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Baumol's Disease and Dematerialization of the Economy

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Abstract

A growing service sector is often proposed as a factor that might reduce per capita emissions of pollutants. This paper argues that this idea is based on a misconception of what the transition to a service economy actually means, by using the insights Baumol provided. It further shows that the service sector has not increased its share of real production in Sweden after 1970. Still, the Swedish CO₂ emissions show a decline after 1970. This is mainly explained by a politically driven change in the mix of energy carriers, but is also related to the stabilization of energy consumption. This energy stabilization is caused by a slow growth of the economy in conjunction with substantial declines in energy intensity within the sectors and an absence of relative growth of the heavy sectors, a growth that had marked the economy between 1870 and 1970. The microelectronics, which form a foundation for the post-industrial society, have contributed to permanently transforming the Swedish industrial sector in a lighter direction, reducing energy losses in heavy industries and stabilizing household energy consumption. So it appears like there may be some environmental relief from the development that was initiated in the 1970s, only not consisting in relatively more service production.

Keywords: Service economy, Baumol, dematerialisation, environmental Kuznets curve, energy intensity, CO₂ intensity

1. Introduction

The environmental Kuznets curve (EKC) hypothesis suggests that environmental degradation follows an inverted U-shaped pattern in relation to economic growth, similar to the pattern Simon Kuznets proposed for the relation between inequality and growth (Panayotou, 1992, 1995, Kuznets 1955). The EKC has often been used to defend a growth optimistic view, where growth and environmental concerns may eventually be reconciled and sustainable development be achieved (Brundtland, 1987). Sceptics have expressed several theoretical reasons why this general

reconciliation still may not be possible, even with the existence of EKCs (Stern 1998, Pasche 2002).

The EKC hypothesis reached a broad audience through the World Development Report in 1992 and has spurred plenty of empirical studies since then. The empirical evidence for the EKC is generally not very strong, and there are several studies that cast doubt on its generality. Still, some studies, mainly of local and regional pollutants and deforestation, show the expected relation.

The most common method used for the EKC studies is regression analysis based on panel data of countries starting around 1960. As a complement to these studies long-term development studies for individual countries should be performed, since the pattern that appears for panel data may either be the result of the aggregation procedure or the result of the model specification. Such country studies enable a decomposition of important mechanisms driving the curve and show the effect of specific historical events. If they cover a sufficiently long time period they also show effects of important economic transitions like the industrialisation.

An inverted U-curve for energy intensity (energy/GDP) was suggested by Reddy & Goldemberg (1990), drawing on the results by Martin (1988). Really long-term country studies in the energy field are until now few (Schurr 1975, Humphrey & Stanislaw 1979, Fouquet & Pearson 1998, Kander 2002, Lindmark 2002, Schandl & Schulz 2002) and the only of these that applies a decomposition analysis separating out the relative effects of structural and technical change, and the importance of international trade is Kander 2002. In addition, there is a growing number of decomposition studies dealing with the last few decades (Grossman 1995, de Bruyn

1997, Bruvoll and Medin 2002, Schipper, Unander and Murtishaw 2001, Stern 2002, Friedl and Getzner, 2003).

The suggested mechanisms behind the EKC stress a combination of technological change and shifts in environmental demand. Initially high, but falling marginal utility of consumption and initially low, but increasing disutility of emissions as incomes rise marks the environmental preferences. Technical change, or shifts of production possibility frontiers, works on the supply side to accomplish the EKC. A changing output structure, from more to less material intensive goods, may be part of these shifts and is the focus of this paper. Sometimes these structural changes have been regarded as part of a three-stage development scheme, where the transition from an agrarian to an industrial society is linked to the upward slope of the EKC and the latter transition to the post-industrial society or the service economy is connected to the downward slope of the curve (Kahn 1979, Grossman & Kreuger 1995). If this is correct it seems like growth itself eventually provides the solution to the problems it has created. The policy implication could be to promote ordinary growth in developing countries, to make them less environmentally harmful.

One objection to this idea is that most developing countries are still at the upward slope of the curve, not being fully industrialized, and that global environmental degradation would continue and even get worse for quite some time with growth (Holz-Ekin & Selden 1995). The necessity for developing countries to press the EKC downwards or “tunnel through the EKC” during their developments has consequently been stressed (Munasinghe 1999).

