A society in movement : the Danish industrial revolution in the nineteenth century

A Society In Movement: The Danish Industrial Revolution In The Nineteenth Century

Vocational Training Report by

Erik van der Vleuten

(idnr. 241426)
Student of 'Engineering Sciences, Innovation and Society' (TWIM)
Department of Philosophy and Social Sciences (W&M)
Eindhoven University of Technology

tutors:
Harry Lintsen, Eindhoven University of Technology
Dan Christensen, Roskilde University Centre
Ole Hyldtoft, University of Copenhagen

Åbyhøj, January 1992

Contents:

Introduction

"Yet, for all that, the industrial revolution was the central event of modern history, British or other, more in memory than in happening." (Donald McCloskey, 1981)

In the 18th and 19th century a process took place in the Western World, which we usually characterize with the term 'Industrial Revolution'. This process started in England, and on the European mainland Belgium was the first country to follow. Later other countries in North Western Europe and Northern America joined in, along with Russia, Japan and presently Taiwan, Korea, Singapore and Hong Kong. As McCloskey's statement suggests, we tend to attribute huge importance to this event; so it has been said to mark the transition from traditional to modern society, the "fundamental watershed in the economic development ... when seen in the timescale of centuries"[1], an escape from poverty "which roughly two-thirds of the inhabitants of the modern world, the people of the underdeveloped countries, are now desparately trying to discover for themselves"[2], a process that "..in size and importance can only be compared with the famous neolithical revolution in food production"[3].
My main theme will be the Industrial Revolution in Denmark. My incentive for studying this event stems from a planned research project on the steam engine innovation in Denmark and Holland, for which the Industrial Revolution in both countries served as a prime context.

As McCloskey observed, the Industrial Revolution happened more in memory (and in history writing) than in happening. Hence, it is not my project to identify the 'correct' or 'true' way of portraying the Danish Industrial Revolution; instead I want to investigate and juxtapose some of those strategies for comprehending the phenomenon 'Danish Industrial Revolution', which have contributed significantly to its shaping in Danish collective memory. Before turning to the Danish case, however, I want to address briefly a number of such strategies that appeared in international literature, and may be expected to have reached 'Danish memory' in one way or another.

Early strategies: capitalism, factories and machines
As early as the 1770's, before the great innovations in textiles, steam and iron technology (which later came to symbolize the Industrial Revolution), Adam Smith and Arthur Young took notice of a rise of British economy, more specificly a considerable expansion in real incomes. They did not, however, see industry as a force that might cause revolutionary changes; Smith predicted a future Britain of merchants, farmers and artificers increasing their incomes at a moderate pace through specialization and trade.[4] But in the 1820's and 1830's contemporaries became gradually aware of a phenomenon of industrialization and accompanying social changes. In 1820 Auguste Comte envisaged the emergence of a new social system based on industrial and scientific capacity, which replaced the old system based on spiritual (papal/theological) and temporal (feudal/military) powers[5], while Henri de Saint Simon may have been one of the first to visualize the machine as the ultimate force in solving the age old problem of poverty. In 1829 Charles Fourier clearly addressed an 'Industrial Revolution' like event when he wrote furiously against the evils of industrial capitalism, which according to him primarily were competition and mechanization[6]. Two decades

later Karl Marx and Frederick Engels followed these early notions of industrialization by referring to modern development as a tranformation from traditional (feudal) to modern (capitalistic) society, accompanied by the emergence of factories and the use of machines under capitalistic production relations; furthermore, Marx introduced the term 'Industrial Revolution' in *Das Kapital* (1867).[7]
Yet, the concept 'Industrial Revolution' first gained general popularity through the works of Arnold Toynbee (1884) and Paul Mantoux (1906), who dropped capitalism as its overall perspective and referred to new technologies and the new factory system as its main features. This view became widespread and appears in a number of modern history books - Henrik Jensen and Ib Thiersen, for instance, wrote in 1980 that the British Industrial Revolution was primarily a revolutionary development in textiles, introducing mass production based on machines and factories.[8]
During the first half of the twentieth century the term 'Industrial Revolution' continued to denote the rise of modern capitalism, factories and new technology. This view appeared also in the work of the Dutch historian I.J.Brugmans (1925), who primarily saw the Industrial Revolution as a transition from the stage of 'early capitalism' to the welcome stage of 'modern capitalism', indicated by three kinds of qualitative changes: (1) technical-economic changes (the introduction of steam power and the factory system and the shift from ordered production for the local market to production for unknown, distant markets), (2) social-economic changes (the emerging class cleavage between employers and employees) and (3) economical- psychological changes (a new unbridled striving for profit and rationalistic view on life and production).[9]

Macro-economic strategies
In the 1950's and 1960's new strategies to describe the phenomenon Industrial Revolution arose in the work of economic historians, who had begun to explore and depend more heavily on statistical evidence bearing upon the rate of growth. In 1955 T.S. Ashton wrote that "after 1782 almost every available statistical series of industrial output (in Britain) reveals a sharp upward turn", and in the same year W.Hoffmann concluded that 1780 was "..the approximate date at which the annual percentage rate of industrial growth was first greater than two".[10] Hereby it became commonplace to date the first Industrial Revolution in England in the 1780's.
Proceeding from the same (macro-economic) angle, in 1960 W.W. Rostow formulated a general theory of industrialization applicable on any industrializing country. In his theory the so called 'take-off' stage, primarily indicated by an increase in national investment from under five to over ten percent of the national income, marks the start of an irreversible process of economic growth. Rostow asserted that the period 1783-1802 was the 'take-off into sustained growth' for the British economy.[11]
Following Rondo Cameron, Peter Mathias has argued that this new way of regarding the Industrial Revolution macro-economically provided the concept with identity. If one defines the Industrial Revolution as mechanization and mass production in factories, its origins disappear in the remote past. Should it begin with the gig mill or the blast furnace innovation in the 15th and 16th century, or with the typically industrial transformation in urban brewing in London in the 17th century? Or in the 20th century, when the ready made suit industry emerged? Innovations form a continuum in history, and to define the Industrial Revolution like this would be to

universalize the term. Hence it is essential to regard the Industrial Revolution as the onset of a fundamental change in the economic structure, where the industrial sector grew faster than agriculture and the total industrial output expanded towards a higher and sustained rate, which in turn caused further changes in society.[12] In other words, macro-economic strategies enabled the exact chronological location of the Industrial Revolution.

Furthermore, these new strategies greatly stimulated industrialization research in general. Also in Holland their influence was felt, ultimately resulting in J.A. de Jonge's basic work of 1968, which with its systematic and statistical approach has been characterized as 'the break-through in the Dutch industrialization discussion'. Using as industrialization indicators (1) changes in relative growth of the single branches of industry (ideally measured in their relative contribution to the gross national product, but for practical reasons measured in their share of the industrial labour force), (2) developments in company size, (3) mechanization and (4) the degree in which Dutch conjuncture waves followed international conjuncture waves, De Jonge noted a significant accelleration in the Dutch industrialization process in the 1890's. Testing Rostow's main criterion, he also found a considerable accelleration of investing activity in this decade; the 1890's were the time of the Dutch 'take-off'.[13]

Long term process strategies

The macro-economic stategies to describe the Industrial Revolution enabled its chronological location within a decade or two, and this certainly contibuted to the convention of seeing the Industrial Revolution as a 'breakpoint'. By contrast, others (like August Comte, Karl Marx and Max Weber) have thought of it as a long term process, which was related to the transition from traditional to modern society and maybe covered several centuries. Recently Chris Bertholet has argued that this process started as early as 1250, and involved such matters as political emancipation, changes in family structure and family functions, secularisation of religion, a demographic transition, changes in class structures, education and science, and radical changes in the way of thinking; over centuries the ideological interpretation of values concerning nature and supernature, human individuality, time and space had altered radically. In the 18th and 19th century this long term process was merely accelerated.[14]

As B.C. van Houten pointed out, from this angle one may regard the term 'Industrial Revolution' as being rather misleading. It was not industrial, because the causes and consequences of the process were mainly situated outside the field of industrial production; and it was no revolution, since there was nothing like a break-point but merely an acceleration.[15] Likewise it can be argued that macro-economic studies of the Industrial Revolution neglected the industrial aspect.

With Phyllis Deane I agree that the strategy of perceiving the Industrial Revolution as a 'long term process' is attractive for those who are interrested in 'the underlying continuity of history'; a macro-economic strategy, on the other hand, might be preferable for those whose curiousity is aroused by significant discontinuities in statistical series.

The 'process-idea', as contrasted to the 'breakpoint-idea', appears also in another tradition of economic theory, nl. cycle theory. Here it is a basic assumption that economic development in a capitalistic society occurs in jerks, showing tendencies to comparatively regular oscillations in economic activity, the so called cycles. A famous example of such a cycle is the Kondratieff cycle,

which has an oscillation period of some fifty years. Currently a basic explanation for the existance of this and other cycles builds upon shifts in investment and innovation activity, i.e. periods of heavy investment and change are relieved by periods of minor alterations. From this point of view it does not make sense to approach the Industrial Revoltion as a quick breakthrough, where the bonds of the old society were broken and a rapid process of modernization started; rather, cycle theory can be an argument for approaching the Industrial Revolution as a gradual process, consisting of several phases with relatively unidirectional trends.[16]

'Technological development' strategies

A relatively new and presently popular series of strategies for comprehending the Industrial Revolution concentrates upon technological innovation in the 18th and 19th century. An example of such a strategy is the recent Dutch research project *Technology and Industrialization in the Netherlands*, where industrialization is narrowly defined as 'changes in production processes'; here 'traditional' production technology is contrasted with 'modern' production technology, concretely operationalized by the shifts from mill technology to steam technology, from wooden tools to iron machines and from production with tools to machinal production.[17] It is this strategy that provides the basis for my planned investigation of the steam engine innovation in Denmark and Holland.

Surely many other strategies for comprehending the Industrial Revolution are possible, but the previous ones have probably had a major impact on the general understanding of this phenomenon; hence, it is not unlikely that they return in accounts of the Danish Industrial Revolution. It is my 'strategy' in the following to juxtapose a number of these accounts. I will do so in Chapter one, by following the industrialization debate in Danish 'industry-historical' research.

In Chapter two I will briefly look ahead at my planned steam engine innovation project, firstly by connecting the Industrial Revolution with the steam engine innovation and secondly by introducing some basic steam engine statistics.

Chapter 1: A glance at industry-historical research in Denmark

1.1 Introduction

During the last two centuries also Danish society experienced some rigorous changes, which are mostly described with concepts like 'industrial revolution', 'industrial breakthrough' or plainly 'industrialization'. Yet it seems to be generally acknowledged that the actual process was much more complex than this term suggests, but even if the appearance of industry was merely a side effect and indication of a 'succession of fundamental changes in the economic and political structure' (the establishment of a modern labour- and capitalmarket, a stable juridical-political framework and an improved infrastructure[18]) like Niels Kristensen asserts, it remains beyond doubt that accellerated industrial activity had huge influence on the creation of modern Danish society, changing -in the words of Hans Johansen- the physical appearance of the landscape, the distribution of people over urban and rural area and the composition of national production and foreign trade.[19]

In this chapter Danish industry historical research is in focus. In an attempt to demarcate such a field of industry historical research, Ole Markussen (1985) has formulated the objective of this research as to consider the presuppositions, the different forms of appearance and the consequences of industrial development. Furthermore he demands that industrial development is at the centre of investigation, and not merely a peripheral issue[20].

Among the writers whose strategies for comprehending the phenomenon 'industrialization' have had decisive influence on the field of industry-historical research before the mid 1970's, P.Munch, Richard Willerslev and Svend Aage Hansen are most freqently mentioned in works of reference, not in the least in the context of the debate on timing the Danish industrial breakthrough. P.Munch is said to be the exponent of the 'traditional view' of the 1940's, placing the Danish industrial breakthrough in the early 1870's; Richard Willerslev was the first to question this assumption, and argued for an industrial breakthrough in the period 1855-1872; and Svend Aage Hansen, inspired by economic growth theory, placed the industrial breakthrough in the 1890's.[21] Paragraph 1.2 is solely devoted to these three writers.

Paragraph 1.3 circles around post 1974 research, which has explicitely turned away from the idea of a time of industrial breakthrough lying out there waiting to be identified, and instead concentrated on various neglected aspects of the Danish industrialization process. Paragraph 1.4 contains an attempt to accentuate some features which may be considered characteristic for the Danish industrialization relative to abroad, and finally in paragraph 1.5 the considered works are placed in relief.

1.2: Pre 1974 research

a.Point of departure: the traditional view of the 1940's

A work that is often taken as a point of departure in surveys of Danish industry historic literature is P.Munch's *Det Danske Folks livsvilkaar 1864-1914* (1942).[22] This work, however, is not an exclusive tribute to the phenomenon of industrialization; rather, Munch's main point of interest is

the material living standard of the Danish people, which was greatly affected by developments in the primary (agriculture, fishing), secondary (handicraft and industry) and tertiary (commerce, service) sectors of Danish economic life in the second half of the nineteenth century. As more or less 'natural' (i.e. institutional) time boundaries of his investigation Munch takes the Vienna Peace of 1864 and the outbreak of the First World War in 1914, thus addressing a period of time in which the Danish Kingdom has stable borders.[23] (see appendix 1: map of Denmark).

For Munch a noticable event in these years was the increasing Danish population - from 1,7 million in 1864 to 2,9 million in 1914. This increase certainly put its stamp on Danish society. In 1864 the Capital Copenhagen lodged ca. 190.000 inhabitants, and was surrounded by modest suburbs of which only Frederiksberg was gaining significance; in this entire Capital area were around five thousand houses (mostly one or two floors). By 1914 Copenhagen had swallowed many former suburbs, counted five times as many houses (mostly five floors) and had increased its population to 614.000 people. In the provinces considerable provincial towns had relieved small market towns of a few thousand inhabitants; Denmark's second largest town in 1864, Odense with ca. 15.000 inhabitants, had now 50.000 inhabitants, and the growth of Århus from 13.000 to 70.000 was even more overwhelming. Finally a number of villages, in 1864 consisting of only a few houses and farms, were transformed into towns: an extreme example is Esbjerg, which reached no less than 20.000 inhabitants in 1914[24]. As a whole Munch characterizes the period 1864-1914 as one of huge progress, since production (both agricultural, industrial and in trade/service) grew even faster than the Danish population, which resulted in a considerable improvement of the material living standard (nutricion, clothing, housing) of the masses .

