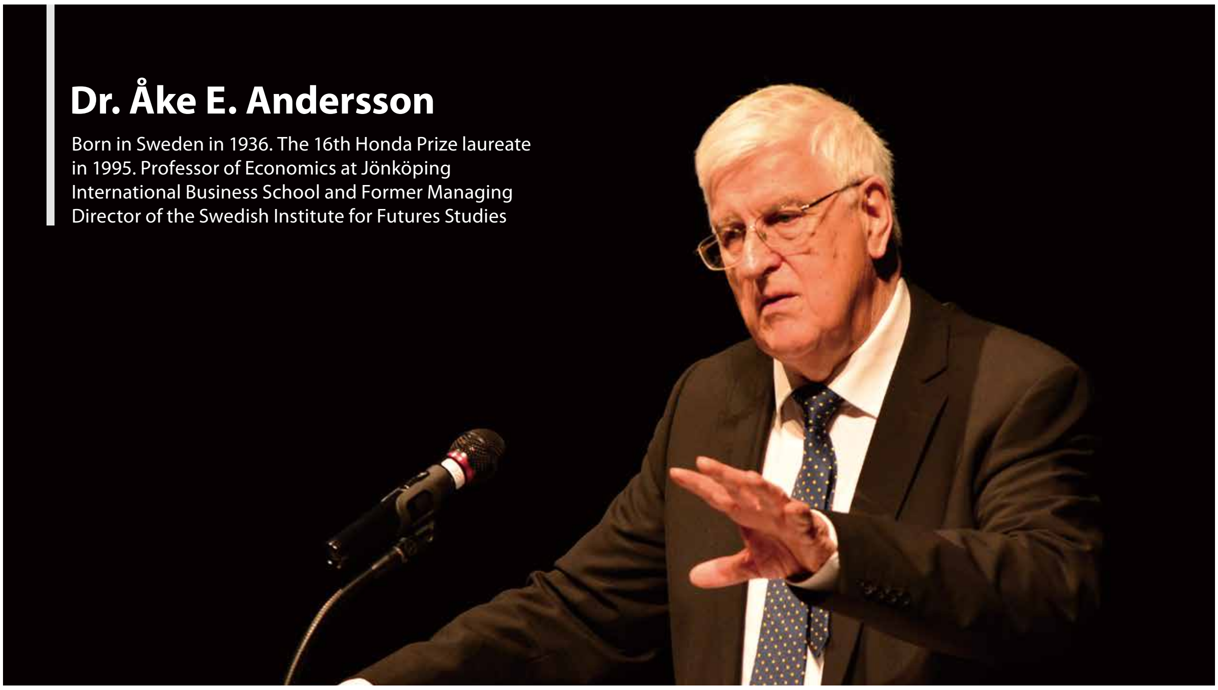
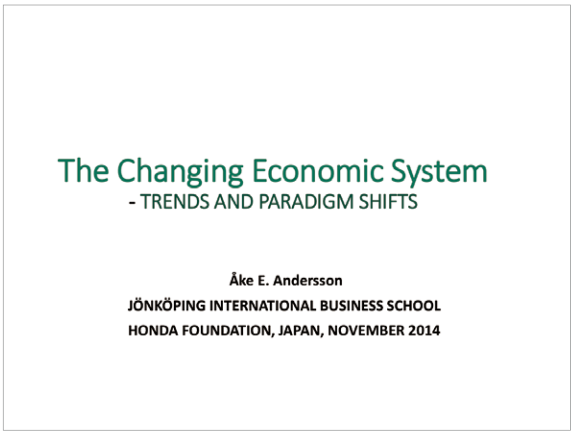


Paradigm Shift

The Changing Economic System



Ladies and gentlemen, I am very honored to be one of the contributors to the Honda Foundation memorial system.

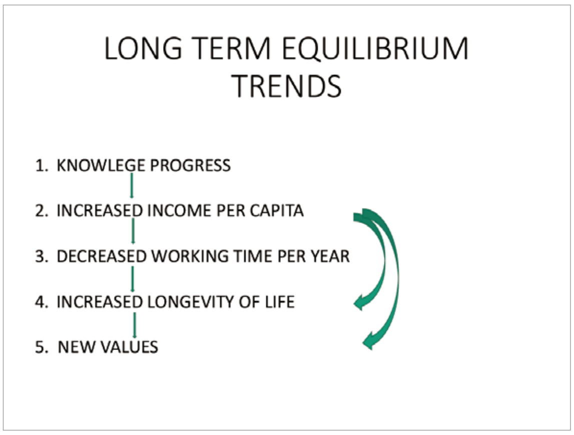
When we are looking at economic development, we must be very clear about two things. The first is that most of the time over history our societies have experienced equilibrium growth, and much of the time we have thus experienced rather predictable situations.

However, once in a while there is a phase transition or a major change of the whole economic structure, and we are currently, after 200 years of industrialization, moving into such a phase transition.

The global economy is now rapidly changing and becoming increasingly dependent on cheap, long-distance communication capacity, cognitive and creative occupations, and a capacity to handle cultural differences and conflicts.