Another objection to an over-optimistic interpretation of such a structural mechanism is that EKCs are identified on the production, rather than the consumption, side of

national economies. The pollution haven argument, or the idea that rich countries live in the service economy, while they import raw material intensive goods from developing countries, could of course impose a severe restriction on the option for all countries in the world to follow this three stage development path, since eventually there will be no countries undertaking the material intensive production. Evidence of trade explanations of the downward slope of the EKC has been found in some cases (Chapman & Suri 1998, Muridian, O'Connor & Martinez-Alier 2002) but not in others (Antweiler 1996, Agras & Chapman 1999, Kander & Lindmark 2003). It is definitely something worth more research, not the least on individual country basis where methods can be finer than in regression analyses.

This paper will present a third argument for not being overoptimistic in interpreting the transition to a service economy as a remedy for environmental problems, which is that the share of real service production is not necessarily increasing in the service economy.

The paper is organised in the following way: section 2 argues that there is a theoretical reason for being cautious in interpreting the transition to a service economy as an indication of dematerialisation of production. Section 3 is an empirical section showing the differences in the share of the service sector in Sweden, when this is expressed in current or constant prices. Section 4 continues the empirical analyses by showing the long run CO₂ intensity pattern in Sweden and decomposing its changes. Section 5 contains a discussion and the paper ends by presenting main conclusions in section 6.

2. Baumol and the service production

If the service sector, consisting of less material intensive production than manufacturing, increases its share of the economy this may lead to a less material demanding and polluting economy in absolute terms, if this structural change takes place at a speed which surpasses the growth of the economy. A relatively growing service sector is thus not sufficient for a better environment; the growth must be fast enough. The point here is even more dismal: there are reasons to believe that the service sector is not expanding its relative production at all. This reason can be inferred from the insights Baumol provided in the nature of the service economy, even though he never addressed any environmental implications (Baumol, 1967).

Ecological economists have not in general paid much attention to Baumol's argument. One exception is Gerlagh and van der Zwaan (2002), who argue that costs of environmental services may increase due to Baumol's disease, so that over time such services will dominate output. The argument here is different and concerns the whole concept of the service transition and dematerialisation of the economy.

Baumol explored the logics inherent in the service economy by a very simple two-sector model of the economy, where one sector is technically progressive and the other is technically stagnant. In the progressive, or the industrial, sector human labour is merely the means for production, which means that labour is substituted for machines when profitable. Workers in this sector become increasingly equipped with machines and hence their labour productivity rises. In the stagnant sector, or parts of the service sector, human time is often a necessary part of the product itself, and labour productivity hence cannot be increased to a similar degree by new machines.

To reduce labour time here often simply means a diminishing quality of production (for instance a pianist cannot play the tune double as fast without severe loss of quality). Baumol then clearly shows that given two fairly reasonable assumptions (that wages and real production develop equally in both sectors) two things will happen: 1) the price of the stagnant sector's products will rise relative to the products of the progressive sector 2) the stagnant sector will employ an increasing share of the labour force. These two things have occurred in developed economies in recent decades and therefore lend some credibility to the underlying assumptions, but do not of course show that they are correct in their extreme form. Does for instance real production in services and industry remain in constant proportions during development? Should we not expect the service sector to increase its share as a country reaches a higher average income level? Such an idea is normally based on some hierarchy of human needs, where humans first seek to fulfil their elementary needs like clothing and shelter and then devote resources to industrial goods and at even higher income levels consume services like theatre performances, concerts etc. While this is a correct description of expenditure within different income groups in a country at a specific point in time it does not hold between countries or over time (Gerschuny, 1978, Ingelstam, 1997). When a country has reached a higher average income level, also the costs of personal services go up, because wages in service professions rise, and hence people cannot afford them anymore than in a poorer country. What people in a richer country can consume more of is what their economy is good at producing, i. e. industrial products. International trade makes no large difference to this overall picture, since personal services cannot in most cases be imported.

So, simple reasoning leads us to suspect that real service production will not rise in developed countries, although service employment and relative prices of services do. Real service production may stay constant in relation to industrial production, in line with Baumol's assumptions, or even decline, due to higher relative price. This does of course have environmental bearing, since it is the real production that matters for the environment.