In 1864 approximately one fourth of the Danish population was mainly living from handicraft and industry. Handicraft clearly dominated industry at this time, i.e. the existing industry was scattered and consisted with few exceptions of small firms with few workers. Both handicraft and industry produced mainly for the Danish home market, but were hardly capable of supplying it: there was a considerable import of foreign industry goods.[25]

Munch regards the period 1864 -1870 as one of great industrial progress, which in the high conjuncture years after 1870 took form of a veritable industrial breakthrough.[26] As a first indicator of this development he mentions the growing number of industrial firms, inclining from 1.000 in 1864 to 1.400 in 1872. Simultaneously, some 200 old firms expanded considerably. In 1872 these 1.400 firms employed 23.000 regular and 7-8.000 interim workers, of which approximately half was appointed by the 600 new or expanding firms. Yet, Munch's rather vague distinction of industry from handicraft devaluates these figures to merely illustrative for increased industrial activity in this period.[27]

As an indicator particularly illustrating the industrial breakthrough in the early 1870's, Munch considers the alternating ownership relations in industrial firms. In 1872 seventeen industrial joint stock companies were founded, among which Denmark's largest firm Burmeister and Wain (a machine factory and ship yard). In the next three years, sixty-nine other companies followed this example.

Finally, Munch uses the emergence of serious labour conflicts as an indicator of the industrial breakthrough, i.e. he stresses that in the early 1870's serious labour conflicts made for the first time clearly visible the emerging class cleavage between employers and employees. Certainly there

had been labour conflicts before, and in the 1840's the Danish citizenry had prevented an escalation of conflicts (and kept socialism away) by organizing early labour organizations for providing housing and organizing worker consumption. But in the early 1870's the foundation for the modern labour movement was laid, starting with the establishment of a Danish department of 1.Internationale in 1871; the following intensified labour struggles, based upon more sophisticated strike tactics possible through organization, made suddenly visible the existing gap between employers and employees. Yet, the labour movement collapsed in the economic regression after 1876, and first in the 1880's and 1890's it obtained its permanent character.[28]

Parallel to this development of the labour movement, Munch suggests that in 1875 Denmark possessed a solid industrial basis, strong enough to survive the depression of the late 1870's and igniting further industrial development in the following decennia. It must be borne in mind, however, that inspite of this development Denmark remained primarily an agricultural nation; as late as 1914 agriculture nourished around 38% of the Danish population, handicraft and industry together 28%.[29]

In an attempt to explain Denmark's sudden industrialization after 1864, Munch identifies two (institutional) causes, which cleared the way for an 'industrial breakthrough' in the next high conjuncture period. Firstly, the freedom to exercise trade (the 1857 Trade Act) provided industry with the freedom to choose location[30]. Secondly, the 1863 Tariff Act and the loss of Schleswig/Holstein to Prussia one year later removed Schleswig/Holstein's industry as a competitor of Danish industry for the Danish market. Both explanations have been criticized; several authors have argued that the 1857 free trade law merely legalized what already happened frequently, and others have questioned the competitiveness of Schleswig/Holstein's industry. Indeed, Morrison has even suggested that the loss of the duchies retarded Danish industrial development, due to a decreased home market.[31]

At present, Munch's work is primarily considered as an example of a strategy for comprehending the Industrial Revolution, which built primarily upon institutional criteria (the 1857 Act, the 1863 Act and the 1864 war) and qualitative indicators (the appearance of joint stock companies and labour conflicts).

Another representative of the 'traditional' view that Denmark experienced an industrial breakthrough in the early 1870's, Georg Nørregaard, is briefly to be mentioned here. Nørregaard employs two other indicators of this event; firstly the import of pig iron doubled in the periods 1864-1868 and 1872-1876, and secondly the 1870's showed a considerable increase of Copenhagen's industrial labour force. Hence, he claims that "..it is reasonable to count the years around 1870 for the time of an industrial breakthrough."[32] According to Nørregaard technological development provided the background for this event; improved steel making methods stimulated machine production, and an improved transport system (especially steamships) entailed reduction of coal prices. This was essential, since "...modern development followed the introduction of steam engines."[33]

b.Richard Willerslev

Neither for Munch nor for Nørregaard timing of the Danish Industrial Revolution was a main

issue. With the appearance of Richard Willerslev's *Dansk Industrihistorie 1850-1880* (1952), however, the timing problem was placed in focus, destined to become a 'gravity centre' in industry historical research.[34] In Willerslev's opinion the industrial breakthrough happened in the 1850's and 1860's, when a decisive wave of industrialization hit Copenhagen and the larger province towns. He mainly derives this conclusion from information on the number of industrial firms and industry workers.

Willerslev pays ample attention to his sources of information. He proceeds from three industrial censuses, held in 1855 and 1871/72 for the entire Denmark and in 1882 for Copenhagen; and since these censuses must be considered incommensurable in their raw form, Willerslev prepares them for comparation (for example he excludes handicraft by defining industry as manufacturing in establishments with more than 5 workers).[35] Still fearing significant emissions in the statistics for rural districts after preparation, he concentrates primarily upon urban industrialization.

Willerslev interprets his revised statistics as showing an overwhelming development in industrial activity in Copenhagen between 1855 and 1872, where the number of industrial firms rose from 188 to 355 and the number of industry workers from 4.400 to 12.400.[36] Hence, the average company size increased from 23 to 35 workers. Supportive to this indication of a breakthrough in Copenhagen in the 1850's/60's was the emergence of many new branches of industry (the cement-, paperbag-, sugar-, clothing- and partly the chemical branch) and industry's considerable geographical expansion, i.e. many firms left Copenhagen with its lack of space to settle in the surrounding communes (in 1855 Frederiksberg had two factories, in 1872 twenty-eight). In the subsequent period from 1872 to 1882 Copenhagen industrialized only at a moderate rate, from 417 to 505 firms and from 15.700 to 16.600 workers.

While the industry of Copenhagen expanded rapidly in the 1850's/60's, the province towns generally made slow industrial progress. Some of them, however, experienced an industrial breakthrough comparable to that of Copenhagen; among these were Helsingør, Roskilde and Slagelse on Zealand, Odense on Funen and Århus, Fredericia, Vejle, Horsens, Silkeborg and Ålborg on Jutland[37] (see appendix 1: map of Denmark). Most other towns, however, had only moderate industrial progress or even stagnation or decline.[38]

Willerslev seeks to explain the industrial breakthrough in economic categories by stressing the role of Great Britain's adoption of an almost unconditional free trade policy; the subsequent boom in Danish export of agricultural products to this nation improved the Danish trade surplus so much, that plenty financial means were available for expansion in all sectors of the Danish economy in the following high conjuncture period.

In his article *Træk af den industrielle udvikling 1850-1914* (1954) Willerslev places this result in a broader time perspective (1850-1914), and again his point of departure are statistics on the number of industrial firms and industry workers. Proceeding from annual increases in these figures, Willerslev distinguishes three phases in the Danish industrialization process: from 1855 to 1872 industrial development primarily occured in Copenhagen (and those province towns mentioned above), from 1872 to 1906 the province towns and rural districts were mainly responsible for Denmark's industrial progress and from 1906 to 1914 Copenhagen (now including Frederiksberg) took the lead again. The industrial breakthrough in phase one seems to be confirmed by a comparatively high annual increase of the Copenhagen industrial labour force (see

appendix 2, table 1).

Willerslev illustrates industrial development in the second phase (1872-1906) with the aid of a new set of statistics, obtained from reports of the Factory Inspectorate which held annual inspections in more than half of all factories[39]; when expressed in growth percentages, these statistics may be supposed to show tendencies representative for general industrial development. The new figures confirm Copenhagen's relative stagnation when compared to the provinces in this phase, and suggest a general industrial revival in the second half of the 1890's.[40] A special feature of phase three (1906-1914) was that the industrial labour force continued to grow rapidly, inspite of the relative regression in the founding of industrial firms.

Willerslev mentions several events that followed the industrial breakthrough. Firstly, there was considerable technological development, operationalized by Willerslev with statistics on the utilization of steam power; his figures give an impression of growth, i.e. in Copenhagen the number of firms employing steam technology rose from 62 in 1855 to 205 in 1882 (from 489 hp. to 3.386 hp.), and in the province towns from 62 (700 hp.) in 1855 via 275 (2.852 hp.) in 1872 to 365 (4.719 hp.) in 1877. Willerslev concludes that mechanization was 'not modest in these years'.[41] Secondly, industrialization was accompanied by the appearance of new social problems, especially in the form of increased child- and women labour. A third event accompanying the industrial breakthrough was the phenomenon of concentration of production in large establishments; in 1855 only 5 Copenhagen factories employed more than hundred workers, in 1872 there were 37 factories approximately employing half of the Copenhagen industrial labour force. This trend continued in the following decades, and in phase three the average factory size in Copenhagen rose from 43,1 workers in 1906 to 50,0 in 1914. According to Willerslev technological development (demanding more capital investment) and an improved transport system stimulated concentration; this was especially true for distilleries, breweries and sugar refineries.

Other branches of industry important to employment were brick yards, lime works, cotton weaving mills, glove/clothing factories, tobacco factories and above all iron foundries and machine shops. Willerslev refers to the last two branches as 'key-branches' in Danish industrialization, providing the basis for economical development in other areas with their products.[42] Yet, a peculiarity of Danish industrialization was the absense of a true leading sector (a rapidly expanding branch which stimulated expansion in other branches so much, that it can be said to have dominated the growth process) comparable to the cotton industry in England, the timber industry in Norway and the timber and iron industries in Sweden. Willerslev attributes this absense to Denmark's modest export of industrial products, i.e. Danish industy continued to produce primarily for the home market.[43]

Finally, Willerslev briefly addresses the fate suffered by handicraft in these times of industrialization. First around 1897 handicraft and industry were of equal size measured in firms and workers, while in 1914 industry clearly had taken the lead. This relative decline in handicraft, however, does not indicate stagnation; handicraft maintained a significant absolute growth, although much less than industry's growth. This may be illustrated by their respective labour increases: from 1897 to 1914 the main handicraft trades increased labour with 12,7%, industry with 48,5%, swallowing 63% of the total labour force increase in the secundary sector. During the same period, Danish population increased with 22,6% .

Richard Willerslev is currently considered an 'innovator' in the Danish industrialization debate, directing attention to the 1850's and 60's as decades of considerable industrial activity, but also introducing economic categories for explanation (export, trade surplus) and using explicitely prepared statistic data as indicators. Yet his work has also been criticized severely, especially by contemporaries. Povl Bagge, for instance, concluded that Willerslev did not succeed in altering the traditional view of an industrial breakthrough in the early 1870's; firstly, Bagge doubted the reliability of the information provided by the industrial censuses, which are the fundament of Willerslev's work. Secondly, he argued that these censuses remain incommensurable inspite of Willerslev's revisions. When labour is used as an indicator, it must be taken into account that this factor alternates significantly according to season and conjuncture; the 1855 census was held in winter time, while the 1871/72 censuses were held in summertime in a high conjuncture period. Hence, industrial progress between 1855 and 1872 may have been considerably less than Willerslev's statistics suggest.[44] And thirdly, Willerslev provided no information for the years in between 1855 and 1872, and cannot exclude the possibility that the main increase happened in the high conjuncture years after 1870.
Finally, Bagge raised the question if the term 'industrial breakthrough' should be applied at all - can one characterize an annual increase of a dozen firms and a few hundred workers as such? To avoid future terminological struggles, he suggested to speak of a long term breakthrough in the way Torsten Gärlund did for the Swedish industrialization process (1830-1913).[45]

c. A macro economic perspective

In the early 1970's Svend Aage Hansen, although acknowledging that Danish industry on the whole seems "..to have experienced a tranquil and protracted evolution.." which "..does not make it easier to pinpoint anything that can be called a revolution..'[46], directed attention to the 1890's as a decade of industrial developments which nevertheless "..justify the term industrial breakthrough".[47] He criticized previous industry historical research for its conceptual uncertainty surrounding the term 'Industrial Revolution' and for its leaning upon doubtful quantitative data: besides remaining incommensurability of both the industrial censuses and the Factory Inspectorate reports, he argued that labour force figures are insufficient as a basis for assessing the productivity trends so crucial in industrialization.
In *Early Industrialisation in Denmark* (1970) and *Økonomisk vækst i Danmark* (1972) Hansen proposed a new strategy, nl. to proceed from macro-economic units as the gross/net value of production (which yield "..a better overall impression of the industrial trend.." than single indicators such as the industrial labourforce or steampower do[48]) and a clearly defined theoretical framework, based on W.W.Rostow's theory on economic growth and especially on Rondo Cameron's extention of it. According to Cameron, the 'stages of early industrialization' (a better term than 'Industrial Revolution') were indicated by (1) decisive changes in the economic structure, (2) accellerated growth of urban production of manufactured goods, (3) substantial growth of the economy as a whole and (4) industry's adoption of a more capital-intensive technology.[49]
Hansen illustrates the first indicator of a changing economic structure with changes in the contributions to the gross domestic product by the different sectors (see appendix 3, table 2).

Hence, it follows that the periods 1890-1900, 1930-1939 and 1956-1967 had substantial industrial growth ('industry' is defined as manufacturing firms with more than five workers, excl. the traditional handicraft trades and dairy works/bacon factories). Looking for an 'early industrialization' Hansen singles out the 1890's, where industry's share of the gross domestic product inclined from 6-7% to 10% while agriculture's share declined from 38% to 30%, and "... structural adjustments of such proportions within a single decennium are exceedingly rare".[50] Furthermore, Hansen argues that the 1850's, 60's and 70's can be passed over when looking for an Industrial Revolution, since industrial developments within such limited margins as a 4-6% share of Denmark's gross domestic product can't possibly have revolutionalized the Danish economic structure. It would be more proper to speak of these decades in terms of a 'commercial revolution', taking into account the huge growth of the share of the tertiary sector in these years from 25% to 40% (this remarkable expansion of the trade/service sector was already noticed by Munch).

Hansen operationalizes Cameron's second indicator, accellerated industrial growth, with the annual growth rates of net industrial production (see appendix 3, table 3). These figures support the view of a smooth and gradual Danish industrialization; but if a single decade is to be picked out, again the 1890's come in focus with an annual growth rate of 7%.