As I said before, the reasons for the changing global economy are to be found in a phase transition that we will soon experience and a persistent equilibrium economic growth caused by the growth of knowledge due to steady growth of education and by research and development activities of research institutions and industry, and the innovations made possible by research and development activities.

The recent phase transition, I will talk about a little later, and it has to do with a soft and hard infrastructure for communications, for financial transactions and trade, and by the increased openness in many respects of many countries.



The long-term equilibrium trends are associated with knowledge progress. In the early 1960s, there was an extensive discussion about the relative role of different factors of production, and an American economist, Robert Solow, claimed that in fact the long-term rate of growth of per capita income in the USA could only, to a very limited extent, be explained by savings, or the growth of the stock of material capital, or the increases of quantitative labor supply.

It is rather the steadily increasing stock of human capital, technological and organizational knowledge that ensures a steady rate of growth of per capita real income of 2% to 3% per annum in the OECD countries and a faster rate of increase, in fact, in the developing economies.

An important contribution by Angus Madison and his associates has made it possible for us to study the macroeconomic accounting data over very long periods of time for a large number of industrialized nations. This database has increased our possibilities to explain the stable rate of growth of real national products, as I will show in a table.

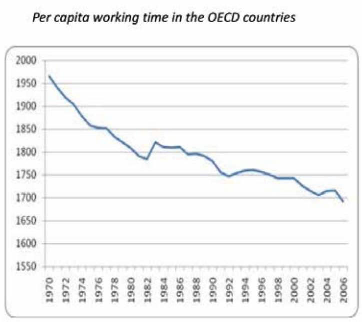
However, if we look at the factors that I will then discuss, we have to start with knowledge progress and look into the impact on the increases of income per capita and how that influences in its turn working time per year, longevity of life of the populations, and finally the emergence of quite new value structures.

So let's look at the rate of growth of economies. If we make a calculation from 1870 to 1979 using Angus Madison's original data, we find that Japan was the world leader. It had a growth rate of 3.0% per year in terms of real per capita income.

Long-term growth rates of real per capita GDP of industrialized market economies 1870–1979 and 1870–2010, per cent per annum

		1870–1979	1870–2010
Japan	wave 3	3.0	2.6
Sweden	wave 3	2.9	2.7
Finland	wave 3	2.7	2.6
France	wave 2	2.6	2.3
Germany	wave 2	2.6	2.5
Norway	wave 3	2.6	2.7
Austria	wave 2	2.4	2.4
Italy	wave 3	2.4	2.2
United States	wave 1–2	2.3	2.4
Canada	wave 2	2.3	2.3
Denmark	wave 2	2.3	2.2
Belgium	wave 1	2.1	2.1
Netherlands	wave 2	2.1	2.2
Switzerland	wave 2	2.1	2.1
Great Britain	wave 1	1.8	1.9
Median		2.3	2.3
Standard deviation		1.5	1.0

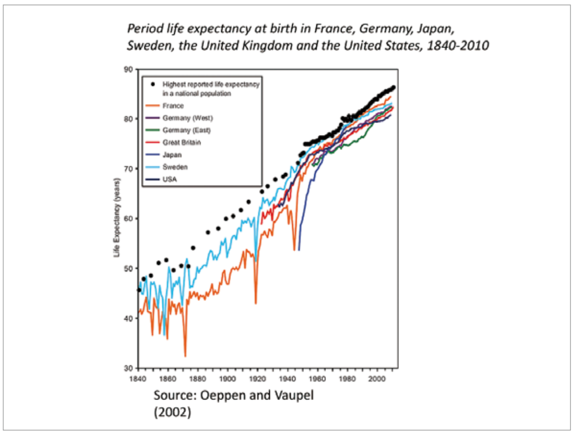
However, if we extend the time until the latest observable material in 2010, the income growth has dropped to 2.6% and it's now closing in on the average rate of growth of the OECD countries. It seems like the OECD area is now tending towards something between 2.0% and 2.5% of real per capita income growth.



What consequences will this have? Well, one of the important consequences is shorter working time and increased leisure time. A persistent empirical regularity in growing economies is the decline in the number of hours a member of the labor force devotes to work within a fixed time period.

An econometric estimate that I've done is based on Madison's data for the OECD countries for the period 1870 to 1980, and it shows that there tends to be a reduction of average working time by about 0.3% per year in the growing industrial economies, if we have this rate of growth of, let's say, 2.5% per year.

And this result supports the old hypothesis of the backward-bending labor supply curve, which essentially says that you'll make a choice between working more and consuming more when you have an increase in productivity. People simply prefer to work a little less when they can afford even more consumer goods. So there is a kind of break to the consumption and demand with the increasing rate of growth of the economies.



The other phenomenon is the increased longevity of life. John Maynard Keynes, who may be the greatest economist in the 20th century, famously remarked that in the long run we are all dead. And that's not a probabilistic statement, he said, it's a certainty.

Every human being has a finite life expectancy but this finite time period has been increasing in most parts of the world. You in Japan would know that. Globally, the increase in human life expectancy averages between three and four years per generation, which corresponds to a year-on-year increase of 0.6%.

