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STS-working paper no. 3/89

ISSN 0802-3573-17

arbeidsnotat
working paper

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THE DISPERSION OF SCANDINAVIAN ENGINEERS 1870-1930 AND THE CONCEPT OF AN ATLANTIC SYSTEM.[1]

Paper to be presented at the SHOT meeting, Sacramento - California, October 1989.

The present paper will seek to trace some characteristics of the dispersal of Scandinavian engineers in the Atlantic area. We will attempt to relate this to varying conditions in Scandinavia. We will also seek to relate the dispersion of Scandinavian engineers to what we could define as a world market in engineering skills. We have restricted ourselves to the Atlantic region. An understanding of this relationship (if any) could be of help in understanding the modernizing process in Scandinavia, and it could also help towards a better understanding of the workings of what one perhaps with some liberty could call an Atlantic system. This "system" has generally been conceived in Anglo-American terms, and we feel that a broadening of the perspective can be of some use.

* * *

The Three Scandinavian countries are culturally much alike, their social structures are comparable and their modernization

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[1]The elaboration of programs and the collection of data has been made possible by grants from The Norwegian Council of Research, NAVF, for which I am very grateful. However, collecting data, getting the program to work properly and getting the University computer to co-operate has proven far more frustrating and time consuming than we had ever expected. I wish to thank Per Østby, Lisbeth Andersen and Stig Kvaal for their truly heroic efforts in getting at least something out of the computers ("All honour, laud and glory..."). I wish also to thank professor Magnus Mörner and his colleagues at the university of Gothenburg for interest and encouragement.

process, although following dissimilar courses are, roughly speaking, synchronous. We will be dealing with Sweden, Denmark anf Norway. Finland has been left out in part because Finnish is a difficult language, and more obviously because this country presents so many contrasting traits (she was a Grand Duchy in the Russian Empire), that any comparison becomes problematic.

The period chosen encompasses the "second industrial revolution" - not a happy term - and the breakdown of the nineteenth century economic world system - again, perhaps not a very happy term. It is certainly the period in which the new science-based industries assumed a leading rôle in the advanced economies, creating an acute need for engineers with a thorough theoretical and practical technical education. It was also a period characterized by vast engineering programs to make the new mammoth cities habitable: water and sewerage, transport (over and under ground) and the new scale and the new technologies characterizibg the building industry. The period 1870-1914 marks the core period of the transoceanic movement of people and capital. Our temporal limits have in practice been determined by the the flow of engineers from the Scandinavian countries. This flow assumes significant proportions late in the second half of the nineteenth century - especially from the 1880's. We use the term significant with some reservation, the degree of significance can always be discussed. The Great Depression put an effective end to this dispersal: we have what could be called "the great return". After the Second World war there is some renewal of geographic dispersion, but circumstances were then, we believe, very different. The period chosen is also the one best covered by the type of sources on which we are basing our investigation.

Our concept "Atlantic system" is essentially derived from the notion of an "Atlantic economy" which is common in the literature covering the period, i.e. the latter half of the nineteenth century and up to 1914. The notion is common enough when dealing with "the Westard flow of capital" (and technology), and has also found its way to migration studies. Re-emigration is here a key concept. The late nineteenth century and early twentieth century European emigration to the New World was largely urban as the frontier was closed. The emigrant was therefore far more exposed to the effects of economic recession and was therefor far more prone to move back. The Mediterranean emigrant was also far more mobile, often crossing and recrossing the Atlantic almost with the seasons and at will. Cheap transatlantic fares contributed to the development of an Atlantic labor market. This "Atlantic system" is characterized by long swings in international resource flows which have been variously described. Following Kuznets (the "Kutznets" cycle), these swings are easily read in construction activity on either side of the Atlantic. Migration is the key element causing opposite variation in what he has labelled "population-sensitive capital formation". The trans-oceanic movement of European emigrants and capital

shows long-swing peaks in the late sixties and early seventies, the eighties and the period preceding the First World War, with troughs in the late seventies and the nineties.[2]

The term "population-sensitive capital formation" covers the areas of housing, transport and urban social capital. This type of capital formation is by its nature highly dependent upon the availability of engineering skills: Bridge builders, tunneling experts, architects and building engineers, electrical engineers, sanitation engineers to mention a few.

* * *

The sources on which we have based our invesatigation are the biographies of Scandinavian engineers registered in various publications - "ingeniørmatrikler" (Nor.). These are mainly national biographical surveys of the engineering profession.[3]

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[2]Brinley Thomas, Migration and Economic Growth,: A Study of Grat Britiain and the Atlantic Economy, Cambridge 1954; Migration and Urban Development: A Reappraisal of British and American Long Cycles, London 1972; Moses Abramowitz, "The Nature and Significance of Kuznets Cycles", Economic Development and Cultural Change, IX, 1961 p. 248. Alan Green and M.C. Urquhart,"Factor and Commodity Flows in the International Economy of 1870-1914: A Multi-Country View", The Journal of Economic History, XXXVI, 1976, p. 217; Charles M. Franks and William W. McCormick, "A Self-Generating Model of Long-Swings for the American Economy, 1860-1940", Journal of Economic History, XXXI, 1971, p. 295; Stefano Fenoalta, "International Resource Flows and Construction Movements in the Atlanntic Economy: The Kutznets Cycle in Italy, 1861-1913", The Journal of Economic History, XLVII, 1988, p. 605.

[3]Our investigation has been based on the following works:B.Bassøe, Ingeniørmatrikkelen - Norske Sivilingeniører 1901-1955, Oslo 1961; O. Alstad, Trondhjemteknikernes matrikel 1870-1915, Trondhjem 1916, and Tillegg til Trondhjemteknikernes matrikel, Torondhjem 1932; L Eskedal, BTS-matrikkelen - Ingeniører uteksaminert ved Bergen Tekniske Skole 1875-1975, Bergen 1975; G. Bodman, Chalmers Tekniska Institut - matrikel 1829-1929, Göteborg 1929; G. Indebetou and E. Hylander, Svenska Teknologiföreningen 1861-1936, 2 vols. Stockholm 1937; R. Jespersen, Biografiske Oplysninger angaaende den Polytekniske Læreanstalts Kandidater 1829-1929, København 1930; Dansk Civilingeniør Stat 1955, København 1956. 100-års biografiske jubileumsskrift - Horten tekniske skole 1855-1955, Oslo 1955.
The Norwegian technological school in Oslo (Krisitiania) is contemporary with the Schools in Bergen and Trondheim, but has produced no biographical survey of candidates and its old archives are either destroyed, lost or largely irrelevant. A series of Swedish intermediate or specialized engineering

Supplementary to these are similar publications which are dedicated to particular schools. Not all technical colleges got round to publishing biographies of alumni. These "matrikler" are a thing of the past. The information which may be gleaned from these is not uniform either from country to country, from publication to publication or from period to period. What we do get seems however to be fairly reliable.[4] One of the particular strengths of the Scandinavian engineering material is that we have information covering what is roughly the whole engineer population in the chosen period. In this sense it is (we believe) unique. Another advantage which distinguishes our data for this group of emigrants from emigration data generally, is that we have precise information on return migration and staggered migration (Norway [date]→ USA [date]→ Mexico [date]→ Norway).

As we are dealing with a great number of individuals, it may be fair to say that the amount of information available is more than adecuate for most purposes: more information than we probably can usefully process. We are generally given date and place of birth (town, village, hamlet). We are given occupation and/or status of parents, education of the boy from primary through secondary and technical education. We are told which schools, what kind of specialization and also what degrees resulted. The engineer's professional career is delineated: public sector or private firms, places and positions (horizontal and vertical mobility). Special achievements and careers outside the profession are also noted. By and large the same kind of information is offered in

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schools have published biographical surveys (mining, forrestry, agriculture, military) which we have not made use of. They are however included in totals of technological graduates published by NOS.

[4]Rolf Torstendahl has checked the Swedish printed biographies against the "vast manuscript material" from the Royal Technical University preserved in Riksarkivet, and seems to have found it satisfactory (p. 292, Dispersion of Engineers in a Transitional Society - Swedish Technicians 1860-1940, Uppsala 1975). The manuscript material for Bassøes survey is unavailable or lost. Our experience so far (occasional crosschecking with other published material - obituaries, notices in Nordmannsforbundet (the publication of the Association of Norwegians residing abroad) and the autobiographical notes in the Student year-books (Studentene fra...) has not indicated that we need worry too much aboput Bassøe's reliability. We have not been able to check on our Danish sources, nor do we know if this has ever been attempted. However the Danish Civilingeniørstat is a publication which has appeared in several editions over the years, with additions and corrections, thus, we believe, ensuring a very high quality of the information offered.

all these sources, and more or less at the same level of specificity. This implies that the material may be used for comparisons. This has so far not been done.[5] The problems involved are still considerable: among them are making sure that categories are truly equivalent accross frontiers. A still more knotty problem arises from the gradual transformation of social and professional categories over time.[6]

The present paper will restrict itself to dealing with the geographic dimension. We can consider our engineers as units of technological expertise. When we register their movements, we have technology on the move: diffusion. We would contend that there is a serious case for considering technological diffusion as primarily a question of technologists moving.[7]

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[5]Apart from Rolf Torstendahl's monumental Dispersion of Engineers it is fair to say that this material has been fairly neglected. More so in Denmark and Norway than in Sweden. This can be explained by the fact that it is patently difficult to use, and it is not always obvious what purpose it can serve. This can also be explained by a stronger quantifying tradition among the Swedish economic historians. Scandinavian comparative historical work is generally very rare.

[6]The basis of the present project is an anlysis of the life-histories of a representative selection of the engineering population of Sweden, Denmark and Norway between 1850-1930. A codebook has been elaborated and a databse ("Scandinavian Engineers 1850-1930 - A biographical Databse" which we hav called "SEB" for short has been established. Some 6000 engineers have already been coded or are in the process of being coded. These life histories duplicate most of the factual information in the sources (The databse programme is described in Even Husby, Knut Stølen and Jo Torsmyr, Ingeniørdatabasen, Trondhjem 1988; Even Husby "Databsen i SEB-prosjektet", Trondhjem 1989; Per Østby, "SEB - PC", Trondheim 1989) and G. Stang "Innføring i systemet for koding av ingeniører"(rev.version), Trondhjem 1989. All Scandinavian engineers who crossed the Atlantic in the period have been registered. In addition a considerable control group is being registered.
The only variable which so far is "complete" is the geographical v. (where born, where studied, where worked, from year to year).

[7]The notion that new technology involves moving the carrier is not new. Both the Swedish and Norwegian goverments encouraged workers, craftsmen and technicians (through a system of grants) to emigrate to the advanced industrial centers, the correct presumption being that, returning, they would introduce new industrial methods. See T. Gårdlund, Industrialismens samhelle, Stockholm 1955; K. Bruland, British Technology and European Industrialization: the Norwegian

Historically it is very difficult to conceive the transfer of technology without moving people. Technological diffusion is a process through which information is passed on, shared, and must therefore lend itself to being analyzed in terms of communication channels. Books and journals, are such channels. Interpersonal channels are however the most effective, and are crucial when it comes to persuading somebody to do something new or something different.[8] Interpersonal channels are effective beyond the moment of face-to-face contact. These contacts help establish more permanent relationships - channels of communication which have the ability to renew themselves bringing in new personnel and extending themselves over time. These relationships can be readily understood as elements in a social system or as a network, and can be analyzed as such.[9]

The channels described and the resulting network must not be conceived as a one-way system, nor is it necessarily a symetrical system. For Scandinavia it provided a vital source of information on technological developments on the other side of the Atlantic.[10] To some degree this network must be seen as the result of an active desire on the European side to learn how things were being done on the American side. Indeed the Norwegian economic historian, professor Even Lange maintains that the movement of Norwegian engineers to the U.S. must primarily be explained in such terms: the desire of these engineers to perfect themselves in their mètier. He sees their journeys across the Atlantic as a continuation of the travelling "lährenjahre"-tradition which were part of the necessary background of the old master-craftsman. They must be

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textile industry in the mid-nineteenth century, Cambridge 1989; Claudius Riegler, "Labor Migration of Skilled Workers, artisans , and Technicians and Technology Transfer between Sweden and Germany before World War 1" in Dirk Hoerder (ed.), Labor Migration in the Atlantic Economies, Westport Conn., 1985.

