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Cultural Diversity and Economic Growth

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During the last thousand years something quite extraordinary has happened in Europe. Since 1000 A.D. the European population has increased 30 times, but with an abundance of food - we have no famine. Life expectancy has increased, not just for the privileged few but for the whole population, to surpass the old biblical goal of three score and ten. Great strides have been made in the conquest of disease. Nowhere else in the world have these great changes occurred, except as spill over from our European achievement. Historians of the long term call it the European Miracle. I want to put this European Miracle in a historical perspective so that we can see better some of the benefits, and some of the hazards, of the movement of the last century towards unification.

In order to do this I ask you to participate in what might be called an Archeological Fantasy.

Imagine that in five hundred years' time a large meteorite hits the earth and that a huge cloud of dust is thrown up into the atmosphere, which settles over the land covering nearly everything to a depth of a couple of metres - a sort of catastrophic Pompeii. Everyone is killed except for a few million people on the shadow side of mountains.

Gradually these people re-established organized life, so that in three thousand years' time a thriving civilization is again populating the world. They know that everywhere beneath them is evidence of their ancestors and they develop a great interest in archaeology, and great expertise in the precise dating of the artifacts they dig up.

Teams go out to all parts of the world and dig down through thousands of years of history. A hundred teams dig sites in Japan, a thousand in China, a thousand in India and in Russia, in Africa and the Americas. Many hundreds of sites are dug around Europe.

The archaeologists bring all their finds back to one central field for study and, just as many archaeologists do today, they lay the artifacts out on long rows of wooden tables so that all the artifacts from any one site were laid out in a row, but in strict chronological order.

Imagine that everyone in this room is transported in a time machine to this large field and that we spend a few days walking up and down the tables, trying to understand what we see.

Suppose we put marks on the tables at one thousand year intervals, and then we look at the changes in the artifacts between the beginning and the end of these thousand year periods.

Ten thousand years ago it would be very difficult to see any difference at all between artifacts a thousand years apart, although from a very few sites we would start to see faint evidence of one of the most important changes in human history, the change from hunter-gatherer to farmer.

Once clusters of farming communities became established the pace of change accelerated, for instance along the Fertile Crescent of Mesopotamia, along the Nile Valley of Egypt, in parts of Pakistan and of China, and bursts of rapid change would appear in the archaeological record.

Most of these changes were decorative, for instance the decoration on pottery or in clothing and jewelry, but some were functional and these were, and still are, the type of change which makes an appreciable difference to the way people live.

By the first century B.C. we would see a large range of artifacts in use, and mastery of a wide range of materials. Copper and bronze, gold, silver and iron, glass and resins and a variety of natural fibres and of ceramics. Ploughs, boats that could sail far from land, wheels for carriages and pipes for water. We would see quite clearly that some sites had a wide range of artifacts in use, and a rapid rate of innovation of artifacts, while other sites - the majority - had hardly any innovation.

In the thousand year period before 1200 A.D. other important changes would become apparent. China would show itself to be the most advanced civilization, with extensive manufacture of high quality products, efficient agriculture founded on large scale hydraulic engineering, effective and reliable sea travel.

The Arab civilization would be at its peak, with mastery of agriculture, many find buildings, great control over the supply of water, precision working of metals and of glass, and above all a reverence for knowledge - knowledge systematically brought in from the Greeks, from Byzantium and from the East, as far away as India and China. The Arabs did not greatly add to the fund of knowledge but they brought existing knowledge together in a way that proved crucial to change in the following centuries. Between 1000 A.D. and 1200 A.D. a great deal of this Arab knowledge was translated into Latin by scholars from many cultures spread right across Europe and became a major springboard fro the eventual rise of European science.

By 1200 A.D. another important aspect of change would be clear from the archaeological record - that decline was just as much part of human experience as was rise. a few centuries of rise, represented on our wooden tables by rapid change in functional artifacts, was always followed by either a dropping back to some simpler state, with the loss of many skills, or by a plateau in which most of the old skills were preserved, but with the rate of innovation dropping to a very low level. This is the state that is sometimes called a 'high level equilibrium trap', a static condition which can last for many centuries, mostly above subsistence level except in times of severe famine, war or disease.