However, according to a study by the National Institute of Health, while some experts assume that life expectancy must be approaching an upper limit, data on life expectancies between 1840 and 2007 show a steady increase averaging about three months of life per year. This is supported by studies by Vaupel and others, as illustrated by the figure above.

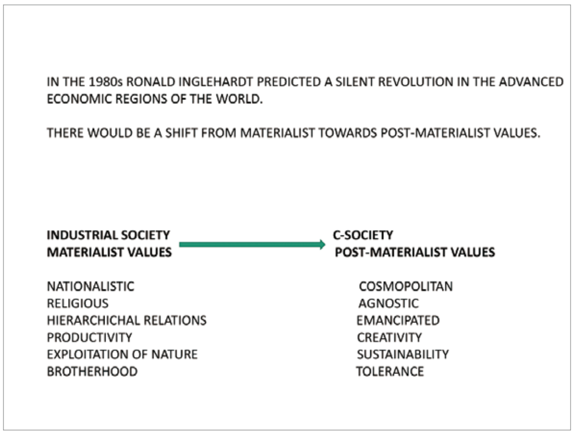
As you can see, it's a fairly linear development over time of life expectancy, and what does this mean? Well, it means essentially that we are approaching a fairly high level of life expectancy, and that will have consequences.

Now if I would summarize some of these long-term trend consequences for people's behavior, I would get the following result. There will be a steadily increasing growth of knowledge and information, even if we don't have a phase transition, meaning that we would move into a new economic system.

There would be an increasing income per capita at the rate of 2% to 3% per annum, with the latecomers having 3% and the early birds having 2% approximately.

There will be an increasing life expectancy towards 100 years in the most advanced parts of the world, and this will, of course, mean that people will have to work for a longer period of their lives. The expectation is that we will have something like 75 years as a fairly normal retirement age in the long run, not the 60 to 65 years that we find currently.

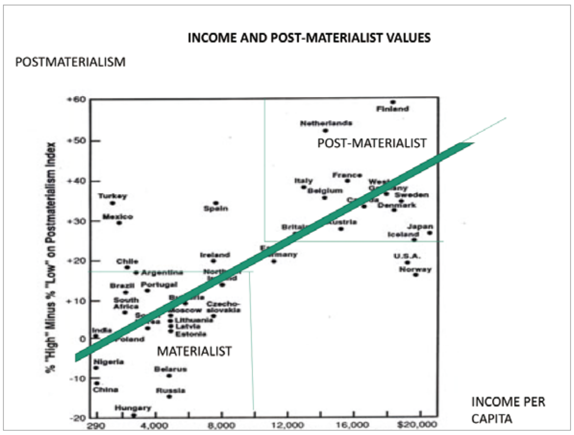
However, the decreasing working time per year is dropping as a consequence of the backward-bending supply curve and that will lead to something like 7%, maybe 8%, of total lifetime being spent working. This is in fact shorter than the share of life that we spend on drinking and eating currently, so in the long run, eating and drinking will be considered a more basic part of life than working.



There will be a steady shift towards a post-materialist value structure. What does that mean? Well, it means that we will move from the industrial society materialist value structure when people were nationalistic, fairly religious on the average, they believed very much in hierarchical relations, productivity was a driving force in every decision process, nature was there to be exploited, and brotherhood was a central aspect of life.

What does it look like in the post-materialist **C-society***, that I would call it? It would be cosmopolitan rather than nationalistic, it would be agnostic, it would be emancipated, it would be creative, it would be sustainable, and it would be rather tolerant. So it's a completely different situation.

* Emerging industrial society as new theoretical model proposed by Dr. Andersson, which aimed at both preserving the natural environment and developing regional economies in the face of aggravated problems with the global environment. "C" features creativity, communication capacity and complexity of products.

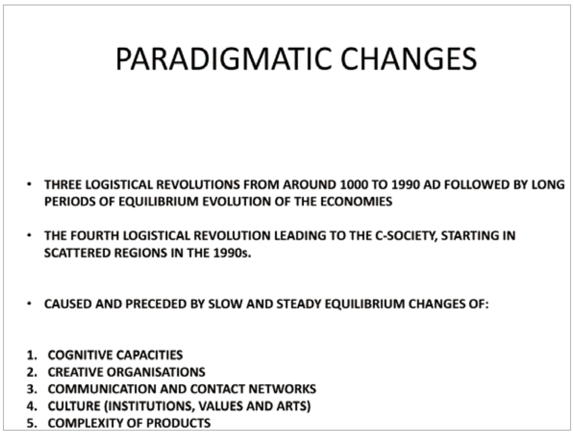


Now, the question is can we observe this shift anywhere? Yes, we can. We can observe it rather clearly. This is a classical picture from Ronald Inglehart's study where on the x-axis he has plugged in income per capita and on the y-axis he has plugged in the frequency of post-materialism.

