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Klinge Jacobsen, Henrik

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TRADE PATTERNS AND THE INDUSTRIAL DEMAND FOR ENERGY: THE CASE OF DENMARK

Henrik Klinge Jacobsen
Risø National Laboratory, Systems Analysis Department

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Abstract

This paper examines the importance of changing structures of foreign trade for a small open economy with respect to industry energy demand. Two different aspects of changing trade patterns are analysed. First the impact of changes of domestic production structure related to changes in import shares for inputs in industry are analysed. Secondly the change in final demand import and export shares is considered. In both cases the effect on energy demand arises through a change in production. The effect of changes in the composition of final demand is not included in this analysis.

Calculations of the change in energy demand associated with the change in trade patterns are analysed using input-output techniques on detailed Danish national account and energy data. The direct Danish energy input in production is used as a measure of energy demand in industries. Present energy consumption is compared to the energy consumption, that is calculated with 1966 trade patterns kept unchanged. It is discussed which category of industries that have higher energy consumption and which industries that are unaffected by the change in trade patterns. The degree to which basic manufacturing industries and heavy industries have decreased their energy consumption by replacing elements of own production that might have high energy content with imports is also examined.

Energy demand changes that are related to change in trade patterns have implications for different issues as energy efficiency developments for industries, international comparisons of energy demand and the discussion of the relevance of different policies to reduce greenhouse gases.

Energy demand for production at the national level calculated from direct energy input might behave quite differently from a measure based on energy content in final domestic demand. As it is shown in this paper the effect of a structural change in foreign trade patterns can lead to an increase in energy demand. This is contrary to what could be expected for a country which is supposed to export increasingly processed products with an increasing share of inputs as skilled manpower, research and development and service. If this change in export products is combined with a supposed increase in the relative share of imports with heavy energy content the effect on direct energy content in Danish production should have been a decrease.

Changes in energy efficiency are also affected by change in trade patterns, but this effect is not considered in here. A national measure of energy efficiency should probably be evaluated as global energy content in final domestic demand rather than as energy intensity in production.

Change in energy input and intensity in industrial production

This study focuses on the development of industry energy input and the importance of changing trade patterns for Danish industrial energy demand.
It is important to distinguish between different measures of energy input and intensity both when examining cross section data and time series of energy intensity. For time series of energy consumption and energy intensity the change in production structure resulting from the change in patterns of foreign trade is important. Focus in here is on changing production caused by foreign trade developments and the effect on energy demand. The effect on energy intensity is only briefly discussed.

