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Håkon With Andersen

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senter for teknologi og samfunn
universitetet i trondheim
7055 dragvoll

tlf: +47 73 59 17 88
fax: +47 73 59 13 27

university of trondheim
centre for technology and society
n-7055 dragvoll, norway

Håkon With Andersen:

SAIL STEAM AND MOTOR - SOME REFLECTIONS ON TECHNOLOGICAL DIFFUSION IN THE NORWEGIAN FLEET, 1870 -1940.

Between the 1880s and 1940 the Norwegian merchant marine underwent profound changes. With regard to technology two of these have traditionally been regarded as particularly important: the transition from sail to steam and the somewhat later change from steam to motor. Two major changes that transformed the fleet twice in a time-span of 60 years, making the former technology more or less obsolete. In addition came the loss of close to half the fleet (of the 1914-level) during the First World War. In other words this was a period of turmoil and deep structural changes. This was no small segment internal to the Norwegian economy, throughout the period the Norwegian fleet counted for somewhat between 4 and 7% of the total world fleet, making the Norwegian fleet one of the largest in the world.

The purpose of this article is to analyse these changes of the fleet as a process of technological diffusion. Neither the steam ship, nor the motor ship were invented in Norway, these technologies were imported. It looks from the outset as if we have a good example which bids itself to the use of conventional diffusion theories; how steam ship technology and later motor ship technology spread to the Norwegian fleet in this period.

The main purpose of this article is therefore to throw some light on a spesific diffusion process. The main point is, however, not so much to contribute to maritime history, as it is usually understood, as to discuss and evaluate the concepts and the analytical tradition of technological diffusion. This is of course, both due to the topic of this book and to the fact that these changes have been discussed and analysed in a broad range of text: from amateur writings to professional monographs. The splitting up into sub-disciplines has, however, not been particular fruitful to the subject in question.

This article deals with the diffusion process primarily on an aggregate level. The reason for this is not that this is of unrivalled usefulness, but it is on this level that different approaches can be compared, and theoretical problems usually can be discussed. It goes without saying that it is also on this level that the most far-reaching statements can be made. This is not to deny the importance of micro-studies, on the contrary, this article builds on several studies of maritime history, but as long as our aim is to deal with diffusion processes in general it is only natural to seek out the problems through an aggregate diffusion process approach.[1]

Who were the suppliers of technology, and were do we have to look to identify a diffusion process? First of all it is important to make two important distinctions. We are discussing the ship owning companies. It is their decisions that we are looking for; how did they decide which technology to choose? For the sake of simplicity we will consider only two kinds of supply. First, supply by contracting for new ships from shipyards, and secondly by purchasing secondhand ships from other ship owning companies. The buying and selling of ships can be made through different channels in our period, one channel in particular is of increasing importance, namely the system of ship brokerage. However, we assume that the technology comes from either the yards or other ship owners, perhaps mediated through a system of brokers, at least up until the end of the period. We want to stress the emphasis on shipping and the operation of a deep see fleet, not on the question of yard and shipbuilding technology. True enough, the question of how do the yards obtained their product technology is important, but we will put this question

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1 A basic source of information to Norwegian shipping history is still the monumental work edited by Jacob S. Worm-Müller, Den norske sjøfarts historie, vol. 1 - 3, Kristiania/Oslo, Steenske forl. 1923 - 1951. An overview in English is to be found in Andersen, H. W. and Collett, J.P., Anchor and Balance. Det norske Veritas 1864 - 1989, Oslo, Cappelen, 1989.

aside in this article.[2]

The structure of the following analysis is the following: We start with a short review and critic of two important transitions of the Norwegian fleet; from sail to steam and from steam to motor. We will then do an international comparison and introduce a seemingly meaningless contradiction: the shift from extreme backwardness to an avante guarde fleet in a time-span of 20 year. In the rest of the article we will discuss alternative perspectives which can explain the contradiction and overcome the shortcomings of traditional diffusion theory.

Technology as artifacts - an approach

Let us turn to a simple figure describing the process of change through the 60 years period, Figures 1 and 2. The relative shares of the different technologies are shown as shares of the total Norwegian fleet. As we would expect we find two nicely shaped S-curves, one for steam and one for motor, as well as falling S curves for the outdated technologies, sail and steam.[3]

This traditional picture from diffusion theory is usually interpreted in terms of individual behavior of the actors in question. Some early entrepreneurs starts the change, early adopters follow suit in an

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2 This problem relates to quite another set of litterateur. Good lists of references is to be found in Andersen, Håkon With, Fra det britiske til det amerikanske produksjonsideal, forandringer i teknologi og arbeid i norsk skipsbyggingsindustri. Trondheim, 1986 (new edition Trodheim, Tapir forlag, 1989, forthcoming). Kent Olsson, Från pansarbåtsvarv till tankfartygsvarv. De svenska storvarvens utveckling til exportindustri 1880-1936. Göteborg, Svenska varv, 1983. Pollard, S. and Robertson, P., The British Shipbuilding Industry 1870-1914. London, 1979.

3 The sources for the Norwegian fleet are derived from Det norske Veritas yarly statistics. Most easily accessible through Det norske Veritas 1864-1914, Kristiania, 1914. See also Andersen, H.W. and Collett, J.P., Anchor and Balance, p.480.

exponential way, making the breakthrough phase evident to everybody. Then follows the growth when the technology diffuses in the economy as the more or less 'conservative' actors take up the new system. At last comes the time of the laggards.[4]

Even if this approach does not say anything about the motivation and rationality of the individual actors it has a strong bias towards technological determinism. That is a genealogic view of technology: as something not in need for expanation, something devolped outside the society with a large inpact on the same society. Technology is regarded as an object moving through and spreading through out a system as if it were a virus or some pollutant. The direction of the process, the progress, is uni-directional, determined by the technological development. Hence this approach also embodies some kind of linear, progressive concept of time.[5]

We cannot here argue that this approach is wrong applied to these particular problems, we can, however, note some of the hidden assumptions behind this approach. It has, however, also a not expressed evaluation of the kind of processes involved. It is structural in the sense that it focuses strongly on the mental resistance of the population in question. In fact, it is this resistance that determines the shape of the S-curve,

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4 One standard reference in this field is E. M. Rogers, Diffusion of Innovations, Third edition, New York, The Free Press, 1983. N. Rosenberg is perhaps the best known opponent to this 'diffusion approach' followed by C. Freeman et al. See Rosenberg, N., Perspectives on Technology. Cambridge, Cambridge Univ. Press, 1976 and Inside the Black Box Cambr., Cambridge Univ. Press, 1982. Freeman C., The Economics of Industrial Innovation, 2.ed. Cambr. Mass., MIT-press, 1982. Dosi, G., Freeman, C., Nelson, R. Silverberg, G. and Soete, L., Technical Change and Economic Theory, London, Pinter Publ., 1988.

