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Productivity studies in Nordic building- and construction industry



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Foreword

I joined the project as project manager in June 2002, when half of the planned time was spent. It has been a challenge to limit the disturbance caused by such disruption of the working processes. By stretching the project period, the team has fulfilled its task, hopefully to the satisfaction of the readers of this report and the project's principals.

The report reflects the intellectual and practical challenges within the wide and complex field represented by keywords like *productivity*, *efficiency*, *benchmarking*, *quantification*, *accuracy*, *comparability*, etc. It also reflects the challenges of cooperation across national borders, even in the Nordic region where *closeness*, *familiarity*, *short distances* and *long time of cooperation* are the relevant keywords.

The report is structured and produced in a certain way: Based on agreed main thematic chapters, I initially submitted a first version of the report. This contained draft of the general parts and the presentation of the Norwegian r&d project under the heading "Norway", chapter for chapter. The next step was for my four colleagues in the project to add information about productivity related r&d activities in their own country *under their own national heading*. No editorial adjustments have been made to the individual, national sections. Thus, the report reflects the width of the r&d work in the field of productivity in the Nordic countries – or to be more precise – the broad understanding of the expression *productivity studies*. I had wanted the report to become more consistent, but on the other hand it gives a true picture of the activities and communication within the project.

I regard the project and this report to be a comprehensive platform for further r&d activities concerning productivity in the Nordic countries. In this respect, a criterion of success is *continuity*. Basically, a step-by-step adoption of common measuring rules and preferred parameters should be conducted. Where international standards exist, like the one covering area and volume measurements (ISO 9836), these should be applied in all countries. This is not the current situation, unfortunately. Eventually, when a set of comparable parameters exists, the joint method for measuring and benchmarking can be decided – and real benchmarking carried out.

During the project period, we have cooperated closely with building- and construction companies and organisations of the industry. Their need of knowledge about own capacity, and general interest in this subject, is another basic condition for success. Adequate project data, provided by the contractors or the owners, is mandatory. The project has confirmed that it is possible to establish suitable, anonymous databases for project based productivity studies within one country. A Nordic database should be achievable, as much as the dominating contractors are operating across the borders between the Nordic countries.

Oslo 2004-06-31
Thorbjørn Ingvaldsen
Project manager

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Abstract

The building and construction industry (B&C industry) is important for each nation. In most European countries it has a 5 – 15% share of the total gross national product (GNP). This importance is strengthened by the influence the industry has on the other sectors in each nation's economy.

The B&C industry in all the Nordic countries is exposed. Even if the national industries still dominate as suppliers of B&C services in own countries, they occasionally experience competition from B&C industry situated in other European countries. To keep their "competitive edge", continuously improvement programs are necessary. An industrial, scientific approach in the improvement work, including productivity measurement and statistic analyses, as recommended in the ISO 9001 international standard, should therefore be given high attention.

In each country the national statistic institutions serve the society and industry with information. This information is mainly based on GNP and other "macro economy" figures, and thereby of limited value for operational decision-making in companies. For evaluation of performance at operative level in B&C industry, it seems necessary to have project-based information. The Nordic productivity project can form a State-of-the-Art concerning r&d activities in this respect. Evaluation of performance, by statistical productivity measurement or other techniques, should be carried out continuously and in small steps. The industry and the r&d institutions in the Nordic countries can cooperate fairly efficiently and should thereby be able to reach a common method for successful execution of long term benchmarking in B&C industry.

Even if there are traditions in the Nordic countries for productivity studies, there are only given public presentation of a few. The last one, a doctoral thesis at University of Luleå, Sweden, was published in 1996. Continuity in productivity r&d in each country is essential if the wanted benchmarking across the national borders shall be reality. Today, the way of studying productivity/efficiency differs between the five countries. In Norway and Finland a non-parametric efficiency analysis, called Data Envelopment Analysis (DEA), is tried taken into use. This scientific method for ranking of building project based on their ability to "produce much for less", needs total project cost and a quantitative description of the project. In Sweden, Denmark and Iceland the productivity evaluation is done through different ways of comparing prices as such, both total prices and prices of building components and elements of the building processes. Attention is put on clients' costs, thus including cost of land, feasibility studies, handling charges etc.

The difference in presented cases emphasises how wide the field of productivity studies is. In worst case this can cause a long time of cooperation before reaching a common method of productivity measurement. On the other hand, the fulfilled Nordic productivity project and this report can make it happened sooner, if the

summary of challenges and possibilities will be taken into consideration when new initiatives are taken. The members of the Nordic productivity project have experienced with some frustration, that the r&d activities in each country are not addressing the same questions at exactly the same time. For the period of this Nordic project, only Norway has had a large, ongoing project on the productivity field. Hopefully the experience from this project will lead to increased efforts and parallelism at this topic, as well as others, in the future.

The building process (value adding chain) is described more or less similar for all the Nordic countries. Though not completely like, the five nations do structure the process, calculate the costs and measure the product fairly similarly. The understanding of productivity and theories regarding measuring also cope. All together, this should ease future, common benchmarking project retry.

Regarding the results of earlier productivity studies, the main conclusion is that the (low) quality of input data causes uncertainty. It seems obvious that the efficiency fluctuates with the general “rise and fall” in local economy. But we are still in lack of knowledge about how to rank projects and how to identify factors that stimulate or pull down productivity/efficiency. The thematic attention to productivity is actualised through the impression that “some alarming things” started to happen to the productivity/efficiency about the years 1993-95 in (almost) all the Nordic countries. If there ever will be an explanation on this is hard to say, but the observation itself should encourage all B&C industries to support further research on the field.

An overall question has been if existing knowledge in each of the countries can be merged together in a joint Nordic knowledge, and if there can be created a common practice concerning productivity measurement and analysis with increased competitive capacity in the companies as result. State of Art is dominated of the lack of relevant data, lack of experience with suitable methods and lack of a common, profound interest of making productivity studies in B&C industry a permanent part of the industry. The challenge is to establish common interest, professional environment and funding for systemized, scientific attention to the problem of efficiency in building and construction industry.

1 Introduction

This report summarizes the studies and discussions carried out by a working group from five research institutes in each of the five Nordic countries in six workshops during the years 2001 – 2004.

The background for the project, funded by the Nordic Innovation - norinnovation.no - (former Nordic Industrial Foundation, NI), is that there in all Nordic countries has been an increased attention to the question of productivity in building and construction industry (B&C industry) in the later years. Productivity in B&C industry is a topic of high attention in many countries, see f. ex. Minchin, 1999 (Australia), Egan, 1998 (Great Britain). The increased interest might be explained by increasing building- and construction cost in general and also by the common opinion saying that the B&C-industry doesn't cope with other types of industries with respect to productivity.

During the seventies, eighties and nineties most attention and effort is put on cost administration, time management, quality management, environmental issues, health- and safety management and other important aspects of the production. This seems to have brought the production process itself, and identification of productivity improvement initiatives by statistic methods, into the shadows. This is what the critics say, and they mean that it is causing increased costs and higher prices for the customers.

To meet the challenge of increasing costs by more efficient processes, new initiatives like "Concurrent engineering", "Total quality management", "Lean construction", "Just in time" and "Construction process-reengineering" has been launched. Their aim has been to improve capacity of the companies and projects. Different R&D-projects have been established, both in the Nordic countries and other countries, to study and support such productivity focusing initiatives.