In the upper-right corner you find the typical post-materialist societies at the beginning of this century. You find countries like Finland, the Netherlands, Italy, Belgium, France, Sweden, Germany, Denmark, Austria, Britain, Japan, and Ireland. And in the lower part of it you find countries like Russia, Nigeria, Belarus, Latvia, South Africa, Brazil, Portugal, and so on.

So there is a kind of hidden conflict between the post-materialist countries in the world and the materialist countries in the world, and within the countries there is a conflict between the people who are linked to the old structure and the people, mainly young, well-educated women, who are linked to the new value structure.

Now, let me then move to the paradigmatic changes that we are facing. The paradigmatic changes are actually a historical phenomenon that we can observe. We've had such changes during the latest millennium. The economic history of the world during the last millennium has been dominated by long periods of equilibrium growth or stagnation interspersed by four logistical revolutions or phase transitions.



The first logistical revolution was caused by the institutional and transport-system changes around the Mediterranean and the north of Europe, permitting a massive trade expansion and growth of wealth among the commercial innovators like the Medicis and the Fuggers in Europe, who actually transformed the European scene in very many respects.

The second logistical revolution happened around the 17th century and was again a commercial revolution based on institutional innovations, but even more by the new sailing possibilities opened up by the creation of the caravel and later the Dutch, very efficient ship, the fluyt.

However, the most important innovation was institutional, and it had to do with the creation of a banking system in Holland and Great Britain where they managed to base the new banking system on governmental guarantees, and that made trade, even over very long distances and long periods of time, something that was viable.

The third logistical revolution, or the Industrial Revolution, started in the 19th century and hit country after country. It is still hitting some countries around the world, the newly industrialized countries. They are still moving from agricultural to industrial structure.

And that was founded on the combined effects of free trade, proper property rights, and specialization of production to reap advantages of division of labor, and trade was no longer then limited to the exploitation of given price differences between regions as it was during the former two big transitions.

It was instead an industrial approach where the focus was on the difference between the price of a good in the importing region and the lowest possible cost of supplying the good.

Importers therefore became interested in influencing the entire chain of logistical costs down to the production sites and bringing the good to the market, including the costs of organizing production and of transporting the product to the market, including the marketing process itself.

So the industrial revolution, which we experienced the last phases of here in Asia and Europe and North America, is a kind of complete logistical chain system.

Now, the fourth logistical revolution is now in effect in parts of the former industrial world. I would say that it's basically a regional phenomenon rather than a national phenomenon. No nation is fully influenced by it, but very many nations are experiencing it in the most advanced regions of those countries.

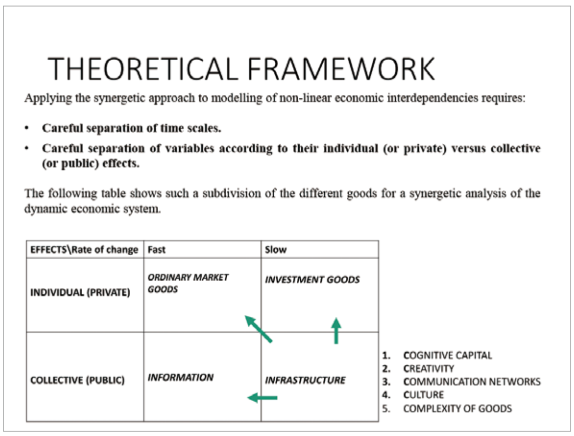
Now this new revolution is based on cognitive capacities; creative organizations; communication and contact networks; culture in the form of institutions, values, and the arts; and the complexity of products. There's an enormous increase in the complexity of products and thus our production system.

In discussions with the Nobel laureate Haavelmo and the Honda laureate Haken, I've found that a seeming paradox can be resolved. What is the paradox? Well, the paradox is the following: all economists and most engineers and policymakers realize that the economic system is essentially very nonlinear, and according to mathematics, the typical character of a nonlinear dynamic system is that it will always go into chaos. So chaos is an inherent problem of the nonlinear economic system.

But Haavelmo, when I talked to him, said, "That's very strange because when I look at the statistics of economic growth, it looks very stable and that's not compatible with the idea of a very nonlinear economic system."

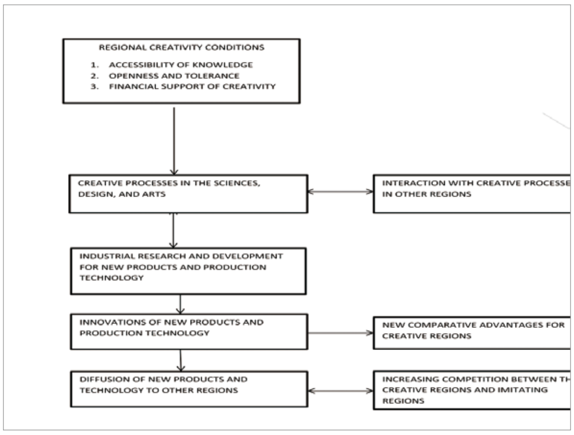
And I discussed this with Hermann Haken, the Honda laureate who could not be here today, and I found that some of his ideas of synergetics could actually be applied to economic theory.