5 In history of technology this is discussed in J. M. Staudenmaier, Technology's Storytellers. Reweaving the Human Fabric, Cambr. Mass., MIT-press, 1985. See also Andersen, H. W., 'Manna fra himmelen. Om teknologihistorie og teknologideterministisk historie', Historisk Tidsskrift (norsk) no. 2. 1987. For a social science accont of technological determinism see MacKenzie, D. and Wajcman, J.,The Social Shaping of Technology, Milton Keynes, Open Univ. Press, 1985. See also Winner, L., Autonomous Technology, Cambr. Mass, MIT-press, 1977.

it is commonly argued. An alternative and equally legitimate approach would be to examine the rationallity behind the pattern - opening up for the possibility that not switching to the new technology is based on rational choise.

The perhaps most important objection to the approach is, however, the dichotomy involved and the implicit concept of the changing technology. The model embodies a concept of two very different technologies with very different characteristics. In the case of sail, steam and motor this is obvious relevant to some extent. It is difficult to see the small step process making a sail-ship gradually change to a steamship, and a steam engine growing to become an internal combustion engine. However, there are two problems connected with the dichotomy. One with regard to the actual technologies and one which relates to other changes surrounding the technologies.

The technology of steam propulsion was not one technology, but involved a whole array of improvements, changes and prerequisites. Changing boilers, development of more efficient and reliable machinery continued throughout the period. Even the fuel changed, from coal to oil at the end of the interval. The concept of one change is thus rivalled by a process of incremental improvements - within some kind of framework of steam technology. However, it is an unquestionable fact that a major change took place, but much developments and improvements occured along the path established by steam engines.

This is, however, not confined to steam, but is at least to the same degree also the case with the competing technologies, sail and motor. The sailing ships were improved and made more efficient from at least the start of the period up to the turn of the century, making the rig more economic in use (lower level of manpower needed) and the ship easier to maneuver. Much the same holds for motor, particularly when it comes to the reliability and economic efficiency of the different motor types.[6]

Hence we are left with a picture of three more or less paradigmatic shifts, opening large possibilities for competing developments inside the paradigms. The paradigm shifts were dramatic and it is possible to call them sail, steam and motor respectively, even if we have the under currents of the developing technologies inside the paradigms. The fact that outdated technologies 'mobilize' to defend their position by developing technological improvements is a well known phenomenon. Frequently the result was an extended life period for the technology in question.[7] The crucial question is wether it is possible to bring the technology into a new positions were the potential for improvements are considerable. The long time periods for the changes we are discussing seems to indicate that the competition between the technologies was fierce and that all of them developed under the pressure of becoming obsolete. The picture given above of early adapters and laggards thus shifts to one in which the different technologies compete and the adopters of the technologies are not laggards but competing in different arenas and with different aims.[8]

When we look at the fleet there were other changes as well, not necessarily connected with the shifts in propulsion. The most commonly recognized changes in the period is the new building materials, and hence new building techniques. Particularly the shift from wooden ships to composite ships (both wood and iron) to iron and finally steel hulls was a development that did occur both with regard to the steam and

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6 For motor technology see Andersen, Fra det britiske and Hetmar, J., 'The Role of the Diesel Engine in Shipbuilding', in Walker, F. M. and Slaven, A. (eds), European Shipbuilding. One Hundred Years of Change, London, MPI, 1983.

7 Later the 'fight' between diesel engine and steam turbine is a good example. See Andersen Fra det britiske, chp. 12.

8 A good example of an econometric approach to this is Harley, C.K., 'The shift from sailing ships to steamships, 1850-1890, a study in technological change and its diffusion.' in McCloskey, D.N. (ed), Essays on a Mature Economy, Britain after 1840. Princeton, N.J., Princeton Univ. Press, 1971.

sailing ships. However, this development was not without dramatic consequences for the steam-sail competition, but it was not regarded as a phenomenon inherent only to steam.

The results displayed in Figure 1 is an overview over a paradigmatic change with particular focus on technology and the paradigmatic shifts in technology. There were, however, also other important changes that was a part of this without being technical in their nature. One obvious variable is the type of trade and the socio-economic setting of the different shipowning companies. The Norwegian maritime tradition from the second half of the 19 century was based on small companies competing worldwide in the tramp markeds. It is significant that in Norway we usually talk about the 'ship owner', not the ship owning or shipping company. The Norwegian language also has a separate word for this: 'reder'. We will return to this later on in conjuncture with another model of diffusion.

Figure 1:

Relative shares of the Norwegian merchant fleet, separated by propulsion. Only ships larger than 100tons. Sailing ships in nrt, others in grt.