The B&C-industry is facing severe challenges when improving the productivity is the subject. One reason is that the industry doesn't have the adequate statistics for carrying out efficiency analysis. Such information is needed to have continuously answered the question: "Are we competitive?" Equipment for collection and processing production data for general benchmarking is still missing. To establish series of empirical data is resource- and time consuming. Thus, a common Nordic effort on this field can generate increased efficiency itself. For the future, one can dream of a common method for collecting and processing statistical data in a Nordic database for productivity. A realistic first step is good understanding of the state of the Art in the Nordic countries. This includes the discussion of productivity measurement methods and the information about the development and achievements in this field. The latter is the ambition of the Nordic productivity synergy project, e.g. exchange information about productivity studies in each country to bring knowledge and ideas to the B&C-industry in each country. The ultimate goal is enhanced productivity and essential profit to the companies involved.

1.1 Potential

In documentation from governments, like major national plans and budgets; productivity is pinpointed as main qualification for national growth. It is mandatory for competitiveness and industrial success. The B&C industry involves many people and is an important service provider for all other industrial and national infrastructure. Its focus is the domestic markets in own country. Through the purchasing of products and services the influence on the total employment in a country is high. In average, approximately 7% of the employed in the Nordic countries are B&C industry staff, and over twice this number of employed persons are influenced by it.

The B&C industry has had low attention on scientific approach. When it comes to industrialisation and productivity improvement, the normal approach is to identify improvement initiatives by intuition (“gut feeling”) and carry them out without further measurements or analyses. Other industries have for a long time been using benchmarking and statistical methods in their continuous improvement programs. As the production in B&C industry is of low recurrence, the establishment of a productivity database is both time consuming and challenging in other ways. On the other hand, much of the procedures and activities are similar from project to project, as it also is from one country to another. Exchange of experience and identification of synergies should therefore be of great importance. Through exchange of information and experiences, based on what is going on in each country, the following has been assumed possible to prepare through a common project:

- *Avoid double work, especial when it comes to the definition of which working processes are of importance and which key figures to be measured and analysed*
- *Identifying similar processes, which again makes benchmarking possible*
- *Develop a base of benchmarking information for all the Nordic countries, which in the next step can serve in benchmarking with other countries in Europe to secure the competitiveness of Nordic B&C industry at an international level*
- *Identification of productivity increasing efforts suitable for cooperated implementation, also with the competitiveness of Nordic B&C industry as the mission.*
- *Develop a professional network, or networks, with participants from the B&C industry, research and development institutes, universities and other stakeholders aiming for innovation and improved productivity.*

It is stated in some Australian R&D work, though not reported yet, that a growth of 10 % in B&C industry generates a growth of 4 % in the gross national product (GNP). Despite the role as a major contributor to the GNP, the B&C industry, through it's domestic orientation, shall not be regarded as a potential common competitor at an international building and construction arena. On the other hand, an efficient B&C industry is of high importance for other industries and trades, as it provides suitable infrastructure, production facilities and suitable buildings and environment, with the lowest possible use of resources. In this perspective the B&C industry should be acknowledged as “Provider of innovative environments for a strong and competitive national – and Nordic - industry”.

1.2 Ambition and goals

In each country, e.g. Finland, Denmark, Sweden, Iceland and Norway, different r&d projects have studied B&C-cost and/or productivity development. Through the six workshops the Nordic productivity project has presented and discussed related papers and relevant information. An overall question has been if existing knowledge in each of the countries can be merged together in a joint Nordic knowledge, and if there can be created a common practice concerning productivity measurement and analysis with increased competitive capacity in each country as a result.

A guiding ambition for the project members has been to identify and present knowledge that can empower cooperation between the Nordic countries on methods and principles for benchmarking of B&C activities, and to carry out benchmarking within the industries in the five countries. The idea of certain common Nordic indicators for productivity, by which initiatives for improvement shall be easier to identify and carry out, has been presented and discussed.

The project was started with following major goals:

1) Carry out an overview on r&d activities on the field of productivity measurement and evaluation in B&C-industry in the Nordic countries. If methods and/or equipment for the purpose are considered to be useful in the common scope, this/these shall be improved and prepared for broader use. Likewise, if there are identified local initiatives of obvious productivity improvement effect, the project shall spread information about this throughout all the five countries.

2) Establish a network for productivity research in the Nordic countries.

- and with following secondary goals:

a) Identify the difference and/or similarities when it comes to the organizing of building and construction projects, and discuss how the productivity is affected by the different ways of conducting the building process.

b) Prepare for developing of measuring methods for productivity in Nordic B&C industry - and propose improvement initiatives with respect to productivity

c) Prepare for benchmarking between B&C companies in all the Nordic countries - and develop productivity indicators for the Nordic B&C industry.

1.3 Distinct goal and scope of work

In the first workshop in the project “Productivity in Nordic building and construction industry”, hereafter named “the Nordic productivity project”, the group had to recognize the enormous width of the theme “productivity in building and construction industry”. Through discussions, the group decided to narrow the attention to *housing*. Due to the ambition of developing common key figures and measuring methods, an even more detailed attention was defined, e.g. the production of residential buildings (blocks of flats). To be able to handle the questions presented as project goals above, the project proceeded with following distinct goals:

1) Carry out an overview on r&d activities on the field of productivity measurement and evaluation in *building of blocks of flats* in the Nordic countries. If methods and/or equipment for the purpose are regarded useful in the common scope, this/these shall be improved and prepared for common use. Likewise, local initiatives of obvious productivity improvement effect should be identified. The project shall also provide information about the activities throughout all the five countries.

2) Establish a network for productivity research in the Nordic countries. The contacts established through the study of blocks of flats should be of a type making this possible.

- with following detailed aspirations:

Identify the difference and/or similarities when it comes to the organizing of building of blocks of flats, and discuss how productivity is affected by the different ways of conducting the building process.

b) Prepare for developing of measuring methods for productivity on *blocks of flats* in Nordic B&C industry - and propose improvement initiatives with respect to productivity.

c) Prepare for benchmarking between B&C companies in all the Nordic countries - and develop productivity indicators for the blocks of flat production here.

1.4 Scope and working plan

The project participants were expected to exchange information about productivity in construction sector through meetings (“workshops”) twice a year in three years, to achieve a broader insight at the field. Through the national activities it was expected to have established a network of productivity studies for the future.

Following workshops have been carried out:

1 Oslo (N)	22 nd and 23 rd of August 2001
2 Tampere (F)	3 rd and 4 th of December 2001
3 Dragør (D)	15 th and 16 th of April 2002
4 Reykjavik (I)	13 th and 14 th of October 2002
5 Borås (S)	7 th and 8 th of April 2003
6 Oslo (N)	16 th and 17 th of February 2004

Minutes from the workshops are transmitted to Nordic Innovation as part of the annual report.