Real production is measured by deflating the values in current prices with a proper price index. All constructions of price indices involve three main problems: the quality problem, the weighting problem and the base year problem, the latter often referred to as *the* index problem. The quality problem has to do with the fact that many goods improve their quality over time, which means that every price increase is not a real price increase, because it may be connected to higher quality of the product. This may be dealt with by linking overlapping price series for similar commodities with different quality or by relating price to performance. Despite such efforts, it is often the case that real growth is underestimated. The weighting problem means that an ideal index should reflect the composition of goods in the sector under scrutiny, which may be especially difficult in periods of rapid change in the composition of goods within this sector. *The* index problem stems from the fact that there is no given base year for the construction. Growth rates may differ with an early and a late price basis. The most neutral result is achieved by avoiding long deflating periods with one common base year, and instead link one-year indices into a chain index, or by using an index that aims at producing an average figure of an early and a late base year, for instance the Fischer index .

Bearing these deflating problems in mind it is evident that there is no such thing as a perfect measure of growth or relative growth of sectors in constant prices. Dividing production in current prices by carefully elaborated price indices does however depict real growth to a reasonable extent. The argument here concerns relative sector growth, especially the growth of the service sector, and this must be measured in real terms.

All constant price calculations necessitate a choice of price level (for instance 1995 USD or 1910/12 SEK, the latter being an average over three years). The choice of price level is a procedure quite separate from the actual price deflator construction, and should not be confused with the choice of price bases for the deflators. While the choice of price bases is part of the index problem and may influence relative growth rates, the choice of price level is relatively unproblematic, since it does not affect the relative growth of the sectors, only their relative sizes, and hence does not have a bearing on the argument here.

Relative sector growth looks profoundly different depending on whether the sectors are expressed in current or constant prices. If the sectors are measured in current prices the relative price increase per se in the service sector, due to unbalanced productivity development, will show as a relative increase of this sector. If on the other hand the sectors are measured in constant prices, the service sector does not increase its share, unless there is a real growth of relative output.

3. Sector shares in Sweden 1800 - 2000

To see how the main economic sectors have developed in the long run we will take a closer look at the Swedish economy, for which a high-quality data set of historical

national accounts exists (SHNA). I have used this material to divide the economy into four main sectors: agriculture (including forestry, fishing etc), industry (including construction), services (both private and public) and transport & communication. Often the transport & communication sector is included in the service sector, but when it comes to environmental concerns it makes sense to separate the two parts.

Figure 1, depicts the sectors in current prices and shows that the service sector share increased substantially after 1950.

If instead the sector shares are measured in constant prices, something that more accurately depicts real production, as in figure 2, there is no relative increase of the service sector. Instead there is a minor increase of the transport & communication sector at the expense of the industrial sector. Whether this has had any positive environmental effects depends on the relative environmental loading of the industrial sector versus the transport & communication sector. In Sweden these sectors have fairly equal energy intensity, because of the heavy industrial structure, with steel and paper & pulp being important branches. The energy carriers employed in the transport sector are, however, generally more polluting than in the industrial sector, not the least with respect to CO₂. We can thus conclude that there is only a small environmental effect from this structural change, but it does not seem to be in a more environmentally benign direction.

It thus appears in the Swedish case as if the transition to the service economy is somewhat of an illusion when it comes to what is important for the environment: a society's actual production. It is of course possible that Sweden is exceptional in its service sector development and not representative for developed countries. Perhaps

other countries show a relative increase of their real service production. This can be doubted for the reasons discussed above, but may nevertheless be interesting to explore in future studies.

4. So why did Swedish CO₂ emissions decline?

What makes Sweden an interesting example in a discussion of the service sector and dematerialisation, is that Sweden is one of few countries that shows a typical EKC pattern for CO₂ in the long run, if temporary world war effects are disregarded, see figure 3.

There is a marked decline in CO₂ emissions after 1970, which does not have anything to do with an expanding service sector. Instead it is caused by a combination of changes in the mix of energy carriers, see figure 4, which lower the CO₂/energy ratio, see figure 5, and a decline in the energy/GDP ratio, i.e. the energy intensity, see figure 6.