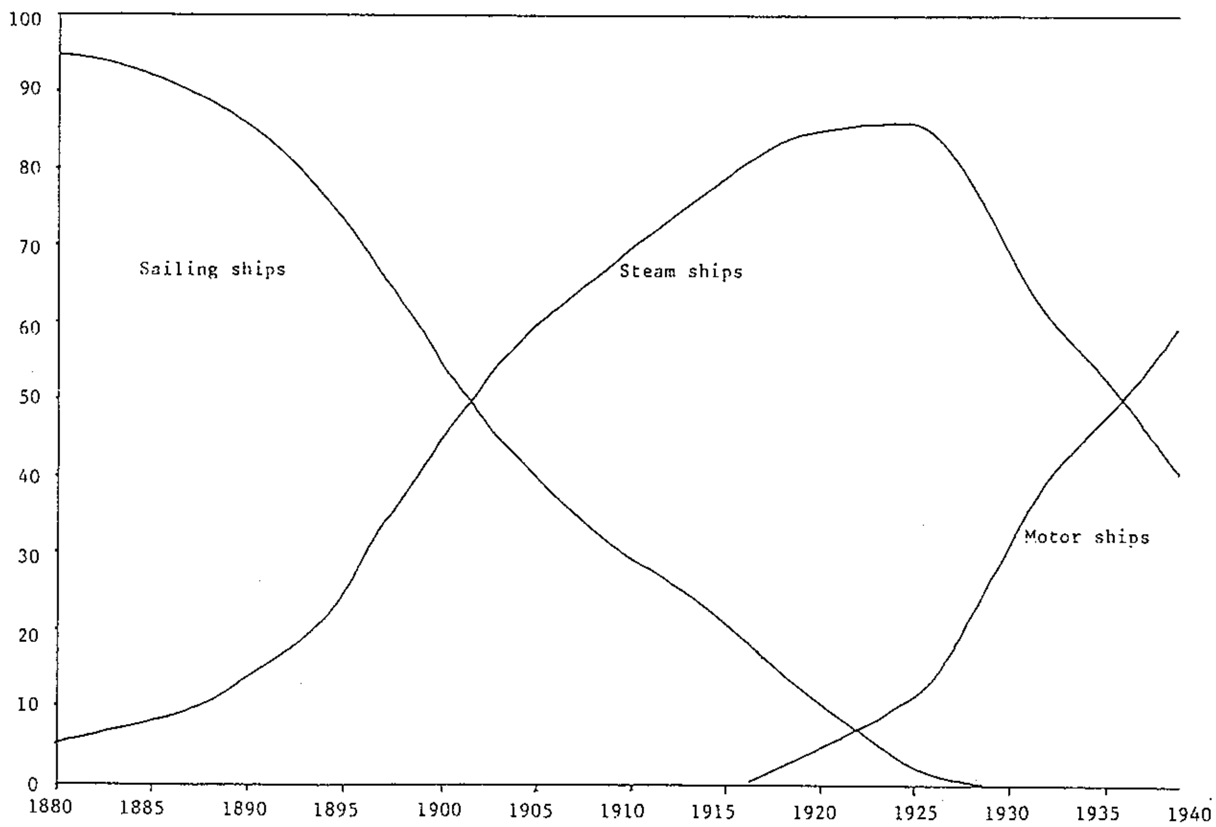
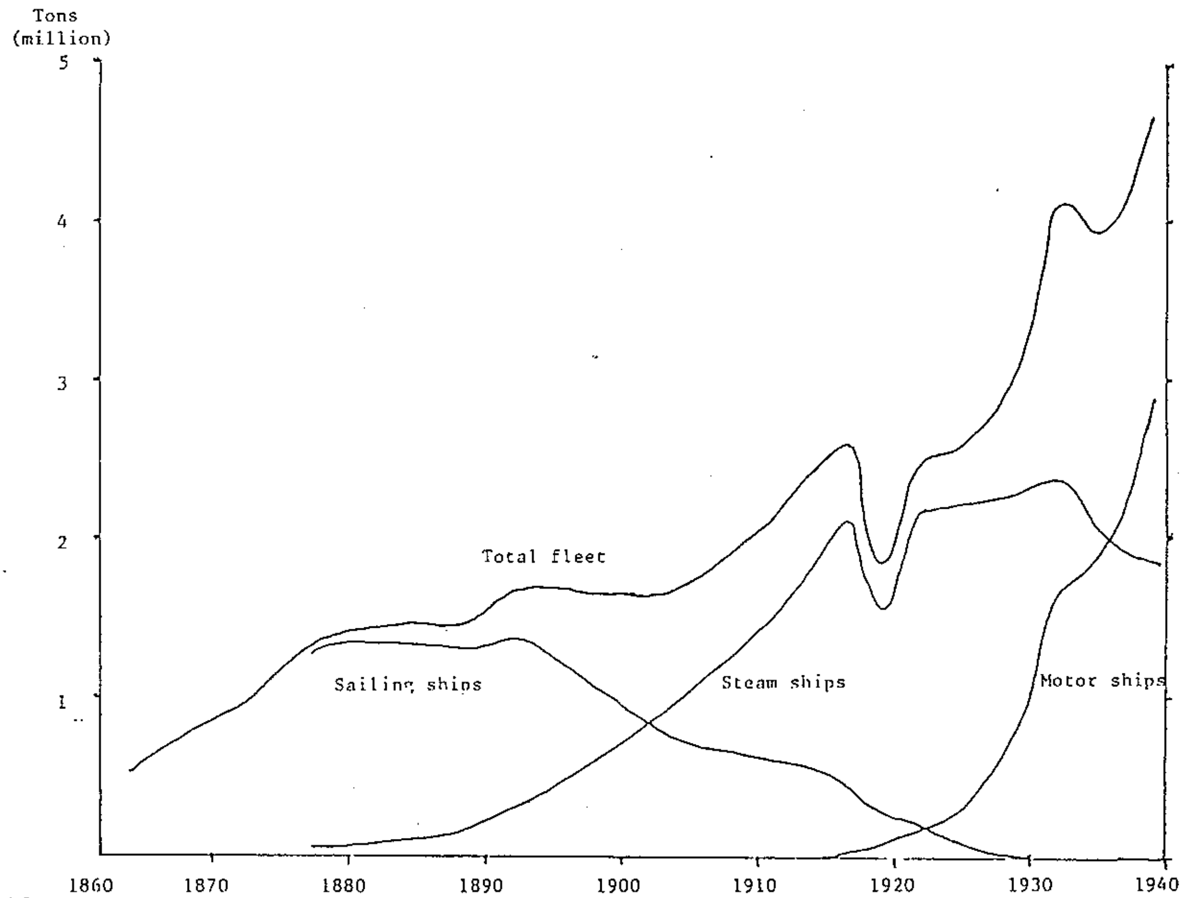


Figure 2:

Tonnage of the Norwegian merchant fleet, separated by propulsion. Only ships larger than 100tons. Sailing ships in nrt, others in grt.



A final word on the diffusion pattern displayed in Figure 1 is related to the way of measuring the change. Accepting the paradigms as real and useful concepts we still cannot say that we have found a good way of measuring the changes. In Figure 1 we have used the tonnage of the ship as criterion for calculating the relative shares. It is not evident that this is relevant to the change in propulsion. It is, however, the most simple way of calculating shares, it is also the most traditional way of doing this. The important argument for this way of calculating is that it is the best way of looking at the economic importance of the different changes. Which share of the capacity is propelled by what technology? In doing this we twist the problem to become one of economic importance, not of the technology per se. Hence we add a new premise for the diffusion process, which perhaps is useful, but nevertheless changes the concepts in question. Thus the argument of demonstrating technological change based on the artifacts is undermined even in the approach focusing particularly on the objects.

For the sake of perfection the figures are even more problematic when it comes to this tacit premise of the figure. The productivity of the technologies does not correspond with tonnage. Steam technology is often regarded as somewhat between twice and three times as efficient as sail even if the tonnage is the same. It depends, however, heavily on the trade and time. In the figure this has been corrected to some degree using net register tons for sailing ships and gross register tons for steam and motor. We have also excluded ships less than 100 tons grt or nrt to remove the typical local ships and fishing boats.