1.5 The project team

Participants in the project has been the following institutions and persons:

Norway:

NBI - Norwegian Building and Research Institute (www.byggforsk.no)

- Grethe Bergly, MSc. (August-2001 – June-2002) - Project Manager
- Thorbjørn Ingvaldsen, MSc. (June-2002 – April-2004) – Project Manager
- Dag Fjeld Edvardsen, Cand. oec. (Workshop 1, in august 2001)

Sweden:

SP - Swedish National Testing and Research Institute (<http://www.sp.se/>)

- Anker Nielsen, MSc, professor (August-2001 – April 2004)

Finland:

VTT, Building and Transport (<http://www.vtt.fi/rte/dms/indexe.html>)

- Antti Lakka, department head (August-2001 – April 2004)
- Tarja Tuomainen, (December 2001 – May-2003)
- Liisa Jaakkonen, (January2003- April 2003)
- Harri Nuuttila (January2003- April 2003)

Denmark:

The Danish Building and Urban Research (By&Byg); (www.byogbyg.dk)

- Jørgen Nielsen, Research Leader (August-2001 – April -2002)
- Niels H. Berthelsen (August-2001 – April -2004)

Iceland:

Rb - The Icelandic Building Research Institute (<http://www.rabygg.is>)

- Hakon Olafsson, (August-2001 – August 2002)
- Benedict Johnsson (August-2001 – April -2004)
- Eyolfur Bjarnason, (August-2001 – April 2004)

The report is written by Thorbjørn Ingvaldsen (general part, N), Antti Lakka (F), Anker Nielsen (S), Niels H. Bertelsen (D) and Benedict Jonsson (I). The representative from each country has written “his” sub-chapter within each main chapter, nominated by the name of the nation. No editorial adjustments have been made to these individual, national sections. The content reflects what each representative regards relevant in connection to the actual main chapter. Within each main chapter, and even most of the sub chapter, there is written conclusive comments by the project manager.

1.6 Conclusive comments

The situation for the B&C industry in all the Nordic countries is challenging in many ways. The national industries still dominate as suppliers of building and construction services in own countries. From time to time, though, they experience competition from building and construction industry situated in other European countries. To keep national/local “competitive edge”, continuously improvement programs are necessary. An industrial, scientific approach in the improvement work, including productivity measurement and statistic analyses, as recommended in the ISO 9001 international standard, should therefore be given high attention.

The Nordic productivity project, here reported, can form a basic State-of-Art concerning joint r&d activities for the industry, telling how it better can “read” the situation and act suitable. Evaluation of performance, by statistical productivity measurement or other techniques, should be carried out continuously and in small steps. The industry and the r&d institutions in the Nordic countries can cooperate fairly efficiently and should thereby be able to reach a common method for precise execution of long term benchmarking in B&C industry.

2 Background

In this chapter the B&C industry is presented through sub-chapters for each Nordic country. First, the building process, or the value chain within building and construction industry, is discussed through different illustrations. Next, attention is put on statistics and data collection in each country. Finally some “historical” works on productivity studies are mentioned.

2.1 B&C activities in the Nordic countries

In the Nordic countries, like in most industrial countries, building and construction is a considerable part of the GNP, see table 2.1.

	Finland	Sweden	Norway	Denmark	Iceland
GNP (total) (mill Euro)	139 700	312 340	190 091	156 590	8 952
Construction sector	19 240	20 400	19 275	8 084	656
B&C/BNP (%)	13,8	6,6	10,1	5,2	7,3
Companies (total)	224 847	842 000	429 910	297 706	8.184
Companies B&C	29 588	57 000	39 191	27 224	656
Comp. B&C/Comp. Total (%)	13,2	6,7	9,1	9,1	8,0
Number of employees, total	2 372 000	4 272 000	2 055 000	2 692 000	156 700
N. of empl. B&C	148 000*	235 000	136 697	173 000	12 200
N. of Empl B&C/ N. of Empl Total (%)	6,2	5,5	6,6	6,4	7,8

* In addition the number of employees in construction products industry is 70.000

Table 2.1, B&C part of total (National statistics, 2002)

The share of construction sector of total GNP is typically between 5 to 15 % in European countries, depending on market situation on short time span – and level of urbanisation on longer time span. The B&C industry is considerably itself, and even more important through the influence on the other sectors in the economy. About the same number of employed within B&C industry is employed in industrial and service branches *related to* the B&C. Of the money invested in the real estate and construction sector, 25-30 % returns to the public sector as direct or indirect taxation (value-added and property taxes) from enterprises and workers, and little below 10 % as social security and employment pension contributions. A significant share of the construction sector’s output is exported in the form of products and projects. In Finland f. ex., exports exceed imports. This means that the construction sector increases the national GNP with foreign earnings. (*Well-being 2003*).

In each country the national statistics collects and publish lot of data about the B&C sector. The published data varies from one country to another depending of the tradition in each country. *The new building statistics* are typically comprehensive unlike *the statistics of renovation and maintenance*, which are more or less educated guesses. The EU Statistics Office *Eurostat* produces comparable information from EU member states based on national statistics. *Euroconstruct* is a network of European research institutes and consulting organisations specialised in the

construction market analyses and forecasts. Euroconstruct uses national statistics as initial data, too – and develops it to comparable and reliable information for decision-makers in general.

The share of renovation construction has been growing up for many years in all the Nordic countries. Another remarkable trend is the decreasing of new building market on long time span. That is the case already, especially in Sweden. The value of Swedish construction market is about the same as in Norway, Denmark and Finland, even if the total size of the economy is larger in Sweden than in other Nordic countries. See table 2.2 and figure 2.1.

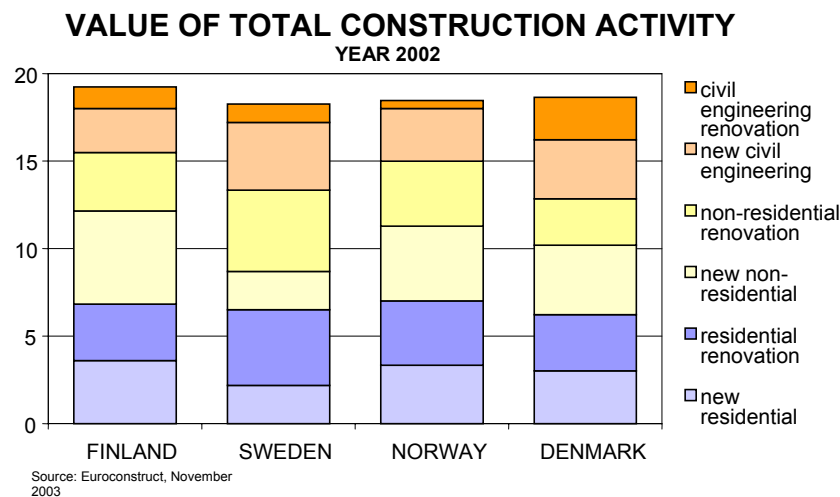


Fig. 2.1 Value of total construction activity in Finland, Sweden, Norway and Denmark 2002 (Euroconstruct 2003)

	Finland	Sweden	Norway	Denmark	Iceland
Residential; new	3,6	2,18	3,34	3,02	0,43
Residential; renovation	3,23	4,33	3,67	3,21	n.a.
Residential; <u>total</u>	6,83	6,51	7,01	6,22	n.a
Non-residential; new	5,32	2,18	4,27	3,97	0,35
Non-residential; renovation	3,34	4,65	3,72	2,66	n.a.
Non-residential; <u>total</u>	8,66	6,83	7,99	6,63	n.a
Civil Engineering; new	2,51	3,87	3,00	3,37	0,32
Civil Engineering; renovation	1,24	1,05	0,46	2,43	n.a.
Civil Engineering; <u>total</u>	3,75	4,92	3,46	5,80	n.a
Total	19,24	18,26	18,46	18,65	(1,11)

Table 2.2 Value of construction sector; Billion Euro at 2002 (Euroconstruct 2003)

2.2 Data collection and statistics

To have reliable information about productivity, data of sufficient quality and in sufficient quantity is mandatory. The main challenge for an organization that is going to study productivity, is to identify the crucial group of data and other information, as well as where this can be found. The next effort is to bring the data and information into suitable processing tool, weather a paper sheet or a computer.

In most country statistics is a public service given high priority. Each of the Nordic countries has its national statistic bureau like Statistics Sweden, Statistics Norway, etc. Information in table 2.2 is collected in each country and processed by Eurostat. Sub-chapter 2.2 informs about the national statistics regarding building and construction industry and especial the part actual for productivity studies.