The mix of energy carriers became less CO₂ intensive after 1970, i. e. the CO₂/energy ratio declined. One reason for this was the increase of the electricity share, an increase that was not driven by fossil fuels, but by nuclear power. The Swedish electricity production is spectacular, since it relies heavily on hydropower and nuclear power and only marginally on fossil fuels. When electricity production started in the 1880s approximately 80% was produced from coal and firewood, and the remaining 20% from hydropower, but already in the 1910s relations had switched and hydropower made up 80% of the primary energy for electricity. For a long time the Swedish rivers were regarded as an endless source of clean energy, but in the 1960s the political

opinion changed in favour of saving some of the few remaining wild rivers. Still the electricity expansion continued, first based on oil, which made up 30% of the primary energy in the early 1970s. During the 1970s the nuclear program started in Sweden, after extensive planning and research since the late 1940s. The nuclear program enabled an accelerated expansion of the electricity share in the Swedish energy system, which was already large by international standards. The nuclear accident in Harrisburg lead to a Swedish referendum in 1980, which decided that only plants that already had been projected should be constructed, and that nuclear power should be abolished as soon as there were feasible alternatives. In total twelve nuclear plants were raised and only one of them has to date been closed down. Nuclear energy and hydro energy made up approximately half each on the Swedish energy production during the 1980s and coal and oil only 5%. After the closing down of Barsebäck 1 and the deregulation of the electricity market some coal-based electricity has been imported from other European countries, thus slightly increasing the combustion part.

Another reason for the declining CO₂/energy ratio was an increase of wood based fuels. From the 1980s refined wood-based fuels like pellets, with less water and ash content than ordinary firewood, came into increasing use among households and in addition CHP (combined heat and power plants) started to make use of firewood. The expansion of wood-based fuels continued also during the 1990s, when the nuclear program came to a halt. It is clear that energy and environmental taxes had a large effect on the expansion of wood-based fuels, by raising the relative price of coal and oil. The internalisation of some environmental costs on the Swedish energy market has thus to some extent succeeded in directing the energy demand in more environmentally friendly directions. For uses that were not oil specific, for instance

heating, firewood regained some of its historically strong position. Other uses, mainly for road and air transportation, where oil has a strong position have not yet been substituted for renewable energy, despite certain attempts. Not only has the use of refined wood fuels increased, in addition waste-wood fuels in the form of spent pulping liquor has been increasingly used in the pulp & paper industry. This is not a minor energy post; in fact it makes up 9% of the Swedish energy system in 2000 and has clearly contributed to the lower CO₂ emissions from energy use.

The mix of energy carriers is very important in explaining the CO₂ emissions during the last two hundred years, as can be seen from a comparison of figures 3 and 5, and the expansion of biofuels and nuclear electricity had a large impact on the decline in CO₂ emissions after 1970. Logically CO₂ emissions depend on the mix of energy carriers and the amount of energy. What is not explained by changes in the mix of energy carriers is thus explained by changes in energy use per se. Figure 6 reveals that aggregate energy consumption in Sweden increased until the 1970s after which it leveled out, if electricity is counted by its heat content (El(h)) and increased slightly if electricity is counted by the primary energy needed for its production (El (p)). The decline in CO₂ emissions between 1970 and 2000 was thus caused by a changed mix of energy carriers together with a concomitant stabilization of energy consumption.

The changed mix of energy carriers was mainly politically driven. Nuclear power and bio fuels would not have expanded in this period without a strong market intervention by the government. The government acted both as an entrepreneur, with large owner responsibility in the power industry, and as a political institution internalizing some of the external costs through energy and environmental taxes. The primary aim for the

government was to make the Swedish energy system less vulnerable to external shocks by expanding the domestic energy resource base and stimulating energy savings, through a more efficient energy use. This was the loadstar for the energy taxes from their introduction in the 1970s. Only from 1991 were environmental concerns important enough to manifest in SO₂ and CO₂ taxes. The internalization of social and environmental costs has not yet reached as far as to forcing the nuclear industry to pay for insurances to cover for all the costs that would hit society in the case of a severe accident; so nuclear electricity still holds a strong position in the Swedish energy market.

5. Discussion

This paper has argued that the shift to the service economy is largely an illusion when it comes to real production structure. Still, it seems counterintuitive that there would be no positive environmental impact from the structural change to the information society, based on microelectronics, where material intensity seems to decline at the same time as human capital becomes more important in production (Castells, 2000). In fact such an impact is present, but it does not show in growing shares of the service sector. Instead it affects energy intensity (energy equivalents/GDP) in at least three other ways.