Now, what do you need to do then? Well, you have to carefully separate the timescales. You have to carefully separate the variables according to their individual, or, as they are called in American economic studies, private goods versus collective or public goods, in the terms of its effects.



Now I've done this in this table. I have a rate of change: is it fast or is it slow? And when I say slow, it's by order of magnitude slower than the fast processes. Effects, on the other axes, is individual or collective.

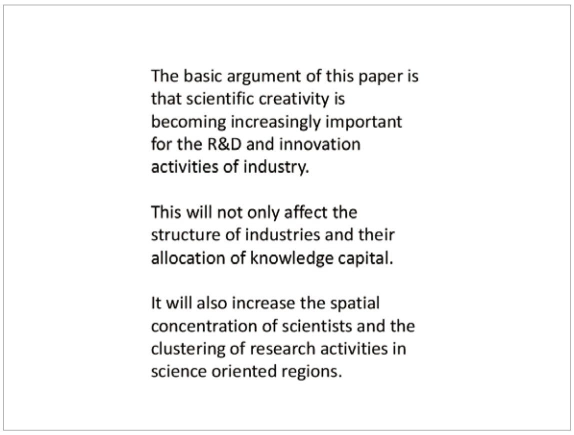
Now in the lower right corner I find the combination of slow and public or collective, and that is what we normally call infrastructure. And basically the idea is that economic decisions are mostly taken by firms and households under the assumption that infrastructure is given and not being changed by, for instance, a natural catastrophe or something like that. It's there as a stage on which the economic games are played.



What is the infrastructure then in this framework? It's cognitive capital, it's creative capacity, it's communication and transport networks, it's culture, and it's complexity of goods. These are the fundamentals on which the exchanges of ordinary market goods are happening and where the growth of private capital is determined.

In fact, with this approach we can actually see the market activities as something that are happening on a stable stage, as long as it is stable and does not change very much. And this was true during the industrial revolution.

Unfortunately, the industrial structure during the growth process goes towards a creative destruction. Sooner or later you come to a point where the arena has changed so much that the classical industrial manufacturing firms do not fit the arena. They start crumbling and fall to pieces and something else must come in its place, and this causes what we call structural unemployment.



The basic argument of this paper that I'm presenting today is that scientific creativity is becoming increasingly important for the R&D and innovation activities of industry. There is going to be a much closer link between scientific studies and industrial research and development and innovation processes.

This will not only affect the structure of industries and their allocation of knowledge capital. It will also increase the spatial concentration of scientists and the clustering of research activities in science-oriented regions.

The accessibility of the labor force with a high level of education is skewed in favor of what I call C-regions, that's regions that are rich in these new resources. The C-regions thus have an accessibility advantage in terms of the dynamics of knowledge accumulation and creation. This in its turn generates a more rapid pace of innovation and the development of new regional comparative and competitive advantages, as will be illustrated.

The knowledge infrastructure determining the conditions of creativity of a region is dependent on accessibility in the spatially extended network for communication and contact. It is also highly dependent on the openness, tolerance, and curiosity of the regional populations, and the allocation of resources to creative activities, and how the intellectual property rights are used in the sciences and arts.

Now, this table shows the overall research and development investments as a percent of GDP. And if we look then at the countries in the north of Europe, Sweden, Denmark, Finland, and the Netherlands, we find rather high values, especially for Scandinavia: 3.43 for Sweden, 3.06 for Denmark, 3.89 for Finland. And if we take the average for OECD, it's much lower: 2.17% of the GDP during the period 2008 to 2011.

Research and Development Spending in selected OECD countries, 2008–2011
Source: OECD Science and Technology Indicators (2012)

Country	Overall R&D (per cent of GDP)	Scientific research (per cent of GDP)
Sweden	3.43	.90
Denmark	3.06	.90
Finland	3.89	.79
Netherlands	**1.83**	**.75**
Switzerland	2.97	.72
Austria	2.71	.72
Canada	1.80	.69
Norway	1.69	.55
Australia	2.18	.54
Germany	2.79	.51
Ireland	1.79	.51
France	2.12	.48
United Kingdom	1.70	.48
Belgium	1.97	.46
Japan	**3.33**	**.45**
OECD	**2.17**	**.44**
New Zealand	1.30	.43
South Korea	**3.58**	**.40**
United States	**2.28**	**.39**
Spain	1.34	.39
Italy	1.25	.36
Greece	.60	.30

10%-30%: SURPRISINGLY SMALL RELATIVE ALLOCATION OF FUNDS TO SCIENTIFIC RESEARCH

Now, if we look at the scientific research, how big is that? Well if we take Sweden, it's much lower than industrial R&D, which means that we have a problem. If we look at the OECD as a whole, it is 0.44 as compared to 2.17 in total. And if we look at Japan, it's a very high total allocation of resources to R&D, 3.33, but only 0.45% of your national product is going to scientific research. It's a surprisingly small relative allocation of funds to scientific research.

Politicians and bureaucrats who control the allocation of resources to science often assume that the currently popular national innovation policies are best at promoting future comparative and competitive advantages to the countries. The implication is, however, that they tend to support industrial R&D rather than scientific research in spite of the much greater and more widespread long-term social returns that scientific creativity would generate.