Building and construction are value-adding processes, e.g. transforming raw materials into a product of higher commercial value. As shown in figure 2.2 the processes are normally involving the three main groups

- contractor
- owner
- user

The basic *sub-group* formed by the sources of production, like materials, working force, machinery etc. is of highest importance when it comes to measuring of productivity¹.

It seems to be an increasing tendency in all Nordic countries that the contractor and the developer are parts of the same company or trust.

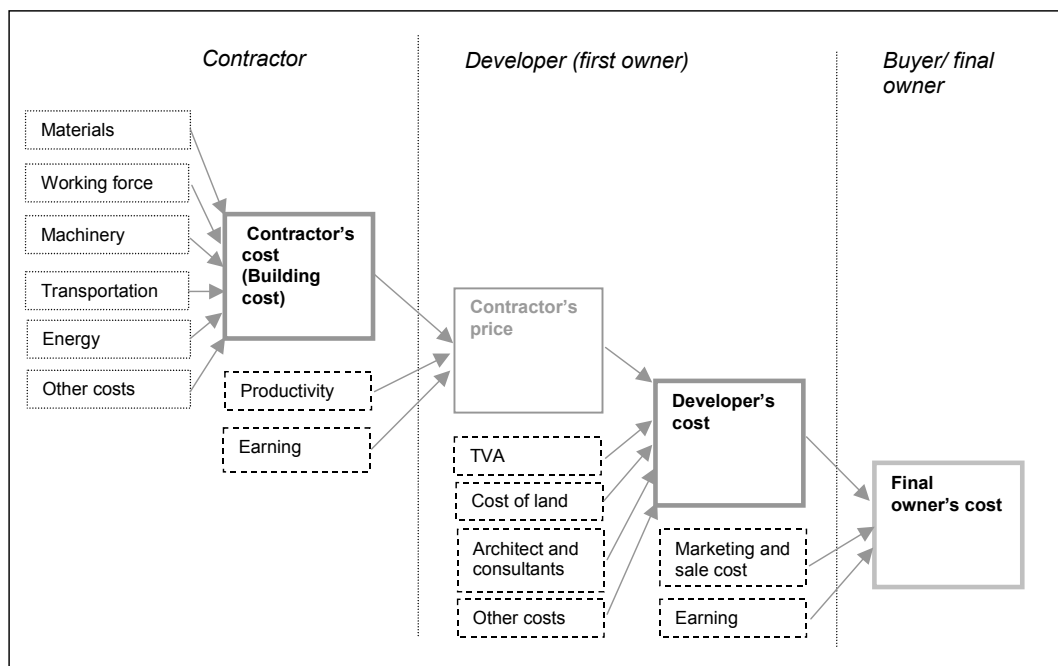


Fig. 2.2 Value chain for building (housing) development – evolving of final price (Owner's cost)

When national statistic bureaucracy collects data, the figure 2.2, originally produced by Eurostat, is an actual reference structure. The figure shows the major steps in the building process from a cost/price focusing point. The basic costs are the prices paid by the contractor for the materials, wages etc. This makes a hub called contractor's cost. When the contractor's earning is added, one component of the developer's cost is given (When the factor "Productivity" is placed where it is, one can understand it as indication of where/when in the value chain this item normally is measured. It is

¹ The figure could as well have the fourth main group, the "Resources/Suppliers", situated to the left of the Contractor and containing the already listed resources (Materials, Working force,).

also a reminder of the fact that it is difficult to part earning and productivity as long as the data is prices at developer/client level).

2.2.1 Norway

Earlier productivity studies in Norway have been based on the data collected by Statistics Norway. Such collection is protected by law and is directed to all types of companies in the B&C industry. The main group providing information regarding productivity is the contractors.

Two types of statistics are presented regarding the B&C industry.

- 1) **Building cost** index for *small houses in wood construction, and similar for blocks of flats* (“input index”), is established to follow the costs in residential construction. The index measures the change in prices of the input factors in building production, e.g. work force wages, materials, transportation, machinery (rental costs). The cost elements are calculated separately and weighted into an index. The measurement is carried out monthly. In the figure, the in-put index is connected to the box named “Contractor’s cost”. Every tenth year, the weighting basis is calculated based on a representative group of building projects. This was last done in 2000. As the figure shows, change in productivity and/or calculated profit of the contractor and subcontractors/suppliers is not included in the index.
- 2) **Price** index for *new one family house in wood construction* is an “output index”; see the box “Contractor’s price” in the figure. This index measures the price development of the completed product, e.g. the building as delivered to the owner. The intention of this index is to have information of what buyers have to pay for new one family house (In Norway approximately 80% of the homes are single family or other types of small houses owned by the user). The index includes the change in productivity and/or profit of the contractors. TVA is included, but not
 - cost of land
 - architect and consultants
 - other costs not connected to the site activitiesThough, the index, to some degree, takes into account the change of standard (comfort).

This is all cost related statistics delivered by Statistics Norway. Information of final price of houses or flats, e.g. what the buyer (final owner) pays, is not available, nor the prices of land or the costs connected to application and approvals².

In addition Statistics Norway regularly delivers aggregated figures concerning

- gross turn over
- gross area built
- total number and area of existing buildings
- Structure (types) of building.

Based on the last group of statistic some cost- and price studies are carried out, as well at the productivity studies going to be mentioned in chapter 2.4.

² Examples – see chapter 3.5.2.3

2.2.2 Sweden

The situation in Sweden regarding data collection and statistics is presented as part of chapter 3.5.3.

2.2.3 Finland

Building construction industry can be divided into site production and the construction products industry. Site production consists of contract work and other site activity. When referring to the construction products industry, we mean primarily industry that manufactures prefabricated components and construction materials. The challenge of measuring productivity of building construction on sector level was studied in Finland some years ago in the commission research project of Statistics Finland and the Finnish Building Industry (Kiviniemi&Alanen 1996).

It was suggested that productivity of site production and the construction products industry be measured on three different levels. On the sector level, annual development of productivity is monitored by an index-type indicator that does not indicate the level of productivity but changes in it. The indicator is reached by dividing the output (value added by the sector) by inputs (worker hours and capital stock). The Statistics Finland adopted this indicator for compiling productivity statistics. See figure 2.3

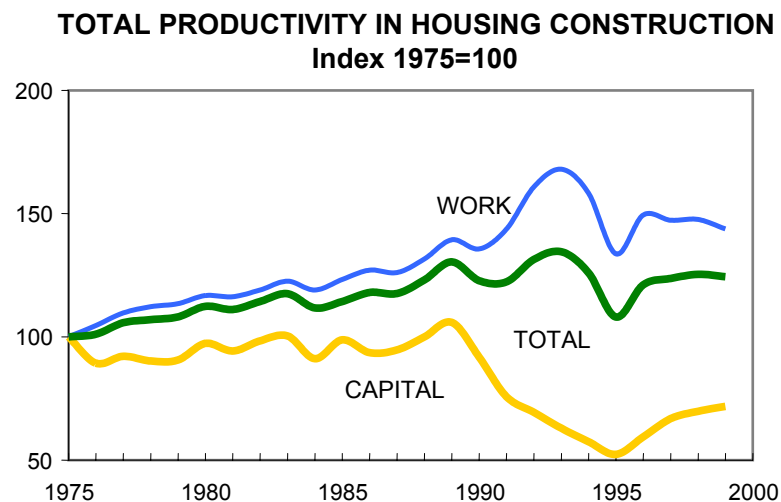


Fig. 2.3 Total productivity index in housing construction in Finland. Index 1975 = 100 (Statistics Finland 2000)

On the second level - it was suggested - productivity is measured by the value added-based characteristics of sub-sectors. They indicate the absolute level of productivity. Companies can compute figures related to their activity and compare them with sector averages. Data on sub-sectors is gleaned from various sector federations' surveys of member companies' productivity or industrial statistics.