[8]Everett M. Rogers, Diffusion of Innovations, 3rd ed. N.Y. 1983, p. 17 and in a more special sense, p.317 and following. It should be noted that we are here equating the diffusion of technology (the moving of technicians) with the diffusion of innovations, the channel with the message.

[9]Rogers, p. 24; Thomas Schweizer (red) Netzwerkanalyse: Ethnologische Perspektiven, Berlin 1988.

[10]Riegler 1985; G. Stang, "Ble det for mange ingeniører?" p. 33-42 in Trondheim ingeniørhøgskole 1912-1987, Trondheim 1987.

considered on a par with the state-subsidized technological "emigrants" mentioned above.[11]

Industrial growth in our period has traditionally been linked to the establishment of adecuate institutions of higher technological education, and the ability and speed with which the different economies adopted the new science-based technologies.[12] A quantitative analysis by Göran Ahlström points in this direction: "Although it is impossible to measure the importance of a specific type of engineer in the growth process...the similarities and deviations found between our four countries (France, Germany, Sweden and U.K.) indicate, and support, the contention that highly qualified engineers, played an essential part in the process of industrial growth and performance".[13] Ahlström maintains that there is a direct relationship between the quantity of highly qualified engineers in an economy and the industrial performance of this economy. If this is so, a large scale dispersion of engineers can very well be either a symptom of a structurally weak industrial sector or a cause of this weakness. The symptom does not exclude the cause. Norway is here a case in point.[14] By the same token, an industrial economy able to attract engineers in large numbers is essentially adding to its own growth-potential. It is irrelevant to ask if these engineers are innovators.

Going back to our hypothesis that engineers relate to each other in networks, we must stress that we are not dealing with single networks. The graduates from a particular school and a certain generation would form a network, and so would Norwegian engineers in Chicago or Scandinavian engineers in Argentina, foreign engineers in Peru, the members of the American Society of Civil Engineers, or university trained (Hochschule) engineers generally and so on. We are dealing

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[11] "Norske ingeniører i Amerika - en moderne svennevandring", paper presented at the Scandinavian symposium in the History of Technology, Stavanger 15.6.
1988. See also Bruland, Gårdlund and Riegler.

[12] A modern, balanced (but short) discussion can be found in Clive Trebilcock, The Industrialization of the Continental Powers 1780-1914, London 1981, pp. 61-67, 194-96, 266.

[13] Engineers and Industrial Growth. Higher Technical Education and the Engineering Profession During the Nineteenth and Early Twentieth Centuries: France, Germany, Sweden and England, London 1982, p.95. See also A. Rupert Hall, Science for Industry, A Short History of the Imperial College of Science and Technology and its Antecedents, London 1982.

[14] Kenneth Bjork in Saga in Steel and Concrete, Norwegian Engineers in America, Northfield, Minnesota, 1947 suggests that Norway overinvested in technological education (p. 83), the loss being not the Norwegian society's, but the fisc's.

with a series of interlocking networks - we may presume a hierarchy. These networks could be formal (qualified membership, publications and meetings) or informal and it is reasonable to assume that an engineer participated in several at different levels.

We would suggest that these networks (social systems) are necessary if we are to understand the geographic displacement of the engineers (dispersion). Market signals find their man most effectively through the informal professional grapevine, or more formally through advertisments in professional publications. It is reasonable to suppose that these networks (social systems) in many ways define the market for technological know-how and determine how it works. By the same token we may surmise that the boundaries of these networks are in some measure effective delimiters of easy access to technological expertise.

Following Even Lange we may conceive that the Norwegian engineer on his way accross the Atlantic was consciously preparing himself for the rôle as innovator or in E.M. Rogers terminology, schooling himself to become a "change agent" or "linker" at home in Norway. Alternately he may very well have been responding to network information of job opportunities and pay levels which he could not find at home. Here again it may be either the attractions of the New World or the constrictions on the market for engineers in the Old which may have been decisive.
Whatever the motive, the chances were that his decision was influenced by network information.[15]

A note should be added concerning the concepts "emigrate", "emigration", and "emigrant". E. Lange distinguishes between bonafide emigrants and "emigrants", i.e. people who did not intend to settle permanently in the new country.[16] Magnus Mörner defines migration as a "... spatial movement with lasting objectives and results. People who migrate have made a decision as a consequence of a comparative evaluation between their situation in their place of origin and a hoped-for situation in the place of destination. Migration has historical importance to the degree that it has exercised a significant influence over the structural change in the

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[15]This is a reasonable conclusion from reading Kenneth Bjork, p. 432-59; The importance of social system in the decision to emigrate has been made clear by Ingrid Semmingsen who has made clear the crucial role of the "America letters" from close realtions, or people one knew personally, when the decision to emigrate was taken (Veien mot Vest, vol 1, Oslo 1942, pp 179-85; vol 2, Oslo 1950 pp. 74-75.)

[16]p. 6.

homeland, the new home, or both."[17] The distinction easily arises between true emigrants and "adventurers"or professionals gathering experience. In our case these last would often be engineers spending maybe some of the most productive years of their professional lives abroad. We can easily find ourselves operating with false dichotomies. Intentions are not always what they seem and are often not borne out by developments; again, researching consequences can be very hazardous for the historian, and some will assert that it is impossible.[18] While we accept that there can be good reasons to distinguish between these categories, we suspect that we are best served with a broad concept which covers the variegated reality charactersistic of our period. We are dealing with labour on the move - migrant labour. The distinction is essentially with tourism - leisure on the move.[19] We must remember that we are primarily concerned with diffusion of technology or technological know-how. An emigration characterized by stability and permanence could very well indicate weak networks and poor technological payoff. A Swedish engineer in Lima may not be the same fount of innovation after twenty years of routine work in Peru as he was when he first came to the country.

One further general remark need be added: A clear distinction between internal migration and international migration cannot always be made, even though it is basic in all statistics.

* * *

The three Scandinavian countries are among the smaller European countries, with a clearly peripheral position. Sweden was the most populous, roughly equalling the other two. All three experienced a considerable growth in population which especially in Norways's case and also Sweden's was in some measure moderated by a very big emmigration.

Swedish and Norwegian population growth was markedly uneven and these fluctuations came to affect the general development of the economy. Population growth was particularly sharp in the 1870's and the 1890's. Danish population growth, although steadier, showed the same fundamental patterns.

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[17]Magnus Mörner, Adventurers and Proletarians. The Story of Migrants in Latin America, Pittsburgh, Penn. 1985, p. 4.

[18] William Dray, Laws and Explanation in History, Oxford 1963, p. 108.

[19]Dick Hoerder (1985) and Jorge Balán, Why People Move Unesco, Paris 1981: two useful books.

Table 1

SCANDINAVIAN POPULATION 1850-1930
In millions

	1850	1870	1890	1910	1930
Denmark[20]	1.4	1.8	2.2	2.8[21]	3.6
Norway[22]	1.4	1.7	2.0	2.4	2.8
Sweden[23]	3.5	4.2	4.7	5.5	6.1

[20]Erling Olsen, Danmarks økonomiske historie siden 1750, Copenhagen 1962, p. 20.

[21]Correct date is 1911

[22]Statistisk sentralbyrå, Norges offisielle statistikk, Historisk statistikk 1978, p. 33; Angus Maddison, Phases of Capitalist Development, Oxford 1982 pp. 180-83.

[23]Statistiska Centralbyrån, Historisk statistik för Sverige, Del 1. Befolkning, Stockholm 1969, pp. 46-7.

Of the three countries Denmark was by far the most urbanized. This may contribute to an explanation of the more even growth in population and also be part of an explanation of this country's greater ability to cope with population growth. All three countries were clearly overpopulated by mid-nineteenth century.

Table 2

RELATIVE DEGREE OF URBANIZATION

	1870	1890	1910	
Denmark[24]	25%	34%	40%	urban
Norway[25]	18%	24%	29%	-
Sweden[26]	13%	19%	25%	-

All three countries were at mid-century overwhelmingly traditional and agrarian in their economic structures, their resource basis was weak: Denmark was well endowed with arable land (69% of her area in 1901[27]) but little else, Norway had almost no arable land (2% of her area in 1901) which was balanced by her moderate forest resources and her rich fisheries. Sweden with a little more arable land (9% of her area in 1901) was rich in forests and iron. Sweden and Norway were net importers of agricultural products throughout the period. With their narrow resource basis and their small populations they would have been seen as marked out to become a dependent periphery.

Norway and especially Sweden had a mercantilistic industrial past. Their economies were not altogether dissimilar from that experienced by the northern New England colonies on the western Atlantic seaboard. Sweden was one of Europe's big traditional iron producers. The agricultural economy in all three countries was primarily based on peasant holdings, the educational level was high (universal literacy), and public

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[24] Salomonsens Konversations Leksikon, Copenhagen 1916, vol. 5, "Denmark"

[25] Jan Eivind Myhre, "Urbanisering i Norge i industrialiseringens første fase ca. 1850-1914" in Urbaniseringsprosessen i Norden, Del 3, Oslo 1977, p. 16.

[26] Calculated on the basis of Historisk Statistik för Sverige, pp. 47-7.

[27] Figures for the relative area devoted to agriculture is taken from S. Pollard Peaceful Conquest, The Industrialization of Europe 1760-1970, Oxford 1986, p. 234.

life was ordered. The modern industrializing process dates back to the middle years of the century. However it is in the last third of the century that the process acquired momentum, and the three countries experienced among the fastest rates of growth of the period. Norway with the highest per capita G.N.P. of the three in the beginning of the period had the most disappointing growth rate.

Table 3

INDICES OF PER CAPITA GNP:
DENMARK, SWEDEN AND NORWAY 1830-1913[28]

	1830	1850	1870	1890	1913
Denmark	86.7	90.5	94.7	129.4	161.4
Norway	116.7	123.7	117.3	134.8	140.4
Sweden	80.8	74.6	68.5	91.8	127.3
Germany	102.1	108.8	118.7	138.4	139.1
U.K.	114.2	161.8	174.9	202.3	180.7
Italy	110.4	97.9	86.9	80.2	82.6

Europe = 100.

The Swedish growth rate (growth of output - GDP - per head of population) for the period 1870-1913, was greater than the corresponding rates for the U.S. or Germany.[29] A look at the above table underlines the importance of the period between 1890 and 1913 for Sweden. In this period (and especially if we include the war years), Sweden, from being an insignificant exporter of engineering products of any kind, became an important exporter of advanced engineerring products with the advanced industrial countries as her mayor markets.[30] Names like SKF (ballbearings), Alfa Laval (separators), L.M.Ericsson (telephone equipment), Bolinder (oil engines), Nya Atlas (compressors), ASEA (high-tension electrotechnology) give an indication of the breadth and strength of this development. Russia and also Norway were early, important markets for these budding industries. The contrast with Norway is particularly sharp.

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[29]Angus Maddison, Phases of Capitalist Development, Oxford 1982, p. 44-45.

[30]Jan Kuuse, "Foreign Trade and the Breakthrough of the Engineering Industry in Sweden 1890-1920", Scandinavian Economic History Review, XXV, 1977, pp 1-36.

Table 4 STRUCTURE OF EMPLOYMENT

	Agriculture	Industry	Services
1870[91]	%	%	%
Denmark[92]	49.5	22.1	28.4
Norway[93]	53.0	20.0	27.0
Sweden[94]	72.4	14.6	13.0
1890			
Denmark	47.3	26.9	25.8
Norway[95]	49.8	22.3	27.8
Sweden	62.1	21.7	16.2
1910			
Danmark	40.2	30.4	29.3
Norway[96]	39.0	25.6	35.3
Sweden	44,0	35.0	21.0
1930			
Denmark	35.6	32.0	32.2
Norway[97]	35.8	26.5	37.7
Sweden	39.4	35.7	24.9

If we break down the economies of the three countries by sectors, looking at the structure of employment, we find that by formal criteria Denmark is the most advanced or the most industrialized of these countries at the beginning of our period. This is consistent with her greater degree of urbanization. She is overtaken by Sweden, while Norway shows a weak industrial development throughout the period. The

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[91] Maddison has calculated the figures for 1870 and his figures are a little different from ours.But he does not give figeres for the Danish and Swedish secondary and tertiary sectors.

[92] The Danish figures in the table have been compiled on the basis of Erling Olsen, p. 20.

[93] The figures are for 1875 and are calculated from Historisk Statistikk,1978, p.36.

[94] The Swedish figures in this table have been taken from Historisk Statistik för Sverige 1, p. 82.