There were no exceptions to this. By 1500 A.D. China and Islam had substantially stopped innovating; the Roman, Hellenic, Egyptian and Mesopotamian innovative periods had left a great legacy to be picked up and built upon by future clusters of innovation, but none of our archaeological sites would show continuous innovation. All would show, ultimately, decline or at best the 'high equilibrium trap' - and this means that these sites would quite soon become backwards, compared with innovating parts of the world.

The sites from Europe would show an interesting departure. Around 1000 A.D. Europe would be seen as a rather backward, peripheral area of the world. Chinese and Islamic technology and civilization were far ahead, but as we have seen, moving towards stagnation (we can only see this with hindsight; in 1000 A.D. both these civilizations would have seemed unstoppable).

By 1900 A.D. the situation had changed completely. A very substantial range of quite new artifacts had come into existence, showing a rate of innovation on many of our sites far exceeding that seen before on any of the non-European sites. These new, innovative artifacts were not confined to any one site but were in evidence in many sites scattered throughout the European continent.

Certainly there was some clustering, some localizing of innovation at different periods, such as a clustering around Northern Italy between 1200 A.D. and 1500 A.D., around Southern Germany somewhat later, in the Low Countries in the 16th and 17th centuries and in the British Isles in the 17th, 18th and 19th centuries.

Innovations in any one part of Europe drifted, sometimes quite rapidly, around Europe as a whole and were taken up wherever the local cultural and economic climate were congenial.

In this movement of the centres of innovation we see the old phenomenon of rise and decline, but we see it in an interesting setting, in which the rise in one area, as a consequence of innovation, spills over into another area and is continued and taken forward so that when the first area declines, as it always does, it has a neighbour who is moving ahead in innovation and whose products spill out, not merely to the declining region, but are available to all the regions around. As Professor Schelter puts it in his paper on Culture in the European Union 'The specifically European about our civilizations is the enormous density of cultural differences in a narrow space.'

The geographical proximity of all these different cultures enabled a resonance to take place between them that has enabled overall advance to be made, even accommodating the decline of previously advancing regions.

As we walk up and down our European tables, we will soon observe another interesting phenomenon - that the lines of artifacts are starting to incorporate new knowledge, knowledge that has simply not been available to previous periods. Nowadays we call this scientific knowledge, but this can be a rather misleading term, and there may be a preference for the term 'reliable knowledge', that is knowledge that has been tested, usually be experiment, in a variety of circumstances and shown to have high reliability and universal applicability so that the knowledge will be reliable and testable anywhere in the world.

Reliable knowledge, scientific knowledge, is hardly ever of use to humanity until it is embodied in artifacts - products - but then it can have enormous impact. Reliable knowledge has been around for millennia - for instance, when a drug company discovers a new drug which cures a widespread serious disease we call is 'science'. When, many centuries ago South American Indians discovered a drug - quinine - that is still the ultimate drug of choice against malaria we tend not to call it science, but it is reliable knowledge.

It was in Europe that this process of generation of new reliable knowledge became established on a steadily growing basis. There had been plenty of instances of new reliable knowledge before, sometimes remarkably sophisticated - subtle and ingenious processes for the refining of zinc in India, systematic astronomical measurements, using carefully contrived instruments, in China and in Islam, even an astronomical predictor incorporating 32 gears, dating from 80 B.C. and originating in the Aegean Islands, but these clusters of intellectual activity were sporadic and the innovation eventually died away, even though the intellectual and material processes they gave rise to may have continued for a long period - an intellectual version of the high level equilibrium trap.

This process of the generation of new reliable knowledge and its embodiment in new functional artifacts, represents, after the hunter-gatherer/farmer transition the second great change in human experience.

The effects have been profound. On the one hand, the rate of innovation of new functional artifacts has permitted a steady improvement in the Malthusian ratio of population - to - resources, so that the area of land of Europe which supported 36 million people in 1000 A.D. supported 390 million in 1900 A.D. with no famine, steadily rising life expectancy and improved quality of life.

On the other hand, the very basis of economic perception had changed. Once, the basis of wealth consisted of agricultural and mineral products, and control and possession of wealth rested on control and possession of land, the prime determinant of agricultural and mineral production. Land (with the small but notable exception of reclamation from the sea) is not expandable. A has it or B has it. If A seeks more wealth it must take land from B, or subjugate B and take away the agricultural surplus or mineral production. Economics is thus conducted as a zero-sum game.