An approach based on the number of machinery installed would perhaps be more relevant if we wanted to measure the number of objects. Here, however, we meet the problem of economies of scale. In the 1870s Norwegian steamships were rather small compared to the deep sea part of the sailing ships. As steam technology was developed steamers came to be the largest. However, in the mobilizing of sail technology in the 1890s sailing ships also became large as steel replaced wood as building material for sailing ships. Much the same holds for motor ships. In the 1910s these ships were often small, but in the late 1920s and 1930s the average size of these ships grew much more rapidly than steamers and ended in 1940 as more than three times as big as the average steamers.[9]

A picture of this development based on objects, not a crude measure on economic importance would thus show a much quicker start for steamers and motor, but a slower diffusion rate, particularly for motor ships. However, measuring numbers is problematic because it depends very much on the composition of the fleet, particularly on the number of smaller vessels, above the lowest counting level (100 tons). One sailing ship og 101nrt would count the same as one large tanker on 9000grt. The idea of counting objects ('technologies') is problematic as long as the scale is so different. The problem is not only that the economic importance differ greatly, but also that it is fundamentally difficult to compare a large diesel engine and the modest rig of a small sailing ship. It is basically two different things.

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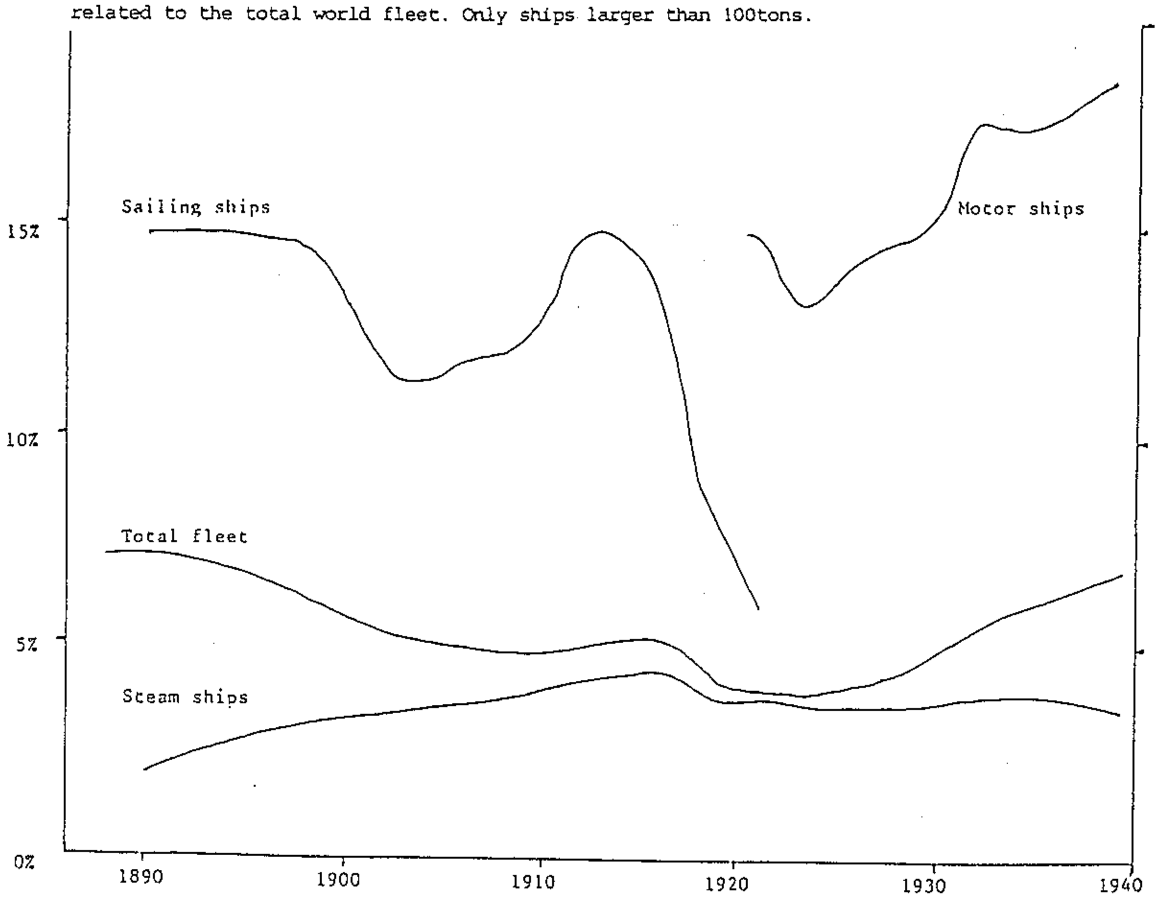
9 Statistics from Det norske Veritas.

The 'object' approach in international perspective.

Beside the description of the phenomenon it is impossible to say anything about the pace of the diffusion process without comparing it with other processes in other countries. It is commonly accepted that the Norwegian transition to steam was slow, and that the transition to motor was rather quick. We also know that the American and the Canadian fleets also were rather slow in the transition to steam, while U.K. and the main continental powers were quick.[10] Instead of comparing the Norwegian fleet with the different countries, we will take another view and shorten the discussion to a comparison of the world average. In Figure 3 we have drawn the Norwegian fleet's share of the world fleet, and those of the Norwegian sailing ship fleet, steamship fleet and motorship fleet as parts of the worlds sail, steam and motor fleets respectively.[11]

Figure 3:

Relative shares of the Norwegian merchant fleet, separated by propulsion, related to the total world fleet. Only ships larger than 100tons.



10 Statistics from Lloyds and Det norske Veritas.

11 Statistics from Lloyds and Det norske Veritas. I particular Veritas (1914) and Det norske Veritas. Beretning til 75 års-jubileet. Oslo, 1939.

This, of course, is based on an acceptance of the approach we have discussed above and the mixture of both an economic impact study and a technological object approach. We shall, however, use it to raise some new question about the concepts we already have introduced.

Figure 3 displays a peculiar phenomenon, at least if we stick to the traditional approach of quick adopters and laggards. From the 1890s up to the First World War the Norwegian share of the world's sailing fleet increased from the double to three times the share of the total Norwegian fleet. In other words a symbol of the more or less extreme laggards. After the war, however, the opposite is the case: Norway has approximately three times as much motorships compared to the world average. Indeed, a very early adopter! In general the steamships are under-proportionally represented in the Norwegian fleet all the time.

It is a bit problematic to use the figures around the First World War as long as the total tonnage of both sailing ships and motorships in the world fleet is rather low. But this aside, in the other periods when the figures are reliable we must conclude that an extreme backward fleet is transformed to an avant guard fleet in a time-span of rather few years. In the terms of technological determinism and a linear, progressive attitude to history this can be regarded as the triumph of reason and clever ship owners. However, this whiggish approach to history is not acceptable to the serious student of history of technology, and we want in what follows to look behind these figures.