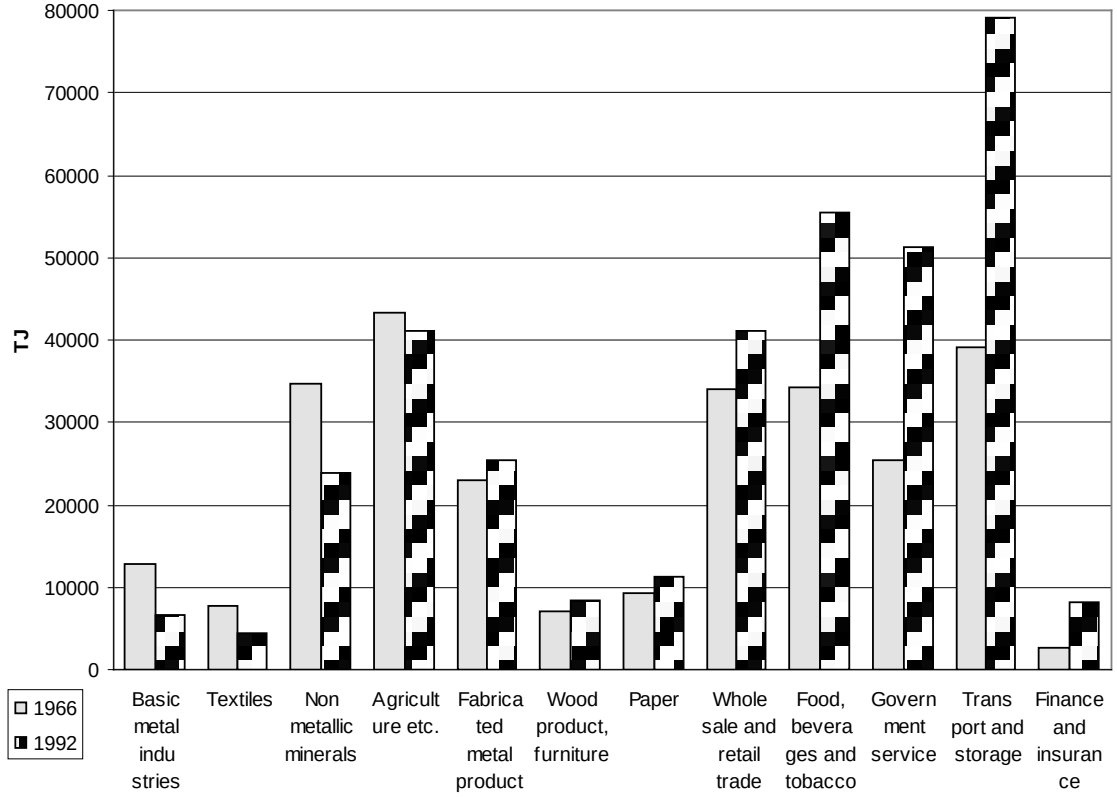

Figure 1 Energy input in Danish industries, 1966 and 1992

It is obvious from Figure 1 that industries have behaved very differently with respect to the change in energy consumption from 1966 to 1992. The reason for the difference is manifold, but important determinants are:

- Different production developments caused by a change in the composition of final demand both with respect to final demand categories and goods.
- Different development in the technology and especially the energy technology used in the sectors.
- A change in the structure of foreign trade.

This analysis focus on the third option, which in turn includes two different elements. Final demand may have shifted towards higher import shares for some goods, that can be either more or less energy intensive than the average good. In the same way the import share of each input in

Danish production may have shifted in a way that leads to either more or less domestic energy input in production. The effect on production and the energy demand of both these structural changes are examined in here.
The industries in Figure 1 are sorted by the relative change in energy demand from 1966 to 1992. In the service sector energy demand have increased quite substantially, while in some of the manufacturing industries and agriculture energy demand have fallen. Much of the explanation for this development must be that the service sectors share of total production have increased relative to the more primary industries, but there are at the same time changes in the energy intensity in the sectors where especially the manufacturing sectors have experienced a fall in energy intensity.
Structural change in foreign trade patterns and the increased participation in the international economy by Danish industries have influenced the production structure and hereby the demand for energy. The effect of the structural change in foreign trade will be examined by performing input-output calculations leaving the structural pattern of 1966 constant but using the total final demand and energy intensities of 1992.

Input-output calculations

Two different but to some extent overlapping experiments have been carried out. First the isolated effect on energy demand of the change in import shares for material input in industries have been examined. This is only one side of the increased participation in international trade. Increased import shares are probably matched by increasing export shares of production and this might have had an opposite impact on energy demand than the increase in import shares. The second experiment includes leaving both the export shares of Danish production and the import shares in final demand unchanged from 1966 to 1992.
Both experiments have been carried out based on Danish national accounts and energy balances. The available data have a time span of 27 years and this period includes both significant shifts in energy technology and energy intensity as well as foreign trade structure.

Changing import shares for industry inputs

The data used here covers 27 industries and the energy measure used is the net energy input in GJ. Calculations of the net energy input with 1966 import shares for each of the 27 inputs in the 27 industries are carried out according to (1).

$$e92x = \left(I - A^g x\right)^{-1} e^g \; e \; ;$$

$$agx_{i,j} = (ag_{i,j} + am_{i,j})\; amk^0_{i,j} \; ; \;\; amk^0_{i,j} = \frac{ag^0_{i,j}}{ag^0_{i,j} + am^0_{i,j}} \qquad (1)$$

The vector of net energy input in TJ for 1992 is ***e92x, A***^{g} is the coefficients of inputs of domestic origin and ***A***^{m} is the coefficients of imported inputs. ***e***^{g} is final demand for domestic goods and ***e*** is the energy coefficient (net energy in TJ per mill. DKK, 1980 prices) in each production sector. The coefficient $agx_{i,j}$ is the input of industry ***i*** production in industry ***j*** for 1992 with the import share of 1966 for each of the inputs in industry ***j***. The imports not referable to a specific good are not included in this analysis.