[95] Calculated from Historisk Statistikk 1978, p. 36. Figures given are based on the total population. We have here selected the grown up, economically active population.

[96] Calculated on the base of HistoriskStatistikk 1978, p. 36.

[97] Calculated on the base of Historisk Statistik1978, p. 37.

relative reduction of the primary sector is in this country's case compensated only in some degree by a corresponding growth of the industrial. The real growth sector being the tertiary sector. The Swedish tertiary sector is relatively the weakest of the group throughout the chosen period.

The Scandinavian countries, small, traditionally poorly endowed and in the European periphery, were obviously dependent upon external markets to achieve significant economic growth. They are all three examples of export led growth. Norway's export economy came to be based on timber products, her fisheries and shipping. Denmark became a specialized producer for the British market of high quality agricultural products, and Sweden's industrialization and modern growth came to be based on her forest riches and especially from the 1890's, on her new advanced engineering and machine industry. For both Sweden and Norway, the access to hydroelectric power opened up a whole series of new industrial possibilities. In Norway's case one may argue that her industrial profile in the new century was to be shaped by this new technology. Her vast, cheap hydroelectric resources laid the base for her important electro-chemical and electro-metalurgical export industries.i However, it must be noted that this new industry, while technologically very sophisticated and also very demanding on the capital side, did not require large cadres of engineers or highly trained labour. It concentrated on the production of industrial inputs, the raw materials for industrial production elsewhere.

Denmark's industrial development was primarily linked to its home market although some found its way abroad: Food (sugar) and drink (beer), tobacco, textiles, cement and construction products, and shipbuilding were all important.[38]

Looking at the export figures of the three Scandinavian countries, it is , ideed, striking how different were the paths chosen in the modernization process. Denmark specializing on agricultural products, Sweden on metal engineering and Norway on shipping. The very considerable problems which the Norwegian economy lived through in what has been called "the long deprerssion", stretching from the mid 1870's to the early 1890's, is intimatly related to the

[38]Hans Chr. Johansen, Dansk Industri efter 1870. Industriens vækst of vilkår 1870-1973 , Odense 1988.

Table 5

ESTIMATES OF EXPORTS BY COMMODITY GROUPS - 1870-1930[39].

All figures are percentages. Gross freight income is not included in export figures.

	1	2	3	4	5	6	7	8
1870								
Denmark	90[40]	*	*	*	*	6[41]	4	*
Norway	9[42]	45	44[43]	1	6	2	1	67
Sweden	19[44]	1	43	1	22	1	13	*
1890								
Denmark	86	*	*	*	*	6	8	*
Norway[45]	1	48	35	3	5	8	1	85
Sweden	3	16[46]	43	8	13	3	14	*
1910								
Denmark	87	*	*	*	*	9	3	*
Norway	1	48	26	7	13	3	1	46
Sweden	0	10[47]	45	5	16	10	14	*

[39]Figures are based on Historisk statistikk 1978, pp. 262.266; Erling Olsen, p. 231; Jan Kuuse, "Foreign Trade and the Breakthrough for the Engineering Industry in Sweden 1890-1920", The Scandinavian Economic History Review, XXV, 1977 p. 29; Statistiska Centralbyrån, Historisk Statistik för Sverige, Del 3. Utrikeshandel 1732-1970, Lund 1972. This is a preliminary version which will be duly revised.

[40]Danish agricultural figures exclude conserves. These are however insignificant. The first figures are for the year 1874. The following are means of the years 1890-96, 1910-14, 1930-31.

[41]Industrial products

[42]Calculated on the basis of yearly averages 1871-75.

[43]Woodpulp is included in the Norwegian figures up to 1922.

[44]Calculated on the base of 1871 figures from Historisk Statistik för Sverige.

[45]Yearly average for the years 1891-95.

[46]"Animal products" - mostly fish.

[47]"animal products", mostly fish.

(Table 5, continued)

	1	2	3	4	5	6	7	8
1930								
Denmark	79	*	*	*	*	17	2	*
Norway	0	34	5	25	29	6	1	60
Sweden	1	11	18	26	*	28[4b]	2	*

1: Agricultural prod.
2: Fiheries
3: Timber
4: Paper and pulp
5: Ores and minerals
6: Engineering products
7: Other.
8: Gros freight earnings, oceanic trade. These figures are given as a % of the total of 1 through 7.

[4b] Base metals and manufactures thereof are grouped together.

composition of her export sector: fisheries, timber and pulp products and shipping services. They were all affected by falling prices and problems connected to structural transformation. In these years Norway had to manage the difficult transition from sail to steam.

The contrast between the three countries goes deeper. Sweden and Denmark were old established polities, Norway was a "new" state. Norway's political and social structure was in some measure more "democratic" than either of the two other Scandinavian kingdoms, and by the same token Norwegian central government was weaker. The "democratic" character of Norwegian society secured a high degree of literacy and social mobility, the educational system being crucial in this respect. [49] Lars Sandberg has argued on paralell lines in the Swedish case.[50] Elementary education gave access to the talented and the determined to higher education and upward social mobility, contributing to the country's scientific elite.

The contrast between Sweden (and also Denmark) on the one hand, and Norway lies in the greater political clout of the agrarian sector - the peasants - in Norway, and the comparative weakness of the executive. This is clearly illustrated in the different fate of a higher technological education in the three countries. The Swedes and the Danes established their polytechnical institutions ("hochschule") in the 1820s, simultaneously as they were being established in the German states. Similar attempts in Norway were blocked by the agrarian sector on the grounds that a new elite education was not needed. Norway had to wait until the 1870s to get three technical schools which however did not have "hochschule"-status.[51] Her technical "høyskole" came in 1910.

The difference between Norway and the other two Scandinavian countries comes out clearly in the lack of a financial elite, closely allied to the state and with strong international connections. It is evident in the weakness of the national bank itself. Sweden was well endowed in this respect even if

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[49] Ingrid Semmingsen, "Standssamfunnets oppløsning i Norge", in Sten Carlsson, Ståndsamhällets upplösning i Norden, Abo 1954, pp. 49-86.

[50] "The Case of the Impovrished Sophisticate: Human Capital and Swedish Economic Growth before World War 1" in Journal of Economic History, XXXIX, 1979, pp. 224-241.

[51] Håkon With Andersen, "Tronhjems tekniske Læreanstalt 1870-1915" in Trondheim Ingeniørhøgskole 1912-1987, Trondheim 1987, pp. 11-31; Tore J. Hanisch and Even Lange, Vitenskap for Industrien. NTH - En Høyskole i utvikling gjennom 75 år, Oslo 1985, pp. 11 -34. Norway did have a school of mining dating from the eighteenth century and a school of engineering (1850) attached to the Naval Shipyard at Horten

she no longer was the Great Northern Power.[52] Similarly Denmark had a heritage of international trade and finance which provided her with an economic culture and institutions which were of importance to her industrial development.[53]

* * *

Scandinavian mass emigration belongs to the "second wave" of the great population movement to America, and starting in the 1850s (Norway) it entered the stage of mass migration in the 1860s which culminated in the 1880s and early nineties.[54] A new wave may be perceived in the first years of the century, and a last wave in the 1920s. These last two waves are dominated by the Norwegian exodus. Calculated in absolute numbers the emigration from these three countries (1850-1930) totalled 2.4 million. Of these 1.2 m. came from Sweden, 0.8 m. from Norway and 0.4 m. from Denmark. The emigration from Norway is singular both because of the intensity of the movement, and its persistence.

Mass emigration from Scandinavia is an answer to the demographic crisis which had been building up since the beginning of the century. It can be said to have expressed a fundamental lack of balance between population growth and economic development. Denmark was touched moderately, which is in keeping with what we already know about the Danish economy. In relative terms Sweden and Norway were among the big emmigration countries of Europe, Norway being bested only by Irland. The migratory push in Sweden is clearly a weakened force after the turn of the century although it is yet quite perceptible. This must be seen in the context of the massive development of the country's industrial economy. The persistence of fairly massive Norwegian emigration in the 1920's may in some measure be explained by the radically deflationary policies pursued in the period by the governments of that country. However, a more structural answer would be

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[52] L.G.Sandberg, "Banking and Economic Growth in Sweden before World War I", in Journal of Economic History, XXXVIII, 1978, pp. 650-680.

[53] Peter Boegh Nielsen, "Aspects of Industrial Financing in Denmark 1840-1914", in Scandinavian Economic History Review, XXXI, 1983, pp. 79-108 gives an indication in this direction, especially if read in the context of Norwegian industrial financing in the 19th century. See Sven Age Hansen, Asmund Egge in Kreditt og kredittinstitusjoner i Norden Trondheim 1978 and Fritz Hodne, Norges økonomiske historie 1815-1970, Oslo 1981.

[54] Hans Norman and Harald Rundblom, Transatlantic Connections. Nordic Migration to the New World after 1800, Oslo 1987, is an excellent introduction to this subject.

more satisfactory. Norway did not yet have a fully industrialized economy."[55]

* * *

We have already mentioned that engineering education got off to an early start in Sweden and Denmark, while Norway lagged behind. Stockholms Tekniska Högskola was the main Swedish institution, but not the only one. Beside it we have Chalmer's Institute in Gothenburg founded in the eighteenth century as a practical technical school but which was upgraded in the nineteenth and twentieth centuries and is today in comparable to the school in Stockholm. Beside these there were the intermediate technical schools. The engineering profession was however dominated by the Stockholm School. This dominance seems to have increased over time. Seven in ten members of The Swedish Technological Society (Svenska Teknologföreningen) born in 1885 studied at STH compared to nine in ten for the cohorts born in 1895 and 1905. This tendency may be seen in the context of the increasing professionalization which is a central development from the 1890s and on.

The Norwegian engineering education came later and was qualitatively less advanced. On the other hand in some contexts the contrast between the two countries need not be so important. Norwegians from the technical schools often "finished" their education at a German technical "hochschule". Beside these there was a sizeable group of Norwegians who took their entire technical education abroad."[56] The model for the Trondhjem Tekniske Læreanstalt was Chalmers Technical Institute in Gothenurg and the German polytechnics."[57] The entrance requirements were lower than those demanded by the Stockholm institution, and the students were therefore also clearly younger. This was in some degree compensated by longer studies. The four year engineering course became statutory in

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[55] To some extent one may read the rapid rise of chronic unemployment in the 1920s as a cosequence of the closing of America to immigration. G. Stang, "La emigración escandinava a la América Latina 1800-1940", Jahrbuch für Geschiqte von Staat Wirtschaft und Gesellschafts Lateinamerikas, XIII, 1976, pp. 293-330. See also F. Hodne, The Norwegian Economy 1920-1980, London 1983, pp. 41-57.

[56] In 1859 there were 55 Norwegians studying in foreign (mostly German) technical institutions (Fritz Hodne, 1981, p. 329). This practice continued throughout the nineteenth century and was renewed after the Second World War. The contrast with Sweden and Denmark is very clear.

[57] Håkon With Andersen (1987) pp. 18 f.

Stockholm during the First World War period; in Trondheim it had become the general pattern a generation before.

Table 6

SELECTED STUDENT COHORT S.T.H. AND T.T.L.
AVERAGE AGE AT INGRESSION AND LENGTH OF STUDIES[58]

	Stockh Tekn Högsk		Trondh Tekn Læreanst	
	AGE	% 3 YRS AND LESS[59]	AGE	% 3 YRS AND LESS
1870	19.5	100	17.3	100
1880	21.2	70	17.5	22
1890	19.5	50	17.4	9
1900	19.5	44	18.2	20
1910	20.2	50	18.1	17
1920		3	-	-

The Technical school in Trondhjem was one of three. It was the most ambitious and maybe the "best" which no doubt determined the final localization of Norway's "Tekniske høyskole", but it was nevertheless not alone. We have figures for graduates from these three schools. These may be set up beside the figures of graduates from the Copenhagen polytechnic and the Stockholm Høgskola. We will then be comparing entities which are not entirely comparable, but, we believe, close enough for our purpose. There is a break in the Norwegian figures in 1910, when the national system of technical education was reorganized. The three schools were then downgraded ("mellomteknikere"), and their graduates were no longer included in the Norwegian figures, the figures that follow this year being exclusively NTH graduates.

[58] Calculations based on Indebetou and Hylander (1937), and Alstad (1916). These are preliminary.