Hansen measures Cameron's third indicator accellerated economic growth- in terms of annual increases in the national income and the national income per person (where 'person' denotes 'worker'[51]). These figures (see appendix 3, table 4) suggest that the mid 1890's were the beginning of an era of higher economic growth: between 1894 and 1914 the real growth of the national income mounted up to 97% or 3,5% per annum, which was decisively higher than the former 2% per annum. According to Hansen the sudden jump to a higher level of economic growth was related to the sweeping investment- and modernizing processes occuring in Danish society in these years. The investment rate increased rapidly from 4% to over 10% of the national income(see figure 1), thus marking Rostow's main criterion for a 'take off into sustained growth';

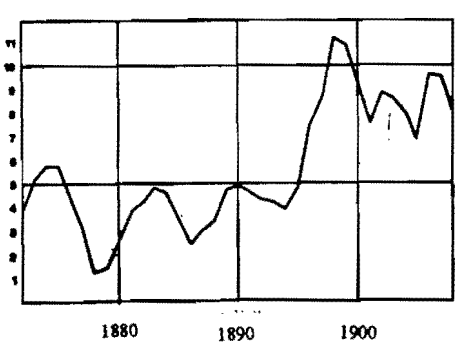


Figure 1: Net investments in % of GNI[52]

and crucial modernization aspects were the impact of electricity (providing a new form of power supply and raising technological development in general), financial developments (the credit system was made a usefull tool in the growth process), economic/tax reforms and education.[53]

Also Hansen addressed several further aspects of industrialization, which remain invisible from a macro economic viewpoint. Firstly, following Rostow's notion of leading sectors, he pointed out

various growth areas; among the emerging industries which fabricated totally new products were the margarine industry, cement making, sulphuric acid production, cable and wire manufacturing, the telephone industry and cycle building, and among the industries where new or improved technologies caused considerable reorganization of the production process were bread manufacturing, soda production and footwear manufacturing. A third growth area comprizes industries with large competitive enterprizes built up from nothing, such as the cotton-spinning mills and the woodworking industry. Finally there was substantial growth in those branches where production was particularly stimulated by pressure of demand, such as the brick works, shipyards, fertilizer- and oil cake factories. According to Hansen developments within these growth areas can explain most of the trends revealed by the Factory Inspectorate's reports, which also indicated (as previously remarked by Willerslev) vigorous industrialization in the second half of the 1890's.

Secondly, Hansen addressed the phenomenon of 'financial concentration' (as Munch and Willerslew had before him), which in contrast to 'technical concentration' has the firm and not the factory as a unit and thus refers to amalgamation. Although proper statistical information is lacking (the Factory Inspectorate reports dealt with factories only), Hansen mentions many examples to suggest that amalgamation put its stamp on the second half of the 1890's and the years immediately after the turn of the century; such examples were for instance the formation of United Malt Factories (1895), Danish Steam Mills (1897) and United Canneries (1901) in food industry, Silvan (1899) and United Constructional Joineries (1897) in woodworking industry and Danish Sulphur- and Phosphates Producers (1902) in Chemical industry.[54] As Munch has pointed out, such mergers sometimes lead to monopolization of the market. This happened for example in the case of beer breweries. In 1891 eleven Copenhagen breweries formed United Breweries in order to withstand competition from the powerful Carlberg breweries, while at the same time a third party, Tuborg breweries, was rapidly gaining significance. In 1894, however, Tuborg joined United Breweries and one year later Carlberg and United Breweries decided to cooperate. In 1902 they also started sharing their profits, and from now the entire beer market was under control.[55]

Developments in finance form a third issue discussed by Hansen. In industry's initial years capital was provided from private sources, namely from landowners and from greater merchants who had profited from the flourishing export of agricultural products to Great Britain. And when finance by agriculture declined after the 1875 depression, commerce -especially wholesale trade- continued to make available commercial capital for financing industrial enterprise. Compared to wholesale, banking had a less clear relation to industrial development. In the early 1890's direct lending to the business world by the Danish National Bank was of minor importance, and of other financial institutions only the larger private banks played a significant part in meeting industry's need for credit; but there was never a deliberate tight connection between banking and industry (in contrast to for example Germany), and Danish banks seldom participated in founding industrial firms. In the words of Hansen, their "..greatest impact .. upon the industrial development in this era .. was .. their beneficient supply of credit to the wholesale trade." [56] Yet it must be borne in mind, that the banks were a necessary element in the founding of joint stock companies.

Svend Aage Hansen has brought the new macro-economic strategies in international research to Denmark, locating the Danish Industrial Revolution in the 1890's by focussing upon industry's

relative share of the gross domestic product, accellerated growth of the value of industrial production and economic growth rates. He also addressed briefly Cameron's fourth criterion of early industrialization, mechanization: the average amount of mechanical power per firm according to the Factory Inspectorate reports increased from 11,4 in 1890 via 11,3 in 1895 to 15,0 in 1900, thus indicating an accellerated tendency towards capital intensive industry in the second half of the 1890's.

1.3: Post 1974 research

a.Beyond the idea of an industrial breakthrough

In the next two decades a remarkable shift in the comprehension of the phenomenon industrialization occurred in Danish industry-historical research. The idea of a brief breakthrough was abandoned, and instead Povl Bagge's suggestion to regard industrialization as process was taken up. Per Boje, for instance, criticized in 1976 Hansen's exact chronological location of a breakthrough as being based upon 'arbitrary and unsufficient criteria and definitions', and proposed instead to address the period between 1840 and1940 (from an early rise in industrial activity to the beginning of the Second World War).[57]

A concrete example of a strategy treating the Industrial Revolution as a process is Ole Hyldtoft's *Københavns industrialisering 1840-1914* (1984). In this work Copenhagen is the unit of investigation, not Denmark. But compared to other Capitals Copenhagen had a special place in the national industrialization process; it was not only Denmark's largest industry town, but it clearly dominated Danish industry (in 1914 47% of all Danish industry workers were employed in Copenhagen factories[58]).

The theory surrounding Hyldtoft's strategy owes a great deal to the writings of Joseph Schumpeter, who in 1939 gave an important theoretical contribution to economic cycle theory. Hyldtoft briefly refers the main points of this contribution. Centrally placed in Schumpeter's explanation of cycles in economic development is the role of capitalistic entrepreneurs, who innovate motivated by pressure on earnings; such innovations may be launching new products, using new production technology or establishing new organizational forms. After some time, however, the upswing created by the innovation levels off (more and more firms innovate, and the surplus profit decreases accordingly), and as a temporary solution to this problem firms may economize and improve efficiency. Still, at some time the limits of the system based upon the now conventional products, technologies and organizational forms are reached, and a new upswing can only be provided by a new innovation. It is this perpetual alternation between periods of innovation and periods of conventional expansion that results in cycles of economic development. The Kondatieff waves, with a fifty years oscillation period, may be based upon qualitatively very important innovations (such as new power sources), which tend to be accompanied by a swarm of other innovations.

Hyldtoft defines industry conventionally as 'production of manufactured goods in establishments with more than five workers (contrary to Hansen, he includes the traditional trades and dairy works/bacon factories)', and industrialization meant 'more production in such establishments, use of more or better labour and capital, use of more natural resources and new organizational forms'.

Following Schumpeterian theory, Hyldtoft considers real capital, the industrial labour force and new production areas the crucial dynamic factors in industrialization. Real capital denotes investments in machines and buildings, and is primarily operationalized as the amount of mechanical power (in horsepower) installed; change in the industrial labour force is mainly operationalized as change in its numbers, and criteria for new product areas were a market breakthrough (the product was beyond the introductory stage) and clear distinction from traditional product areas (in product, production method or organization).

Proceeding from the annual growth rates of the Copenhagen industrial labour force and horsepower installed (he greatly improved statistical information on both quantities[59]) Hyldtoft firstly asserts that Copenhagen's industrialization process occurred gradually between 1840 and 1914. Secondly, he distinguishes three phases in this gradual process. From 1840 to 1865 the annual mechanization increase was relatively high (around 10%, see appendix 4, table 5) and so was the annual industrial labour force increase (ca. 3%). From 1865 to 1896 the mechanization rate was substantially lower (ca. 6,5%), while a high annual labour force increase was maintained (3-4%); and from 1896 to 1914 there was again a high mechanization rate (ca. 9%), but a lower annual labour increase (ca. 2%).[60] Hence, during the entire period the number of installed horsepowers inclined faster than the number of workers, indicating a trend towards a more capital intensive industry; yet the speed of this trend variated according to phase, see figure 2 (hp. per worker figures on a log scale). In order to emphasize the (Schumpeterian) contrast between the phases, Hyldtoft defines two types of phases in an idealtypical way. The one was characterized by in-depth development, showing many new product groups as well as new production methods demanding relatively much capital outlay. The other was characterized by en expanding production of traditional products through the use of well established production methods. The first and the third phase in Copenhagen's industrialization showed greatest resemblance to the in-depth type, the second phase to the in-width type.

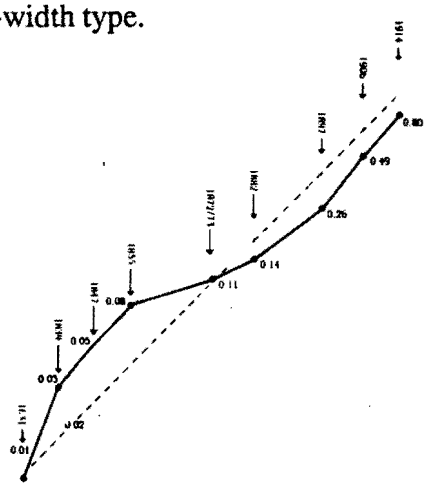


Figure 2: hp. per worker in Copenhagen's industry 1831-1914, log scale[61]

So besides vigorous growth of mechanical power and the industrial labour force, phase 1 (1840-1865) logded considerable changes in the branch structure and new production methods. While in 1840 textile industry was absolutely dominating the industrial scene, employing ca. 40% of

Copenhagen's industry workers, it was but one of many branches in 1855 (employing only 14% of the industry workers[62]). Traditionally large branches as tobacco industry and shipyards consolidated their share of the labour market (6 resp. 9%), and came with cigars resp. steam driven iron ships as new products. Expansive branches were particularly the machine industry (which is characteristic for accellerating development towards a more capital intensive industry), but also clothing (gloves, shoes) and construction works experienced a boom. The emergence of new production methods in this phase is primarily indicated by the rapidly growing popularity of the steam engine, which incipient spread according to Hyldtoft was "..the hallmark of the subperiod.."[63]. Especially the machine industry (iron foundries and machine factories), distilleries, sugar refinaries, mills and breweries were subject to modernization.

Hyldtoft describes industrial expansion in the second phase (1865-1896) as a consolidation of products and technological gains of the preceeding period. The branch structure stabilized, and the industries that expanded fastest were typically labour intensive industries (tobacco, clothing and knitwear). Few new product areas were established (can factories, gun factories and machinal joiner shops), while the knitting machine and the sewing machine experienced their breakthrough (yet, knitwear remained a typically labour intensive industry).

Compared to the second phase, the third phase (1896-1914) was characterized by a higher mechanization rate, new technology and many new product groups. Like in phase one the machine/transport industry grew relatively fast, from employing 16,2% of the Copenhagen industrial labour force in 1897 to 20,3% in 1914 and from lodging 18,9% of the total amount of horsepower installed to 21,6%.[64] The most remarkable new branch was the electrical industry, but many new goods were produced in established branches: cement in building industry, cigarettes in tobacco industry, motorships, electric railroads, bikes, cars and motorbikes in transport industry and butter and bacon in food industry. Finally, also cotton spinning mills in textile industry experienced a breakthrough. Most of the mentioned new industries had predecessors in the 1880's before breaking through in the 1890's. The new production methods of this phase were inspired by developments in the United States and Germany; modern labour machines were faster and could be operated by less workers, and the production process could be divided into seperate steps for which a special machine was available. Furthermore, the introduction of electric motors enabled 'single drift' (the machines had their own motors). These developments enabled a more rational setup of the production process, and there was a tendency towards mass production of standardized goods (Taylorism). These developments were characteristic for the third phase in Copenhagen's industrialization, inspite of the fact that many firms continued to produce in the traditional way.

Since Svend Aage Hansen's work of 1972, the strategies for comprehending the Industrial Revolution built more and more on a process view, and at present this process view is convention. So in 1987 Henning Bender remarked in his desciption of Ålborg's industrialization that "..to speak of an industrial breakthrough is hardly meaningfull.."[65], and instead he addressed various periods of accellerated industrial growth between 1808 and 1940[66]; and in a recent work (1991) Henning Lauridsen considered different phases in Viborg's industrialization between 1742 and 1990.[67] Against the notion of a short industrial breakthrough period in Denmark Hyldtoft

explicitely argued that (1) there was considerable industry in Copenhagen before 1850 (i.e. before the breakthroughs of Munch, Willerslev and Hansen), (2) mechanization and labour figures for Copenhagen suggest primarily a gradual development between 1840 and 1914, (3) the term 'breakthrough' denotes that society changed character in a very short period of time, but the criteria for timing are arbitrary[68] and (4) even after the 1890's, where Hansen located a breakthrough, Denmark's industry had a comparatively modest size; hence a character change in society would depend much more on agriculture, the dominating sector at that time. Yet apart from their claims of a breakthrough, Hyldtoft's work confirms Munch's, Willerslev's and Hansen's suggestions of noticable industrial prosperity in the early 1870's, from 1855 to 1872 and in the second half of the 1890's.

While Hyldtoft's study of industrialization as a process used single production factors as indicators, Niels Kristensen (1989) applied a strategy building upon both the process-view and macro-economic data. Kristensen departed from improved figures on the industrial value added and on industry's share of the gross domestic product; but his new figures were not that different from Svend Aage Hansen's; also Kristensen's industrial value added figures reveal particular industrial growth in the late 1890's, and industry's share of the gross domestic product developed pretty much the same as Hansen previously assumed (showing the same ups and downs, only at a constant 1% higher level). Yet Kristensen's case illustrates the modern convention of looking at the Industrial Revolution as a process, since he interpreted the figures radically different from Hansen: against the appearance of an industrial breakthrough he argued that the four years period at the end of the 1890's was to short a time for structural changes in the economy, and that the accellerated industrial growth didn't have a lasting effect (there was a slower growth after 1900). Instead he asserted that his figures suggest a phase of accellerated industrialization in the fourty years period between 1872 and 1913.[69]

b. Other aspects of industrialization

Oversimplifying the picture, the discussed works of Munch, Willerslev, Hansen and Hyldtoft can be placed in the context of the 'timing'-discussion, which according to Ole Markussen constitutes the traditional gravity point of Danish industry historical research. Yet similar to trends in international research, recent Danish industry-historical research has addressed a number of previously neglected industrialization aspects. Initiated by the 1974 research project *Industrial buildings and dwellings* a second gravity point emerged, which focusses upon the industrial environment, denoting the 'physical and social surroundings' of the industry workers.[70] The key themes of the project are, as the name indicates, the working place and the worker habitation.[71]

Naturally, many industrial envirement studies focussed upon Copenhagen. Between 1840 and 1914 the Danish Capital was transformed from a big garrison city and fortified town, with a conglomeration of functions and social groupings in the centre (within the city walls), into a modern, industrial metropolis with a relatively clearcut geographical division between the various business functions and social districts. It is Ole Hyldtoft's thesis, that changes in the business structure next to the violent growth of the population (from 133.000 in 1840 to 589.000 in 1911) provided a decisive factor in this transformation.[72] In 1840, pre-industrial businesses as handicrafts, the military and public serving were the dominating occupations in Copenhagen; in

1914 modern businesses as trade, transport and industry had taken over. Noticable is the dropping share of Copenhagen's population that worked in the military, from an estimated 11,2% in 1840 to 1,6% in 1911.