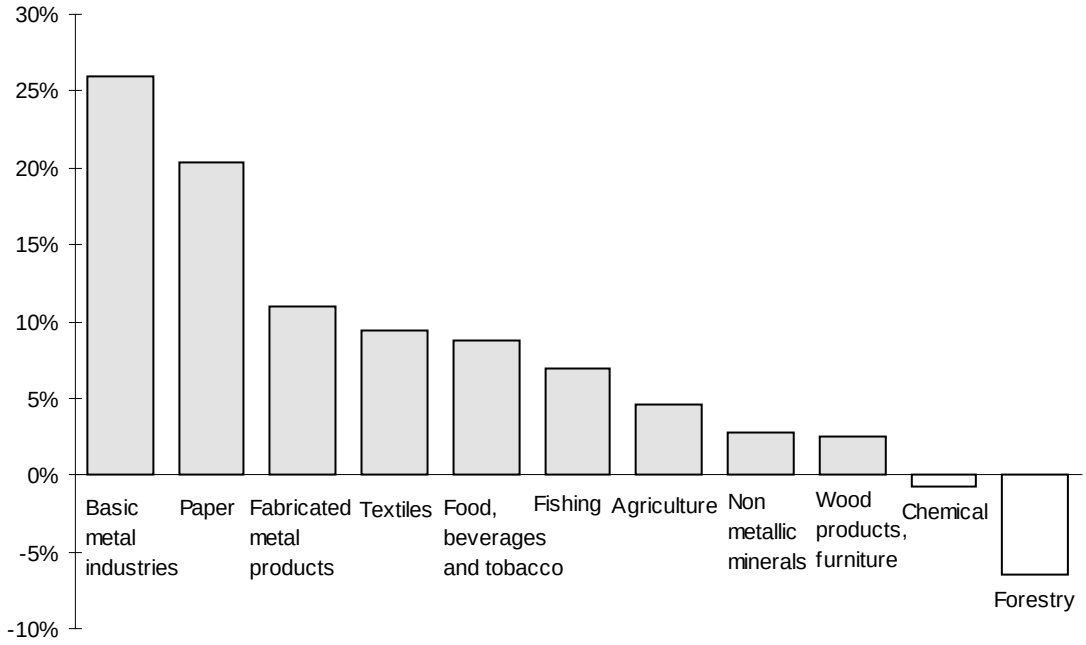

Figure 2 Energy demand in Danish industries in 1992 calculated with 1966 import shares relative to the actual energy demand in 1992

The industries included in Figure 2 are the industries to which the structural change in import coefficients has the highest impact on their energy demand. It is the manufacturing and primary industries that are represented in this group. The corresponding impacts on service sectors are close to zero. Iron and metal industries would have had 25% higher energy consumption if the import share of all inputs in Danish sectors had been like in 1966.

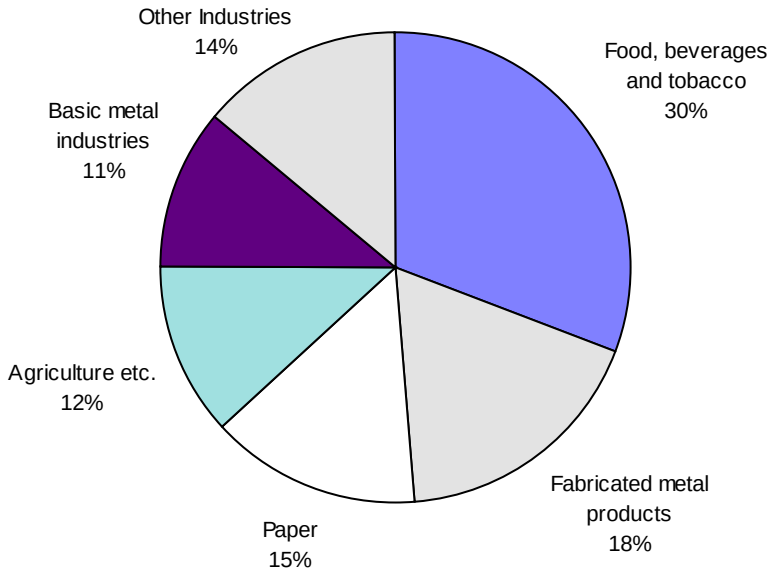

Figure 3 The relative importance of industries in the calculated increase in energy input