[59] Students taking their engineering course in 3 or 4 years account over 90% of the cohort members. Students who did not take their exams have not been included. There are a few 1- and 2-year students - mostly "special students".

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Table 7

SCANDINAVIAN GRADUATES IN ENGINEERING 1870-1930 BY YEAR[60]
Graduates from **(1)** Stockholms Tekniska Högskole, **(2)** Københavns Polytekniske Højskole, and **(3)** Trondhjems Tekniske Læreanstalt, Kristianias Tekniske Skole and Bergens Tekniske Skole up to 1910, and Norges Tekniske Høyskole thereafter.

YEAR	SWEDEN (1)	DENMARK (2)	NORWAY (3)
1870	19	11	--
1871	26	7	--
1872	22	6	--
1873	18	7	9[61]
1874	27	7	9
1875	28	9	9
1876	51	11	42
1877	63	21	42
1878	49	25	42
1879	52	18	42
1880	54	18	42
1881	49	21	42
1882	36	18	23
1883	38	23	14
1884	27	25	17
1885	29	11	20
1886	34	19	14
1887	27	10	19
1888	39	8	36
1889	48	12	29
1890	58	15	45

[60]The Swedish figures are calculated from Indebetou and Hylander (1936), the Danish figures are taken from the 5th edition of Dansk Civilingeniørstat (1958) and the Norwegian figures are taken from Historisk Statisktikk 1978, table 356, "Universities, number of graduates". The Danish engineering profession was almost exclusively the product of the Copenhagen polytechnic "højskole". Of the 9543 engineers registered the 1954 "stat", only 287 had "another" education.

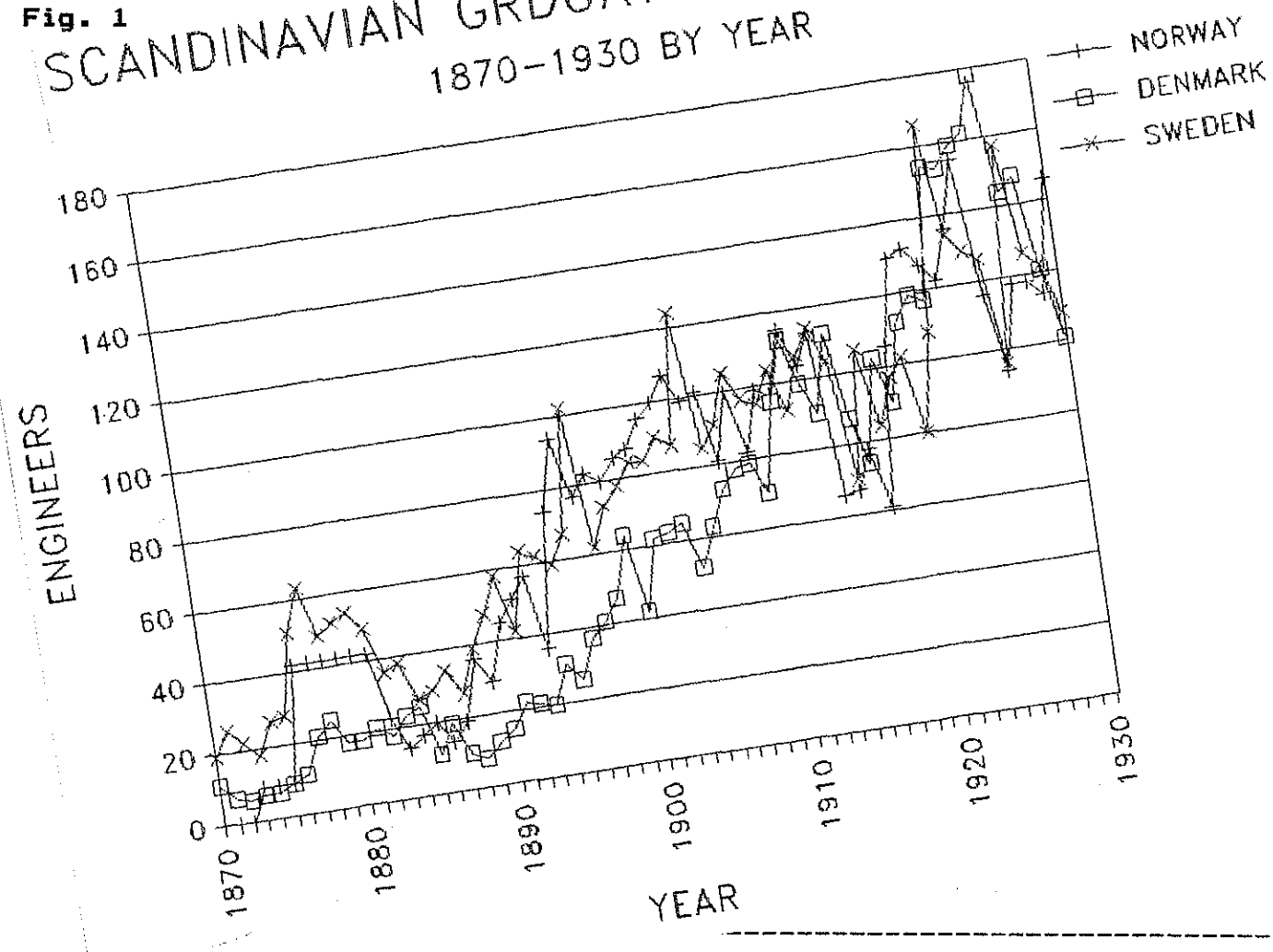
[61]The Norwegian figures for 1883-5 and 1876-81 are calculated yearly means. At a later stage an attempt will be made to disagregate these figures.

1891	42	22	51
1892	64	21	57
1893	62	20	36
1894	59	31	74
1895	67	26	94
1896	102	37	77
1897	62	41	83
1898	73	47	80
1899	78	64	86
1900	84	42	88
1901	84	62	96
1902	90	63	100
1903	87	65	107
1904	124	52	99
1905	85	63	101
1906	91	73	81
1907	105	78	100
1908	97	79	82
1909	95	70	99
1910	104	95	97
1911	92	112	115
1912	107	99	104
1913	114	90	113
1914	104	112	66
1915	70	87	67
1916	106	74	78
1917	84	103	61
1918	97	90	106
1919	102	112	130
1920	80	119	132
1921	108	117	127
1922	166	154	122
1923	134	153	136
1924	129	159	155
1925	126	162	116
1926	96	178	94
1927	157	144	118
1928	126	148	118
1929	122	121	114
1930	108	101	146

When we consider these figures we must keep in mind that Norway's population was half Sweden's, that her degree of urbanization was not significantly greater than her sister kingdom's and much lower than Denmark's, and also that her industrial sector was relatively weaker, especially in the latter half of the period. We may keep in mind that the Norwegian group of engineers (before 1910) does not have the same academic status as their Swedish and Danish colleagues. At the same time we must remember that there is a hidden group of mostly German "hochschule"-educated engineers which we can

safely presume to be significantly larger than any corresponding group in Sweden and Denmark.[62]
In addition we must include for Norway a group of foreign engineers. In the latter part of the nineteenth century and the first years of the present century, foreign direct investment in Norway was considerable, and [illegible] f

Fig. 1



[62] These engineers are included in the Swedish and Danish "matrikler", and are also included in Bassøe. The latter however does not cover the nineteenth century, here we are dependent upon the "school" matrikler. A systematic search through the collected biographies of the the Norwegian "artium" graduates (these were collected in yearly publications marking a "class'" 25th jubilee) would give a good indication of the size of this group. For figures after 1905 see footnote 65.

capital there was also a limited but important influx of foreign engineers and specialists.[63]

Göran Ahlström writes, "the explicit purpose of the institutionalised technical education in France, Germany and Sweden was to improve the national industry....it was realized that the means to raise the national industry was a thorough (according to the standards of the time) technical education, which should include theoretical and practical components."[64] The status of the engineer in Norwegian society was not perceptibly weaker than his Swedish peer, and he seems to have been as oriented towards the industrial sector as was his colleague over the border. In other words, as far as we can judge on present evidence, we have neither an English situation (weak in social prestige) or a French situation in the early part of the nineteenth century (strong public sector orientation).

With these points in mind, it would seem that Norway,s relatively weak industrial developemt in our period cannot be explained in terms of an inadequate supply of technological expertise, in the prestige of the profession or in the basic orientation of the profession itself. A case could be made that the professional qualifications of the Norwegian engineers were relatively poor, and not adequate to the task of projecting an effective industrialization in Norway. However, we must resist the acceptance of this position by default. It does not suffice to argue that Norwegian technological education was inferior. An acceptable argument has to localize the strategic areas of inferiority, relating them to the industrial situation in Norway, and has also show that the large contingent of foreign trained Norwegian engineers were not in a position to correct a weak situation.[65] These are both questions which merit some investigation. Our present knowledge would tend to suggest that Norway had an ample supply of adecuately trained engineers, some of them brilliant, and that the structure of Norwegian capitalism, and the drive of Norwegian modernization did not give these cadres the scope their peers had in Sweden.

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[63]Fritz Hodne (1981), pp. 321-330; Arthur Stonehill, Foreign Ownership in Norwegian Enterprises, Samfunnsøkonomiske studier nr. 14, Oslo 1965, pp 13-28.

[64]Ahlström, p. 96.

[65]Using Bassøe's figures (p. xii), one can deduct that in the period 1905-1930, 651 Norwegians graduated as engineers in foreign schools (mostly Germany). Of these, 152 remained abroad (23%), leaving a substantial group who returned. The brain drain involved is however substantially greater than if these had been educated at home. Comparing with our figures above (Table 7), we find that the group of Norwegian engineers trained abroad represents just under 1/5 of the total population of qualified engineers in Norway.

A slightly different explanation which does not entirely exclude our first suggestion, would state that at the general stage of economic development the country was in, she would naturally tend to have an oversupply of technological competence, and that the consequent brain-drain could very well be interpreted as a process which helped to close a gap between Norwegian economic life and the more advanced industrial societies.[66]

Whatever interpretation we choose, we find that the other side of this coin is emigration.

* * *

Engineers are a geographically eminently mobile social category, we may well speak of a peregrine profession. This is the case today and it has also been the case as far back as we care to go. They travel to aquire competence: an engineer fresh from school is still considered an unfinished product. They travel also because the market for their specialist competence has since the mid nineteenth century been mor or less world wide. The barriers which hinder other migrant groups are less evident.

In the period we are concerned with, German was the language of engineering in Scandinavia, and the German schools were the prestige institutions. There is a broad contact between the Scandinavia and the continent. The United States provided ample field for experience, and there is a broad current of Scandinavian engineers who find their way accross the Atlantic. We find Scandinavian engineers garnering experience throughout the Americas, and indeed in most corners of the world. Heavier concentrations obviuosly in regions undergoing rapid development, Argentina is a case in point.

Not all this experience could be readily transformed into the kind of prestige which secured better opportunities at home. This is the case with those who found work in municipal bodies in an obscure Argentine province, and it would also be the case of those working in the drawing office in a large American corporation. The pay was good both places, better than a beginning engineer could hope for at home.[67] Leafing

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[66] This is my main argument in "Ble det for mange ingeniører?" (1987).