The first impact is on the industrial structure, which has become permanently lighter. Schön (1990, 1998, 2000) has found a cyclical pattern in Swedish economic development, with periods of approximately 40 years, separated by structural crises, in the 1890s, 1930s and 1970s. Each crisis has meant problems for heavy industry. After the crises in 1890 and 1930 heavy industry recovered rather rapidly again. The

structural pattern after 1975 is different from the previous cycles, because light industry appears to have increased its share more permanently. The rising oil-prices in 1973, which were accompanied by a fiercer international competition, produced a deep crisis for heavy industry like iron and pulp. Swedish industry was hit severely by this crisis and there was a strong incentive to restructure and find new paths of development. The composition of Swedish industry changed during the 1970s when light industry expanded, while heavy industry shrank in absolute terms. During the 1980s heavy industry grew again, but at a slower pace than light industry. This resulted in an overall increase of light industry. Schön has estimated that this structural change led to a decrease in industrial fuel consumption by 20% and a corresponding decrease in electricity by 5% in the period 1970-1987 (Schön 1990). This more permanent change in industrial composition in the direction of light industry was of course not only due to the combined energy and structural crisis of the 1970s, but in addition due to the profoundly different character of the new growth engine of this industrial phase: the microelectronics.

A first impact from microelectronics is on the industrial branch structure. Microelectronics has formed the basis for several development blocs. Its application in PCs constitutes one obvious expansive bloc of development. In telecommunications it has enabled both a substantial growth in telephone contacts and in network communication between computers. Another progressive development bloc that relies on microelectronics is biotechnology. The relative expansion of these, knowledge intensive, energy light branches, based on microelectronics, has resulted in a decline in the overall energy intensity (energy/value added) of industry.

A second impact from microelectronics is that it enables a more efficient control of material and energy flows, with less waste. This impact is not restricted to the light industries, but plays a role for energy demands in heavy industrial branches as well. For instance electric-hydraulic drills substituted pneumatic drills in the mining industry during the 1970s, which stimulated a more extensive electrification of the mills, with electric transportation, which improved the working condition in mills and reduced the need for ventilation, thus reducing energy demands. In the metal industry electro-steel played an increasingly large role, constituting 50% of the Swedish steel in 1985. Improvements of this process meant that scrap-metal could be used, which saved material and energy. Another energy saving improvement in the metal industry was that the process became more automatic and integrated, using direct production lines from raw steel to refined steel, without the former cooling down and heating up the metal before the final treatment into steel products. Likewise the pulp & paper industry became more integrated and automatic with electronics. The process went direct from the pulp to the paper, which meant that there was no longer any need to dry the pulp, which saved energy.

A third impact from microelectronics is on household energy consumption. While the industrial products in the past, like the car, vacuum cleaner, refrigerator etc, demanded substantial energy when they were used, the IT-products (cell phones, digital cameras etc) can cope with little energy. This means that these products not only need less energy at production in relation to their economic value, but in addition do not tend to increase household energy consumption very much. On the other hand, these products have a short lifecycle, which may increase the material demands of the economy unless recycling of components and material is employed, and in addition

many countries experience growing concerns about harmful radiation from these products and their infrastructure. The total environmental impact may thus be less positive than solely energy figures indicate.

Besides these three effects from the information technology, one could argue that the fact that relative industrial expansion came to a halt around 1970 contributed to the stabilization of energy consumption. A decomposition analysis shows that structural changes before 1970 contributed to the increase in energy consumption, while technical change (or changes within the sectors) tended to decrease energy intensity. Table 1 shows the relative effects from structural changes, i. e. changes in sector shares, and changes within sectors for energy intensity during some sub periods.

The four main economic sectors differ with respect to energy use. Industry and transport & communications are heavy industries that consume relatively much energy, while services and agriculture demand relatively less. It is clear from table 1 that between 1870 and 1970, when the industrial and the transport & communication sectors expanded relatively to the other sectors, structural changes tended to increase energy intensity, but in the period 1913-1970 the changes within the sectors were large enough to outweigh this and the net effect was a decline in energy intensity of 0,74 % per annum. After 1970 the two heavy sectors as an aggregate stayed constant (even though transport & communication grew at expense of industry), and in the absence of structural changes working to increase energy intensity, there was an impressive decline of 1,6 % per annum. This rapid decline of energy intensity in conjunction with the relatively slow growth of the economy after 1970 resulted in the

stabilisation of energy use, which was important for the downward slope of the CO₂ emissions.

6. Conclusions

It is sometimes wrongly assumed that the transition to a service economy automatically will decrease environmental stress. This idea is based on a misconception of what such a transition really means. There is no theoretical reason to expect real service production to grow relative to industrial production, because relative prices of services rise, due to inferior productivity development. This relative price increase is the main explanation to the growth of the sector's share in current prices. The empirical results for Sweden shows that the real share of the service sector has stayed rather constant in the long run, and that it shows no increase after 1970.