In 1840 nearly all business and habitation was cramped together inside the city walls; building activity outside the walls was restricted by military law, demanding the possibility of quick demolition in case of an enemy attack (so the enemy couldn't find easy cover). An obligatory fee for passing through the city gates further discouraged building outside the walls. The removal of both restrictions in 1852 released a first wave of building activity directly outside the centre area, Copenhagen's so-called 'bridge areas' (Nørrebro, Vesterbro), which constituted the first suburbs. Yet in 1860 the 'fortified town' character of the Capital was almost intact, with approximately 75% of its inhabitants living in the centre and its suburbs still being underdeveloped.

So, in 1855 industry was concentrated at the heart of the city (3/4 of the industrial labour force worked within a 3 km^2 area). Most industrial firms were small at the time and had a handicraft character (small scale production), and settled in cellars and backyards. In 1873 the great majority of the industrial labour force still worked in the inner city. Between 1870 and 1890, however, many larger firms transferred their production activities from the inner city to the outskirts, while the old premises were maintained as stores or salesrooms; in this way industry contributed to the gradual transformation of the old city into a service area. When industry generally gained a more large scale and capital intensive character in the 1890's and the period up to the First WorldWar, this trend was clearly implemented in Copenhagen's structure: unlike in 1840, when the density of industrial activity fell with increasing distance from the centre, the density of industrial activity was highest at the outskirts of what was then the city of Copenhagen, where a number of industrial estates had emerged. In 1916 merely 1/4 of Copenhagen's industrial labour force worked in the city core.

It was in the period from 1870 to 1890, when Copenhagen's population nearly doubled (from 215.000 to 390.000), that Copenhagen's fortification character was decisively blurred to the west and the north, and here the classical labour quarters were created (the bridge-quarters Nørrebro, Vesterbro and Østerbro). The relatively open areas yielded for hundreds of five or six storeyed tenement houses, commonly with two room apartments plus kitchen and entrance hall. The living standards here were considerably higher than in the labour quarters in the inner city, which growing population was housed in extra build attics and side- or backhouses.

In the two decades between 1870 and 1890, the number of Copenhageners living in the centre area fell from 60% to 30% of the total. In the next 24 years, Copenhagen exploded decisively into a modern metropolis. Its area tripled with the absorbsion of several suburbs (Valby, Brønshøj) in 1901/02, and the inner city obtained a service area character with a rapidly declining population from 123.000 in 1890 to 86.000 in 1911. Industry estates were situated in the outskirts, the poorer workers lived in the classical labour quarters and the richer workers often realized their ideal of an owned house-with-garden in the newly emerging villa areas, still further from the centre.

Copenhagen's geographical restructuration in this period was supported by developments in transport, i.e. extention of the harbour area up north and the railroad net eased both goods-transport from and to the industry quarters and everyday worker transport between home and

work. The latter was further stimulated by the electrification of the railroad net (starting 1897) and the increasing use of bicycles; in 1911 13% of Copenhagen's population (incl.Frederiksberg) cycled between home and work, 21% used trams.

A second example of this new research field, the industrial environment, is Hans Johansen, Per Boje and Anders Møller's account of the industrial environment in Odense between 1840 and 1940. In the founding phase of Odense's industry (1840-1870) (!), industrial enterprises mainly produced in already existing buildings (warehouses, houses); only iron foundries settled in new buildings, which were equipped with characteristic high chimneys. When in Odense's main industrialization phase (1870-1914) the phenomenon large factory building emerged, the inner town soon proved short of expansion possibilities; first the backyards were occupied, and next many industries settled in the zone between the city and its surrounding fields. Industry's location was hence determined by space- and economic considerations of the single firm, while fire- or health considerations were still subordinate; the incipient discussion about a separation of housing and working area did not have practical importance yet.

The early worker houses, typically one-floor establishments of 20-30 square meters, were situated in the town center. During the vigorous urbanization in the late 19th century many backhouses and attic appartments appeared all over the inner city, together with better quality buildings away from the centre area. In sum the average floor-space per inhabitant decreased a little in the labour quarters, but there was considerable hygiene improvement due to the establishment of a water supply system and a sewer system. After 1900 the building companies started their activities, creating many-floor properties of good standard and even minor villas for the richer workers and their families (especially in the interbellum). In 1940 common standard was a 2-3 room appartment with electricity and toilet facilities, while the latest buildings even had central heating.[73]

Birte Broch has distinguised five different types of worker housing, derived from the situation in Køge[74] around 1900. Firstly, many workers lived in properties together with people from other social layers, as a rule in the lowest standard appartments. Secondly there existed buildings, where employer and employees lived together and which simultaneously functioned as working place. A third possibility was to live in a labour quarter, holding people of comparable social layers and being considered the worst living area in town. A relatively new phenomenon in 1900 Køge was to house workers in large barracks near large working places. Finally, out of town laid a fifth housing type: a kind of factory society, with housing to all categories of employees.[75]

The emergence of the industrial environment as a new research area may be considered as an important step towards the emergence of (again) a new series of strategies to comprehend the Industrial Revolution, nl. as a process with numerous different aspects. In 1980 Flemming Mikkelsen published a study of another aspect, nl. of the industrial entrepreneur as a social category. In the Odense of 1870, entrepreneurs formed a solid social group from high middle/over class offspring, with background in the agricultural expansion of the 1850's and the following commercial prosperity. To become an entrepreneur, normally one had to be born in the proper circles, a stiffness that was also apparent in their marriage pattern. Furthermore their close contact was stimulated by membership of 'Odense Club', and they were centrally placed in a number of important institutions (the city council, industry unions, banks, the South Funen railways, Odense technical school); and finally, sharing business interest with the large merchants and financial

institutions resulted in veritable class solidarity, with common values and attitudes.[76]
Another aspect of the Industrial Revolution attractive to explicit investigation is technological development (what about the steam engine innovation in Denmark in the 19th century?). The recent TISC (Technology, Innovation and Society in a Cultural perspective) project, for instance, intents to publish a history of technology in Denmark during the past 250 years and is about to publish a work on the introduction of the first steam engines in Denmark (before 1840), according to Helge Kragh "a painfully badly described chapter in Danish history"[77].

1.4: A Danish style?

Up till now little has been said about the character of the Danish Industrial Revolution compared to abroad. Having primarily observed that the Danish Industrial Revolution generally presented similar features as industrialization processes elsewhere (e.g. the absolute and relative growth of the industrial sector, labour conflicts, an economic take-off, application of science to production and use of modern production methods and technology, urbanization and the emergence of the modern city), I would like to focus upon specificly Danish industrialization features, searching for a particularly **Danish style** of industrialization. Likewise, B.C. van Houten has depicted the 'revolutionary industrialization' of Great Britain and the 'American production system' as national styles of industrialization[78], and Harry Lintsen and Rik Steenaard's comparation of steam technology in Belgium and Holland in the first half of the 19th century suggests decisive style differences between both countries (an economy based upon large scale industry versus an economy based upon agriculture and trade with a modest small scale industry).[79]
In 1933, in a writing on the Danish Industrial Revolution, Thormod Kirstein related the economic growth of the previous period primarily to the shift in agricultural production from corn to cattle in the 1870's; as a result of this shift, a great number of dairy works and bacon factories appeared in the 80's and 90's, organized as cooperative movements and taking a large part of traditional agricultural production away from the single farm. This was the beginning of a fruitfull interaction between agriculture and industry, and in Kirstein's opinion this interaction was 'particularly advanced' in Denmark.[80] This view was shared by Vagn Dybdal in 1975, who regarded agriculture as decisive for the development of Danish society and also paid special attention to dairy works and bacon factories.[81]
Certainly this is an important point to be made. The origins of the agrarian stamp which was put on Danish society may lie in the early 19th century, when the peasants underwent a process of gaining self-consciousness and increased their power gradually by organizing. This organizing process started in the 1820's with a boom of religious revival movements. In the 1840's political demands were put up explicitly, and by the time that the absolute monarchy collapsed in 1848 a self aware peasant class had emerged.[82] Here the ideas of the thinker N.F.S.Grundtvig (1783-1872) and his formulation of a 'common people ideal' (read: peasant ideal) were taken up, and in the 1870's transformed into what became a dominant ideology, Grundtvigianism, which according to many has sunk down into Danish mentality.[83] At the same time powerful peasant organizations appeared in all sectors of social life, for instance politics; from the 1876 election Denmark had a two party system, in which the peasant's political party 'Venstre' (the Left) opponed 'Højre' (the

Right, the conservatives) in a struggle for obtaining equal voting right for peasants. When this was accomplished in 1901, Venstre was the biggest party in parliament.[84]

In sum, after the 1870's Danish society got an agricultural stamp, and this surely gave the industrialization process an agrarian 'style'; as an indication, in 1897 54% of the Danish steam engines were applied in food industry, and no less than 33% of the total stood in dairy works (see appendix 5, table 8)! But it must also be said that the impact of agriculture on the Danish Industrial Revolution has been obscured by the perpetual efforts of Grundtvigian schools, Venstre and other peasant organizations to emphasize this role of agriculture and by doing so certainly have influenced Danish collective memory. Therefor it must not been forgotten that dairy works and bacon factories, the pride of the peasant organizations, were a phenomenon of the 1880's and 1890's, while actually the industrialization process started half a century earlier (in 1840 according to Hyldtoft).

A second characteristic of the Danish Industrial Revolution is, that (contrary to England and Belgium) first after 1890 an industry fitting the traditional image of industrialization emerged, with large scale production and modern labour machines (Hyldtoft), technical concentration (Willerslev) and financial concentration (Munch, Willerslev and Hansen). Nils Elvander has explained the dominating position of small manufacturing firms before 1890 by the almost exclusive production for the home market.[85]

Industrial production for the home market and a production that was typically concentrated in towns (primarily Copenhagen) may be further elements of a Danish style of industrialization; yet, these features faded away when the export oriented agriculture-based industry emerged in the 1880's and 1890's.

Finally, when industrialization is assessed as the growth of the industrial sector relative to agriculture and counted in the share of the labour force employed in these sectors, the Danish Industrial Revolution seems to have had a gradual character compared to its surrounding countries (Norway, Sweden and Germany), Belgium and England, while it was comparable to Holland.[86]

1.5: An impression of the Danish Industrial Revolution

In this chapter I have attempted to give an impression of the Danish industrialization process, by juxtaposing a number of those strategies for comprehending this event which have had considerable influence upon the Danish industrialization debate. Generally speaking these strategies converge on their definition of industry, commonly denoting "manufacturing establishments with more than five workers"; yet, in more recent accounts the traditional handicraft trades and dairy works/bacon factories are included, while earlier they were counted as 'handicraft' resp. 'agriculture'.

Munch, Willerslev and Hansen approached the Industrial Revolution as a breakthrough of a decade or two, and noticed decisive developments in the early 1870's (regarding the 'Industrial Revolution' as the emergence of new ownership forms and violent class struggles), between 1855 and 1872 (seeing the 'Industrial Revolution' as abnormally high increases in the numbers of industrial firms and workers in Copenhagen and the large province towns) and in the second half of the 1890's (defining the 'Industrial Revolution' as accellerated industrial and economic growth).

After 1972 it became more popular to approach Industrial Revolution as a process rather than a breakthrough; in Hyldtoft's strategy it was a 70-years process consisting of different phases with varying rates of mechanization, labour increase and product innovation, while Kristensen perceived it as a 40-year process departing from macro-economic indicators similar to Hansen's.
Also since 1972 the 'Industrial Revolution' conception was extended to a process with various aspects, among which changes in the industrial environment, the emergence of the industrial entrepreneur as a social category and technological development.
In paragraph 1.4 I have attempted to trace a specific Danish style of industrialization, and found a central role of agriculture, dominating small scale production before the 1890's, production for the home market and a particular town industry (both mainly before the 1880's) and a comparatively gradual character of industrialization. In this context it is interesting that also in Holland small scale production dominated before the 1890's, and although Holland traditionally was a typical trade country, also here agriculture was important and accounted for a large share of the economic growth; Rik Steenaard and Harry Lintsen even found here an explanation for the relatively late breakthrough of 'modern' industry, i.e. in Holland "steam had to compete with fertile land". But in contrast to Danish industry, Dutch industry produced both for the national and international (not in the least the colonial) market.[87]
Finally, it seems that the trends in international research sketched in the introduction of this essay influenced the course of the Danish industrialization debate. While Munch approached the Danish Industrial Revolution primarily with institutional criteria and qualitative indicators, Willerslev joined the international trend using economic categories and statistic method; and in his time, Hansen was inspired by modern economic growth theory (Rostow, Cameron). Furthermore the theory behind Hyldtoft's strategy was derived from economic cycle theory (and especially Schumpeter's contribution to this), which experienced a revival after the crises of the early 1970's, and currently the internationally reniewed interest in technological development is being implemented in Danish industrialization research.

Chapter 2: Steam engines in 19th century Denmark and Holland

2.1: Steam engines and the Industrial Revolution

Having considered several aspects of changing nineteenth century Denmark in the previous chapter, I will now focus explicitely upon the steam engine innovation. My intention is conclude this chapter with suggestions for a comparative investigation on the developmental path of this steam engine in Denmark and in Holland, in which I am interested from a technology-historical point of view; before that, however, I would like to address the relationship between the steam engine innovation and the Industrial Revolution.