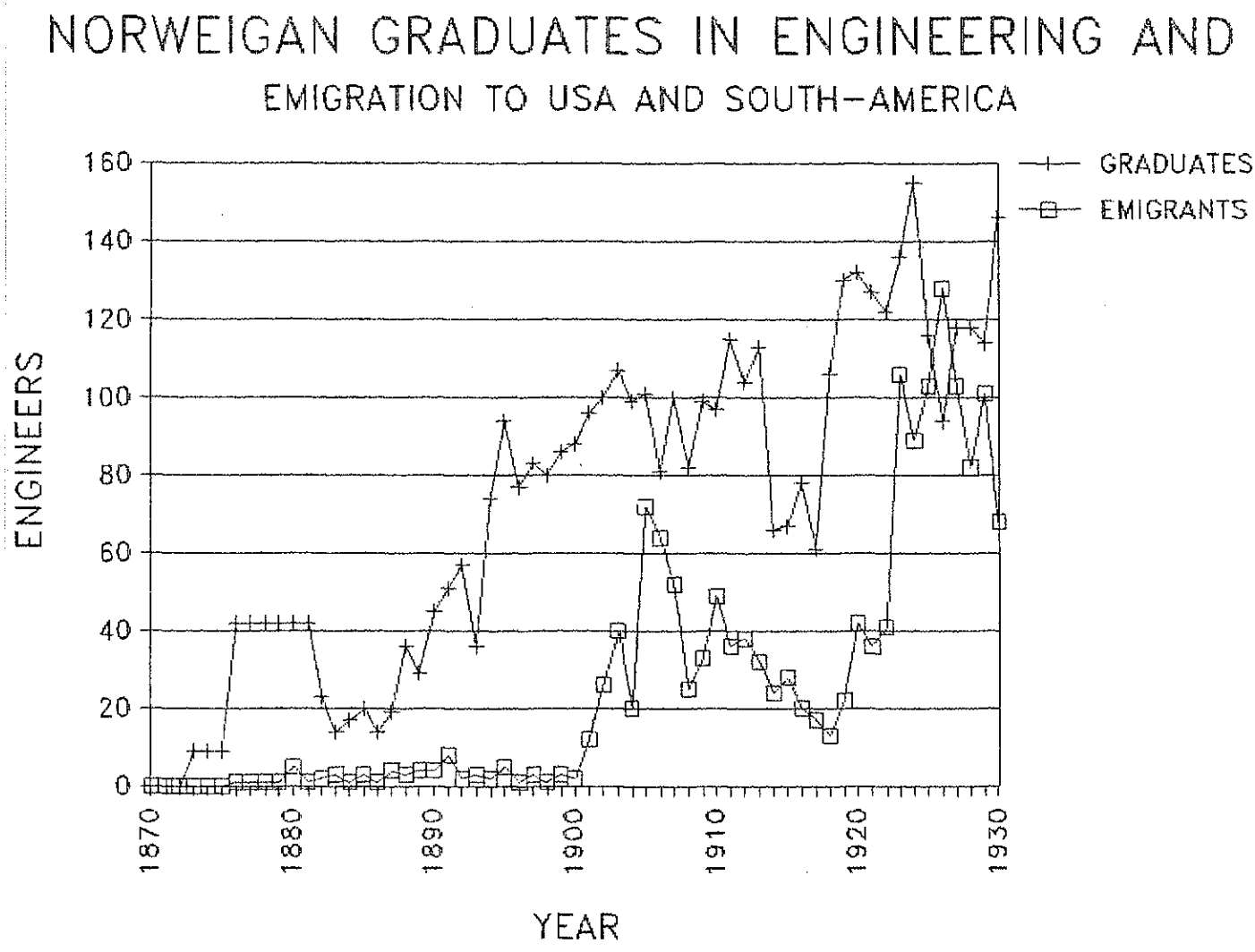
[67] Kenneth Bjork, Saga in Steel and Concrete, Northfield, Minnesota 1947, pp 36-8. For levels of pay in South America see G. Stang, "Aspectos de la poitica de personal de las empresas britanicas en America Latina 1880-1930" in Capitales, empresarios y obreros europeos en America Latina, Stockholm 1983.

through our biographies, it is obvious that the group of Scandinavian engineers working as assistants in drawing offices is not entirely insignificant.

Scandinavian engineers could also gain their experience abroad working with a company: that is, the company would send them. This presupposes that there are "transnational" companies at home who use engineers in their operations abroad. Companies of this sort do develop in Denmark and especially in Sweden. Barring the odd exception, it is quite clear that we do not really find them in our period in Norway.[68]

* * *

Fig. 2



[68] The ownership structure of the larger Norwegian concerns goes far to explain this situation. We find a heavy concentration of foreign capital on the owner side and cooperation with international capital in cases were a national company looks abroad.There are of course significant exceptions. We hope to come back to this in a later study.

If we take at Table 8 below, three facts seem to us immediately apparent. The first is that Norwegian engineers propensity to emmigrate is far greater than the among his Swedish or Danish collegues. This need not surprise us. The second is that the pattern of emmigration seen here is at variance with the general picture of Scandinavian emmigration which was almost exclusively directed towards North America. This was particularly so in the Swedish and Norwegian cases. This departure from the norm of Scandinavian emmigration would be even more apparent if we had included figures for South Africa, Australia and continental Europe, and also the inter-Scandinavian movement. Again, this should not cause surprise. The third fact is the relative heaviness of this movement overseas, considering the size of the countries involved. This last fact may not be significant in a larger context unless we are dealing with a more general phenomenon of which this may be considered an example. A contemporary experience comes to mind: the drain of engineers, technologists and scientists experienced by a series of middle income countries with in some respects better

Table 8

SCANDINAVIAN ENGINEERS TO U.S. AND LATINA AMERICA
1870-1930[69]

	U.S.A	LAT. AM.	
DENMARK	467	124	
NORWAY	1323	189	
SWEDEN	703	106	
	2493	419	2912

than average educational systems.[70] More relevant would be a comparison with the Italian experience in the same period. Certainly Italian engineers, skilled workers and professionals generally, were of great importance in the development of Latin America in the period we are concerned with, nor were they alone. Belgians, Swiss, Spaniards, Germans, Poles and many more have also contributed.[71] The big group of foreign

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[69]This and the following tables are extracted from our database, **SEB** (Scandinavian Engineers 1850-1940 - Biographies), and are the fruit of the first successful attempts at search.

[70]Examples are Argentina, Uruguay, India, Taiwan, and Egypt. The list could be extended considerably.

[71]Diégues Júnior, Manuel. Imigração e industrialização, Rio de Janeiro 1964; Vicente Vázquez Presedo, "The Role of Italian Migration in the Development of the Argentine Economy, 1875-1914", Economia Internazionale, Rivista dell' Instituto di Economia Internazionale, Genoa XXIV, 1971; Eugenia Scarzanella, "L' industria argentina e gli immigranti italiani: nascita della borghesia industriale bonaerense", Annali della Fondazione Luigi Einaudi, XV 1981; Eddi Stols, "Penetração económica, assistencia técnica e "brain drain". Aspectos da emigração belga para a América Latina por volta de 1900, Jahrbuch für Geschichte von Staat, Wirtschaft und Gesellschaft Lateinamerikas, XIII 1976; George F.W. Young, The Germans in Chile: Immigration and Colonization 1849-1914, New York 1974; Domenico E. Sindico, "Inmigración europea y desarrollo industrial: el caso de Monterrey, México", Capitales, empresarios y obreros europeos en América Latina,

engineers in Latin America were the British. In Buenos Aires they had their own engineering society. British engineers came with the railways, the gasworks, the trams, and "big" mining. They came with the big direct investments. They also came in on indirect investments - bonds: Local governments looking for somebody to build a new port, a new hydroelectric power station or a new railway, would as often as not direct themselves to one of the big foreign construction companies - often British - who would bring in their own technical personnel, exclusively.[72]

The new world was the foremost importer of capital from the old, and with much of this capital followed technological expertise. The United States, the greatest importer of capital was an exception.[73]

The resources of technological expertise available in the nineteenth century in the new world essentially three:

(i) Engineers trained at home; and the railway age became also an age of the founding and development of engineering schools throughout the Americas. The possibility of training them abroad was illusory as the cost of a German or a Spanish or Italian education was prohibitive. The Central American region (including Colombia) did make some use of U.S. Schools, but to most of the Southern continent, the U.S. was even more remote than Europe.

(ii) Engineers attached to foreign capital investments. These were contracted abroad and returned when their contract terminated. This practice was universal and not limited to the British companies.[74] These engineers never properly entered a local market for technological expertise, nor did they contribute to the local entrepreneurial class.

(iii) Engineers who came "unattached" from the old world. They were excluded from the foreign capital sector as these did not recruit locally. They therefore either went into the local

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vol 2, Stockholm 1983. Those wanting a good guide to the litterature should consult Magnus Mörner, Adventurers and Proletarians. The Story of Migrants in Latin America, Pittsburgh 1985.

[72]G. Stang, "The Shaping of a Market for Technical Know-how in Latin america 1870-1930" in Scandinavian Journal of History XI, 198.

[73]L.H.Jenks The Migration of British Capital to 1875, New York 1927.

[74]G. Stang, 1983; Eddy Stols, 1976; Domenico Sindico, 1983.

public sector or contributed to the local entrepreneurial class.

The second group was without any significance in the United States or in Canada. The third group was important in this period, and is still of importance, even if the sources have changed.[75] However it never assumed the importance which it had in those Latin American countries going through periods of very rapid development: Argentina is the prime example.

The first group, the engineers trained in the New World would seem to have a very different professional profile according to origin. This is very clear when comparing two dynamic economies like the U.S. and Argentina. Several factors contributed to this. The large sector of the economy dominated by foreign capital effectively excluded locally trained engineers. To illustrate this point it is only necessary to remind that modern technological training is very much tied to the railway, the first mass market for modern engineers. Latin American engineers with little access to the centers of modern industrial development in Europe and the U.S. and excluded from a large part of the heavy part of the modern technological sector of their home economies tended to look to the government for employment. The public sector in all modern societies is a very considerable employer of technological expertise: public works and services, higher education, control of the technological sectors run by foreigners and so on. In Argentina the government entity which controlled the foreign railways (40,000 km of track) was one of the high prestige emploers of senior engineers. Local engineers had a very long and thorough formal training, and were generally considered theoretically more competent than foreign engineers employed in the railways or even German hochschule-candidates. The length of their studies was in part fruit of the necessity to give them a good all-round competence. It often resulted in engineers who were no longer willing to rough it.[76]

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[75] S. Dedijer and Svenningson, Brain Drain and Brain Gain: A Bibliography on the Migration of Scientists , Engineers, Doctors and Students, Lund 1967; Brinley Thomas has written on the subject on various occasions, see Migration and Economic Growth, second edition, Cambridge 1973, chapter XVII.

[76] Fran Safford, The Ideal and the practical. Colombia's Struggle to form a Technical Elite, Austin 1976; H.W.Kirsch, Industrial Development in a Traditional Society. The Conflict of Entrepreneurship and Modernization in Chile, Gainsville 1977; W. Dean, The Industrialization of Sao Paulo 1880-1945, Austin 1969;R. Thorp and G. Bertram, Peru 1890-1977. Growth and Policy in an open Society, London 1977; Mario Cerrutti, La formación de capitales preindustriales en Monterrey (1850-1890), Immigrantes y configuración de una burgesía regional, Monterrey 1981; E. A. Zalduendo, Libras y Rieles, Buenos Aires 1975.

The third category is a very mixed and variable group. Among them one will find the core cadres employed to build up the new central and provincial government technical offices and services. Among them one will find specialists who are eminent in their fields.[77] At the other end one could find "engineers" with doubtful diplomas and incomplete studies. In between these extremes we find solid engineers who found their careers both in public service or in private economic enterprise. The mix of these elements would vary from period to period and from place to place. As technological education matured in the new world, and as the pioneer period ebbed, we find a clear trend to reserve the public sector for native engineers. This trend was reinforced in periods of economic downturns, when it was argued that only the native born engineer could really undersatand the problems involved.

The private sector remained open to them (always excluding the foreign capital sector). The strength of the foreign element in most of Latin America in this sector is remarkable. This is especially the case in Argentina, but Chile with a traditionally strong national entrepreneurial class showed the same trend.

Table 9 (A)

INDUSTRIAL OWNERSHIP BY NATIONAL ORIGIN - CHILE[78]

	Chilean	Foreign	Mixed	Total
1914	727	846	77	1683
1920	1323	1273	77	2874
1925	1335	1446	120	3110

[77]Top people in this group were often recruited abroad by the national government. In a sense they were therefore brought in much like a railway engineer is brought in. However, the foreign capital nexus is not there, and they integrate into the national technological elite which they help to build.

[78]Chile, Oficina Central de Estadistica, Annuario Estadistico, quoted by Kirsch p. 167.

Table 9 (B)

INDUSTRIAL OWNERSHIP BY NATIONAL ORIGIN 1895[79]
(Figures include artisanal activity)

	Argentine	Foreign
Owners	3498	18706
Employees	52356	145650

The Scandinavian engineer coming to Buenos Aires or Santiago de Chile would not necessarily experience this local industrial sector as open. Nor would he find the public service field "open" to all comers. Network relations were important in both contexts and would seem to have shaped the market.

Table 10

DISPERSION OF SCANDINAVIAN ENGINEERS 1870-1940
United States and Latin America[80]

	DENMARK		NORWAY		SWEDEN	
	U.S.	L.A	U.S.	L.A.	U.S.	L.A.
~~1870~~	1					
					1	1
1871	1				1	3
1872					1	2
1873	1					1
1874		2				
1875						1
1876			1		3	
1877				1	2	2
1878				1		3
1879			1		7	3
1880			5		10	2

[79]República Argentina, Segundo Censo Nacional, Buenos Aires 1895.