I could give you many examples. If we look at information technology, it's often assumed that that is something that happened primarily in the US on the West Coast during the 1980s and 1990s, but the basis of it was created in the 1930s by mathematicians in Britain and at Princeton.

Most of this was, so to say, highly dependent on rather ill-funded scientific research being done under very bad conditions in Great Britain in the 1930s. And it's probable that we will have the same problems emerging today because of the low relative share of scientific research.

TWO OPPOSING HYPOTHESES ON THE ROLE OF SCIENCE

Baumol's hypothesis: *The R&D divisions of the large firm tend primarily to require personnel who have undergone training for mastery of extant information and analytic methods, while the work of the independent entrepreneur and inventor may prove to be more effectively facilitated by avoidance of that sort of preparation to the extent that it impedes imagination and originality.*
INVENTORS WORK IN ISOLATION FROM SCIENCE

Hollingsworth's hypothesis : *The increasing complexity of fields such as biomedicine means that large and multidisciplinary science teams are becoming increasingly important for basic research, which is the domain that has always been responsible for the most revolutionary creative breakthroughs.*
INVENTORS ARE INCREASINGLY DEPENDENT ON SCIENCE BECAUSE OF THE INCREASING COMPLEXITY OF PRODUCTS

What is complexity of products ?

There are, however, two opposing hypotheses on the role of science. The first one is called Baumol's hypothesis. Baumol is an American economist, associated for a very long time with Princeton, and he says inventors work in isolation from science. The other counter-hypothesis by Hollingsworth says that inventors are increasingly dependent on science because of the increasing complexity of products, and he went around to prove it.

Now the question is then what is complexity of products? What do we mean by complexity of products? Well, there are numerous proposed definitions of complexity. Most of these are, so to say, beer talk based on intuitive reasoning. However, Ray Solomonoff, Andrey Kolmogorov, and Greg Chaitin, three rather famous mathematicians, provided a mathematical and precise definition of complexity.

Complexity of algorithms and products

Kolmogorov and Chaitin provide a mathematical approach to the study of complexity.

Both claim that complexity is measurable: *it is the minimal length of a program or algorithm that yields an exact solution to a pre-formulated problem.*
This can be clarified with two examples.

Example 1: 00200030000400000500000006…
Example 2:121543699821345798709812699943333.

It is easy to formulate an algorithm that is shorter than the number sequence of Example 1. In contrast, number 2 has no computation formula shorter than the series itself. It is thus more complex.

They claim that complexity is measurable and can be defined as the minimal length of a program or algorithm that yields an exact solution to a pre-formulated problem. So it's minimal length that defines complexity.

What did they mean? Well, I would say it's easier rather to show you. Let's say that we have example one, which says 002000300004, and then five zeros and 5, and then six zeros and 6 and so it goes on towards infinity.

The other example is 121543699821345798709 81269994333. It can be shown that there is no possibility of finding a computation formula that is shorter than the series itself. It is thus more complex than the first example because anyone can write a short computer code to generate the first example.

COMPLEXITY OF PRODUCTS

It is possible to generalize the complexity of computer algorithms so that this definition of complexity also applies to phenomena such as design of products blueprints and production instructions.

Standard goods must follow strict rules of composition production instructions. An example is the blueprint and production plan for a new automobile.

It has thus become possible to produce an automobile by 3D-computing as recently demonstrated in USA.

Now, can we use this in engineering and sciences and technology and so on? Well, Solomonoff already claimed that it is possible to generalize the complexity of computer algorithms so that this definition of complexity also applies to phenomena such as design of products, blueprints, and production instructions because standard goods must follow strict rules of composition and production instructions.

An example is the blueprint and production plan for a new automobile. It has, according to this procedure, become possible to produce even an automobile by 3D computing, as recently demonstrated in the United States by some scientists.

However, there are limitations. I could give an example. In Sweden, we make Swedish fish soup and that's a very simple soup. And the contrast is a French bouillabaisse soup. I would claim that the French bouillabaisse soup is by orders of magnitude more complex. It takes a minimal instruction that is very long compared to the instruction that is minimal for making Swedish fish soup.

Complexity, inputs and cost

The *cost and revenue* of production will depend on (at least) three factors:

1. the complexity of the recipe (blueprint or design);
2. the quality attributes of the inputs; and
3. the skills of the workers (labour or human capital).

Besides the complexity of production there is also the complexity of consumption. These two types of economic complexity do not coincide. More complex production often causes *less* complex consumption.

But it also shows that there is a limitation that arises from the difference between a set of numbers in an algorithm and the set of ingredients in the soup. Soup ingredients have a much greater scope than numbers: they are heterogeneous rather than uniform in having an open-ended set of underlying attributes.

A second limitation is that soups, unlike numbers, are sensitive to the skill of the individual using the recipe. A recipe-using individual is not as homogeneous as an algorithm-using computer. A skilled worker can adjust the recipe if the delivery of an input is for some reason not good enough.

In the short term: Algorithmic complexities of the products are given by earlier investments in new knowledge.