Georg Nørregaard's suggestion that 'modern development followed the introduction of the steam engine' is one way of expressing what may be called the 'classical' interpretation of the relationship between the steam engine innovation and the Industrial Revolution, suggesting that the steam engine triggered massproduction in factories, mechanization and economic growth. This classical view has roots back to the late 18th century, when contemporaries applauded James Watt's improvements of the Newcomen steam engine as the greatest invention the Western world had seen (possibly excluding the ship). One century later economic historians confirmed this notion; Arnold Toynbee asserted that general mechanization would have been retarded had the prime mover (cotton industry) not been mechanized, and that of all great inventions in cotton industry none would have revolutionized English industry unless Watt's patents had been applied. He pictured a hierarchy of inventions, with the new energy source at the top.[88] This idea was widely adopted. Illustrative is John Sandfort's (1962) suggestion that when in the 18th century the first applicable heat engines were built, Western civilization entered a new power era; exploitation of the huge energy resources of the Earth caused the remarkable emergence of our high-tech society, the rise of particular countries as military super powers and the highest living standards ever seen.[89] In 1969 David Landes expressed a similar but yet more nuanced view, posing that without the steam engine "the development of mechanized industry concentrated in large units of production would have been impossible", and that the steam engine had "revolutionary effects on the pace of economic growth" because it consumed mineral fuel and hence made available to industry a "new and appearantly boundless source of energy". Yet coal and steam were necessary but not sufficient causes of industrial performance: they did not make the Industrial Revolution, but permitted its extraordinary development and diffusion.[90] Also W.W. Rostow imagined the steam engine, causing "radical reduction in cost of power", as having "revolutionary consequences over a wide range of industrial processes in 1800 Britain.[91]

A diametrically opposite stand towards the 'classical' interpretation of the relation between steampower and the Industrial Revolution was taken by G.N. von Tunzelmann, who in 1978 asserted that the steam engine only marginally contributed to economic growth during the British take-off (1783-1802). He assessed this contribution by tracing the spinn-offs of the steam engine generated through its forward and backward linkages (effects on industries undergoing mechanization resp. effects on output and innovation in industries supplying raw materials). The backward linkage to iron industry was negligible; even in the 1790's, when the production and sales of Watt engines peaked, their iron consumption constituted less than 0,25% of the annual

domestic output in iron industry. The backward linkage to coal industry was more profound. Von Tunzelmann also doubted the persistance of forward linkages; firstly, by counterfactual analysis he assessed the 'social savings' that accompanied the use of steam technology, defined as "the quantum of scarce resources formerly tied up in production now released to seek employment in other productive enterprises". So the hypothetical replacement of all Watt engines by the older Newcomen engines (which they presumably replaced) in the year 1800 would raise costs with merely £233.000, mostly additional fuel costs (£185.000)[92]; with an estimated national income in 1800 of £210 million, this implies that the social savings of the Watt engines were a tiny 0,11% of the 1800 national income.[93] Likewise the hypothetical replacement of all steam engines by water wheels, the cheapest available power alternative at the time, would raise costs by £500.000, implying that the social savings of steam technology were only 0,2% of the 1800 national income![94] A second questionable forward linkage is the steam engine's stimulation of general mechanization in Britain's take-off stage; the most famous inventions in cotton industries were designed for human-, animal- or waterpower. Furthermore, normally large cotton mills were waterpowered, and the emergence of the factory system may be attributed to water power as well as steam power.[95] Although the range of von Tunzelmann's calculations is necessarily limited, his rejection of all three causal links posed by the 'classical' view offers quite a different interpretation of the effects of the Watt engine on Britain's take-off; as he remarks ironically, possibly "Watt's major gift to early nineteenth century English society was in reducing the level of smoke pollution below that created by the atmospheric engines."[96] And even this had its reverse, since the more widespread use of Watt engines in town area caused an acceleration of pollution problems! It was first in the 1840's, half a century after the take-off, that cheaper forms of steampower became available and steam power acquired important forward linkages.

In 1981 another scholar of economic history, Donald McCloskey, reached a different conclusion from a different perspective. He stressed two major events in 18th and 19th century Britain: an enormous increase in population and dito in national income. The latter was rather surprising, since the national income should be expected to fall due to the growing population according to both historical evidence and economical reasoning: more people produce more, but less in proportion to their increase if the tools and land they work with do not increase as well (the 'law of diminishing returns'). According to McCloskey considerable technical improvement broke this cycle, "ingenuity ... governed the Industrial Revolution".[97] Locating this ingenuity, he concluded that the modernized sectors (those employing new iron and steam technology) contributed to the growth of the British national income between 1780 and 1860 with 0.52% per annum on a total growth of 1.19% per annum. This implies that the sectors without steam and iron contributed with 0.67% per annum, having a lower growth of productivity rate (0.6% a year towards 1.8% a year) but a considerably larger part in the total production output of the country than the modernized sectors. Hence, 'ordinary' innovations can explain most of the rise of the British national income, but "the great inventions ... deserve special attention, for their effects were indeed out of proportion to the sizes of the industries in which they flourished."[98]

Recently R.A. Buchanan has critizised counterfactual method such as used by von Tunzelmann and McCloskey for its "developing such speculations with a considerable degree of statistical specificity", which "remains historically hazardous because there is literally no telling how things

would have happened without the coming of the steam engine"; in other words, many spinn-off effects may remain invisible for the statistical eye.[99] Nevertheless I would like to emphasize the great value of the counterfactual contributions, explicitely questioning the myth of absolute determinism which can easily come to surround the steam engine innovation.[100]
Regardless of the probematic assessment of the exact relation between steam technology and the Industrial Revolution, the fact remains that 19th century industry massively adopted the steam engine as a power source, and therefore it was certainly a technological key feature of industrialization. In the following I will approach this innovation from a technology historical angle, and therefor approach the Industrial Revolution primarily as a replacement of traditional power sources (human, animal, water and wind) by steam power.

2.2: Steam in Denmark and in Holland: an initial basis for a comparative investigation

a. The phenomenon of technology transfer
The 'classical' interpretation of the steam engine innovation, which I have addressed above, tends to coincide with a deterministic view on its diffusion; the technically and economically superior new technology is presumed to spread out like an uncontrollably expanding ink stain, demanding only sufficient infrastructure to reach other localities and replace traditional inferior technology. Accordingly, technology historical accounts tend to focus upon the 'headers' of technological innovation, while the 'copiers' are passed by.
Yet, in addition to the questionable unambiguity of a new technology's technical/economical superiority[101], this view with its conception of technology as an autonomous force in history offers only a very poor notion of technology transfer. When instead technology is conceived as a form of human activity (and a part of human culture), previously invisible nuances appear in the process of technology transfer: after imitation technologies may be actively recreated in a thousand ways in order to make them fit the demands of their new users (adaption), and simultaneously traditional technologies may be radically altered in the face of the new competitor(s). This variation of old and new technology and the resulting choice situation depends upon the specific social and physical environment, and hence one basic technology may follow very different developmental paths in different localities. Thomas Hughes, who has illustrated this point for the transfer of electric light and power systems, remarked in this context that "exploration of the theme of technology transfer leads easily to the question of style, for adaption is a response to different environments and adaption to environments culminates in style."[102] Likewise, Harry Lintsen has related the Dutch steam engine innovation to a specific Dutch technological style of small scale technology. Such nuances in technology transfer are often neglected in technology studies, but 'when we have overcome the facination for the pioneers and spearpoints in technology a new scene opens up, nl. the various ways in which humans make use of the technical possibilities.'[103]
It is in this context of investigating the intriguing process of technology transfer that I intend to compare the steam engine innovation in Denmark and Holland.

b.An initial basis for a comparative investigation
As a point of departure for such a comparative investigation to the steam engine innovation in

Denmark and Holland I would like to address the numerical spreading of steam technology in both countries, thus provisionally neglecting the style aspect. But statistical information on the number of companies using steam technology, the number of steam engines and the amount of power installed is incomplete and uncertain; hence, such information can only provide an initial impression of (1) the chronological gravity points of innovation and (2) the location of the innovation centres. Furthermore, if a numerical comparation of steam innovation is to have any meaning, it must be related to the country's population size; notably, in 1850 France considered itself a backward nation with regard to steam technology employing around 5.000 steam engines gathering some 63.000 horsepowers, while Belgium was generally considered a leading country with 2.000 steam engines gathering some 51.000 horsepowers and thus having a considerably higher 'steam density'.[104] During the 19th century Denmark and Holland were countries of comparable area, while the latter had ca. twice as many inhabitants.[105]

According to Hyldtoft's figures steam technology was a rarity in Denmark around 1840, when 19 companies used 333 hp. steampower. In 1855 their number had risen to 174 using 1586 hp., in 1882 885 companies used 11326 hp. steampower and by 1897 steam had become a major energy force in Danish industry and handicraft, being employed by almost 3000 companies gathering around 39000 hp. (see appendix 4, table 6). Between 1839 and 1897, the amount of steam power installed increased steadily with more than 7% per annum. In order to assess the time when the steam engine became a crucial factor in Danish power supply, one can address the ratio of steam power and other forms of mechanical power; this provides some difficulty, however, since figures for windpower are missing (see appendix 4, table 7). If windpower is excluded, Hyldtoft's figures suggest that steam power accounted for 62% of industry's mechanical power as early as 1855, a number that was increased to 87% by 1897. Simultaneously, the share of water power decreased from 38% to 5%. But it must be borne in mind that these figures build upon an industry definition of manufacturing companies with more than five workers; if smaller companies as well as wind power are included, the picture looks radically different. In 1897 no less than 859 companies used waterwheels while the previous calculations include only 62, and 2719 companies employed windpower. Since 2996 companies used steam, 704 gas and 188 petrol, in 1897 wind- and waterpower was still as persistent as power derived from mineral fuel when assessed as the number of companies using it[106]; this lead Hyldtoft to conclude, that steam probably first became dominant in the 1890's.[107]

Steam technology figures for Holland, processed by Steenaard and Lintsen for the period before 1850 and by Mariani for the period after 1850, suggest that in 1829 Dutch steam had a similar position as Danish steam a decade later, i.e. only 38 steam engines were installed.By 1839 there were already 152, by 1853 392 and by 1884 3796, gathering over 47000 hp. in over 3000 companies. In 1913 5000 companies used steam (see appendix 6, table 9 and table 12). The steam share of the total amount of mechanical power in Dutch industry is calculated by Blanken and Lintsen as ca. 10% in 1850; in 1904 steampower accounted for 81%, while wind- and waterpower were reduced to 11% and combustion engines made up 8% of the industrial mechanical power, see figure 3.[108] Appearantly steam overtook wind- and waterpower's dominating position in power supply in the 1870's, but my not knowing the statistical background for these figures forbids direct comparation with the Danish case. Nevertheless, the figures above clearly reveal that, in

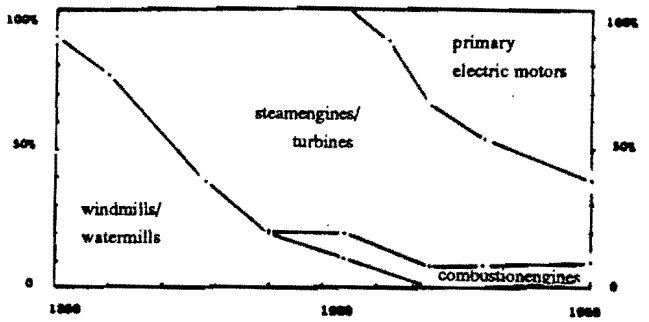


Figure 3: Dutch power engines relative to total power 1850-1950 [109]

contrast to England and Belgium, both Denmark and Holland innovated relatively late, nl. in the second half of the nineteenth century.

An impression of the gravity centres of innovation may be obtained from statistics on the application of steam technology in different branches of industry. For Denmark, I have only consulted the 1897 industry census (see appendix 5, table 8); here it shows that food industry accounted for the largest share of Danish steam technology in 1897, with 54% of the total number of steam engines and 36% of the total amount of steampower. Within food industry, a considerable share was made up by the dairy works (with 33% resp. 13% of the total amount of steam engines and steampower). Other branches crucial to steam in 1897 were metal (8% resp. 8%), brickworks (6% resp. 7%), woodworks (8% resp. 7%) and textile (6% resp. 11%); in the latter, cotton weaving dominated (3% resp. 7%).

For the Dutch case I have consulted statistics for the period 1824-1882, as processed by Steenaard and Mariani (see appendix 6, tables 10, 11 and 13). Also in Holland food industry was a key branch, having the largest share of the total amount of steam engines since 1850 (ca. 30% between 1850 and 1882). But in 1882 dairy works were of minor importance, while corn mills accounted for 9% of the total Dutch steampower. Before 1850 textile industry had most steam engines; after 1850 it's share of the total amount of steam engines fell to 11-12%, of which in 1882 cotton weaving accounted for 3% but also for 7% of the total Dutch steampower. Other relevant branches were chemical industry (22% of all steam engines in 1856, 13% in 1872), woodworks (7% of all steam engines in 1856 and 1882) and machine factories (8% of the gathered steampower in 1882).

In sum, the impression prevails that several branches of industry were more relevant for the steam engine innovation than others: a comparative investigation of Danish and Dutch steam technology may especially lean on developments in food industry (dairy works, corn mills), the importance of which indicates the previously mentioned 'agrarian style' of industrialization of both countries. Other important branches for the steam engine innovation were metal industry (machine factories), textile (cotton weaving), chemical industry, brickworks and woodworks.

Yet, it needs to be stressed that further consultation of statistics is necessary; for Denmark I still lack figures for other years than 1897 (dairy works were a typical phenomenon of the 1880's and 1890's!), for Holland the years later than 1882. But assessment of these data is beyond the ambition of this chapter, and I hope to have provided an initial basis for a comparative investigation of the steam engine innovation in Denmark and in Holland.

Summary:

An underlying objective of this essay on the Danish Industrial Revolution was to gain an impression of the society in movement that surrounded the steam engine innovation in the 19th century, an innovation I plan to investigate closely in a future project. I have proceded by juxtaposing those strategies for comprehending the phenomenon Industrial Revolution, which have had major importance for the industrialization debate in Denmark. Furthermore I have tried to accentuate some features of the Danish industrialization process which may be national-specific and indicate a kind of 'Danish style' of industrialization.
Secondly I have addressed the connection between the Industrial Revolution and the steam engine innovation, and concluded with a brief consideration of some basic statistics on steam technology in Denmark and Holland.

International literature is rich of strategies to tackle the phenomenon 'Industrial Revolution'. Some approached it as the rise of industrial capitalism, the establishment of the factory system or a general trend of mechanization (or a combination of these). Others defined it as an acceleration of economic growth, a 'take-off into sustained growth'. And those primarily interested in technological development may approach the Industrial Revolution plainly as a replacement of traditional production technology (wind- and waterwheels, wooden tools) by modern production technology (steam engines, iron machines).
As a point of departure in the Danish industrialization debate I have taken the work of P. Munch, written in the early 1940's. Here, based upon qualitative indicators such as the emergence of joint stock companies and serious labour conflicts, Denmark's industrial breakthrough is placed in the early 1870's. As explanation Munch stressed two institutional causes, nl. the 1857 Trade Act (giving industry the freedom to choose location) and the 1863 Tariff Act/the 1864 war with Prussia (reducing competition from Schleswig/Holstein), the consequences of which enabled an industrial breakthrough in the next high conjuncture period (the early 1870's). Munch's institutional explanations have later been denied by others.
In the early 1950's this 'traditional' view of an industrial breakthrough in the early 1870's was challenged by Richard Willerslev, suggesting an industrial breakthrough between 1855 and 1872. Following an international trend, Willerslev used statistic method to illustrate accellerated industrial activity in Copenhagen and some larger province towns in this period, i.e. he counted a rapidly increasing number of industrial firms and industry workers. Explaining the sudden breakthrough he used an economic category, nl. the trade surplus based upon export of agricultural products to Great Britain which provided the financial means to industrialize.
Svend Aage Hansen, writing in the early 1970's, approached the industrial breakthrough with a macro-economic strategy, i.e. he followed Rondo Cameron's definition of this event as (1) radical changes in agriculture's, industry's and commerce's relative shares of the gross domestic product (to the advance of industry, of course), (2) accellerated growth of the value of industrial production and (3) substantial growth of the economy as a whole (the gross domestic product pr. inhabitant). From this point of view, Hansen located the industrial breakthrough in the second half of the 1890's.