[80]The Norwegian figures for the period previous to 1905-10 are incomplete (Norwegian emmigrant engineers) and can only be taken as indicative of trends. This has to be taken into account when reading fig. 2 on page 24. The global figures for Norwegian engineers are, as far as we can judge, correct (see fig. 1, p. 21). This weakness of the Norwegian figures has to be taken into consideration for all the figures that follow.

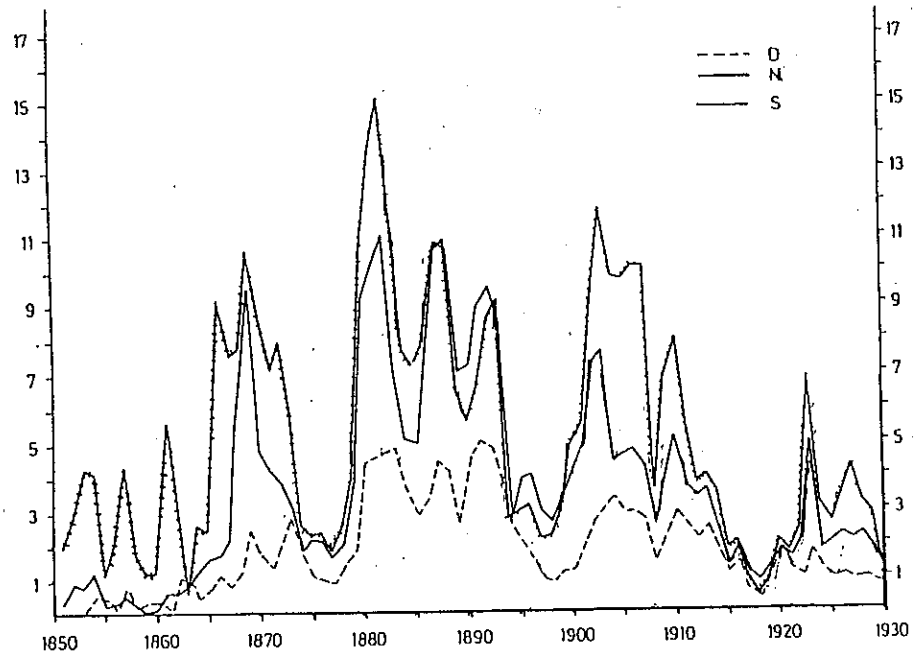
	DENMARK		NORWAY		SWEDEN	
	U.S.	L.A	U.S.	L.A.	U.S.	L.A.
1881	1	1	1		21	4
1882	0	2	2		3	3
1883	1	0	2	1	8	2
1884	0	0	1		5	1
1885	1	0	1	2	5	2
1886	1	0		1	7	1
1887	0	1	2	2	12	
1888	0	1	1	2	13	4
1889	1	2	1	3	6	12
1890	0	2	1	3	12	7
1891	0	3	3	5	5	3
1892	1	1	1	1	11	1
1893	3	2	2	1	11	1
1894	2	0	2		1	3
1895	0	4	2	3	2	3
1896	3	2		1	4	1
1897	1	0	2	1	7	2
1898	3	0	1		8	2
1899	1	1	2	1	3	
1900	6	0	2		12	4
1901	5	1	11	1	28	2
1902	7	1	25	1	25	1
1903	22	4	38	2	25	
1904	9	3	16	4	13	4
1905	20	6	66	6	15	5
1906	18	6	58	6	23	6
1907	17	5	35	17	14	6
1908	7	9	11	14	4	2
1909	10	6	22	11	7	8
1910	18	2	33	16	23	8
1911	20	7	28	8	14	3
1912	26	3	24	14	12	4
1913	14	3	24	8	11	4
1914	21	4	19	5	8	2
1915	18	4	19	9	8	1
1916	17	9	15	5	11	1
1917	21	6	13	4	4	4
1918	20	2	10	3	3	1
1919	35	2	20	2	10	9
1920	28	3	36	6	24	8
1921	21	5	29	7	14	6
1922	20	5	30	11	24	5
1923	64	3	93	13	36	5
1924	67	7	79	10	36	1
1925	68	5	80	23	25	9
1926	70	14	106	22	27	9

	DENMARK		NORWAY		SWEDEN	
	U.S.	L.A	U.S.	L.A.	U.S.	L.A.
1927	68	10	77	30	19	5
1928	54	15	83	29	14	11
1929	59	16	63	38	12	7
1930	24	6	37	31	9	9
1931	2	9	29	15	15	6
1932	10	2	13	11	15	4
1933	13	2	16	6	3	4
1934	14	5	21	8	11	
1935	11	1	18	3	12	3
1936	15	4	16	6	9	1
1937	18	7	10	6	11	
1938	13	4	14	1		
1939	15	11	22	6		
1940	22	7	26	5		

As a point of reference we append here a figure which gives an indication of the rhythm and varying intensity of Scandinavian emigration.

Fig. 3

YEARLY EMIGRATION TO NORTH AMERICA FROM DENMARK, NORWAY AND SWEDEN[81]
Number of emmigrants per thousand inhabititants



[81] Hans Normann and Harald Rundblom, Norisk Emigrationsatlas. Text och kommetarer Uddevalla 1980, p.7.