On the third level, labour productivity is monitored by studying product group- and building type-specific indicators. Labour productivity is measured with a physical productivity indicator. Monitoring of these indicators is suggested to sector federations. Product group- and building type-specific monitoring of productivity

form complements to federations' traditional monitoring of their sector's production volumes and profitability.

The study gave sector federations, companies and Statistics Finland suggestions on improving productivity monitoring in building construction. Productivity monitoring involves collecting the necessary initial data and computing productivity characteristics as well as providing feedback to companies. Active productivity monitoring and wide participation in it increase the sector's awareness of the importance of productivity and interpretation of productivity indicators. Computed results set goals for the development of companies' operations.

These second and third level suggestions has not been realised in large scale. Anyway, some companies have made internal studies about their key productivity indicators. These studies are either ad-hoc studies or the results have been integrated as a part of company's internal reporting system. This national initiative by VTT and Nordic initiative by other Nordic research institutes is **one** complementary effort to develop methods for productivity indicators for construction site level.

2.2.4 Denmark

The situation in Denmark regarding data collection and statistics is presented as part of chapter 2.3.4.

2.2.5 Iceland

The Iceland Building Index is calculated regularly by Statistics Iceland. The typical building is an apartment house with 10 apartments, built in a suburban area. In addition to this apartment building, there are calculated indices for industrial buildings and for single-family houses. By law, however the standard official building index structure is an apartment building.

The Iceland Building Index measures the changes in the prices of material, labour and all other supplies needed for the building ("input index"). It does not take into account changes in sales prices on the market, productivity, or the contractors' profit. At regular intervals, the typical building is updated to keep up with the changes on the market.

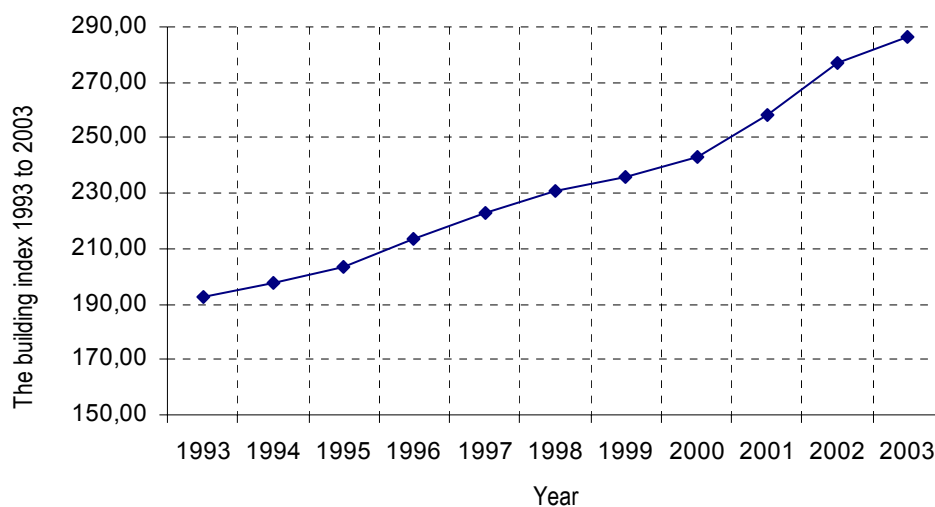


Fig. 2.4, Iceland , The building index 1993 to 2003. (The graph shows the average value of the index for each year. Source: Statistics Iceland.)

The index is calculated and published monthly and in addition an average value of the index for each year is calculated.

Statistics Iceland annually publishes statistics over number of dwellings, and number of dwellings completed during year.

Year	Number of dwellings		
	Begun during year	Completed during year	Under constr. 31. December.
1993	1.376	1.604	3.364
1994	1.350	1.714	3.000
1995	1.234	1.237	2.996
1996	1.280	1.620	2.657
1997	1.165	1.369	2.453
1998	1.016	1.427	2.042
1999	1.266	1.381	1.927
2000	1.643	1.258	2.312
2001	1.811	1.711	2.412

Source: The Statistical Yearbook of Iceland

Table 2.3, Iceland , The dwelling production of Iceland 1993 - 2001

In the past years, the number of completed dwellings varies from a minimum of about 1.200 to a maximum of about 1.700. The statistics on dwellings are published regarding the number of the dwellings, their size in cubic meters and the number of rooms.

	Total	One- and two family houses	Apartment buildings	Other dwellings
Total for the year 2002	108.577	58.781	48.786	1.010
1 room with kitchen	1.482	411	1.008	63
2 rooms with kitchen	15.014	2.978	11.924	112
3 rooms with kitchen	23.582	6.832	16.608	142
4 rooms with kitchen	24.553	11.916	12.457	180
5+ rooms with kitchen	41.705	35.241	6.151	313
Not stated	2.241	1.403	638	200

Source: The Statistical Yearbook of Iceland

Table 2.4 Iceland, Dwellings by number of rooms and type

The number, size and type of all structures are registered at the Land Registry of Iceland, but that information is not published regularly by Statistics Iceland.

The Land Registry of Iceland keeps statistics over sales prices and calculates monthly an index showing the change in the average sale price of all apartments.

The following graph shows an index for such changes in the prices of apartments in the capital region. The graph shows only the indices for the average sales prices in July of each year. If other months were chosen the graph might look slightly different. But this would not change the fact that the increase is considerable. As can be seen on the graph, the main increase started in 1998/1999 after a relative slow annual increase in the previous years.

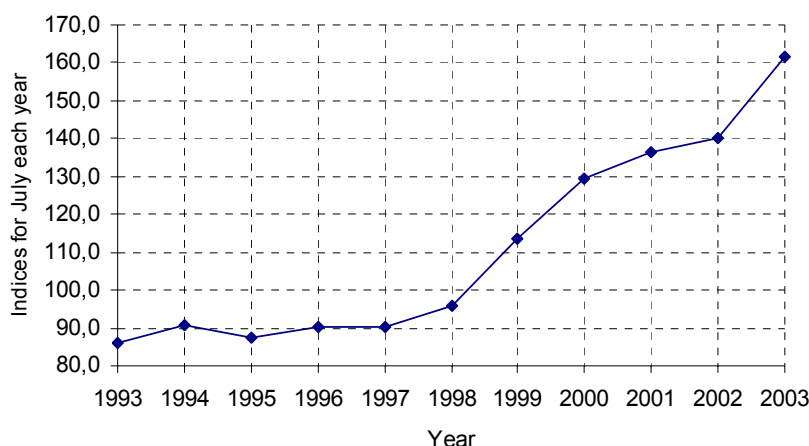


Fig. 2.5 Iceland, Change in the average price of apartments, in multi-apartments buildings, in the capital region of Iceland (The graph only shows the indexes for the month July. Source: The Land Registry of Iceland).

The index for average sales prices in July 1999 was 113,4 points and the index in July 2003 was 161,7 points. The building index in July 1999 was 235,5 points, and in January 2003 it was 286,4 points. So the increase in the average sales price of the apartments in the capital region was by far higher than the increase in the building index over the same period.