This has been a prime rational for territorial wars, wars over land possession. This is not, of course a sole cause of war - differences of belief, desire for power or for honour are significant, but control of land and its produce have been dominant.

Artifacts, products, had by 1900 become the measure of wealth in Europe, and products are expandable. The new wealth can be created, and created most effectively, by the process of generating new knowledge and using it to design new functional artifacts.

When this two part process of wealth creation proceeds smoothly, some of the pressure for territorial war is relieved. When one cultural network has been successful in this mode of wealth creation, while another cultural network becomes trapped in an uninnovative mode, or in a mode in which new knowledge fails to become embodied in new artifacts, stresses a rise reflecting the two different rates of wealth generation. The culture which sees itself as being disadvantaged in wealth creation by its political economy may take extensive action to attempt correction, as for Japan in the 1860s and the Communist countries in the 1980s and 90s.

This, then, is a view of Europe's economic growth over a thousand or so years. Two component growths - new knowledge and new functional products plus, of course, a large but diminishing measure of wealth acquisition by the old zero-sum business of invasion and colonization.

Very little is known of the processes, either within the individual mind or in the interaction of many minds, involved in the generation of new knowledge; similarly little is known of the process of long term innovation of a sequence of artifacts - the most promising lines of enquiry at present seem to be in branches of complexity theory and in the modelling process of Artificial Life.

Nevertheless, some plausible conjectures can be made to give us some understanding of cultural conditions needed for intellectual and material innovation.

Suppose we examine our lines of artifacts, taken from sites in Europe for products made in 1800 A.D. and products made in 1950 A.D. They will exhibit a great amount of innovation over this very short historical period, both in function and in the new knowledge, knowledge not available in 1800, embodied in the later products. In 1800 no one could have predicted the knowledge available, or the products made using this knowledge, in 1950. As Carl Popper has pointed out, prediction of human affairs is impossible, because our future is profoundly influenced by discoveries, and by their nature new discoveries cannot be known until they are made.

No one, however well intentioned, wise and learned in 1800 could possibly plan a route to the products and knowledge of 1950 because knowledge of the outcome is impossible.

The history of science and the history of technology was once written as if science and technology were like ladders reaching upwards into the sky, with god like figures occupying the rungs - Bacon, Galileo, Descartes, Newton, Maxwell, Einstein...

In the last three or four decades this way of describing the historical processes of discovery and invention has been largely dropped. This is not to deny that unusually talented individuals have made great contributions - they most certainly have, but historians have increasingly come to realize that the processes of discovery of new knowledge and invention of new artifacts rely on extremely extensive and complex networks of individuals and groups of individuals interacting together. This becomes apparent if we consider an area of knowledge that arose almost entirely in Europe, and has had a profound effect on all our lives, the art of understanding the very small, of investigating the world in very fine detail. This has led directly in the last century to understanding the nature of infectious disease - the discovery of infective bacteria and viruses - to the revolutionizing of medicine, the discovery of the processes of cell division, of reproduction, of genetics, and an understanding of DNA, the very stuff of life. Nowhere outside Europe could such a remarkable story unfold.

The story starts in the Low Countries in the early years of the 17th century, with the discovery, within a small group of opticians in Middelburg, of the microscope and of its close relation the telescope. Initial development was slow, but within a century some of the fine detail of the living world had been uncovered, and enough interest generated to ensure an ongoing process of discovery and exploration. Red blood cells were seen travelling through capillaries - first in Bologna in the mid 17th century, and equipment for seeing blood flow in the tails of small fish became part of the accessory kit of microscopes for over a hundred years.

Robert Hooke, working in London in 1665 and Anton van Leeuwenhoek, a draper and chamberlain to the Sherrifs in Delft in Holland, described a minute living world which previously had been quite beyond comprehension. Early microscopes produced quite indistinct images - coloured fringes, around the objects being observed and fuzziness at the edge of the picture. It took a period of 240 years to improve the microscope to a level of refinement at which it would display details of bacteria and of the mechanism of dividing cells and of reproduction.