Fig. 4

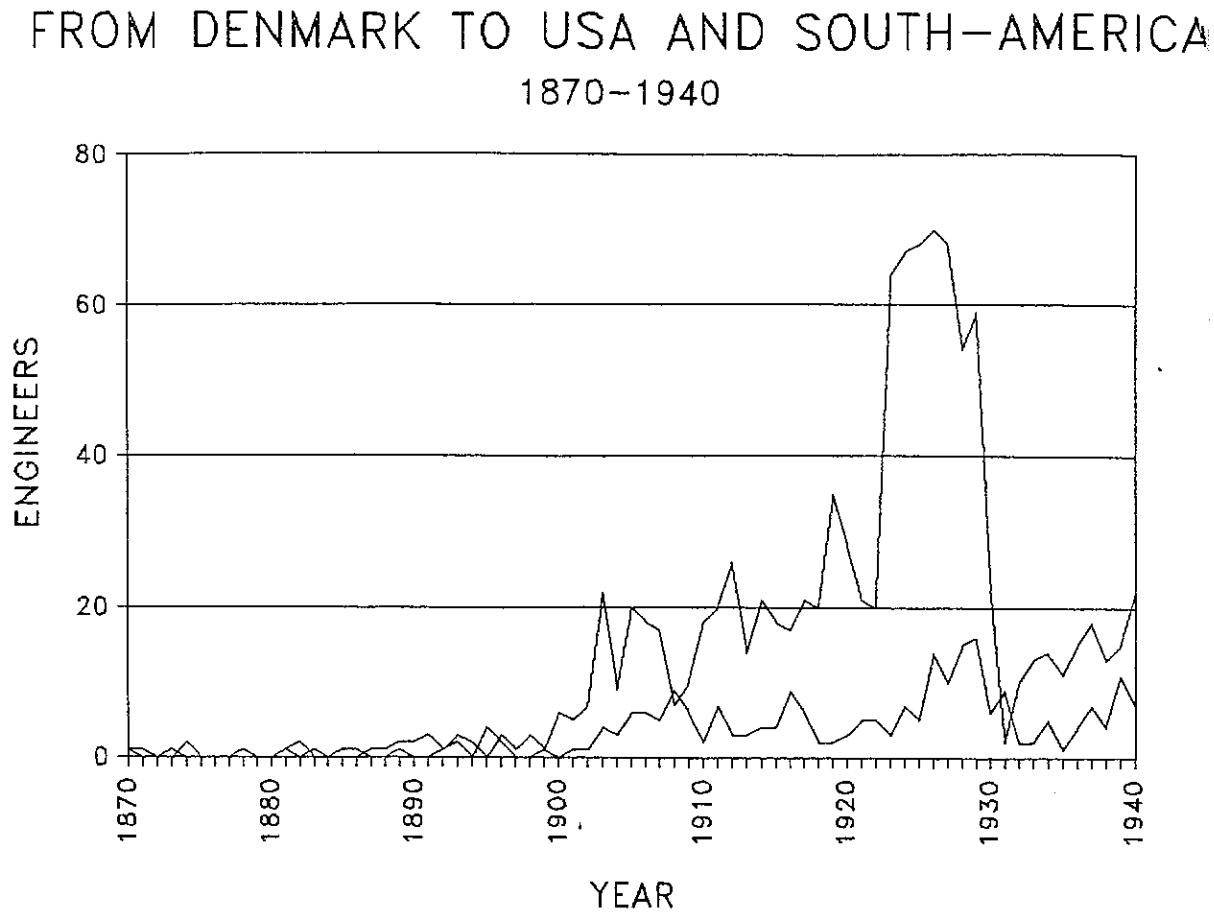

FROM DENMARK TO USA AND SOUTH-AMERICA
1870-1940
ENGINEERS
80
60
40
20
0
1870
1880
1890
1900
1910
1920
1930
1940
YEAR

Fig. 5

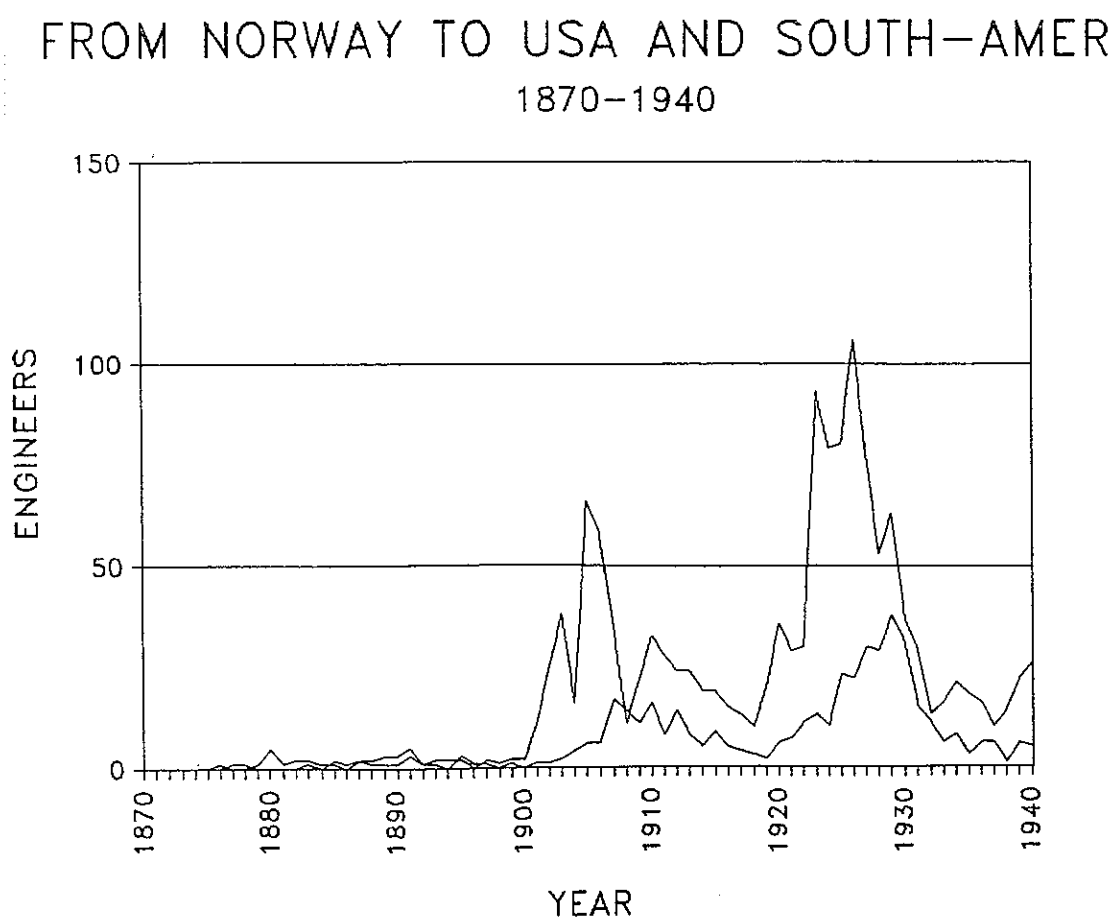

FROM NORWAY TO USA AND SOUTH-AMER
1870-1940
ENGINEERS
150
100
50
0
1870
1880
1890
1900
1910
1920
1930
1940
YEAR

Fig. 6

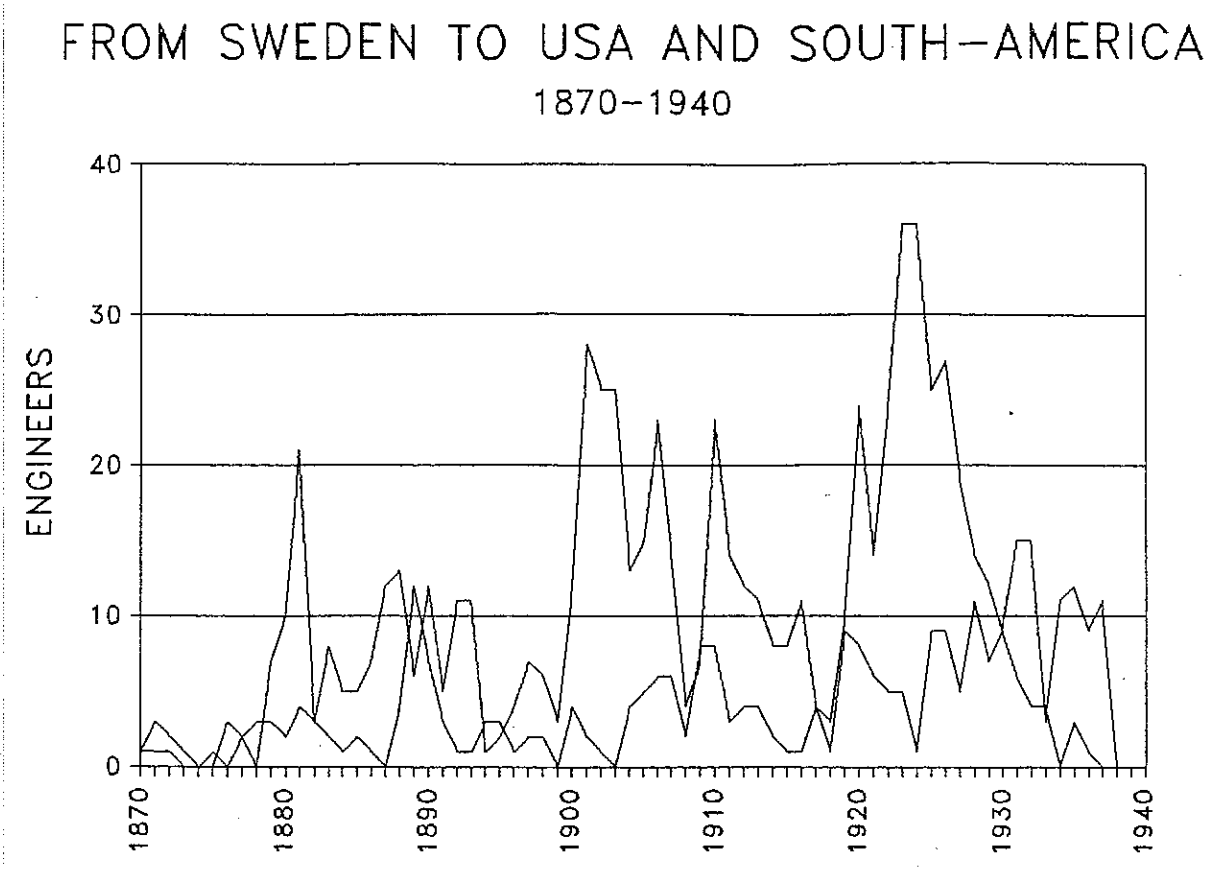
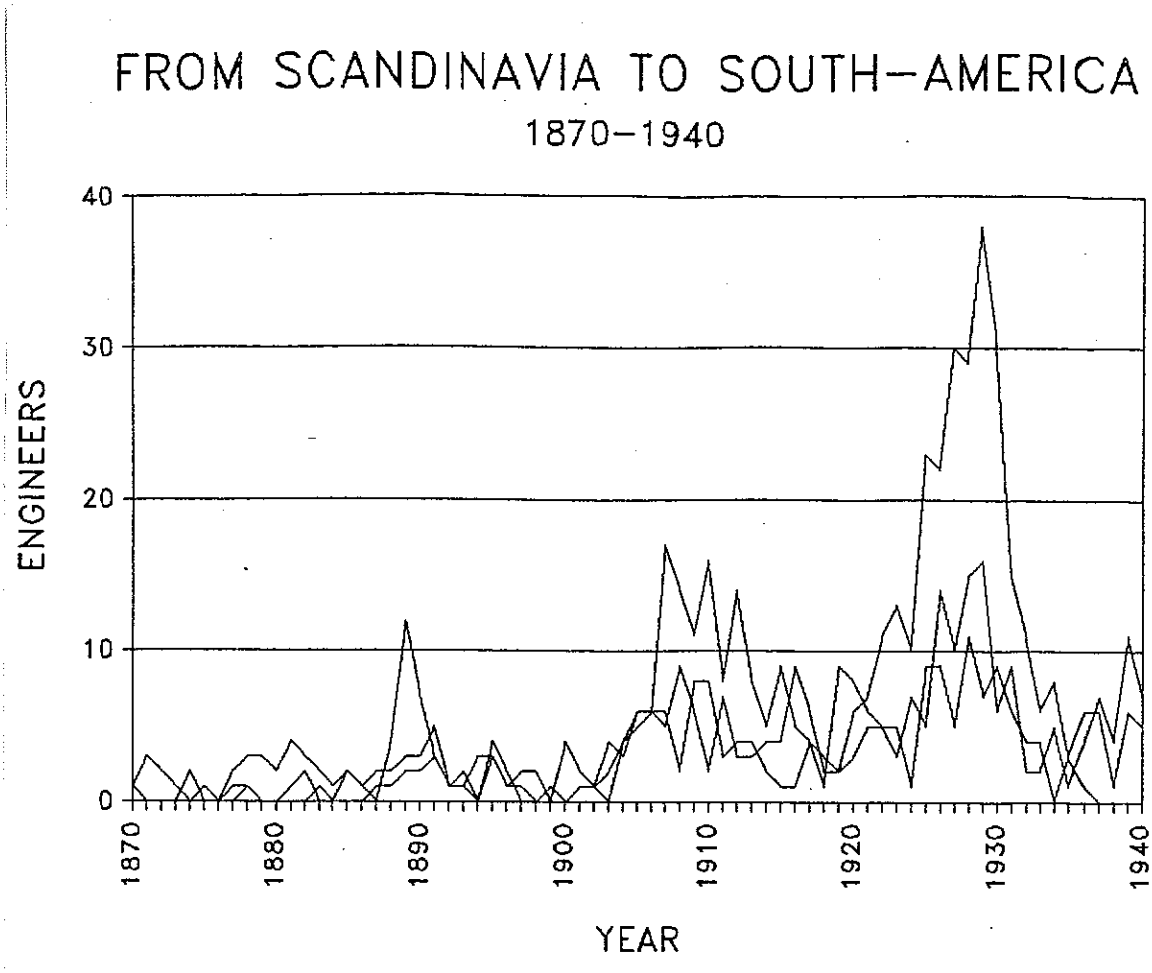
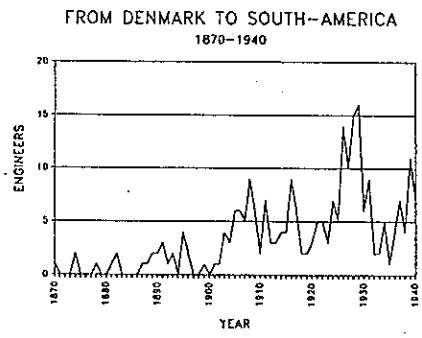
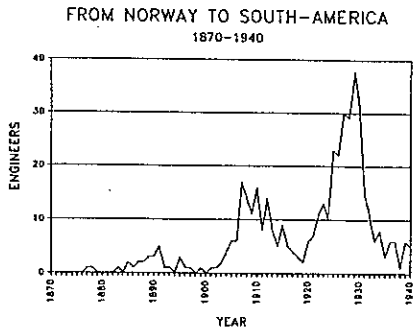

FROM SWEDEN TO USA AND SOUTH-AMERICA
1870-1940
ENGINEERS
40
30
20
10
0
1870
1880
1890
1900
1910
1920
1930
1940

Fig. 7


FROM SCANDINAVIA TO SOUTH-AMERICA
1870-1940
ENGINEERS
40
30
20
10
0
1870
1880
1890
1900
1910
1920
1930
1940
YEAR


FROM DENMARK TO SOUTH-AMERICA
1870-1940
ENGINEERS
YEAR


FROM NORWAY TO SOUTH-AMERICA
1870-1940
ENGINEERS
YEAR

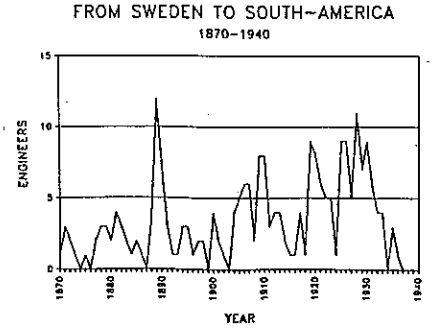
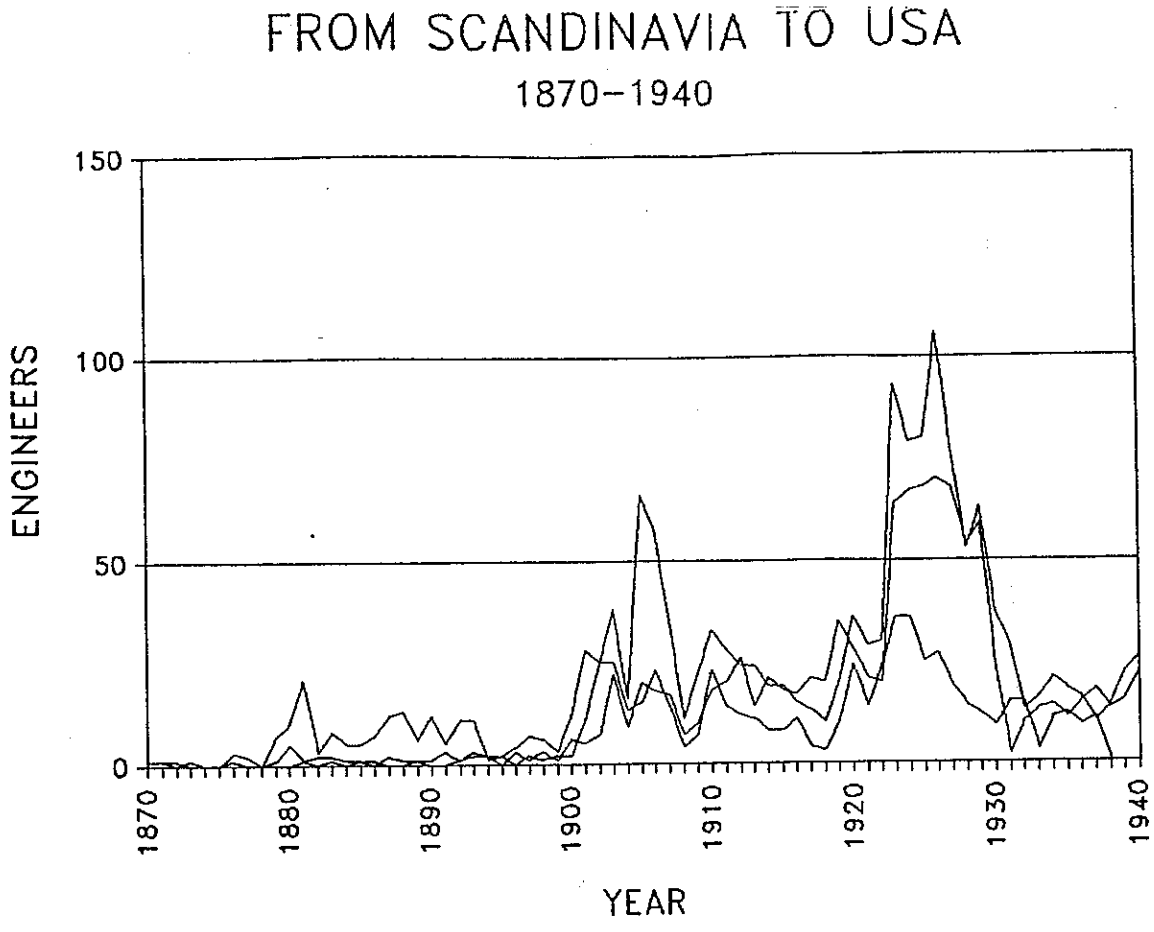
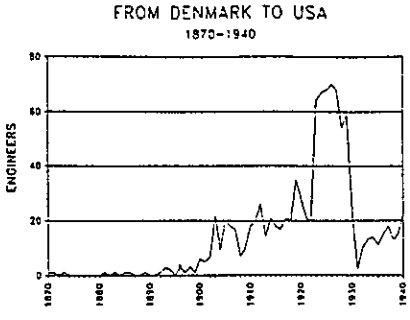
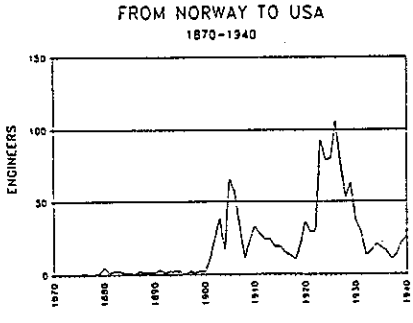
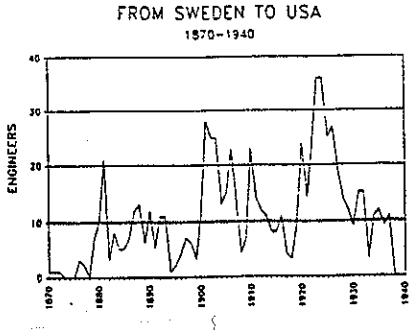