As always, there are, of course, various reasons for such an increase in the price. Such reasons may be a large migration of people from the rural regions to the capital region due to a better employment situation there, or favourable condition in the national economy, or better access to loans/money, or more young people entering the market, or perhaps a lack of sufficient land for building in this area, etc.

However, it is currently felt that some indications show this rapid increase in the prices of apartments in the capital region will be slowing down. The migration of people to this region seems to be diminishing. This is in part possibly because the employment situation is no longer so much better in the capital region.

In addition to above, the main information published about the construction industry, as for other industries, is the gross turnover and other information from the income statements from the industry as a whole.

2.2.6 Conclusive comments

The data collection and use of data seems quite similar in the Nordic countries. Statistical knowledge about the building and construction industry is in general based on national statistics and national account figures. Most of the available data and statistics are *macro economical type*, which means that the pictures given are rough and not very suitable for control and decision-making at company operational level. Nevertheless, the information is useful for the industry as general background. But when it comes to measuring productivity and efficiency, the need of project level data is essential.³

³ Within some institutions, like the Norwegian State Housing Bank, project data are collected. In some extent this has been used in statistic presentations, but not as broad and specific that generic analysis

2.3 The building process (The value chain)

In chapter 2.2 the Eurostat value adding chain illustration is shown in figure 2.2. The figure shows the three (four) main stakeholders in the value chain. The basic cost, e.g. the contractor's cost, is achieved by adding the actual resource costs ("input costs"). When the contractor's earning is added, approximately 2/3 of the developer's cost is given. Through the process each part is adding values by deliverance of services and products, receiving his prices and normally has his profit.

Figure 2.2 illustrates the process with attention on the accumulation of cost/price. Fig. 2.6 shows the process from a *managing* point of view. The building process consists of two main activities, *the development* and *the production*; see *upper part* of the figure. These are normally connected through the owner's/developer's decision regarding the investment. In principle this is the "point of no return". When the major contract(s) between the developer/owner and the contractor(s) is/are signed, the figures at the invoices are strongly growing, as is the building.

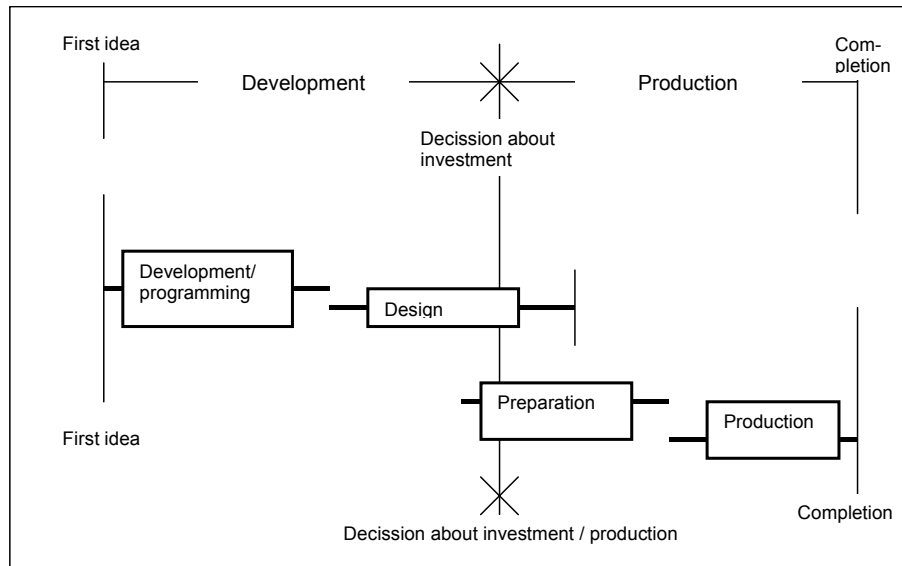


Fig. 2.6 Building process (activity chain), form the managerial point of view.

The *lower part* of the figure 2.6 shows the process slightly more detailed. Here the two major activities have been detailed through putting attention to some of the typical cost demanding activities/functions: The first activity/phase is the feasibility study. This is normally of limited costs, often carried out by the developer himself or by one, or a few specialists hired for this very task. (One of the specialists will often be an architect producing sketches based on defined functional needs and/or the architectural aspect). When the building program is fixed, the time comes for carrying out the design. This phase implies contracts with the design team members and will thereby represent a phase of more costs, even though not more than 5 – 10 % of total costs. When planning is brought to a certain point, there will be enough documentation to have the cost of the project evaluated, as an expert estimate or as

have been reported. Project data collected by the "Building commission" (Byggkommisjonen), SOU 2002:115 is used in the report "Skarpning gubbar", see chapter 3.5.3

result of a bidding. Then comes the moment of decision - shall the building process start or not? The decision implies substantial cost and a severe responsibility and risk for the developer. Through different *contracting models* the owner can have the risk negotiated down by paying the contractor to take over the risk. After having solved all questions of design, contract/procurement model, permissions, practical preparations on the site, etc., “only” the sole production is to be carried out.

The building process consists of a large number of integrated processes and activities, as roughly shown in figure 2.6, lower part. For different reasons it is from time to time regarded suitable to divide the main processes into even more detailed processes, activities and procedures. Figure 2.7 shows the “next level” of detailing the building process. The original two phases are divided into six phases, in other words two more than in figure 2.6. Further more there are added another two “phases” to the figure, the Maintenance phase and the Demolition. This way of illustrating the “lifespan” of a building is used in Norway, Finland and some other European countries as model for structuring generic (quality) management systems.

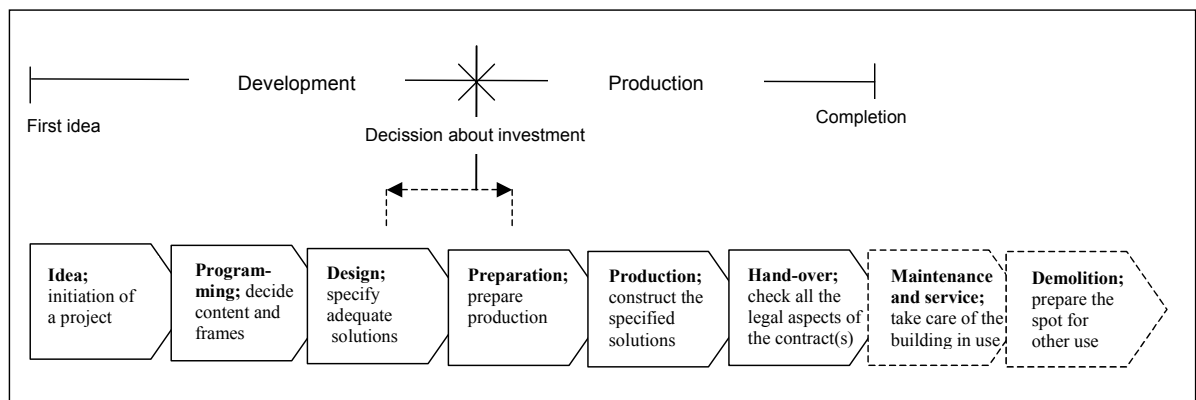


Fig. 2.7 Building process, detailed, from the managerial/main activity point of view.

A (very) simple way of measuring productivity of a building process is to measure the *working time productivity (labour productivity)*. Based on the working time of the working force at the site and the produced floor area, one can calculate the ration *Gross area produced pr. hour*, which in some situations can be used to compare different project organizations’ ability to compete. These situations are when projects are very similar (copies of each other). In such cases, a comparison of productivity/efficiency is just as to compare the cost of the most suitable measuring unit, f. ex. *cost pr. flat* or *cost pr. gross area*, etc. Most companies have their individual own key figurers of this type.