It has often been argued that economic backwardness can be turned to an advantage later because one do not have to do all the wrong things that the forerunners have done.[12] In this case, we could argue that the reason to the swift transfer to motor technology has its roots in the weak steamship tradition, which again is explained by the strong sailing ship tradition. However, such an approach underestimates a traditional argument of technological change: the binding and stiffness of the

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12 The tradition of this view goes back to Gerschenkron, A, Economic Backwardness in Historical Perspective, Cambr. Mass, Harvard U. P., 1966.

capital already invested.[13] Investments done on shore are often an irreversible act in the sense that it is difficult to sell the capital goods and start once more with a new technology. At sea, however, the buying and selling of secondhand tonnage is quite common, and has always been. Hence the traditional argument for the advantage of being backwards is not linked to the investment in technologies, but more to other elements: new ways of organising the fleet, the possibilities for quickly entering new trades and so on. Thus, another tacitly accepted premise of the 'object' approach does not hold: the binding of earlier investments. In shipping the investment cycles are different because of the possibilities to sell real capital objects on the international marked. The putty-clay approach usually accepted turns into more of a putty-putty situation for the shipowners.[14]

Empirically there are very few signs on that the Norwegian owners should have been better organized, stronger financially or having built better and larger companies. To some extend the last was the case, but that was a development that strengthened the steam ship companies and not to the motor ship owners. We are still left with the problems of the 'laggards' that became the 'innovators'.

An economic approach.

The object approach and the language of technological determinism (laggards and early adopters) have their obvious limitations. As we have seen already when we start counting the technologies the economic impact creeps into the concepts. Why then not try to use a purely economic

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13 Typical in this tradition is a study by Salter, W. E. G., Productivity and Technical Change, Cambr. Mass., 1966 (2.ed.).

14 The concept of putty-putty models and putty-clay is taken from L. Johansen and E.S. Phelps. Johansen, L., 'Substitution vs. Fixed Production Coefficients in the Theory of Economic Growth, a Synthesis' Econometrica, vol. 27, 1959, pp 157-175. Phelps, E. S., 'Substitution, Fixed Productions, Growth and Distribution', American Economic Review, vol. 51, 1961, pp 638 - 643.

approach to the process of diffusion, translating anything of importance into economic concepts and values. Perhaps it is possible to compare steam-engines, rigs of sailing ships and motorships, and make up a common denominator - a measure of value?

At hand we find the neoclassical approach of product functions whose main objective is to compare different input-output functions on the basis of three different input concepts: labor, capital, and the rest: technology. The most important analysis done on the Norwegian fleet along these lines is a ph.d. theses by Ole Gjølberg.[15] His work is restricted to the first transformation, from sail to steam, so we limit ourselves to analyse this type of perspective only with the first change in mind.

Gjølberg's work is interesting, because he sets up two models of behavior to explain the diffusion of new technology: one based on what I have called early adopters and laggards; that is an approach according to Gjølberg built on the psychological behavior of the owners. The other is based on rational and maximising behavior of the firm. Gjølberg concludes that the shift was based on a continuous adoption process based on prices, costs and productivity of the different technologies in question. He arrives at this after having estimated production functions, including having made the traditional marginalist arguments. In his eyes steam was accepted from the start in the Norwegian fleet while the implementation rate was dependent on real economic considerations[16].

There can, of course be made arguments against Gjølbergs approach and his conclusions. One important critic has been raised on the estimate

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15 Gjølberg, Ole, <u>Økonomi, teknologi og historie. Analyse av skipsfart og økonomi 1866 - 1913.</u> Bergen, NHH, 1979, mimeo.

16 Ibid, p. 254.

on wages which has been criticised for being too low.[17] Another is of course the assumptions of the model, were the marginal substitution rate and the marginal economic approach in general is taken for granted and results in a conclusion that the owners behaved in a way that they were presupposed to act. Gjølberg is, of course, aware of this. Nevertheless the conclusion of rational behavior may be and probably are correct. There are, however, two important modifications. In history, that is in real life, we never find static equilibrium, and there is no reason to belive that the situation can be simulated with such an theoretical assumption. What Gjølberg misses and hence underestimates is also the different freight options open to the owners. These two factors: dynamic unstability and knowledge of marked alternatives focus the flexibility and puts serious constrains on what we will conceive as rational behavior.

The critique against this type of approach is not only the assumptions made on the behavior and the transformation of different technologies to a common value concept, it is also a question of the limits for the rationality. It is possible to argue that the owners were locally rational with regard to the tradition they were acting within, but not necessarily in a global meaning of the word rational. In other words it is possible to argue a type of bounded rationality were economic considerations are important within the boundaries, but not outside the limits[18].

This leads us to an important question: What were the boundaries

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17 Fisher, L. R. and Nordvik, H. W., "From Namsos to Halden: Myths and Realities in the History of Norwegian Seamen's Wages, 1850-1914", Scandinavian Economic History Review, 1986, p. 41-64. They criticise Gjølbergs for his estimates because he has based his analysis on wage levels in Norwegian ports, not in international ones. Besides the deflatation of the wages has been critical revised in Fisher and Nordvik.

18 See Simon, H. , Administrative Behavior, New York, 1976 (3rd ed.), Nelson R.R. and Winter, S.G., An Evolutionary Theory of Economic Change, Cambr. Mass, Belknap, 1982. Dosi, G. 'Technological paradigms and technological trajectories', Research Policy, vol 11, 1982, pp147-162.

and how were they conceived? May be Gjølberg is right at least half the way: technology was not the limit of this bounded rationality, at least not alone. The result of action taken, however, made it look like technology was the problem.

Gjølberg has an interesting observation in his material on this. If we accept his preconditions for the neoclassical model, and his empirical series, he shows a switch in the bias of technological change in the 1890s: Up to 1890 and after 1900 he finds a neutral technological change. However, in the 1890s he finds a labour saving change. This change has not necessarily anything to do with technological shifts, but is more an answer to increased competition and rationalization of both sailing ships and steamships. However, the 1890s was a time for increased size in the Norwegian steamship fleet, from 600 grt to close to 1000 grt (ship above 100grt). From 1900 to the First World War the steamers grew only very slowly in size. The sailing ships, however, had a fairly stable average size of around 500nrt.[19] Hence Gjølberg may have made an account of two different phenomena: increased investment in larger steamships, including labour saving effects due to economies of scale, and rationalisation on board sailing ships - making it possible to sail the same ships with a smaller crew. In addition Gjølberg has also calculated a stagnating real wage. However, it is not crucial to the theoretical argument that the real wage was stable or falling - the point in question was the tendency to cut costs, may it be of whatever kind possible.[20]

This leads us back to the question of bounded rationality and the traditions the shipowners worked within. Accepting Gjølberg, this tradition was not marked with different technological trajectories.[21] On

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19 Det norske Veritas, 1864-1914, pl. 7 and 8.