FROM SWEDEN TO SOUTH-AMERICA
1870-1940
ENGINEERS
YEAR

Fig. 8


FROM SCANDINAVIA TO USA
1870-1940
ENGINEERS
150
100
50
0
1870
1880
1890
1900
1910
1920
1930
1940
YEAR


FROM DENMARK TO USA
1870-1940
ENGINEERS


FROM NORWAY TO USA
1870-1940
ENGINEERS


FROM SWEDEN TO USA
1870-1940
ENGINEERS

It is time to sum up. We have shown that there was a heavy dispersal of engineers from Scandinavia in the period 1870-1930. The two countries that were the most successful in industrializing partook to a lesser degree in this dispersal, and the character of the dispersal from these countries seems to have changed in some measure around the turn of the century and a little later. In Sweden's and Denmark's cases engineers increasingly went abroad on the payroll of a Swedish or Danish company, although this is particularly a Swedish trait.

Norway was industrially less successful and experienced in periods a formidable diaspora of engineers; mostly to the United States, but also to the rest of the World. The Norwegian figures for the period before 1905 are incomplete. We must calculate that roughly between 20 and 40% of the cohorts emigrated. A sample of TTL graduates would seem to indicate this was the case.[82] South of the Rio Grande it was the region which today goes under the name "The Southern Cone" was the favoured area for Scandinavian engineers, Argentina taking the majority, but no country seems to have been neglected and Mexico and Cuba were also in some degree important. Early Danish engineer migration to "Latin America" was primarily directed to St. Croix, the Danish colony later bought by the U.S..

Latin America was second only to the U.S. in terms of European capital transfers, Argentina being a particularly favoured country. The dispersion of Scandinavian engineers can therefore best be understood in terms of a complex Atlantic system where European capital flow is a key element. The Scandinavian dispersion would also seem to reflect the consequences of the differing modernizing strategies adopted both in Scandinavia and in the New World and also the different degree of development as registered in for example varying degrees of urbanization: Argentina was one of the two most urbanized countries in Latin America. The other was Uruguay.

From the evidence we have gathered so far it would seem clear that The dispersal is not a haphazard phenomenon, and reflects the educational situation only insofar as large cohorts opens for the possibility of a large emigration. The pattern we see is heavily cyclical for all three countries. While the picture we get is complex and no doubt opens for a series of interpretations, there can be little doubt that the element of "push" is very strong. In periods of heavy emigration to the United States (general and engineers) we can experience a hiatus (the period immediately before 1910) in the flow, and at this point we see a compensating upsurge (in this particular cas) in the figures representing Danish

[82] G. Stang, 1976, p. 323.

and Norwegian migration to Latin America. A similar pattern can be seen for other periods also in the Swedish figures.

Of particular interest is the development in the 1920,s. Engineer emigration in these years has close to epidemic proportions in Norway, where we see that the exodus for a period almost equals the size of the graduate classes, and one year exceeds it. We must remember that we are not dealing with total engineer emigration but with only that part which went to the U.S. and Latin America. Australia and South Africa become increasingly important as we move towards the end of our chosen period. A correct picture of the development in the 1920's is not possible until we can map the return of these engineers. Our preliminary investigation would indicate that the return was largely a product of the Great Depression and therefore belongs to the 1930's. Apart from Norway, Denmark would also seem to present a remarkable situation. Danish emigration had up to that point been on the moderate side, and has been interpreted by us as an indication of balanced process of modernization. It is Sweden that seems to have broken the out of the tyrany of the cycles. It is in any case too early to come with any hard and fast conclusions on the evidence we have presented so far.

Although many caveats may be suggested we would think that the Scandinavian experience is not entirely unlike that of other countries of the European periphery modernizing in this period. They were quite consciously in a process of closing the gap between themselves and the modern industrial powers. They had limited internal markets (small or poor) and had often to depend to a large extent on an export economy. Even if the export economy was not industrial, industry was seen as the basic element in a modern economy. A surplus of engineers is a natural consequence of this situation. Training engineers was necessary. Only England which was far ahead could neglect this strategy. The engineering schools were consciously founded as tools of development. It is in the nature of things that in the initial stages of industrialization, the education of engineers will run ahead of the capacity of a country's nascent industry to employ the bright young experts. These have therefore to search further afield. The world of 1870-1930 was open to their endeavours. A more mature industrial economy will tend to absorb what the market can offer in the way of bright young experts.

The dispersal of engineers may be explained as a result of the wish to see and experience best practice. It can also be explained as a way to get a job at the desired level of competence and adecuately paid. Motives can be mixed. This dispersal, particularly in the Norwegian case, has often been perceived as a loss to society and the national economy, its growth potential: The taxpayer - Norwegian taxpayers - subsidizing American big industry. There is some truth in this position. At the same time it must be remembered that engineers are mobile and that they very often return home. The Great Depression effected the Great Return: there was a

massive re-emigration of engineers (as far as we can make out so far). These brought home a broad experience of "best practice", and this return may go some way to explain the beginning industrial resurgence Norway experienced in the 1930's, and which continued through the post-war years. Certainly, as the engineer emigration was massive in the twenties, so also the return in the thirties was a massive phenomenon. We must remember that the schools did not stop graduating engineers in these years.

We have already suggested that the the Scandinavian dispersion must be seen in terms of network. A network which over time must have become finely meshed and solid. The return of engineers to Scandinavia must also be seen in terms of network and communication. The broad contacts of the Scandinavian technological milieu with their peers on the other side of the Atlantic, and the closing of the technological gap between them is closely tied together.

The strong pull of Latin America on young Scandinavian engineers makes it obvious that best practice was not always uppermost in their minds: adventure and good pay was compensation good enough. However, we must not leave it at that. The emigration of Scandinavian engineers to Latin America is (as the case was with the Northern continent) a small and hardly significant part of a much greater movement. In some ways the development here was similar to that experienced by Scandinavian countries: countries in the periphery in the process of closing a gap. Argentina was the great success in this respect. In 1930 her per capita GNP was higher than Sweden's. The Great Depression put an end to this process of closing the gap: since then it seems to have grown. The international economic system which had carried the world forward through the second half of the nineteenth century and into the twentieth, had broken down. What replaced it, was never able to duplicate the first system's abilituy to integrate the whole Atlantic area in a development process. An indication of this can be traced in the dispersion patterns of engineers in the 1960's and later. Engineers from the industrial core regions (and Scandinavia is part of this core) have full scope for their talents within the core region. When they travel or "disperse", they do so within a transnational company structure. When they venture out of the core area it is either in company service or in the service of one of the big aid organizations. The local markets in the periphery does not have the power to tempt them. On the other hand, the periphery is providing a steady and growing stream of scientists, engineers and technicians to these core regions without any substantial sign of reversal, of return movement.

* * *

Table 11

VALUE OF EXPORTED COMMODITIES 1870-1930 BY YEAR[83]
SCANDINAVIAN EMIGRATION TO NORTH AMERICA IN THE SAME PERIOD[84]

Export values in 1000s.
The Scandinavian "crowns" were largely interchangeable up to 1914. Their values converged again in the 1920's when they reestablished their pre-war parities. Early Norwegian and the Danish export figures are given in yearly means over five-year periods. This will be corrected in a future version. Emigration figures are given in absolute numbers, and are place immediately to the right of export figures.

	DENMARK (DK)[85]		NORWAY (NOK)[86]		SWEDEN (SEK)[87]	
	Ex	Emm	Exp	Emm	Exp	Emm
1870		3041	73	14838		15430
1871		2346	106	12276	159	12985
1872		3758	106	13865	200	11838
1873		5095	106	10352	218	9486
1874	156	3188	106	4601	225	3380
1875	147	1951	106	4048	204	3591
1976	147	1624	102	4355	223	3702
1977	147	1617	102	3206	215	2921
1878	147	2688	102	4863	184	4242
1879	147	3532	102	7608	185	12761
1880	163	8778	109	20212	236	36263
1881	163	8951	121	25976	222	40620
1882	163	12769	123	28804	254	44359
1883	163	9747	116	22167	256	25678
1884	163	7633	112	14776	239	17664
1885	151	5870	102	13981	246	18222
1886	151	6634	103	15158	228	27917
1887	151	9305	107	20741	247	46264
1888	151	8756	122	21452	282	45567
1889	151	5504	133	12642	302	28543
1890	206	9366	131	10991	304	29499

[83]This is a preliminary table to be reworked.

[84]Hans Norman and Harald Rundblom, Transatlantic connections, Nordic Migration to the New World after 1800, Oslo 1988, pp. 289-90.

[85]Erling Olsen, p. 228.

[86]Historisk statistikk 1978, p. 261.

[87]Historisk Statistik för Sverige, vol 3, pp.260-63.

(Table 5, continued)

1891	206	10659	130	13341	323	36165
1892	206	10593	126	17049	328	41103
1893	206	8779	136	18778	328	37382
1894	206	5581	132	5642	298	9559
1895	238	4244	137	6207	311	15002
1896	238	3167	148	6679	340	14911
1897	238	2085	168	4669	358	10148
1898	238	1946	159	4859	344	8569
1899	238	2690	159	6699	358	11875
1900	321	2926	173	10931	391	16302
1901	321	4431	165	12745	353	20363
1902	321	6572	181	20343	392	33336
1903	321	7867	193	26784	441	35768
1904	321	8789	193	22264	415	18866
1905	417	7611	218	21059	450	20773
1906	417	8080	246	21967	504	21606
1907	417	7345	229	22135	524	19724
1908	417	3947	219	8497	482	9117
1909	417	6150	243	16152	473	18664
1910	608	8232	283	18912	593	24184
1911	608	7553	298	12477	664	16240
1912	608	6926	336	9105	760	14507
1913	608	7744	393	9876	817	17021
1914	608	5683	410	8522	772	9900
1915	958	3163	677	4572	1316	4577
1916	958	4183	988	5212	1556	7421
1917	958	1614	791	2518	1349	2538
1918	958	793	755	1226	1350	1473
1919	1165	3087	782	2432	1576	3889
1920	1165	5816	1247	5581	2278	6945
1921	1578	4675	638	4627	1097	5693
1922	1578	3307	787	6456	1154	8758
1923	1578	6894	831	18287	1142	26370
1924	1578	5853	1066	8492	1260	8228
1925	1578	3895	1048	7009	1360	9375
1926	1503	4838	812	9326	1420	10847
1927	1503	6797	685	11881	1617	10727
1928	1503	6980	683	8832	1575	11485
1929	1503	5730	752	8029	1812	8833
1930	1392	2902	684	3673	1550	3474
1931	1392		467		1122	
1932	1159		569		947	
1933	1159		558		1079	