Today, building projects seldom are copies. From project to project standard and technical solutions are different. In such cases the comparison of productivity figures will not be as easy as mentioned above. How can two blocks, f. ex. an ordinary, “box-like” block of flats with normal functional and material standard, produced on site in cast concrete – and a terraced apartment building with high standard, steel frame and fabric produced concrete floor slabs? The answer on this question is that there might be methods that can be made suitable for comparing such unlike units. On such method is tested in the national Norwegian productivity project, as reported in chapter 4.3.

Access to the contractors *cost* is not always easy. Often the only achievable “cost-information” about a building project is that one presented to the buyer(s), e.g. the market price. This price includes the profit of the developer, the main contractor and the sub-contractors. One could ask if the comparison and ranking of projects by efficiency might as well be based on the “price to buyer”-figures. Differences in technical and material standard must nevertheless be respected, either in a mathematical way or as verbal comments. This question will be discussed in chapter 4 and 5. Below is given national comments to the building process models shown in fig. 2.2, 2.6 and 2.7, with reference to each Nordic country.

2.3.1 Norway

Regarding how B&C projects are organized and conducted, the building and construction market has always contained alternatives to mainstream. Concerning housing, the mainstream for a long period was *the strong owner vrs. the many competing contractors*. The owner, assisted by “his” architect and consultants, prepared bidding documents and invited rather many small or medium size contractors to bid on the whole job or parts of the job. This has been the ruling model from after World War II, through all the years of reconstruction and the following period of urban growth.

During the eighties and nineties the dominant way of organizing the production of dwellings gradually changed to turnkey contracts. In this period started the evolving of big, and vanishing of small and medium size contracting companies. Gradually the contractors, big and small, moved into other positions than their traditional ones, e.g. as designers and developers. Today, the whole process, from “Idea” to “Handover” (to final buyer), seems to be more and more dominated by the initiating, planning and producing developer.

The tendency is concentration and “all risk at one hand”, not only in housing, but in other building and construction projects too. BOOT-contracts⁴ are tested and evaluated by government and local authorities, f. ex. for roads, senior citizen service centres etc. The picture still is scattered, with contracts of all kinds, but the typical picture is that the contracting companies have “climbed to a higher position in the value chain” and made an increasing number of building and construction projects to an almost complete in-house business.⁵

2.3.2 Sweden

The Swedish government has two import evaluations of the building sector to increase the competition.

The first commission worked from 1996-2000 with the report:

Byggekostnadsdelegationens betänkande, Från byggsekt till byggsektor, SOU 2000:44, 2000

Some of the conclusions were:

⁴ BOOT – build – own – operate - transfer

⁵ In the period 1998 – 2002 was 84 % of residential project financed by The Norwegian State Housing Bank (Husbanken) by professional developing companies.

The building sector is static with rather fixed rules between the parts. It is therefore very important to find solution that can change the structure, culture and traditions in the sector.

- The building owners (“bygggherrar”) must be more active and in co-operation with the market and its partners develop a more effective structure and variations. The building owner must influence the result.
- The building sector must be more like other industrialized sectors.
- The competition in the market must more open in all part of the value chain. Prices and cost must be open for all buyers.
- The building sector must be more efficient and productive through co-operation between the partners. Design, production and maintenance must be integrated in the design. In production must the borders between different craftsmen be more open.
- The sector must be more oriented towards the customer.
- The end customer must have more influence on the result

The report also includes information on the structure in the building industry, as this is important for the supply chain discussions. The tendency is *concentration* in many part of the sector.

Contractors

In Sweden there has been a concentration among the contractor with 3 large firms, Skanska, NCC and Peab that covers the whole country. These firms are all strong in the other Nordic countries:

- Skanska (DK, N, SF)
- NCC (DK, N, SF) and
- Peab (N, SF).

These large firms have a competition advantage for large building projects. They will have the possibility of making work by using own workers instead of using subcontractors. In smaller building project will other, more local, firms succeed in the competition for a contract.

The large contractor firms have expanded to include more links in the supply chain. For multi dwellings as flats and single-family house groups they evaluate the customers demand, buy land, build houses and sell them. Many dwelling is build for tenant-owner associations, which will be formed by the buyers of the dwellings.

Building service installation firms

These firms make heating, ventilation, water installations and drains. They will normally act as subcontractors. Their bidding prices will normally include both materials and work. As they get discount from wholesale dealers on their buying of materials will the price on work be subsidized. It is impossible, or very difficult, for a main contractor to buy installation materials if it is not done through an installation firm. This building service installation firms are a few large firms and many small, local firms.

Producers of building materials

The table 2.6 shows the concentration of producers. In many cases have a few producers 80-100% of the market. It is also found that in the area of aggregates, prefabricated concrete elements, asphalt, ready-made concrete and concrete pipes is

many producers owned by the large contractor firms. This gives the large contractors an advantage in the competition.

Building material	Concentration
Cement	1 has 95%
Aggregate (stone and gravel)	4 has 80%
Ready-made concrete	5 has 80%
Asphalt	2 has 80%
Steel for reinforcement	1 has 80%
Prefabricated concrete elements	2 has 60%
Lightweight	1 has 100%
Concrete pipes	3 has 100%
Plastic pipes	1 has 50%
Gypsum boards	3 has 100%
Mineral wool	2 has 90%
Floor materials	2 has 60%
Windows	2 has 70%
Doors	1 has 50%
Kitchen and wardrobes	4 has 80%
Bath tubes	2 has 100%
Sanitary equipment of porcelain	3 has 90%
Stainless steel sinks	2 has 80%

Table 2.6 Sweden: Concentration in building material supplying industry

Development firms

Developer firms, as JM, have an increasing influence in the building sector. Such firms buy land, designers and contractor and sell the completed dwellings to the price the market is willing to pay. These firms can get a profit of up to 15%, which is much more than the traditional contractor firms can earn. The large contractors are also active as developers.

The second commission has been working during 2002. The results is the report: *Betänkande av Byggharvet "Skärpning gubbar"*, *SOU 2002:115*. This is only a few of the results:

Causes for missing competition and quality.

The commission finds that the competition is low in the market. This gives a risk for cartels as the market is concentrated, homogenous products, high barriers against new actors and many contacts between the firms. This makes it difficult to make changes in the market.

No balance between the partners

The owner ("Beställaren") that orders the building has today much less knowledge and influence than before. Multifamily houses are in many cases ordered by a tenant-owner association with individual consumers. This gives the professional contractor an advantage and makes it difficult to influence the design, price and quality.

New laws against failures

The basis is to give the consumer a better protection against building failures. Moisture is found as a serious problem and quality control in moisture design must be included. A permanent commission for investigation into serious building failures can be a solution.

The Swedish building industry has also made their own reports about these problems, see reference list.

2.3.3 Finland

There is both social housing development and private housing development on Finnish housing market. The social housing is supported by the government owned organisation named ARA and the apartments are mainly rented. The other mainstream is owner occupied private sector housing. The both mainstreams has been designed by the same architects and constructed in the same architectural style within the immediate vicinity. During last years the share of social housing has gone down to few percents.

The both main methods of organizing a building project are used in Finland.

- The main contract project
- The design & build project.

The main contract project is often modified as divided project where the client contracts out several partial works like construction, prefabricated elements, heating, plumbing, air conditioning and electronic contracts.

Contractors themselves are developing housing projects and using design & build method in these projects (2). Clients like housing associations are using more main contract procurement method (1) and controlling the design phase themselves.

