has been increasing at a fast pace, in particular since population has also been growing, further stimulating the growth in demand. Until the late 1960s, although supply has been increasing at a fast pace it rarely exceeded demand by a large amount or protected time span. Firms were, therefore, capable of setting prices at such a level that allowed demand to grow but which also permitted them to increase their profits at a healthy rate. By the late 1960s, however, the markets for standardized products in industrialized countries were saturating as consumers possessed practically all durable goods
they desired and population growth was diminishing. Firms, however, continued expanding their capacity, as they believed that demand would continue growing at its historical pace. Such an expansion coupled with the entrance of Western Europeans and Japanese multinational firms in the world markets further added to existing capacity at a time when the demand for standardized products was slowing down. In the face of increased competition, and in order to maintain their global competitiveness, firms had to reduce their prices, at a faster rate than in the past, and cut their profit margins (see Figure 11). To achieve such objectives they were obliged to downsize while, at the same time, improving their effectiveness and efficiency.

**Industry Boundaries:** Until the late 1960s industry boundaries were well established and respected. Although some multinational firms, mostly of USA origin, operated across countries, competition from abroad was constrained by custom and other barriers in order to protect firms at home. In such an environment competitors could be easily identified within a single, well-defined industry and their intentions be known. Competitive analysis to determine the strength of the various competitors and an evaluation of their signals could, therefore, be used to predict competitive moves in order to make capital expansion, pricing or other decisions that maximize a firm's profits without creating overcapacity and falling prices in the industry involved. Since the early 1970s, however, as growth slowed down, firms, traditionally part of a certain industry, ventured outside their own, taking business away from other firms and forcing them in turn to search for opportunities, in other industries outside their own. For instance, there was to be a telecommunications, computer, commercial TV and cable TV industry. Today there are no obvious boundaries between them, as telecommunication firms want to provide interactive computing services to homes using fiber optic cables. Moreover, entertainment companies, publishing houses, and software firms are also competing for the same business, making it impossible to assess competitive threats as new entrants can come from other industries, like satellite or wireless transmission companies, that can render fixed wiring telecommunication systems obsolete. Moreover, competition can come from a number of countries making it impossible to assess its strength and estimate
future capacity. Furthermore, it was impossible for typewriter firms to predict that their products would become obsolete because of computer word processors, or for banks to estimate the negative effects on their business by credit cards issued by AT&T, GM or lately by newspapers like the London *Times*. Moreover, stockbroker firms have been providing banking services (checking accounts and credit cards) to their customers while banks feel obliged to enter into the insurance business to compensate for the loss in their traditional businesses.

**Brands and Luxury Products:** The quality of brand and luxury products was, usually, much higher than less known or generic products. Consumers were, therefore, willing to pay a price premium for such higher quality rather than risking buying a cheaper, non-brand, product of unknown, doubtful quality. During the last decade, however, little known brands as well as generic products have improved their quality to the point that there is little or no difference with that of well known brands. As differences in quality from cars and computers to soft drinks and food products has shrunk, so has brand loyalty as an increasing percentage of consumers are not willing to pay a higher price just because of a brand name, or the luxury status of a product. The Malboro Friday (when Philip Morris was obliged to cut the price of its Marlboro cigarettes by 20% because it was losing market share to generic brands), the problems of Heinz's and Borden as well as those of IBM, Coca-Cola and Pepsi and other well-known firms proves beyond reasonable doubt that brand awareness does not suffice to increase sales or charge a price premium for a "company" or "brand" name. Such a change further increases competition as brands cannot be used as a way of limiting supply and therefore controlling prices.

**Rules of the Game:** In addition to well-defined and respected boundaries that existed before the 1970s, and the advantages that economies of scale and scope as well as brand recognition brought to large, established companies, there were also established rules that firms accepted. There was, for instance, a price leader, usually the biggest firm of the industry, whose decisions were followed by other firms. This was the case in the automobile industry with
GM in the leader role. Alternatively the strongest and usually most profitable firm of an industry set its prices at such a level that the highest cost producer could survive. By letting high cost producers continue, it permitted the strongest firm(s) to reap handsome profits while avoiding anti-trust actions against it. Such was the case in the computer industry before the late 1970s with IBM being the strongest and most profitable player. In other industries, and in particular in Europe, there were widespread gentlemen's agreements and informal cartels whose purpose was to maintain high profits and prevent new entrants from establishing themselves in an industry. Governments used to and in some cases still continue to help firms to impose such rules. For instance, airlines and telecommunication companies in the great majority of European countries still operate using rules that make competition impossible. The same is true in public procurements or large construction projects where competition is regulated in ways that allow insiders to reap large profits while excluding outsiders. A major objective of the European Union is opening up competition at the European level by breaking down barriers to entry, thus forcing prices down and improving quality and service. The globalization of business and the spread of C&C are bound to intensify competition and speed up the fall in whatever barriers, national or industry-wide, still exist at present. Consumers will be the main beneficiaries of increased competition that will force prices to drop further.