This process of improvement was driven almost entirely by curiosity - there was no economic use for the microscope until 1840. Crucial contributions to improvement came from all around Europe. Great improvements in the glass for the lenses was made by Pierre Guinand, a Swiss working with Joseph Fraunhofer at Benediktbeuern, near where we are meeting here in Munich, and by Otto Scott in the Carl Zeiss Company at Jena.

To correct the coloured images produced by simple lenses, which limit the magnification and clarity which can be obtained, two differently shaped lenses made of two different types of glass are needed. Newton, trying to eliminate colour fringes by combining lenses of different shapes, but made of the same type of glass, had not succeeded and had concluded that the task was impossible.

Before 1670 only one type of glass had been available, but a second type, lead glass, was developed by Italian glassworkers working in London, for an English entrepreneur, George Ravencroft. Ravencroft had been importing large quantities of wine glasses from Venice and he wanted to set up manufacture in England, using a strong and more brilliant type of glass.

He succeeded in producing this new type of glass, but he had no thought of its use in telescopes or microscopes. Ravencroft had developed it for use in wine glasses, jugs and bowls. It was 70 years before it was used in telescopes by John Dolland, in London. Dolland was the son of a French Huguenot refugee, who came to England after the revocation of the Edict of Nantes in 1685 - just one hundred years after Flemish opticians were fleeing Antwerp and seeking to establish themselves in their new lives.

The theoretical development of the new lens, central to the improvement of the microscope, had important inputs from Klingenstierna, Professor of Mathematics at Upsala and from Leonard Euler, a Swiss mathematician working at St. Petersburg.

Further improvements to the theory of the microscope were made by Joseph Lister, a London wine merchant encouraged by David Brewster, a Scottish scientist.

Ernst Abbe, a German physicist working in the Zeiss company at Jena with Scott, the glassmaker, refined the optical theory, and the practices of manufacture, to a standard at which the microscope could open the door to our new understanding of the world. The microscope was crucial to Pasteur, the

French chemist and microbiologist in his work on the germ theory of disease and in his proof that life did not spontaneously generate.

The story as related above is misleading in its simplicity. Many more individuals were involved, each situated in a complex network essential to their contribution. Nevertheless the tale is typical of any of the stories of product development over long periods of time, which collectively make up our modern work, our European Miracle.

These are stories of widespread activity from a very diverse range of cultural backgrounds, dozens of intellectual and economic networks interacting in a supremely fruitful way.

Italy, Flanders and Holland, Germany, France, England, Switzerland, Russia and Sweden have all figured as sites in this chaotic burst of creativity which created the microscope. The microscope is just one specialized artifact among the thousands that comprise our material culture, but all the others - automobiles, drugs, the great range of electrical equipment we use, computers, plastics - they and many more are the products of this diversity-driven process. Every European cultural region has provided innovating minds which have contributed to the development of our various functional artifacts. Refugees brining with them that peculiar propensity to innovate so characteristic of their type, amateurs pursuing sheer interest and curiosity, merchants moving goods between cultures, the new breed of professional scientist/educator generating reliable knowledge, humble craftsmen and tradesmen making lenses, tubes, gears and castings - all part of this process. Collectively they **are** the process.

Cultural diversity is the engine that drives the innovative process along. Uniformity leads to stagnation because there are no new ideas flowing into the network. Isolated islands - even large ones like Japan settle into uniformity; on land we look for remote villages to witness an unchanging past. Japan is an instructive case to study.

Some degree of geographical remoteness, reinforced by long periods of strict politically imposed isolation, had left it, after 250 Tokugawa rule with an economy that could truly be called commercial capitalism; free trading, banking, high literacy and a broadly based education system, agricultural sufficiency, a meticulously clean culture with little epidemic disease.

It puzzled many nineteenth century European visitors - it had many of the characteristics of a European country, set in an Eastern sea. What it lacked notably was the capacity to generate new reliable knowledge; its products, which were well made and of great variety, were all craft products, requiring solely craft skills in their manufacture. There was very little product innovation, practically nothing that could be called technical innovation.

Within less than a century after, in effect, membership of the chaotic network of Western Civilization, Japan is innovation prolifically and producing new reliable knowledge at a growing rate. Previously, it had been a homogeneous culture. The remarkable transformation came with immersion in the pool of cultural diversity.