20 This may be somewhat underestimated by Gjølbergs opponents L. Fisher and H. Nordvik: From Namsos to Halden.

21 The concepts of technological trajectories have been stressed by economists criticising the marginalist argument as for instance Nelson and Winter, An Evolutionary Theory and Dosi, "Technological Paradigms".

the contrary the limitations must have been of other kinds. If this is correct we can go a step further to look at the introduction of the motor ship. If the constrains were not technical in nature then the paradox of figure 3 is no longer a paradox, but simply a measure of something that had other reasons than a shift from technological conservatism to technological radicalism.

The sources of ship technology.

One way of studying the hypothesis of technological conservatism is to take a look at the flow of technology in shipping. As we have argued above, the shipowners themselves usually had rather small companies with little technical expertise in house. In fact the companies often were rather loose organisations as the part ownership companies and the single ship companies. Typical is our earlier remark of the language used, the shipowner as 'reder' in Norwegian. Hence it was tacitly understood that the shipowner (reder) was the same as the company and that his obligation was to run a ship and not have a staff of experts in-house.

The technology had then to be transferred to the owner from outside experts. This was done in several ways. Other owners, shipyards and brokers were the most important ways of acquiring ships, new or old. Here it is again very important to make the distinction between shipowners and shipyards. The Norwegian shipyards had to accept and transfer new technologies in quite other ways than the shipowners. The active building process presupposed quite other learning processes than the use of their different products.

Looking at Norwegian yards we can virtually see the problems of switching from sail to steam. The sail ship yards were situated along the south coast of Norway, integrated into the local communities in numerous ways. Included in this was of course also the owners, which in the days of sail also was situated at the south coast, so was also the sailors. However these yards had severe problems shifting to iron and steel steam ships. In fact very few of them managed to do so. Instead another tradition took over, that of the old mechanic companies in the larger cities. However only one of these yards managed to or intended to produce motor ships before World War Two (Aker mek. Verksted in Oslo).[22]

If the yards had problems with the changing technologies, it was a lot easier for the owners. A ship may be regarded as a package of technology, bought ready for operation. Thus the learning process of operations is much more easy to overcome than the production of the same package. Besides, operations in international waters also made possible the use of the international labour marked for skilled seamen. Ship had also the particular feature of being an investment it was easy to trade after the investment first was made. Thus the concept of a putty-putty model instead of a factory on shore which often was very difficult to sell once the investment was made.

In fact, Norwegian owners had a very long tradition of buying and selling ships internationally. From the 1860s up to around 1880 most of the new Norwegian sailing ships were built at the south coast yards. From then on, however, a steady and large influx of second hand sail-ships took over. They were bought from all over the world where ever ships were sold. The transition to steam rendered old sailing ships obsolete to foreign and better off owners. These ships found their way to the Norwegian fleet. They were cheap, but not always in a good condition. The Norwegian fleet changed slowly to a fleet with one of the worst wrecking statistics in the world around the turn of the century. The statistic was on average two or three times as high as the world average in the ten years following 1900. It is from this period also the fleet got the name for being backward and the owners for being technological laggards.

New steamship technology entered the fleet from two main sources: national yards and British yards. Up to World War One about half from each country.[23] In this the Norwegian owners followed suit with the rest of the international fleet. The important point was, however, that this

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22 Andersen, Håkon W., Norsk skipsbygging gjennom hundre år, in Lange, E. (ed), Teknologi i virksomhet. Verkstedindustrien i Norge etter 1840. Oslo, Ad Notam forl., 1989.

23 Statistics from Central Bureau of Statistics in Norway-Shipping statistics, several years.

development was rather slow, compared with other nations fleet. British shipbuilder became, however, the major suppliers not only to the Norwegian fleet, but to most other countries as well.[24] In addition came after a time also the second hand steamer fleet bought from all over the world.[25]

The source of motor ship technology was, however, other countries. Of crucial importance here were the Swedish yards, in addition to Danish and German. In the early phase, in the inter-war period, the second hand marked for this technology was not much developed, hence the technology was mainly acquired from newbuildings at yards in these countries. As mentioned, only one Norwegian yards did build large diesel motors in the period, as a licensee of the yard Burmeister and Wain in Copenhagen.

This picture the typical Norwegian shipowner as a man who could choose between technologies without too severe constraints on the choice of technology seen from the supply side . The international marked for ships was well known to him as we might have suspected as long as his trades to a large extend was based on international shipping. Only a small fraction of his trades concerned Norway and Norwegian goods. Most of it was cross trade between foreign countries.

From this short overview of the availability of new technologies we must conclude that the typical Norwegian owner did have a real choice of alternative technologies and that the different options were open to him most of the time. In shipping the diffusion process or better, the potential diffusion process was only to a very small extend hindered by lacking technology. For shipyards, however, the problems were quite different and much worse. This important distinction, between owners and yards, is crucial to the understanding of the diffusion process as the two activities; shipping and shipbuilding feature quite different

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24 See Pollard and Robertson, The British Shipbuilding Industry, and Lloyds statistics, several years.

25 This became a major problem for the classification company in Norway. See Andersen, H.W. and Collett, J. P., Anchor and Balance. Det norske Veritas 125 years. Oslo, Cappelen, 1989.

characteristics both as social and economic activities.

Traditions and constraints in shipping.

Even if the owners were free to choose technology, their choices were not without constraints. Technology was only a part of their business strategy or business tradition. The third way into the problem of technology transfer is as typical as it is traditional: is the problem of diffusion put in a fruitful way? In fact this is a question often raised regarding technological innovation and diffusion. Is it possible to take out some part of the human experience and study it in its own context? Obvious the answer is yes (history would have been impossible without it), but with important modification. What we actually do when we study transfer of ship technology is to isolate one part of an experience that to the shipowner present itself as a whole. Traditional methodology in history makes this problematic. In fact we devaluate what is the strong side of historical studies: to understand particular phenomenon as a whole, regardless of what type of variables or field of human experience that can contribute to the understanding.

To the owner technology is only one part of his activity, may be not even the most important one. Economy, technology, cultural tradition, financial strength, social facts and phenomenon, relationship, information of trades and so on adds up the system in which the owner is engaged and on which background he makes his decisions. Technology is integrated into this web of knowledge, phenomenons and facts in a very integrated way, not as some external force with an even more external impression of progress.