Future Competition

The overcapacity prevailing at present in the great majority of industries will, in all chances, continue into the future, fuelled by the effective marriage of the mechanical and computer technologies to superautomate all standardized, repetitive tasks whether manual or mental. Although C&C will significantly contribute to maintaining, if not exaggerating, prevailing overcapacity, their major impact will be in the way information is disseminated and used, and the way firms are organized and run, including the kind of products and/or services they offer to their customers.

In the last decade airlines have lost many billions of dollars. A major reason is the computerization of reservations and prices. By connecting to a central computer, any travel
agency or individual can figure out not only the most appropriate and convenient route to go from point A to B but also the cheapest one. Information is perfectly and instantly disseminated by being available to anyone having a computer terminal and permission to connect to the central computer. As the service offered by the various airlines is pretty similar (standardized), no carrier can afford to charge a higher price than its cheapest competitor, thus the price wars and huge losses -- even in Europe where airlines are still protected by monopolistic barriers.

C&C will, by the end of this century, put the great majority of products and services into a similar situation as that of the airline industry. A consumer will be capable, from his or her own computer, to connect through regular telephone lines to centralized selling networks. Once connected, he or she will be able to compare prices and buy the product/service that provides the highest value for its price. With such a computerized system, information will be perfectly and instantly disseminated, eliminating or reducing to a minimum local or time-dependent scarcities and intensifying competition as firms will have to list the prices of their products/services together with their technical and service-related characteristics.

A computerized selling system will allow consumers to buy directly from manufacturers, or providers or services, overpassing all intermediaries, and getting the lowest possible price. In addition, there will be no geographical constraints as many products and most services can be bought from far away places. In such a computerized selling environment firms will not be able to charge higher prices than their competitors by counting on physical proximity, or the lack of information on the part of consumers.

C&C will also allow for brand new forms of organization which will be very different to the traditional bureaucratic and hierarchical structure present in most firms. Computer networks and groupware are allowing "network" organizations where information is exchanged irrespective of ranks or positions, giving rise to horizontal, extremely flat organizations. Moreover, in the future, firms will not have to occupy large offices in some centralized
location. If we assume that teleconferencing will spread and computer networks will continue to become more user-friendly and cheaper, then, in the near future, it will be possible to have access to company information, hold meetings and run firms with employees who are not necessarily present physically. As being a low cost producer will be a prerequisite for long-term survival, firms may not have much choice but to avoid occupying expensive offices and instead organize themselves in new forms that use telework, subcontracting, outsourcing, and part-time or consulting work to a much greater extent in ways that would substantially decrease their fixed costs. This would be particularly true for firms producing/offering standardized products/services.

Gaining and/or maintaining competitive advantages in an era of superautomation when information is instantly and perfectly disseminated will require different skills and strategies than during the past. As technology will be equally available to anyone who can pay for it, producing or offering standardized products or services will provide few or no competitive advantages except to those who manage to use the technology in more efficient/effective ways. But being more efficient/effective than one's competitors will require a well-trained and highly motivated workforce capable of using their heads to improve their work beyond the normal capabilities available through the standard application of technology. Alternatively, the service offered to customers ought to be speedier or of higher quality than that of competitors, again requiring well-trained and motivated employees.

Competitive advantages could be gained by firms that make and/or sell new products or offer new services. The newness of such products/services would exclude overcapacity and will assure firms of higher profit margins, at least until imitators come up with similar products/services. For firms to be successful innovators, they must have well-educated and highly motivated employees capable of conceiving, inventing, developing and successfully marketing new products that consumers will buy. In addition to the creativity required to be an innovator, firms will also have to invest, often heavily, in R&D and be willing to assume the risk that their investment might not pay off. Finally, they will have to be fast in
conceiving and bringing to market new products/services as their competitors will be also attempting to do the same. Greater speed to be the first in the market will require team work and a well-trained and motivated workforce.

In summary, when the information revolution becomes widespread, firms will have to provide their customers with real value in order to survive in the long run. This can be done by providing the lowest cost, with an acceptable quality, or by offering new products and/or services ahead of their competitors. In both cases they must continuously innovate either by internal improvements to cut costs, by improving quality, or by identifying existing or new customer needs, and by coming up, faster than their competitors, with new products/services to fulfill such needs. The single most important factor determining success will, therefore, be the education, creative potential as well as the motivation of those working, or better being part of the firm. Their knowledge, innovative potential, entrepreneurship, and ability/willingness to give their customers value for money will be the critical factor for success in an environment where superautomation and the instant and perfect dissemination of information on a global basis will be widespread. In such a highly competitive environment, continuous improvements and doing something better than the competitors will be prerequisites for long-term survival and success as C&C will eliminate barriers and intensify competition.
REFERENCES


15. See reference 2.

16. See reference 4 and


26. See reference 2 and 10, and