Still, CO₂ emissions in Sweden show a clear decline after 1970, despite no relative growth of the service sector. This is mainly an effect from the changed mix of energy carriers caused by the politically stimulated expansion of nuclear power and biofuels. In addition, the switch from growing energy consumption to energy stabilization eased the decline.

The stabilization of energy consumption after 1970 is partly related to the transition to the information society, or the diffusion of microelectronics. This does not manifest in a growing service sector, but in three other important changes: 1) the industrial structure becomes lighter 2) the microprocessor enables fine tuning of material and energy flows, thus reducing waste 3) stabilization of household energy consumption because the usage of IT- industrial products do not demand much energy.

In addition the stabilization of energy consumption was affected by the structure of the economy in the sense that those structural changes that prior to 1970 had acted to increase energy intensity was no longer present. Changes within the sectors caused a strong decline in national energy intensity, which, together with a slow growing economy, resulted in a stabilization of energy consumption.

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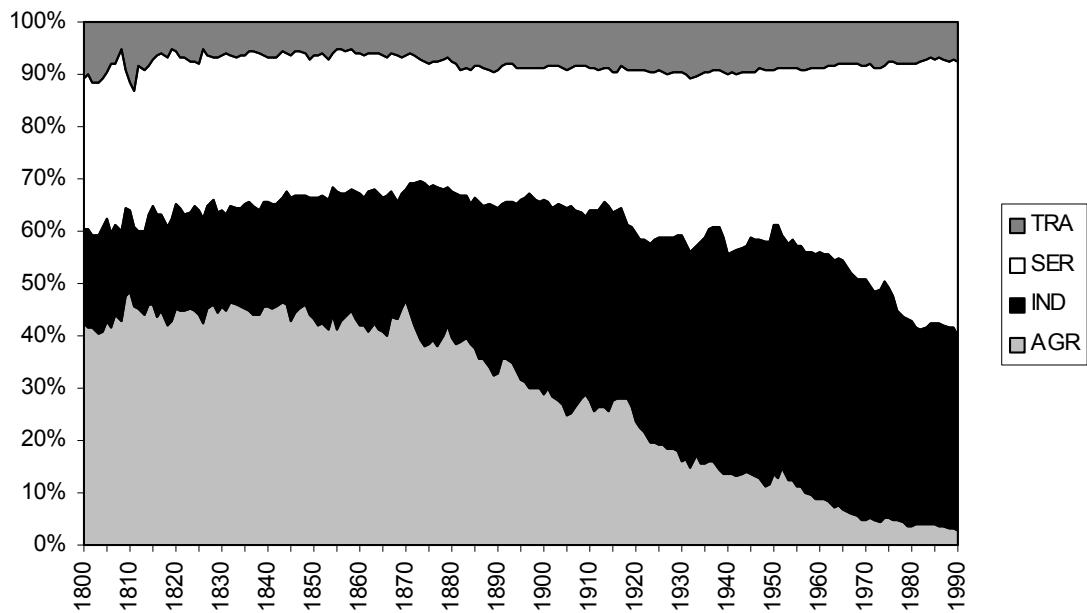
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Table 1. *Impacts of structural shifts and changes within sectors on the annual percentage change in energy intensity.*

	1800-1870	1870-1913	1913-1970	1970-1998
Annual change in energy intensity	-0.61	0.48	-0.74	-1.6
Of which:				
Agriculture	-0.28	-0.16	< 0.01	-0.02
Industry	-0.32	-0.41	-0.42	-1.1
Services	-0.02	-0.07	<0.01	-0.4
Transport & communication	0.01	0.67	-0.86	-0.07
Structural shifts	<0.01	0.45	0.54	-0.02