This approach, it can be argued, is typical for historians.[26] Thomas Hughes, for instance uses the metaphor of technological systems

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26 See Noble, D, Forces of Production, New York, Alfred A. Knopf, 1984. Most systematic perhaps in T. Hughes, "The Evolution of Large Technological Systems" in Bijker, W., Hughes, T. and Pinch, T., The Social Construction of Technological Systems, Cambr. Mass., MIT-press, 1987, p. 51-82.

where technology, economy, culture and politics is woven in a seamless web.[27] However social scientists alike have taken up the idea and tried to develop new concepts and theories around it. It is not so difficult to argue a kind of convergence between historical an sociological studies of technology. However, the concepts may vary considerably even the ideas in this new sociology of technology is not as diverse as the concepts may indicate. Concepts like actor-network building of heterogeneous associations, stabilisation and closure of technological solution, socially shaped technology and heterogeneous engineering are only some examples of this very interesting development which probably also will influence the historical studies of technological diffusion.[28] Another slogan in science and technology studies is set by B. Latour: 'follow the scientists'.[29] In our context it should be rephrased: study the owner, regardless of what field the society's web he is currently working within: technology, financing, culture, politics and so on.

Let us try to follow this path of inquiry to see if it can offer a more satisfying explanation on the seemingly contradictory pattern: the owners as laggards in the transition from sail to steam and after a short time, the avant guard of the new motor ship technology.

To follow the owners is not an easy task, particularly not on an aggregated level. Such a study can only be based on micro studies of the owners and their business strategies, their traditions and their hopes. This alone is, however, not enough. We also have to compare their attitudes and strategies with those of shipping companies in other seafaring nations. That is, we must study Norwegian owners as members not of the Norwegian society, but as members of the international

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27 Hughes, T., 'The seamless web: Technology, Science, Etcetera, Etcetera' in Social Studies of Science, vol. 16, no. 2, 1986.

28 An introduction is to be found in Bijker, Hughes and Pinch, Technological Systems. See also Callon, M., Law, J. and Rip, A., Mapping the Dynamics of Science and Technology, London, Macmillan, 1986.

29 Latour, B., Science in Action, Milton Keynes, Open Univ. Press, 1987.

shipping community. Then at last it may be possible to draw some more stable conclusions of the particularities of Norwegian shipping.

Much has been done i studying Norwegian owners behavior. However, the literature has two main drawbacks. Firstly, it has been occupied with the large and usually successful companies. That is companies who have succeeded in the different technological transitions. For our purpose the selection of histories of shipping companies should be in a way an average, but what has been studied is the group of large and successful ones. Secondly, shipping history in Norway has always been a part of Norwegian history, not as part of the worlds shipping community's history. This can only be understood on the background of the particularities in Norwegian history. As a small country in the periphery of Europe with one of the worlds largest fleets shipping was a way to success in Norway. Nobody bothered how the fortunes were established in a large and unfriendly world, as long as the status and recognition inside Norway was obtained.

The first decades of the century put some owners at the top of the society's ranking list. Owners became prime ministers, other ministries. Hence the story of shipping in a way became partly mythology inside Norway, stressing the pioneering efforts on new trades and the heroic efforts of owners, captains and seamen as well. This legacy also put its mark on many of those who wrote the history of Norwegian shipping.

Even though the situation is cumbersome and our knowledge about the owners behavior and strategies is far from satisfying we may at least make some tentative conclusions, or perhaps even better, hypotesis about their behavior as members of the international shipping community.

Follow the owners!

The structure of the sailing ship industry in Norway inhibited some crucial limitations opposed to the transition to steam. Let us start with the structure of ownership. Even though different arrangement were made it would be fair to say that the typical form (in the sense of an ideal type) of ownership in sail was the part-owning arrangement. That is participants bought one or more parts in the ship, they were responsible for this part, but not for anything more. This system worked very well at the south coast of Norway, because it mad it possible to concentrate capital to ships. In a district with scarce access to liquid capital a system of part-ownership made it possible to concentrate the capital accessible, may it be in the form of money, raw material, labour or other services. The system of shipping and shipbuilding established at the south coast became a cultural form, involving the small communities in a number of ways: as shipbuilders, as sailors, as owners and as part time farmers and fishermen. But this served the purpose only up to a certain point. The capital was concentrated in one ship, but the command over larger capital was problematic.

When a part-ownership was dissolved the capital was spread among the part owners. It made it difficult to build up larger capital under one control. In the early period this was not much of a problem. Shipping were a growing industry and the particularly type of trade chosen made the system able of reproducing itself. Tramp became the typical kind of trade for the Norwegian owners.

As the price on transportation based on steamship fell and competition hardened during the last decades of the 19th century two solutions were open for the south coast owners: one was to enter the more capital intensive steam freight service, the other to continue to reduce costs and stay in the business of sailing ships. The first option was hindered by the problems of concentrating capital, changing trades and price competition; the other was more compatible with the social end economic setting of the south coast owners.

To continue to compete with help of the old technology was not easy. However, as long as tramp-freight involved cargoes with a rather low price per ton, as timber, coal and other goods, the time spend in transportation was not very important. The capital requirement was reduced by buying second hand tonnage abroad, or continue to sail the old sailing ships. The logic of competition became to cut whatever cost possible. Ships were rigged down in order to be sailed with a less crew, salaries were cut as much as possible and insurance, maintenance and classification expenses also cut back. At the same time the slow down of world trade reinforced the cost-cutting line and made the competition even more fierce.

Of course this was a strategy that could earn the owners income only in a limited number of years. There were of course owners who tried to change to steam, and managed. But over all, the days of the south coast owners were numbered for the time being.

Instead the merchants in Bergen became the dominant owners of the early steamship fleet. Bergen gave a much more easy access to a limited capital, and the organisation form of companies with limited responsebilities opened for better control and command over the accumulated capital. In the first decade of the 20th century, however, the crucial point of the steamship technology was linked to a new arrangement of the trades, that of the liner companies. Contemporary observers argued that the future of Norwegian shipping was dependent upon a change away from the small tramp-based companies towards larger multi-ship liner companies. This was the more so as long as internationally the more advanced western societies for a long time had developed this kind of trade. The important fact was that the quasi-monopoly established by the liner conferences expelled the small Norwegian owners from trades and made it difficult for them to enter trades were they dominated.

Some owners mainly in Bergen and Oslo succeeded in building large companies, but their part of the fleet remained rather modest. In 1911 9.2% of the fleet consisted of liners, however, only a small 0.2 % was working exclusively abroad.[30] Steam technology remained problematic for the bulk of Norwegian owners as the old system of capital accumulation and concentration was not sufficient for the new technology, at the same time their tradition of tramp trade was threatened.

What then about the new technology, the motor ship? How is this to be explained on the background of the typical tradition of Norwegian shipping: tramp shipping on rather marginal fields with a rather weak company structure? To understand the development of the motor fleet is to

30 Worm-Müller: Den norske sjøfarts historie, vol. 2.3, p. 408.

understand the particularities of the international oil trade and the new shipbuilding nation: Sweden.