The manufacturing industries have experienced diminishing market shares on the domestic market for industry inputs. Without the drop in domestic industry demand manufacturing

production would have been higher in 1992 and thus the energy demand would have been higher.
From Figure 3 it is seen that the major contribution to the increase in total calculated amount of energy input of 15.737 TJ originates from a few of the manufacturing industries.

Industry	Increase in energy input when 1966 import shares are used	Energy consumption 1992 (TJ)	Energy coefficient 1966 (TJ)/mill. DKK	Energy coefficient 1992 (TJ)/mill. DKK
Agriculture etc.	1898	41030	1.41	0.95
Forestry	-10	151	0.10	0.20
Fishing	786	11438	3.01	4.53
Mining	-1700	4546	1.91	0.25
Food, beverages and tobacco	4838	55438	0.72	0.69
Textiles	420	4489	0.82	0.43
Wood products, furniture	211	8487	1.16	0.75
Paper	2293	11245	0.79	0.64
Chemical	-200	27759	1.01	0.71
Non metallic minerals	657	23767	5.79	3.63
Basic metal industries	1722	6640	4.95	2.34
Fabricated metal products	2791	25487	0.73	0.39
Other manufacturing industries	56	1104	0.45	0.31
Electricity, gas and water	202	3529	0.21	0.20
Construction	65	17139	0.26	0.35
Wholesale and retail trade	700	41089	0.80	0.55
Restaurants and hotels	39	8408	0.83	0.68
Transport and storage	593	79226	1.27	1.25
Communication	50	4303	0.83	0.38
Finance and insurance	36	8250	0.29	0.55
Dwellings	0	1924	0.04	0.04
Business services	248	12613	0.26	0.34
Private education and health	6	2907	0.52	0.46
Recreational and cultural service	-83	1963	0.62	0.32
Household services	82	8799	0.90	0.54
Other service	0	388	0.04	0.12
Government services	35	51275	0.48	0.41
All Industries	15737	463392	0.80	0.59
Manufacturing	12789	164416	1.10	0.70

Table 1 Net energy input and energy coefficients for 27 Danish industries

Change in import and export shares in final demand

The constant import shares from the experiment above are combined with constant import and export shares in total final demand. This experiment should bring some more balanced effects of the structural change in foreign trade. The vector of total final demand is recalculated using the share of final demand for domestic produced goods from the year 1966. Export share of total final demand is calculated in 1966 and used in the calculation of the final demand for domestic produced goods and services for 1992 ($e^{s}x$).

$$e92x \;=\; \left(I - A^{g}x\right)^{-1}\; e^{g}x \;\; e\;;$$

$$\left(e_t^g x + e_t^m x\right) = \frac{\left(e_t^g + e_t^m\right) - x_t}{\left[1 - x_0 \Big/ \left(e_0^g + e_0^m\right)\right]} \qquad \textbf{(2)}$$

$$e^g x = (e_t^g x + e_t^m x)\; ke_0^g \quad ; \quad ke_0^g = \frac{e_0^g}{e_0^g + e_0^m}$$

The inverted matrix from the first experiment is the same but the vector of final demand for Danish production ($es x$) is now calculated based on unchanged export share of total final demand ($es+em$) from the base year 1966. Export (x) includes re-exports. The adjusted total final demand ($esx+emx$) is then split by the 1966 domestic share (kes) into demand for Danish production and imports.