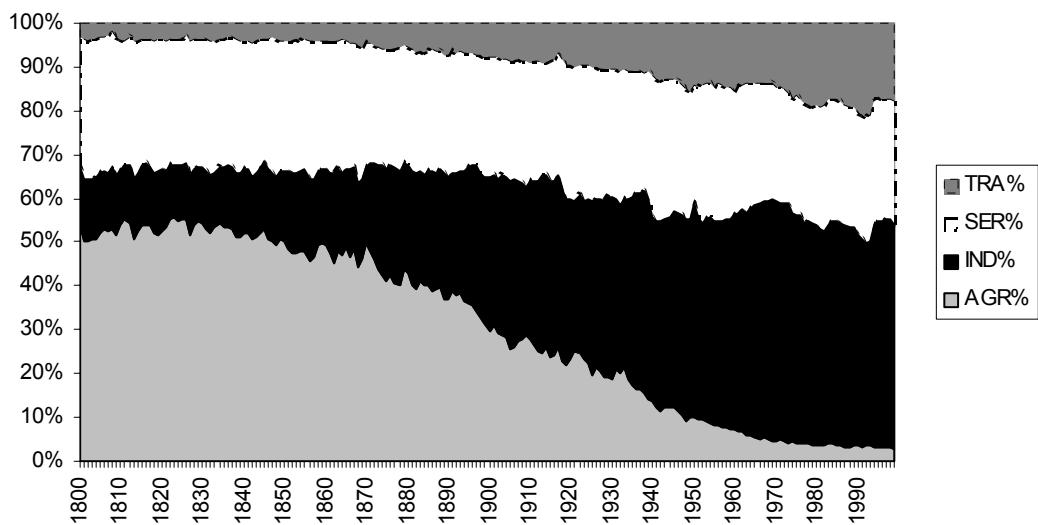
Source: Kander, 2002.

Figure 1: Sectors' shares in Sweden 1800-1990 in current prices



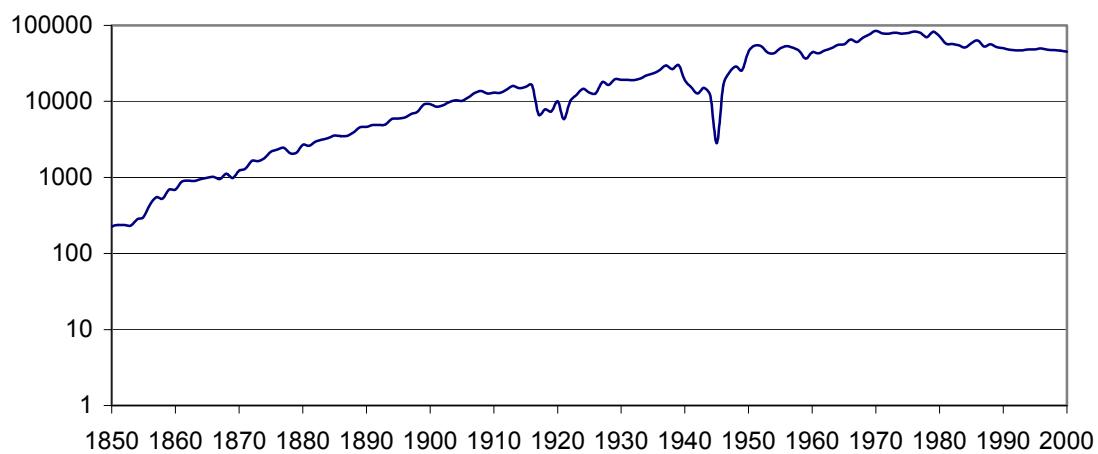
Source: Kander, 2002, based on series from SHNA, provided by Lennart Schön

Figure 2: Sectors' shares in Sweden 1800-1999 in constant prices, price level 1910-12.



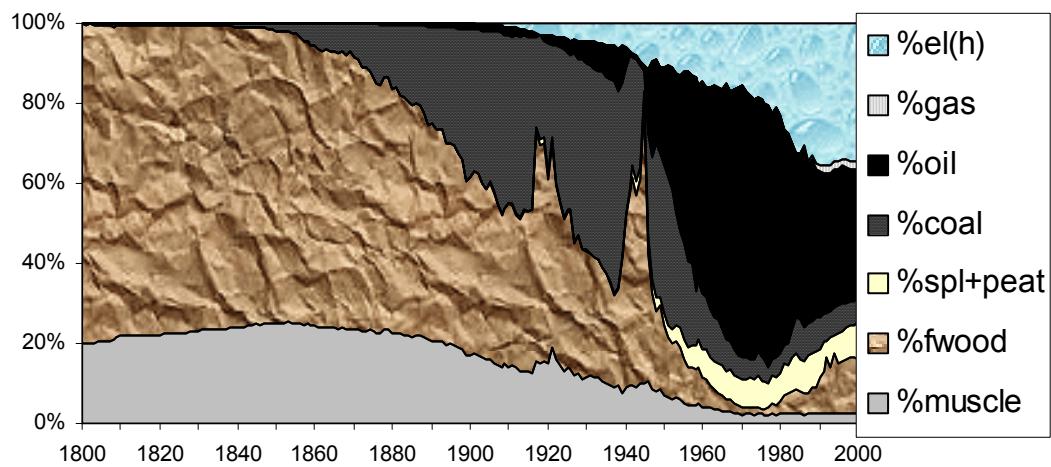
Source: Kander, 2002, based on series provided by Lennart Schön from the SHNA, with annual linked price deflators calculated by Kander & Schön.