In the long term: Algorithmic complexities, input structure, and required skills can all change as a result of creativity in scientific research.
Such changes are possible only on much slower time scales than the typical time scale of ordinary business decisions, which in this case includes R&D-induced incremental improvements.

The accumulation of scientific knowledge thus occurs through a slow and creative process that changes the algorithmic complexity of goods.

Now, how can this be handled in an economic analysis? Well, algorithmic complexities of the products are basically in the short term given by earlier investments in new knowledge. In a way, the investments in knowledge provide a stage on which algorithmic complexities can be calculated.

In the long term, however, algorithmic complexities, input structure, and required skills can all change as a result of creativity in scientific research. The accumulation of scientific knowledge thus occurs through a slow and creative process that changes the algorithmic complexity of goods, mostly in an increasing respect.

KNOWLEDGE
INFRASTRUCTURE FOR R&D

Firms have to treat the current stock of established scientific knowledge as a fixed constraint on their opportunity set.

We may therefore treat the algorithmic complexity of a specific long time period as the knowledge infrastructure.

Firms would thus treat this infrastructure as a stable basic input into the much more rapid applied and incremental research processes that transform scientific results into product and process R&D and innovations.

The development of science toward increasingly complex theories, models and products causes a need for more complex cognitive capacity among scientists, within laboratories and other research institutes.

So, algorithmic complexity over a long time period can be seen as the knowledge infrastructure. The development of science towards increasingly complex theories, models, and products causes a need for more complex cognitive capacity among scientists within laboratories and other research institutes.

Now this is much talk, but it has been tested, and the test was done by Hollingsworth who actually addressed the question by connecting scientific complexity to the frequency of creative breakthroughs and the internal organization of universities, research institutes, and laboratories. And his focus was on biomedical science, which is unusually concerned with understanding and predicting highly complex systems. So biotechnology is now a focus of the complexity analysis.

Hollingsworth noted that high cognitive complexity is the capacity to observe and understand in novel ways the relationships among complex phenomena, the capacity to see relationships among often-disparate fields of knowledge, and it is that capacity which greatly increases the potential for making a major discovery. These were his conclusions.

COMPLEXITY, CREATIVITY AND
RESEARCH ORGANIZATION

Attribute	Type A Lab	Type B Lab
Cognitive	High scientific diversity	Low or moderate scientific diversity
Social	High and diversified network connectivity	High network connectivity within a single discipline
Material	Access to funding for high-risk research	Limited funding for high-risk research
Personality of the Lab Head	High cognitive complexity; high confidence; high motivation	Low cognitive complexity; risk-averse
Leadership	Excellent grasp of how different fields may be integrated	Not concerned with integrating distinct scientific disciplines

Table 2: Organizational Attributes of Type A and Type B Laboratories
Source: Hollingsworth (2007)

Then he said, “Let’s look at different types of labs. How are they organized?” And he found that there are Type A labs, which are characterized by high scientific diversity, high and diversified network connectivity, they are connected internationally in a diversified way, and they have access to funding, even for high-risk research.

The personality of the lab head is very central according to this analysis. High cognitive complexity, high confidence, and high motivation are the three characteristics of this type of lab head. And the leadership implies excellent grasp of how different fields may be integrated.

The Type B labs had a low or moderate scientific diversity and high network conductivity but only within their own single discipline. If they were analyzing some chemical substance, they had excellent relations with all people looking exactly at that chemical substance around the world. They had low cognitive complexity, they were risk-averse, and they had very limited funding for high-risk research.

And the leader was not concerned at all with integrating distinct scientific disciplines. He was not interested in interdisciplinary science.

The surprise was when they evaluated the success rate of these activities: “all of the 291 discoveries in our project were made in Type A laboratories. Significantly, none of the 291 discoveries in our research occurred in Type B labs.” So this gives us a fairly clear understanding of in what way reorganization of research should move.

Hollingsworth: "**all of the 291 discoveries in our project were made in Type A laboratories**. ...

Type B laboratories are at the opposite end of the continuum on virtually all the lab characteristics.

Significantly, none of the 291 discoveries in our research occurred in Type B labs."

The problem is, however, because these are high-risk problems, there were a lot of mistakes also in the Type A laboratories. They made mistakes but they were on the whole much more successful than the risk-averse, highly concentrated Type B labs.

INCREASING COMPLEXITY AND REORGANISATION OF RESEARCH

There is a need for reorganization of research into Type A departments, labs and research institutes.

Increasing complexity of science requires good accessibility of new and diversified external knowledge.

This provides strong arguments for locating Type A research organizations in large, open and diverse C-regions.
(cf. Andersson, 1985; Kobayashi and Andersson, 1990 (in Japanese), Florida, 2002; Hollingsworth, 2007; Simonton, 2011)

There is a need for reorganization of research into Type A departments, labs, and research institutes. Increasing complexity of science requires good accessibility of new and diversified external knowledge. This provides strong arguments for locating these Type A research organizations that are growing into large, open, and diverse C-regions. It gives an advantage to some metropolitan regions in the world like Tokyo.