After Hansen's work the 'breakthrough' view became obsolete. This does not imply that the substance in the contributions of Munch, Willerslev and Hansen became less valuable; rather, it was argued that to call one period for a breakthrough at the expence of another is pointless since this nomination is based upon arbitrary criteria. Illustrative for the newly arising strategies approaching the Industrial Revolution as a process is Ole Hyldtoft's approach of Copenhagen's industrialization as a 75 year process (1840-1914), thus comprizing Munch's, Willerslev's and Hansen's periods of accellerated industrialization. Inspired by Schumpeterian theory Hyldtoft departed from the changes in capital, labour and product areas as indicators of industrialization; these indicate three phases in Copenhagen's industrialization, an 'in-depth' phase (1840-1865) with many new production areas, new technologies and an accellerated trend towards a capital intensive industry, an 'in width' phase (1865-1896) in which expansion occurred mainly within established production areas, and again an 'in depth' phase (1896-1914).
With a strategy radically different from Hyldtoft's, but fairly comparable to Hansen's, Niels Kristensen (1989) also concluded that the 'industrial breakthrough' was at least a 40-year process. This may illustrate that the 'process-approach', as contrasted to the 'breakthrough-approach', became conventional in industry historic research.
In addition to the new process view, since 1974 the field of industry historical research was considerably widened. Attention was paid to subjects previously neglected, such as the changing industrial environment (the physical and social surroundings of the industry workers), technological development and the emerging social category of industrial entrepreneurs. This trend cleared the way for a conception of the Industrial Revolution as a process with numerous aspects.
In order to relate the Danish industrialization process to developments elsewhere, I have attempted to identify some of these aspects as elements of a specific Danish style of industrialization. So agriculture played a crucial role in Denmark's economical development in general as well as its industrial development, i.e. a large part of especially post 1880 industry was based upon agricultural products (not in the least dairy works and bacon factories). Also there was and is a tendency in traditional Danish peasant institutions, which were and are comparatively powerful in Danish society and certainly capable of influencing Danish collective memory, to emphasize Denmark's agricultural roots again and again; therefor it is important to remember that the Danish industrialization process started half a century before it obtained an agrarian style.
Another feature of the Danish Industrial Revolution is that first after 1890 firms adopted large scale production.
Finally, Danish industry was traditionally primarily a town industry (especially concentrated in Copenhagen) producing mainly for the home market. Yet these two characteristics of Denmark's industrialization process faded away, when the export oriented argiculture based industries emerged in the 1880's and 1890's.

Having considered some aspects of changing 19th century Denmark, I then turned to the steam engine innovation. The exact relation between this innovation and the Industrial Revolution is hard to assess; yet it is obvious that although steampower was a major factor in industrialization, it can easily be subject to technological or economical determinism, regarding steam technology as autonomically determining the way of history. In this respect, inspite of their necessarily limited

calculation range, I would like to attribute great value to counterfactual analyses (von Tunzelmann) challenging this myth, by arguing that steam technology only contributed marginally to economic growth in the take-off stage.

Furthermore, a determinist view generally coincides with the description of the steam engine diffusion as an uncontrollably expanding ink stain, where human interference is reduced to a predestined copying. Yet technology historical studies of the 1980's have pointed out that technology transfer is a lot more; technological innovation is a form of human activity, and humans may recreate new technology in a thousand ways according to their specific situation. Consequently, new technology may develop radically different in different physical and social environments, which shape the technology in their own style; it is in this context of studying the intriguing process of technology transfer that I plan to investigate the steam engine innovation in Denmark and Holland.

An initial basis for such an investigation may be provided by statistical material, hence provisionally neglecting the style aspect and taking for granted omissions and uncertainties. The information I reconsiled reveals that both Denmark and Holland innovated massively well in the second half of the 19th century; furthermore, the most crucial branch for steam technology innovation was food industry, especially in Denmark. Other branches attractive for further investigation are metal-, textile- and chemical industry, brickworks and woodworks, but additional assessment of statistical data is desirable.

Literature:

Bagge, Povl , "Anmeldelse af Richard Willerslev", in "Historisk Tidsskrift" (11.r/ 4.b/ pp.105-122), Copenhagen 1953-56

Bakker/van Hooff/Lintsen/Verbong 1988, "Industrialiseren en renoveren in de 19e eeuw", in "het Jaarboek voor de Geschiedenis van Bedrijf en Techniek" nr.5/1988

Bender, Henning 1987, "Aalborgs Industrielle Udvilking fra 1735 til 1940", Aalborg Kommune

Bertholet, C., "Een terreinverkenning in de probleemgebieden van de ontwikkelingssociologie", material for the course 'Inleiding in de ontwikkelingsproblematiek' in 1988, intern publication Eindhoven University of Technology

Blanken,Ivo/Lintsen,Harry 1981, "Mechanical power in the industrialization of the Netherlands (1850-1950)", later published in "Energy in history, the topicality of the history of technology", ICOHTEC, Düsseldorf 1984

Boje, Per 1976, "Det industrielle miljø 1840-1940", Akademisk Forlag, Copenhagen

Broch, Birte 1990, "Arbejderboliger i Køge købstad omkring 1900", in "Fabrik og Bolig" nr.1/1990, pp.3-15

Brugmans, I.J. 1967 (1925), "De arbeidende klasse in Nederland in de 19e eeuw 1813-1870", Aula boeken, Utrecht

Buchanan, R.A. 1991, "Theory and Narrative in the History of Technology", in "Technology and Culture" vol.32/no.2

Busck, Steen/Christensen, Jens/Jepsen, Asger 1973-74, "Klassestrukturen i Danmark 1870-1920", "Den Jyske Historiker" nr.3-4

Comte, Auguste 1974 (1820), "A brief appraisal of modern history", in "The Crisis of Industrial Civilization - the early essays of Auguste Comte", R.Fletcher(ed.), H.E.B., London, pp.79-110

Christiansen, Niels Finn 1989, "Fagbevægelsens historie", Fagbevægelsens Interne Uddannelser

Danish membership commitee of the World Energy Conference, "National Energy Data Profile - Denmark", 14th W.E.C. congress, 1989

Danmarks Statistik 1988, "Data on Denmark", Copenhagen

Deane, Phyllis 1979 (1965), "The first Industrial Revolution", Cambridge University Press

Dybdahl, Vagn 1975, "Industrialisering og folkestyre 1849-1939", Gyldendal, Copenhagen

Elklit, Jørgen 1986, "Det klassiske danske partisystem bliver til", in "Valg og Valgeradfærd", Elklit/Tonsgaard(ed.), Politica, Århus

Elvander, Nils "Skandinavisk arbetarrörelse", Stockholm

Encyclopedie voor Zelfstudie - deel III, Beeloo(ed.), Universiteit voor Zelfstudie, The Hague/Antwerpen

Fisher, E.J. ,"Historiografie van de Nederlandse nijverheid in de periode 1815-1930", in "diktaat 'Geschiedenis van de Techniek'", Eindhoven University of Technology

Greve 1987, "Grundbog i arbejdsmarkedsforhold", Kaleidoscope, Copenhagen

Gundelach, Peter 1986, "Bøndernes organisering i 1800-tallet", in "materialesamling til 'politisk introduktionskursus'", Department of Political Science, University of Aarhus

Gyldendals Leksikon "Fakta i fire bind", Gyldendals Bogklubben, Copenhagen 1990

Hague,R/Harrop,M 1987, "Comparative Government and Politics, an introduction", Macmillan, London

Hansen, Svend Aage 1970, "Early industrialisation in Denmark", G.E.C. Gads Forlag, Copenhagen

Hansen, Svend Aage 1972, "Økonomisk vækst i Danmark - bind 1", Universitetsforlaget/G.E.C.Gads Forlag, Copenhagen

Houten, B.C. van 1983, "Techniek, wetenschap en maatschappij in historisch perspectief", in "Techniek, Innovatie en Maatschappij", Vaags/Wemelsfelder (ed.), Utrecht

Houten, B.C. van 1986, "Techniek geschiedenis, een historiografische beschouwing", in "het Jaarboek voor de Geschiedenis van Bedrijf en Techniek" nr.3/1986

Hughes, Thomas P. 1987, "The evolution of large systems", in "The social construction of technological systems", Bijker/Hughes/Pinch(ed.), the MIT press, Cambridge/London

Hyldtoft, Ole 1978a, "Industrial buildings and dwellings. The industrial environment in Denmark 1840-1940", in "Industrial buildings and dwellings nr.2/1978", pp.34-46

Hyldtoft, Ole 1978b, "From fortified town to modern metropolis. Copenhagen 1840-1914", in "Growth and transformation of the modern city", The Stockholm Conference 1978, University of Stockholm

Hyldtoft, Ole 1984, "Københavns industrialisering 1840-1914", Systime, Herning

Hyldtoft, Ole 1987a, "Med vandkraft, dampmaskine og gasmotor. Den danske industris kraftmaskiner 1840-1897", in "Erhvervshistorisk Årbog 1987/pp.75-126

Hyldtoft, Ole 1987b, "Københavns industrialisering 1840-1914. En kommentar om teorier, faser, dampmaskiner m.v.", in "Historisk Tidsskrift" nr.87-2/1987

Hyldtoft, Ole 1987c, "Den teknologiske udvikling i dansk industri i det 19. og 20. århundrede -en introduktion til litteraturen", in "Fabrik og Bolig" nr.1/1987

Hyldtoft, Ole 1991, "anmeldelse af Henning Lauridsen", in "Fabrik og Bolig" nr.1/1991, pp.42-44

Hyldtoft, Ole 1991b, "Fra fæstning til moderne storby. København 1840-1914", unpbl. paper

Ibsen/Jørgensen 1979, "Fagbevægelse og Stat 1: den faglige organisering, arbejdskampe og staten 1870-1930", Gyldendal, Copenhagen

Jensen,Henrik/Thiersen,Ib 1980, "Verdenshistorie", Gyldendal, Copenhagen

Johansen, Hans.Chr. 1988, "Industriens vækst og vilkår 1870-1973", Odense Universitetsforlag

Johansen,Hans Chr./Boje,Per/Møller,Anders M. 1983, "Fabrik og Bolig - det industrielle miljø in Odense 1840-1940", Odense Universitetsforlag

Jonge, J.A. de 1976 (1968), "De industrialisatie in Nederland tussen 1850 en 1914", SUN, Nijmegen

Kirstein, Thormod 1933, "Fra Haandværk til Industri i Danmark", 'Faglig læsning' nr.56

Kragh, Helge 1991, introduction to "i Røg og Damp - kapitler fra dampmaskinens indførelse i Danmark ca. 1760-1840", preliminary version

Kristensen, Niels B. 1989, "Industrial Growth in Denmark 1872-1913 - in relation to the debate on an industrial breakthrough", in "Scandinavian Economic History Review" nr. 1989/1

Landes, David .S. 1980 (1969),'The Industrial Revolution in Britain", in "Geschiedenis van de Techniek", E.J.Fisher(ed.), Martinus Nijhof, The Hague

Lintsen, Harry 1985, "Van windbemaling naar stoombemaling; innoveren in Nederland in de negentiende eeuw", in"het Jaarboek voor de Geschiedenis van Bedrijf en Techniek" nr.2/1985

Lintsen, Harry 1988, "Stoom als symbool van de industriele revolutie", in "Het Jaarboek voor de Geschiedenis van Bedrijf en Techniek" nr.5/1988

Lintsen, Harry 1990, "Een revolutie naar eigen aard - technische ontwikkeling en maatschappelijke verandering in Nederland", Delft University of Technology

Lintsen/Steenaard 1990, "Stoom en het vruchtbare land, Belgie en Nederland 1790-1850", unpubl.

Mariani, Tonino 1988, "De kleinschalige toepassing van de stoomtechniek in Nederland in de periode 1950-1920: appendices", unpubl., Eindhoven University of Technology

Markussen, Ole 1985, "Dansk industrihistorie - præsentation af et forskningsområde", in "Fortid og nutid" nr.32/2 1985

Marx, Karl (1867), "Capital Vol.1", progress publishers, Moscow

Marx,Karl/ Engels,Frederick (1848), "Det kommunistiske manifest"

Mathias, Peter 1983 (1969), "The first industrial nation - an economic history of Britain 1700-1914", Methuen London/N.Y.

Mikkelsen, Flemming 1980, "Industrielle foretagere i Odense omkring 1870", in "Erhvervshistorisk Årbog", 1980

McCloskey, D.N. 1981, "The Industrial Revolution 1780-1860: a survey", in "The economic history of Britain since 1700, Volume 1: 1700-1860", Floud/McCloskey(ed.), Cambridge University Press

Munch, P. 1942, "Det Danske Folks Livsvilkaar 1864-1914", in "Schulz Danmarkhistorie - bind 5", Friis/Linvald/Mackeprang(ed.), J.H.Schulz forlag, Copenhagen, pp.491-675

Nielsen,Keld/Nielsen,Henry/Jensen,Hans S. 1990, "Skruen uden ende - den vestlige teknologis historie", Teknisk Forlag, Copenhagen

Sandfort, John F. 1965 (1962), "Varme, Arbejde og Energi i Teknikkens Tjeneste", Gyldendals kvantebøger, Copenhagen

Shapiro, J.S. 1962, "Movements of social dissent in Modern Europe"

Statens Statistiske Bureau 1899, "Danmarks Haandværk og Industri ifølge tællinger den 25. maj 1897", in "STATISTISK TABELVÆRK 5.r, litra A, nr.1", Copenhagen

Steenaard, Rik 1989, "Stoom en Stoomwezen, 1824-1850", unpublished paper, Eurasmus University Rotterdam

Tetzschner 1979, "Arbejdsmarkedets parter - kollektieve arbejskonflikter", Nyt fra Samfundsvidenskaberne, Copenhagen

Thomsen, Niels 1985, "Anmeldelse af Ole Hyldtoft", in "Historisk Tidsskrift" (14.r, 85.b, pp.328-342)

Thomsen, Niels 1991, "Industri, Stat og Samfund 1870-1939", Odense Universitetsforlag

Tunzelmann, G.N. von 1978, "Steam power and British Industrialisation to 1860", Clarendon Press, Oxford