Traditionally, oil transportation had been in the hands of the larger oil companies. In the second part of the 1920s, however, as the demand for oil rose steadily, the companies changed their policy. From then on the marginal transportation capacity was hired from independent owners. The break through for the Norwegian owners came with the selling of the old Anglo-Saxon fleet of steam tankers from 1926 onwards.[31] With the sale came also contracts for carrying oil for the oil company for several years. The strategy of the oil transportation company was thus to hire marginal capacity and let independent owners bear the risk for reductions in the oil trade.

This set up was not particular appealing to the larger shipping companies. But for the smaller ones it posed a possibility. Even for the former south coast owners it became a possibility to be back in trade. Being rather marginal in international shipping over all, taking large risks was not new to the smaller Norwegian owners. Buying the old and outdated Anglo-Saxon fleet, with a very close connection to the mother company the owners took a risk, however, not a too big risk for individuals with very little to loose.

It was typical of the trade that at the same time as the new and small owners entered the oil trade at a larger scale, some of the larger shipping companies in Norway withdraw from the same trade, probably evaluating the conditions to be too unsecure.[32]

The oil trade was in a way a continuation of the old tramp tradition at least if we compare it with the liner tradition. In a way at

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31 Nørgård, L.: Tankfartens etablerings- og introduksjonsperiode i norsk skipsfart 1912 - 1913 og 1927 - 1930, Bergen, NHH, 1961. See also Andersen and Collett: Anchor and Balance, chp. 3.

32 The Wilhelmsens company was one that withdraw. See Nørgaard, Tankfartens and Olsen, Kr. A., Wilh. Wilhelmsen i 100 år, Oslo, 1962.

least part of the transportation contracts involved several years of work for the oil company. In this respect the contract terms differed from the traditional tramp contract. In oil the ship was not only chartered for one or a shorter series of trips but for several years. I have chosen to consider this as a prolongation of the tramp tradition as long as it not involved a large professional organisation at the ship company's head office. The oil trade invited instead to a decrease in this organisation. Subcontracting for the larger oil companies removed even the work with different tramp contracts from the owners organisation. The residual was linked to personnel administration, supplies etc, a lot of it taken care of on board the ship itself. The tradition from the days of the sailing ship with strong captains and weak organisational structures on shore prevailed due to the oil companies. But in the modern days of the 1930s the captain's work was confined to operating and maintaining the ship, and not to negotiate shipment contracts any more.

This could all have been a sad and tragic story of the fall of Norwegian shipping if not two important feature had occurred: one independent of the owners and the second in symbiosis with them. The first was the fact that oil demand increased in the world during the whole inter-war period. This was partly due to an increase in energy consumption, partly to the substitution of coal with oil. This stable increase in demand combined with an increasing distance of transportation made the marginal fleet become very essential to the oil companies, trying to require a satisfying transportation capacity. Hence, what could have been a traditional and very dangerous situation turned to a very favorable one. The tragedy remained to be seen until the collapse of the oil marked in the middle of the 1970s when the Norwegian tanker fleet were hit perhaps more serious than any other nation's fleet.

The oil trade became a flourishing trade for the Norwegian owners. It was a trade that made it possible to pursue economics of scale in an hitherto unknown scale. A more or less fluid cargo, carried over very long distances, between a few specialised ports over several years opened for a specialisation of ships in just this trade. Motorships became early the most economic alternative for this type of trade (large ships, long distances), while steam still was dominant among the more flexible tramp carriers and liner ships.

Just as the Norwegian entered the oil trade as subcontractors for the large oil companies and thus as outsiders, the Swedes entered modern shipbuilding of this type of tankers. The link between Norwegian owners and Swedish yards grew strong, both had in a way hit 'black gold' as outsiders. One reason for the fruitful symbiosis was that the Swedes spesialised on welded motor tankers built particularly for the growing number of Norwegian owners.

There were, however one more link in this system, relating to the capital question. With freight contracts with large multinationals up to eight years it was possible for the Swedish banks in collaboration with Swedish yards to offer large credits and loans to the always capital hungry Norwegian owners. This system worked through bills of exchange. At what future date these bills were to be redeemed and at what rate of interest, were regulated by the shipbuilding contract. The yard could then cash the bills at an earlier date and the bank carried the credit[33]. There were several reasons for the banks to accept this system: the contract with the oil company was a good security, the other was the guarantees of the large Swedish yards.

In this way a modernisation based on large motor ship was a continuation of the old tramp tradition with small shipowning companies. What appeared as a paradox, the backward owners who became the most progressive, can instead be analysed as both a continuation of a tradition (size of companies, trades, and problems with capital concentration) and as intentional choices based on the limitation set by the same tradition (taking the risk of being dependent on just one oil company and one trade). Development outside the Norwegian owners control secured the success of the owners choice (the increasing demand) as well as the owners demand for ship was countered by the much stronger Swedish yards and bank system to meet this demand. Hence the success of the Norwegian owners and the Swedish yards were two sides of the same

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33 Bohlin, Jan, Svensk varvsindustri 1920-1975, Lönsamhet, finansiering och arbetsmarknad. Meddelande från ekonomisk-historiska institutionen ved Göteborgs Universitet, no. 59. Gøtegorg, 1989, s. 105 - 131.

international development.

We have gone a long way now from the start stressing the dichotomy of the technology in question and raising the problem of the laggards that became the modernists. We looked briefly at the rational choice approach as base for neoclassical economy and ended in a combination of culture, traditions, and intentions; a kind of bounded rationality were the boundaries are explicitly set, both with regard to the culture and to the economic and structural facts. In this we have subsumed technology under a larger understanding of the situation and intentions of the owner, were technology was only a part. What appeared as a contradiction evaporated and became understandable as soon as we stuck to the old tradition of historical analysis: never to extract pieces of reality out of its proper context, whatever the proper context may be. History, even history of technology is concerned with history of human beings. It is here we find the whole, or the proper context.

Even though the empirical results of this study is tentative and stresses the theoretical sides of technology transfer and diffusion in perhaps an unusual way, it is possible to draw some conclusions of how technological transfer and diffusion should be studied. The danger is to be seduced by the genealogical approach so easy to accept. The artifacts are charming, so is the model with a country of origin and the spreading of technology. But the origin is only one part of the story. As we switch to a more dialectic approach it is not only the origin that count for the diffusion, but the whole process of diffusion has to be studied as a field in its own right, stressing the human activity that is involved. It can never be explained only from the 'origin' of the technology.

History of technology, economic history or history of technological diffusion has to deal with humans, the units of these types of history is all the time humans, not artifacts. The artifacts may raise problems, but the answer to these problems lay on the human side, not in the artifact themselves.

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