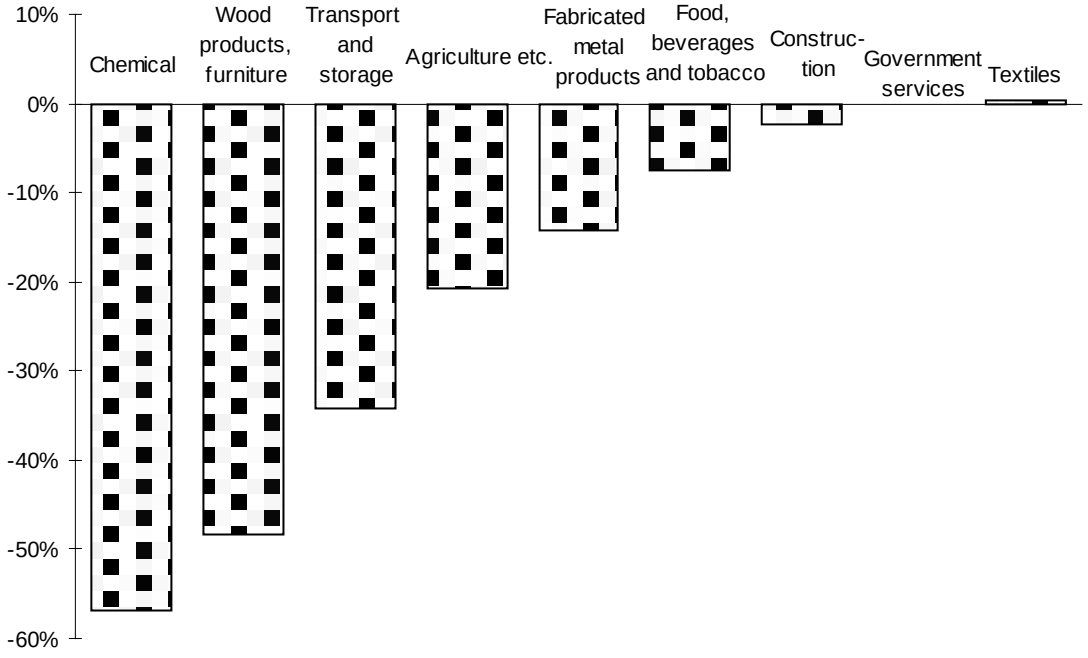

Figure 4 Energy demand in industry with constant export and import shares in final demand relative to actual energy demand in 1992

The procedures described above results in export increasing at the same rate as final domestic demand. Import increases at the same rate as total final demand, which is the same rate as for final domestic demand.

Denmark is often characterised as a country producing and exporting processed products with a high and increasing content of research and development, skilled manpower and design. The change is supposed to lead to less energy content in exports and more energy content in imports, that are supposed to be increasingly dominated by intermediate products for further processing and consumer goods with relatively high energy content as cars and other durable consumer goods. This way it could be supposed that the change in the structure of foreign trade leads to

less energy demand from industries in Denmark. This is not found in the material used here. To the contrary energy demand is much higher today than without the change in structure.
The industries that are included in Figure 4 have less energy input in the calculation than the actual figures for 1992. The industries with the highest negative figures in the graph above are those that have had the best relative export performance from 1966 to 1992. If those sectors had not been this successful in export markets their energy demand would have been up to 50% less. The best performers are the chemical industry, wood products and furniture, transport and agriculture. Chemical industry includes the successful medical industry, that is not energy intensive. Furniture has succeeded in export markets and the transport sector includes a large export component in the overseas fleet. The last industry with a good export performance is agriculture.
Government service has not been influenced by foreign trade changes as the import and export shares are still close to zero. For most of the other service industries that are not included in the graph the same applies, except for the transport industry which has a large and increasing share of international shipping. The only industry that would have had higher energy without the change is textiles. This manufacturing industry has undergone a radical change of composition, with more and more of the processing being located outside Denmark and the design, administration and sales activities undertaken from Denmark.