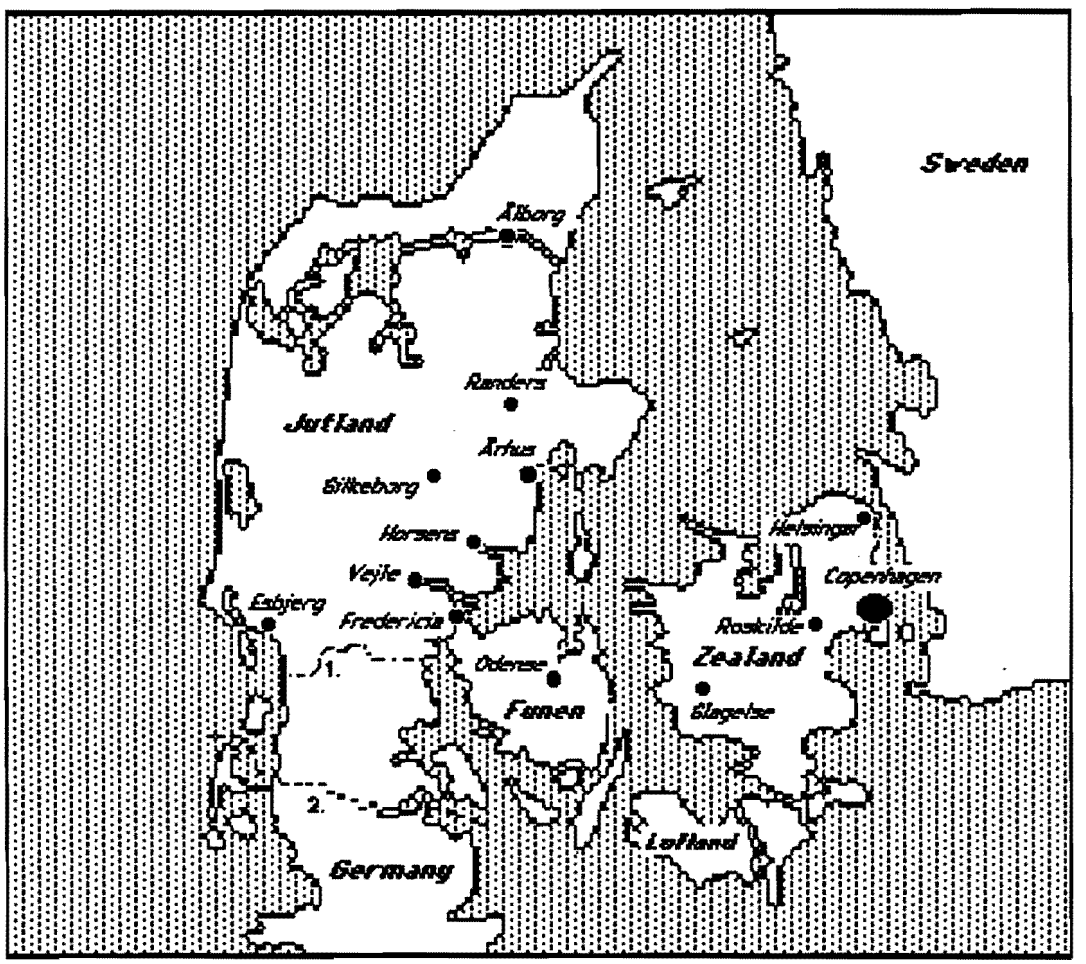
Weber, Max 1982(1904/05), "Samfunnvitenskapenes 'objektivitet'", in "Makt og Byråkrati", Gyldendals Studiefakler, Oslo, pp.161-220

Willerslev, Rich. 1952, "Studier i dansk industrihistorie 1850-1880", Einer Harcks, Copenhagen

Willerslev, Rich. 1954, "Træk af den industrielle udvikling 1850-1914", in "Nationaløkonomisk Tidsskrift" 1954/pp.242-262

Østergård, Uffe 1988, "Bøndere og danskere - et essay om dansk mentalitet og politisk kultur", in "Historien i kulturhistorien", Wåhlin(ed.), Århus Universitetsforlag

Appendix 1: Map of Denmark
(incl. a selection of main industrializing towns)



1.= Danish-German border 1864-1920

2.= present Danish-German border

Appendix 2: A selection of Richard Willerslev's figures

Table 1: Average annual increase in the numbers of industrial firms and industry workers in Copenhagen and the provinces 1855-1914, exclusive 'interest on interest'

	Copenhagen		Province towns		Rural districts		Denmark	
	F	W	F	W	F	W	F	W
1855-1872	8,3%	12,5%						
1872-1906	2,7%	2,7%	3,1%	4,6%	2,6%	4,5%	3,0%	3,9%
1906-1914	1,0%	3,2%	1,1%	1,9%	1,8%	2,2%	1,2%	2,5%

F= firms annual increase, W= workers annual increase

These approximate figures are calculated from **Willerslev 1954, p.250 (table 2)** and demand some remarks:
(1) the absolute figures on which they are based differ slightly from the figures presented by Willerslev in 1952, which is probably due to his efforts to make his different sources commensurable;

(2) against the figures of table one may be argued, that an incline in small absolute fugures always shows an overproportionally large incline in relative numbers; Willerslev, however, anticipates such criticism by emphasizing that the absolute industrial labour force incline between 1855 and 1872 matched that of 1872-1897;

(3) Willerslev neglects 'interest on interest' in his calculations. According to Willerslev, the Copenhagen industrial labour force increased from 4380 to 13700 workers in the 17 years between 1855 and 1872 (Willerslev 1954, p.247,table 1) , matching a three-fold (13700/4300= 3,13) or a 213% increase (313%-100%). Now, neglecting 'interest over interest', he deduces that the annual increase was 213%/17=12,5%.
This last figure, however, is not what is generally understood as an 'annual increase': if the Copenhagen industrial labour force increased its number with 12,5% each year, it would end up in 1872 with 4380 * 1,125 * 1,125 * 1,125 * ... = 4380 * $(1{,}125)^{17}$= 4380 * 7,4= 32.412 workers, which would imply a 640% increase (740%-100%) over 17 years rather than 213%!
Instead, the 213% increase from 4380 to 13700 in 17 years implies a $\sqrt[17]{(13700/4380)-1}$= 0,069 or 6,9% real annual increase (a calculation including 'interest on interest'). In general formula:

$$b = (1+x)^n * a \qquad \text{or} \qquad x = \sqrt[n]{(b/a)-1}$$

in which a= beginning year value,
b= ending year value,
n= number of years,
x= annual increase, x * 100 = annual increase in pct.

I have chosen to quote Willerslev's original figures in table 1, assuming that they nevertheless provide an impression of the contrast between Copenhagen and the provinces when industrial development is concerned; in the rest of the essay, 'interest on interest' is included in annual increase figures.

Appendix 3: A selection of Svend Aage Hansen's figures

Table 2: Distribution of the Danish gross domestic product at factor cost by sector (pct.) 1855-1967

	1855	1870	1890	1900	1930	1939	1956	1967
Primary sector	55,7	50,1	37,8	30,2	21,1	18,5	18,8	9,4
Secundary sector	19,8	20,0	22,3	26,2	27,6	32,1	35,2	40,1
of which: Manufacturing industries	3,8	4,3	6,5	9,9	11,6	15,5	17,8	19,2
Handicrafts	11,9	11,8	12,3	10,0	8,7	9,5	8,6	9,4
Tertiary sector	24,5	29,9	39,9	43,6	51,3	49,4	46,0	50,5

(N.B. the rest category in the secundary sector is made up by public works and building/construction works)

source: Hansen 1970, p.11 (table 1)

Table 3: Annual growth rates (pct.) of industry in net value of production

	annual growth(%)		annual growth(%)
1855-1872	4,7	1890-1897	7,2
1872-1882	4,4	1897-1905	4,4
1882-1890	4,8	1905-1913	5,4

source: Hansen 1970, p.14 (table 2)

Table 4: Annual growth rates of the gross national income (GNI) and the gross national income per worker (GNI/W) in pct. 1857-1914

	GNI	GNI/W
1857-1868	2,1	1,0
1868-1876	2,3	1,5
1876-1894	2,2	1,5
1894-1914	3,5	2,3

sources: Hansen 1972, p.239 (table IX.6) and p.23 (table I.3).

The figures are based upon the gross national income figures in fixed (1929) prices.

Appendix 4: A selection of Ole Hyldtoft's figures

Table 5: The industrial labour force and mechanical power in the Capital area 1831-1914

	ind. labour force (estimate)		mechanical power*		
	number	annual increase(%)	firms number	horse power number	annual increase(%)
1831	5900	1,4	5	55	16,3
1839	6600	3,2	14	183	9,8
1847	8500	2,8	47	386	9,9
1855	10600	4,0	82	819	6,1
1873	21400	3,1	182	2384	6,8
1897	44800	1,8	780	11500	9,2
1906	52000	2,1	1257	25443	8,6
1914	61500		2104	49100	

* incl. mechanical power in firms with less than six workers

source: Hyldtoft 1984, p.52, table 3

NB. For 'Copenhagen' the figures were only marginally lower than for the 'Capital area' (see Hyldtof 1984, p.485, tables C1 and C2)

Table 6: Steampower in Danish industry and handicraft 1839-1897

	industry, >5 workers[1]		handicraft + industry[2]		
year	companies	hp.	companies	hp.	annual hp. growth
1839	19	333	19	333	10,3
1855	156	1500	174	1586	7,8
1872	394	4733	528	5640	7,2
1882	585	9556	835	11326	8,6
1897	1256	34176	2996	38926	

1. incl. building/construction works, gas works and water works, excl. electricity works

2. excl. building/construction works, gas works, water works and electricity works

source: Hyldtoft 1987a, p.95, table 3

*Table 7: Mechanical power in Danish industry (>5 workers) 1839-1897**

	1839		1855		1872		1882		1897	
power form	companies	hp.	comp.	hp.	comp.	hp.	comp.	hp.	comp.	hp.
steam	19	333	156	1500	394	4733	585	9556	1256	34176
gas	-	-	-	-	5	8	50	131	443	2607
petrol/electricity	-	-	-	-	-	-	-	-	105	526
water	?	?	58	934	60	1330	61	1806	62	2000
wind	?	?	67	?	45	?	46	?	71	?

* incl. building/construction works, gas works and water works, excl.electricity works

source: Hyldtoft 1987a, p.77, table 1

Appendix 5: Additional figures on Danish steam power

Table 8: steamengines/horsepower pr..branch for handicraft and industry in 1897, according to the 1897 industry census

branch	steam engines(1)	hp.(2)	% of total steam engines(3)	% of total hp.(3)
food industry	1883	17048	54,0	36,0
of which: dairy works	1146	6115	33,0	12,9
malt/beer manufacturing	167	2320	4,8	4,9
corn and rise mills	158	3067	4,5	6,5
sugar refinaries	126	2498	3,6	5,3
metal industry	294	3747	8,4	7,9
of which: iron foundries, machine works and ship yards	230	2727	7,0	5,8
stone/clay/glass industry	283	5604	8,1	11,8
of which: brickworks	214	3421	6,1	7,2
wood industry	261	3253	7,5	6,9
of which: saw mills and wood carving	206	2280	5,9	4,8
textile/clothing industry	223	5047	6,4	10,7
of which: weaving/carpet factories	106	3491	3	7,5
spinning mills	74	785	2,1	1,7
chemical industry	135	1436	3,9	3,0
furniture industry	61	645	1,7	1,4
leather industry	51	297	1,5	0,6
paper industry	50	1652	1,4	3,5
book industry	22	187	0,6	0,4
subtotal:	3263	38916	93,5	82,2
building/construction works	98	2343	2,9	4,9
water works	56	1775	1,6	3,7
gas works	45	320	1,3	0,7
electricity works	27	4035	0,8	8,5
total:	**3489**	**47389**	**100,1**	**100**

(1). owned steam engines

(2). incl. rented steam engines

(3). incl. building/construction-, water-, gas- and electricity works

source: Statens Statistiske Bureau 1899, pp.146-157, table 7A

Appendix 6: Dutch steampower

a. 1824-1850

Table 9: number of steam engines in Holland 1800-1851

branch	1800	1829	1839	1851	% of total s.e. in 1851
textile	-	12	58	68	23,3
metal	-	12	24	49	16,8
mining	-	4	4	2	0,7
others	<5	10	66	173	59,2
total	<5	38	152	292	100

source: Lintsen/Steenaard 1990, table 1

Table 10: number of factories using steam power pr. branch , inspectorate reports[1]

branch	1824	1829	1839	1849
food industry	0	1	12	43
textile indusry	2	6	29	40
chemical industry	0	2	11	20
metal industry	0	5	10	17
ship/carriage industry	0	1	1	8
wood industry	0	1	3	4
steam engine factories	0	0	1	4
paper industry	0	0	3	4
others	0	1	4	11
total	2	17	74	152

source: Steenaard 1989, p.34, table 4

Table 11 steamengines /horsepowers installed in factories pr. branch ca.1850, inspect. reports[1]

branch	steam engines	horse power	% of total s.e.	% of total hp.
food industry	54	589	31,2	26,8
textile industry	40	527	23,1	23,9
metal industry	21	402	12,1	18,3
chemical industry	17	218	9,8	9,9
ship/carriage industry	9	126	5,2	5,7
steam engine factories	7	82	4,0	3,7
paper industry	7	74	4,0	3,4
wood industry	4	64	2,3	2,9
others	14	118	8,1	5,4
total	173	2200	99,8	100

source: Steenaard 1989, p.40, table 5

1. Tables 10 and 11 are based reports of security inspectors, and hence must be considered incomplete. In addition, the province of Limburg is excluded in both tables. After comparation with other sources, Lintsen and Steenaard have estimated that they represent ca. 50% of the steam engines installed in Holland (see Lintsen/Steenaard 1990, p.23, note 2 and table 9 above)

b. 1850-1914

Table 12: companies with steam power , steam engines and steam power 1853-1913

year	1853	1856/58	1862	1872	1884	1901	1913
companies	378	585	825		3117	4787	5019
steam engines	392	598	941	1822	3796		
steampower (hp.)	7193	8444	12512	21403	47271		

source: Mariani 1988, pp.16-25

Table 13 Dutch steam engines and power per branch 1856-1882

	1856/58		1872		1882		% of s.e.			% of hp.		
branch	s.e.	hp.	s.e.	hp.	s.e.	hp.	1856	1872	1882	1856	1872	1882
food industry	178	2403	685	6559	1064	?	29,8	37,6	30,2	28,5	30,6	-
of which: corn mills	56	905	-	-	242	3661	9,4	-	6,9	10,7	-	8,8
corn chandlers	29	226	-	-	136	870	-	-	-	-	-	-
beetroot factories	-	-	-	-	242	2366	-	-	6,9	-	-	5,7
dairy works	-	-	-	-	100	1157	-	-	-	-	-	-
sugar refinaries	40	447	-	-	52	629	6,7	-	-	5,2	-	-
beer breweries	-	-	-	-	75	670	-	-	-	-	-	-
chemical industry	132	1964	241	2417	-	-	22,0	13,2	-	23,3	11,3	-
of which: oil/fat/soap	39	722	87	1208	136	2554	6,5	-	-	8,6	5,6	6,2
textile industry	74	1094	389	6615	390	-	12,4	21,4	11,1	13,0	30,9	-
of which: cotton spinning	16	245	-	-	-	-	-	-	-	-	-	-
cotton weaving	7	188	-	-	104	3073	-	-	-	-	-	7,4
cloth factories	-	-	-	-	80	2279	-	-	-	-	-	5,5
metal industry	85	1193	-	-	-	-	14,2	-	-	14,1	-	-
of which: machine factories	22	277	-	-	291	3171	-	-	8,3	-	-	7,7
ship yards	13	139	18	168	85	1248	-	-	-	-	-	-
wood industry	40	567	111	1434	259	4044	6,7	6,0	7,4	6,7	6,7	9,8
of which: sawing mills	31	493	-	-	-	-	5,2	-	-	5,8	-	-
stone/clay/glass industry	8	111	51	584	-	-	-	-	-	-	-	-
paper industry	10	94	53	927	77	1967	-	-	-	-	-	-
printing industry	-	-	53	173	88	431	-	-	-	-	-	-
building/construction works	11	118	-	-	-	-	-	-	-	-	-	-
gas works	14	78	-	-	72	366	-	-	-	-	-	-
rest												
Total:	593	8444	1822	21403	3519	41322[1]						