Figure 3: Emissions of CO₂ from fossil fuels in Sweden 1800-2000, thousand tons



Source: Kander, 2002

Figure 4: Mix of energy carriers in Sweden 1800 - 2000.



Source: Kander 2002. Comments: el (h) means electricity counted by its heat content, spl means spent pulping liquor, muscle energy includes draught animals and human labour, calculated by energy of the fodder and food intake.

Figure 5: The average CO₂ emission factor in Sweden 1800-2000, g/MJ, lin-log scale.

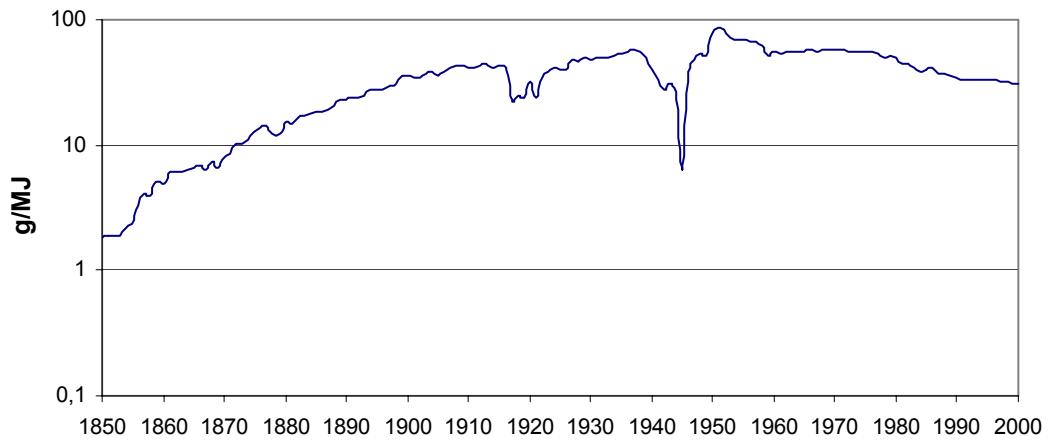
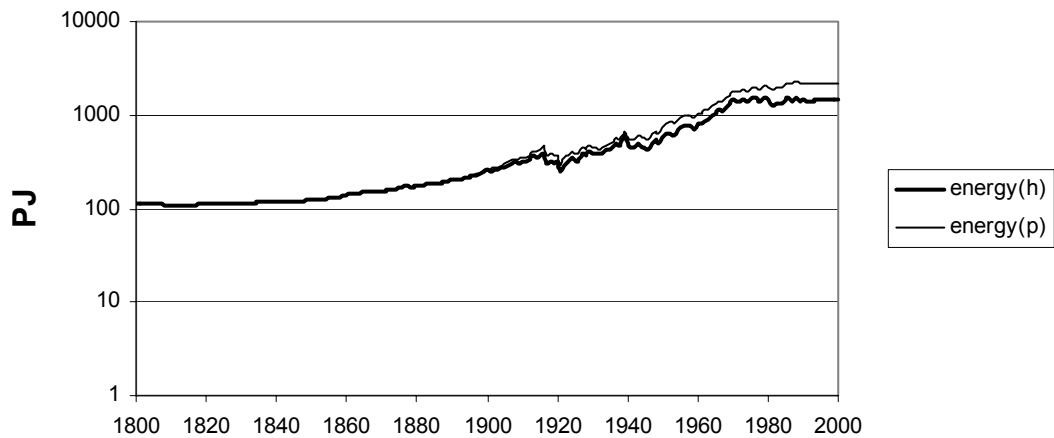


Figure 6: Aggregate energy consumption in Sweden 1800-2000, in PJ, lin-log scale.



Source: Kander 2002