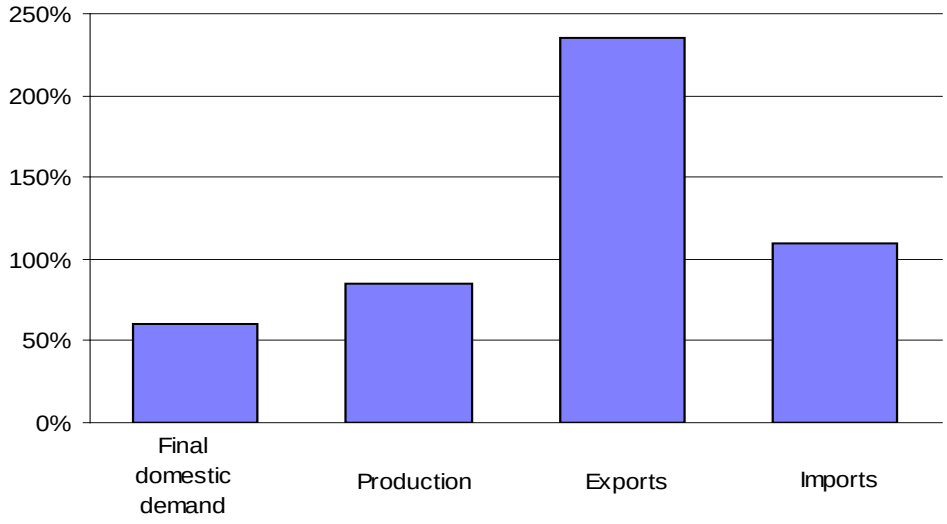

Figure 5 Change in major economic variables 1966-1992

The striking results of this experiment are caused partly by the development of real variables shown in Figure 5. Export performance has already shown its importance as an explanation of the different results between industries. At the aggregated level export is also a main explanation for the much lower energy demand in the calculated figures for 1992 relative to actual figures.
Exports have increased much more than imports and have increased about four times as fast as final domestic demand. The time period that is examined here includes a change from a substantial trade deficit to a substantial trade surplus. From a deficit of around 30% of exports in real terms for 1966 the trade balance has improved to a surplus of around 25% of exports for 1992.
The changing trade patterns have influenced energy demand in industries in 3 ways:

- Rising import shares for production inputs in industries have decreased the industry energy demand.
- Rising export shares relative to total final demand have resulted in an increase in energy demand.

- A rise in import shares relative to total final demand has resulted in less energy demand in Danish industries.

The net result is higher energy demand from industries today than would have been the case without the change in foreign trade structure. The effect of strongly increasing export relative to imports in the period studied has resulted in the dominance of the export effect and hereby an increase in energy demand.

Conclusion

In the analysis above it is shown that changes in the structure of foreign trade have an important influence on the direct energy consumption in production sectors of a small open economy as the Danish. Three different effects are identified and analysed by input-output calculations.
Increasing import shares for inputs in production has resulted in manufacturing industries experiencing a decline in market shares in the domestic market. This decline has resulted in a lower energy demand than otherwise. It is not obvious whether the decline is caused mainly by a change in the output mix within the industry (less demand from the industry itself) or it is caused by a decline in domestic market shares for the output products on average. It is the manufacturing industries and agriculture that have higher energy demand in this experiment, and especially food and beverages is important for the total calculated higher energy demand from industries.
The two different effects of increasing import and export shares in final demand have been analysed in combination with the first effect. Increasing import shares have resulted in less domestic production and less energy demand but increasing export share of final demand have resulted in higher production and higher energy demand than would have been the case without the change in foreign trade patterns. The net effect of this experiment is that energy demand from industries is about 20% higher today than with an unchanged trade pattern.
The explanation for this higher energy demand is reflected in the comparison between industries, which shows that industries with the highest relative increase in energy demand are those with the best export performance in the period from 1966 to 1992. Export has increased twice as much as import, which has resulted in production rising more than final domestic demand.
This shows that developments in energy consumption never should be judged alone based on the development of the direct or direct and indirect national energy content in inputs. A measure of global energy content in final domestic demand would be a much more meaningful indicator for national energy consumption even though the approximation that the energy coefficient in imported goods equals the coefficient for domestic produced goods is very rough.
This is only one aspect of the importance of structural changes in foreign trade. Another important aspect is the question of how much the structural change in trade patterns has influenced the energy intensity of production in different industries.

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