My son has been working with the top 12 science city regions, and he has shown that there are some persistent regions in the world that will probably be the world leaders in research and development also in the future.

The world's top-12 science city regions

Source: Andersson D. et.al. (2014) : Calculated by the authors on data from Thomson Reuters' Science Citation Index (SCI)

PERIOD	96-98	papers	02-04	papers	08-10	papers
1	London	69,303	Tokyo-Yokohama	81,798	Beijing	100,835
2	Tokyo-Yokohama	67,628	London	73,403	London	96,856
3	San Francisco Bay Area	50,212	San Francisco Bay Area	56,916	Tokyo-Yokohama	94,043
4	Paris	49,438	Osaka-Kobe	54,300	Paris	77,007
5	Osaka-Kobe	48,272	Paris	53,005	San Francisco Bay Area	75,669
6	Moscow	45,579	New York	51,047	New York	70,323
7	Boston	42,454	Boston	49,265	Boston	69,250
8	New York	41,566	Los Angeles	44,401	Seoul	67,292
9	Randstad (Amsterdam)	37,654	Randstad (Amsterdam)	44,094	Randstad (Amsterdam)	65,527
10	Los Angeles	37,437	Beijing	42,007	Osaka-Kobe	60,615
11	Philadelphia	29,376	Moscow	41,001	Los Angeles	58,176
12	Berlin	24,514	Seoul	33,083	Shanghai	50,597

London is one case, Tokyo/Yokohama is another case, and an upcoming case is Beijing, and if we look at this table that goes all the way from 1996 to 2010, it gives a kind of stable picture of the global leaders in terms of regions of the future.

PARADIGM CHANGES IN THE RESEARCH SYSTEM

A. **FACT :INCREASING COMPLEXITY OF R&D CAUSES HEAVIER RELIANCE ON SCIENTIFIC RESEARCH**
CONSEQUENCE: MORE RESOURCES OUGHT TO BE ALLOCATED TO SCIENTIFIC RESEARCH IN ALL ADVANCED COUNTRIES

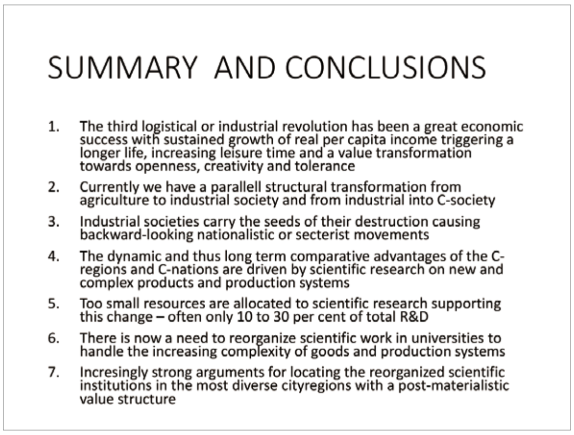
B. **FACT : SCIENTIFIC R&D ON COMPLEX PRODUCTS AND SYSTEMS IS ALREADY CLUSTERED IN LARGE C-REGIONS**
CONSEQUENCE: THE INCREASED COMPLEXITY IMPLIES A FUTURE OF INCREASED CLUSTERING OF SCIENTISTS AND INDUSTRIAL R&D IN LARGE C-REGIONS

C. **FACT: INTERNATIONAL SCIENCE COLLABORATION IMPROVES DIVERSITY AND QUALITY OF KNOWLEDGE INPUTS**
CONSEQUENCE: MORE FUNDING OF SCIENTIFIC COLLABORATION IS NEEDED

So we have some paradigm changes ahead in the research system. The first fact is increasing complexity of R&D causes heavier reliance on scientific research. Consequence: more resources ought to be allocated to scientific research in all advanced countries.

B. Fact: Scientific R&D on complex products and systems is already clustered in large C-regions. Consequence: The increased complexity implies a future of increased clustering of scientists and industrial R&D in the larger C-regions of the world.

C. Fact: International science collaboration improves diversity and the quality of knowledge inputs, according to the study by Hollingsworth, but also studies I've performed together with my collaborators. Consequence: More funding of scientific international collaboration is needed. Unfortunately, the resources to do this are quite limited in parts of Asia, and especially in China.



So let me then summarize and conclude. The third logistical or industrial revolution has been a great economic success with sustained growth of real per capita income triggering a longer life, increasing leisure time, and a value transformation towards openness, creativity, and tolerance.

Currently, we have a parallel structural transformation from agriculture to industrial society in parts of the world, and from industrial into C-society in countries like Japan.

Industrial societies carry the seeds of their destruction causing backward-looking nationalistic or sectarianist movements like we see in Europe today.

The dynamic and thus long-term comparative advantages of the C-regions and C-nations are driven by scientific research on new and complex products and production systems. Too small resources are allocated to scientific research supporting this change, often only 10% to 30% of total R&D.

There is now a need to reorganize scientific work in universities to handle the increasing complexity of goods and production systems. There is an increasingly strong argument for locating the reorganized scientific institutions in the most diverse city regions with a post-materialistic value structure.

Thank you.