[1] .extrapolation between 1872 (21403 hp.) and 1884 (47271 hp.), see table 12 above

source: Mariani 1988, pp.14-35

[1] Mathias 1983, p.6

[2] Deane 1979, p.4

[3] Bertholet, p.1 (my translation)

[4] Deane 1979, p.19 and McCloskey 1981, p.103

[5] Comte 1974

[6] see Shapiro 1962, pp.25-29

[7] see Marx/Engels (1848) and Marx (1867), p.446

[8] Jensen/Thiersen 1980, pp.238-243

[9] see Brugmans 1967, p.15

[10] Deane quotes Ashton and Hoffmann, Deane 1979, p.3

[11] De Jonge 1976, pp.339-243 and Deane 1979, p.3

[12] Mathias 1983, pp.1-2

[13] De Jonge 1976

[14] Bertholet, pp.1-7

[15] van Houten 1983, p.50

[16] Hyldtoft 1984, pp.38-45 and pp. 423-424

[17] Bakker/van Hooff/Lintsen/Verbong 1988, pp.67-68

[18] Kristensen 1989, pp.3-4

[19] Johansen 1988, p.11

[20] Markussen 1985, p.81

[21] in their historiographic accounts of industry-historic research Per Boje, Ole Hyldtoft and Ole Markussen have all related the significance of Munch, Willerslev and Hansen to the discussion on the industrial breakthrough, see Boje 1976, pp.25-28, Hyldtoft 1984, pp.23-26 and Markussen 1985, pp.84-89

[22] see Boje 1976, Hyldtoft 1984 and Markussen 1985

[23] in 1864 Prussia and Denmark fought the Second Schleswig War, and according to the Vienna Peace treaty Denmark had to abandon its claims on Schleswig, Holstein and Lauenburg

[24] Munch 1942, pp.491-492. By the way, urbanization is not a very good indicator for industrialization, although this is often suggested; it was the tertiary sector that expanded fastest in this period, and may be hold responsible for a large part of this urbanization

[25] Munch 1942, pp.568-569

[26] Munch 1942, p.573

[27] Munch proceeds from the published 1871/72 industrial censuses, which did lodge a category 'factories and factory driven handicraft'; but the decision of what was to be included in this category was left over to the judgement of each city- or regional counsil, because contrary to other industrial censuses (1855, 1882) the 1871/72 inquiry did not operate with a predefined list of occupations. See Willerslev 1952, pp.36-37

[28] see Christiansen 1989 and Ibsen/Jørgensen 1979

[29] Munch 1942, p.672

[30] the main part of the Act was enacted by law in 1857; yet, some paragraphs were first enacted in 1862 (for example guilds were allowed to exist until then)

[31] see Hyldtoft 1984, p.24 and Boje 1976, p.48

[32] Nørregaard 1942, p.114 (my translation)

[33] Nørregaard 1942, p.116 (my translation)

[34] Markussen 1985, p.85

[35] he also transforms the unreliable 1871/72 censuses (used by Munch) into a more reliable '1872 census',which he constructs with the aid of two other unpublished censuses held in the same years

[36] a number of industrial branches included in the 1872 census were excluded in the 1855 census; to make the censuses commensurable, Willerslev subtracts the firms and workers attached to these branches from the actual 1872 figures (417 resp. 15.700)

[37] Helsingør expanded from 16 firms and 288 workers in 1855 to 17 firms and 920 workers in 1872, Roskilde from 7/65 to 19/199, Slagelse from 3/56 to 15/301, Odense from 23/556 to 61/1647, Århus from 29/483 to 42/992, Fredericia from 12/282 to 17/622, Vejle from 7/61 to 18/173, Horsens from 16/288 to 17/920 and Silkeborg from ? to 9/327. For Ålborg no information is available for 1855

[38] Willerslev asserts a relation between the town size and its rate of industrialization. Proceeding from the proportion of the total town population employed in industry as an indicator, he shows that the largest towns as a rule had the highest percentages of industry workers in 1870/72: in Odense (17.000 inhabitants) 9,7% of the population worked in industry, in Horsens (10.500 inh.) 8,8%, in Fredericia (7.200 inh.) 8,6%, in Ålborg (11.799 inh.) 8,3%, in Århus (15.000 inh.) 6.6 % and in Randers (11.400 inh.) 5,8%. In Willerslev's list of towns with a proportion of industry workers over 4% appear only four towns with less than 3.000 inhabitants. Thus, oversimplifying the results of his research, Willerslev asserts that between 1855 and 1872 Copenhagen and the larger province towns experienced an industrial breakthrough, while province towns of average size showed only moderate progress and small towns remained untouched by the phenomenon of industrialization-Willerslev 1952, pp.80-81.
Yet Willerslev's method is criticizable; Copenhagen had a low industrial worker percentage, since many other occupations were attached to the capital. Furthermore Willerslev neglected those small province towns which were build around industry and consequently had the highest percentages in his list (Frederiksværk, Silkeborg).

[39] compare Willerslev 1954 table 3 (p.252) with table 1 (p.247)

[40] between 1895 and 1900 the industrial labour force in Copenhagen increased in average with 7,5% a year, and in the provinces with no less than 10,7% a year; these figures are calculated from Willerslev 1954, p.255, and I have neglected 'interest on interest', so that the figures can be compared to the figures in appendix 2, table 1

[41] Willerslev acknowledges that these statistics are unreliable due to emissions (Willerslev 1952, p.87), and besides an increase in firms using steam power is of course a very incomplete measure for technological development

[42] Willerslev 1952, p.242

[43] According to Hansen the export ratio (in value of industrial production) rested around 10% as late as the 1890's, see Hansen 1970, p.18

[44] Bagge, pp.108-109

[45] Bagge, p.122

[46] Hansen 1970, p.8

[47] Hansen 1970, p.64

[48] Hansen 1970, p.9

[49] Hansen 1970, pp.10-11

[50] Hansen 1970, p.12

[51] hence Hansen's measure is an expression for productivity increases; if 'person' refered to 'population', it would be an expression of the material living standard increases - Hansen 1972, pp.11-12

[52] source: Hansen 1972

[53] Hansen 1972, pp.304-312

[54] Hansen 1970, p.26

[55] Munch 1942, p.594

[56] Hansen 1970, p.67

[57] Boje 1976, pp.27-28

[58] Hyldtoft explains this special position of the Danish Capital by some extra advantages besides the advantages of any Capital for industrial firms; besides a large local market, relatively modern transport and communication possibilities, a large and varying labour market and presence of the main part of Denmark's political, administrative, financial and cultural institutions Copenhagen offered a well situated harbour, and since natural resources played an unimportant role in Danish industrialization all these advantages had extra weight (there was no incentive to settle near for example coal mines in the provinces), Hyldtoft 1984, p.11

[59] for example the Copenhagen industrial labour force in 1855 was much larger than previously assumed, nl. nearly twice as large as Willerslev suggested, see appendix 4, table 5

[60] the exact chronological boundaries of these phases are derived from the conjuncture situation (each phase begins with a rise) and influential institutional criteria (the 1863 Tariff Act/the 1864 loss of the duchies and the First World War

[61] source: Thomsen 1985, p.341. Originally Thomsen used the figure to deny the existance of phases in Copenhagen's and Denmark's industrialization, and indeed the figure confirms a high mechanization rate relative to labour force increases during the entire period 1840-1914. As Thomsen said, it is a matter of temperament how the figure is interpreted; while he chose to emphasize the long term tendency towards a more capital intensive industry, Hyldtoft focussed upon medium term variations within this trend - see Thomsen 1985, p.338 and Hyldtoft 1987b, p.352

[62] Hyldtoft 1984, p.79

[63] Hyldtoft 1984, p.425

[64] incl. production of electrical machines, Hyldtoft 1984, p.286

[65] Bender 1987, p.464 - my translation

[66] these periods were 1808-1818, 1840-1857, 1870-1875, 1895-1899, 1908-1920 and 1933-1940

[67] Hyldtoft 1991

[68] in this context I would like to refer Hyldtoft's criticism of Svend Aage Hansen, who applied Rostow's general criterion of a rise of annual investments from 5 to 10% of the national income upon a specific country, Denmark. Rostow presumably based his criterion upon the famous Harrod-Domar capital output model, C=v*Y, in which C=Capital, Y=production result and v=capital coefficient, normally estimated to have the value 3. Hence, with Y= C/3 a 5% annual investment increase gives a 1,7% annual production increase, which is minimal in real terms if the population grew simultaneously with 1,5% (which wasn't abnormal). Yet a 10% annual investment increase would cause a 3,3% production increase, twice the growth of the population; if investment maintained at this level, there would be a real growth in production per inhabitant, and this constitutes Rostow's 'take off into sustained growth'.
Hyldtoft argues that the criterion is useless for Denmark in the 1890's. The theory presupposes a constant value of the capital coefficient around 3, thus assuming that labour expanded in tact with capital. Yet in Denmark the annual growth rate of labour decreased considerable in the late 1890's, especially relative to the mechanization rate (which represented capital); consequently the capital coefficient must have increased, and Rostow's 10% investment increase probably gave a much lower production increase than expected. Hence, this 10% boundary can be said to have an arbitrary character - and is therefore useless for an exact chronological location of half a decade of industrial breakthrough. Furthermore, in Denmark the 10% investment level was not maintained; after 1899 it fell to 5-7% of the national income, and stayed there until the First World War, thus making a 'take off' at this time rather doubtful (Hyldtoft 1984, pp.60-65).

[69] however, Kristensen is very aware of the fact that such a statement shouldn't be based upon one or two indicators only, and besides the average annual growth in this period (5,2%) did not deviate markedly from the prior and subsequent period (1850-1872: 4,7% and 1920-1939: 4,5%) - Kristensen 1989, pp.18-20

[70] Markussen 1985, pp.90-93

[71] for a presentation of the project, see Hyldtoft 1978a

[72] the following account is based on Hyldtoft 1978b and Hyldtoft 1991b

[73] Johansen/Boje/Møller 1983, pp.361-363

[74] according to Richard Willerslev Køge (situated south of Copenhagen) increased its number of industrial firms between 1855 and 1872 from 5 to 11, and its industrial labour force from 117 to 183.

[75] Broch 1990, pp.4-14

[76] Mikkelsen 1980, p.118

[77] see Kragh 1991

[78] van Houten 1986, p.39

[79] Lintsen/Steenaard 1990

[80] Kirstein 1933, pp. 20-21

[81] Dybdahl 1975, p.13

[82] see Gundelach 1986

[83] see Østergaard 1988

[84] see Elklit 1986

[85] see Elvander; as a second explanation for Denmark's small scale production Elvander mentioned the comparatively large production of consumption goods, where his point of reference are the other Nordic countries

[86] Norway industrialized later but faster than Denmark, while Sweden experienced a veritable industrial boom - that is, according to Elvander's figures on developments in the labour distribution per sector. A comparation with Fisher's figures learns that Denmark's industrialization also was more gradual than Belgium's and Germany's, while Holland industrialized at similar rate:

Share of the labour force employed in industry(%)

	1870	1890	1910
Denmark	24	26	28
Norway	16	22	25
Sweden	13	19	29

source: Elvander, p.24 (table II:2)

Share of the labour force employed in industry(%)

	1850	1880	1910
United States	17,7	25,0	32,1
Belgium		38,7	50,1
Germany		36,5	52,0
Holland	27,7		33,4

source: Fisher, p.65 (table 4)

[87] for an attempt to distinguish a Dutch style of industrialization, see Lintsen 1990

[88] von Tunzellmann 1978, p.2

[89] Sandfort 1965, pp.11-12

[90] Landes 1980, pp.148-152

[91] von Tunzelmann quotes Rostow 1975, von Tunzelmann 1978, p.4

[92] these costs include fixed and variable costs for both Watt engines and their pirates

[93] von Tunzelmann 1987, pp.141-149

[94] for many locations probably no satisfactory stream was at hand; to correct for this situation, von Tunzelmann doubled the water power costs per horsepower in his calculations, so that water power becomes more expensive than steam power. But still then the additional costs of water power would only be £2,2 million, of which £1,7 million returned to the owners of water rights. Hence, the netto difference was merely £500.000 - von Tunzelmann 1978, pp.149-156

[95] von Tunzelmann 1978, p.289

[96] von Tunzelmann 1978, p.288

[97] McCloskey 1981, p.108

[98] McCloskey 1981, pp.114-117

[99] Buchanan 1991, pp.367-368

[100] while Sandfort's proclamation has a distinct determinstic sound, Landes' view may be characterized as a kind of 'soft' determinism, following Lynn White jr.'s notion that 'a new device merely opens a door; it does not compell one to enter' - see van Houten 1986, p.25

[101] in the steam engine case unambiguous economical superiority was doubtfull in the early 19th century, where water and wind power presumably provided cheaper alternatives; and with respect to technical functioning, the early steam engines had a considerable breakdown risk and explosion danger.

[102] Hughes 1987, p.68

[103] Lintsen 1990, p.14 (my translation)

[104] Steenaard 1989, pp.27/28

[105] The Danish and Dutch population in the 19th century:

Denmark 1850:	ca. 1,4 milj.
Denmark 1900:	ca. 2,4 milj.
Holland 1850:	ca. 3,1 milj.
Holland 1900:	ca. 5,0 milj.

sources:
Danmarks Statistik 1988, p.4, Lintsen/Steenaard 1991, table 2 and De Jonge 1976, p.260

Danish and Dutch area

Denmark at present:	ca. 43000 km^2
Holland at present:	ca. 36000 km^2
Northern Slesvig at present:	ca. 4000 km^2

sources:
Danmarks Statistik 1988, p.2, Encyclopedie voor zelfstudie, p.193 and Gyldendals Leksikon 1990, p.1170

Since Holland had approximately the same area in the second half of the previous century and Danmark lacked Northern Slesvig from 1864 to 1920, their areas were of comparable size.

[106] Statens Statistiske Bureau 1899, p.157

[107] Hyldtoft 1987a, pp.76-78

[108] Lintsen 1985, p.48

[109] source: Blanken/Lintsen 1981, p.4