2.3.4 Denmark

In the eighties different reports and analyses from the organisations and national authorities put focus on the weak productivity development in the construction sector compared to other sectors. In 1993 The Ministry of Trade and Business Affairs published a trade economical analysis on the construction and housing area (DK lit.1). To improve the productivity it was proposed that the following initiatives must be initiated: Project Renovation, Product and Processes in Construction and Project House.

All three initiatives are completed. In Project Renovation a large number of development projects (around 100) (DK lit. 2) demonstrated on different building parts and type of old buildings how renovation and renewal can be improved. Several of the projects included benchmarking and productivity e. g. 'Quality in project control' (Kvalitet i projektstyring) (DK lit. 3). In Products and Processes in Construction four consortia compete on efficiency and quality improvements in planning and construction of a number of non-profitable housings at different locations in Denmark (DK lit. 4).

In Project House ten different working groups with more than 200 participants from all corners of the sector have analysed literature, models and experiences, and as results they have presented a large number of proposals to improve productivity in different areas. For example has working group 10 a proposal

on key figures, performance indicators and benchmarking of productivity (DK lit. 2). See also DK enclosure B.

It is the experiences from these development programs that the individual parties have different interests and intentions. It is therefore importance to understand and accept this and at the same time try to form a common strategy, where power, commitment and improvements are in balance between the importance actors. With the building and its price and quality in centre the market is understood in the following three layers: The regulation market with authorities and public, the building sector with owner, contractors and producers and last the knowledge market with education and research.

Related to the value change with customer on one hand and deliverer on the other hand the building sector are split up in the three main segments: The real estate market with the finished building in focus, the construction market with the construction site in focus and last the product market with the building products and materials in focus.

Together we are therefore talking about five different markets, which shall act as one unit if we can be successful in improving productivity and quality. And as seen in Figure 2.7b the building has 'real estate' as its customer and 'construction and production' as its deliverer.

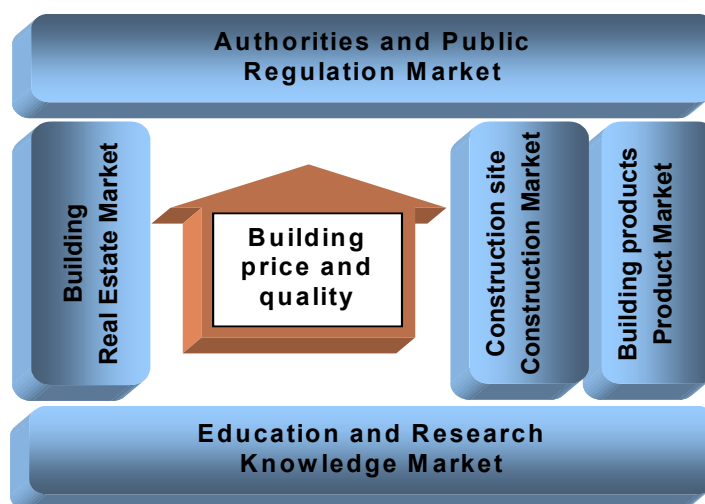


Figure 2.7 b With the building in centre the actors are divided into five different markets which shall act together if productivity can be improved.

2.3.4.1 The Regulation Market – Legislation and Innovation Programs

In November 20th 2001 there was a change in The Government in Denmark. The former Ministry of Urban and Housing Affairs was divided between several other ministries, and the part concerning building techniques and the like was placed in three agencies under The Ministry of Economy and Business Affairs (www.em.dk). Building regulations was placed in The Agency of Trade and Housing (EBST) (www.ebst.dk), statistic was kept in Statistics Denmark (www.dst.dk), and building research was kept in The Danish Building and Urban Research (www.byogbyg.dk).

The business development in EBST has focus on value making by improving the competition means in the sector and reduction of cost in comparison to international level. Politically there are put weight on developing the digital construction, partnering, public-private co-operation, the public owner as leaders in change in the sector and evaluation of contractors activities. The different initiatives

as in most cases bases on the proposals presented in the report 'The future for the building sector – from tradition to innovation' (Byggeriets fremtid – fra tradition til innovation) (www.ebst.dk) (DK lit. 15). The objective are to improve productivity and quality, which is a national problem compared to the international level. In practise the focus is mainly on cost reduction and large-scale construction and evaluation of construction companies to expose the problems.

In relation to EBST there are three organisations with activities on evaluation and benchmarking of certain building types. The Foundation for Building Defects (Byggeskadefonden) (www.bsf.dk) covers public financed new-built non-profitable housing and houses for youths, elderly and housing co-operative. The Foundation for Building Defects on Renewed Buildings (Byggeskadefonden vedrørende Bygningsfornyelse) (www.bvb.dk) covers public financed building renewals. Both foundations were founded in 1986 in relation to the new regulation on quality assurance, and they do 1-year and 5-year inspections by help of appointed consultants. The Inspection of Houses (Huseftersyn) (www.hesyn.dk) covers private housing which are occupied by the owner alone. The inspection is done by appointed consultant in relation to sale.

2.3.4.2 The Real Estate, The Construction and The Product Market

The market for real estate can be divided in: Public owned buildings (The State, county and municipality owned), non-profitable housing and other public partly financed housing, private owned housing for rental, single family housing, holiday cottages and buildings for productions, storage, sales and other businesses. In general the value added tax (VAT) is 25 % on all construction activities, but there are special rules on non-profitable housing. The markets segments differ in content and conditions, so it is difficult to compare buildings from one segment with others and buildings with different locations around the country.

The construction market is these years undergoing a lot of changes. The owner and the end-user claim for more quality, less defects and a lower price and last but not least a more open and confident co-operation with focus on the end-user and not the constructions conditions. On the other hand industrialisation change site production step by step into industrial productions and in finish building systems.

Internally the planning and construction processes are growing more and more complicated. New systems for co-operations are implemented e.g. partnering, value management and public-private co-operations, and they are mixed with old tendering systems. Large international contractors trying to get a total production control over consultants and subcontractors, and there has been specialisation of contractors, and consultants are pressed from different angles in the market.

Generally there is a large openness in the sector to the proposed changes and to use benchmarking and improve productivity. However is it difficult to see any improvement yet in productivity and quality in spit of the many development projects and good efforts spend both from the government, the building owner and the companies.

In 2001 a new organisation was establishing - The Benchmarking Centre for the Danish Construction Sector (Byggeriets Evaluerings Center) (www.bygge-evaluering.dk). The centre is a private organisation funded by the building sector and supported by EBST as part of the governmental policy which was presented the first time in Project House and the report from EBST 'The future for the building sector – from tradition to innovation' (DK lit. 15). The centre is now established and methods for benchmarking construction companies are presented, and some benchmarking cases are demonstrated. The centre hope in the future to extend theirs activities to

smaller construction companies and to consultant activities, but at the moment the methods are not simplified and adjusted for daily use in companies, and it covers primarily costs and time parameters but not quality parameters seen from the owners' point of view.

2.3.4.3 The Knowledge Market - Education and Research

Initiated from EBST a committee has analysed the total knowledge market and its influence on the building and construction sector. In their report presented 2002 'The building in the knowledge society' (Byggeriet i Vidensamfundet - analyse og anbefalinger fra Udvalget vedr. byggeforskning i Danmark). (www.ebst.dk) (DK lit. 14) nine proposals will improve learning in construction and increase building research. A central proposal is a new Innovation Foundation for the Building Sector, which from 2005 to 2012 will have a yearly budget at 85 mill DKK to support strategic research programs.

There is no formal co-operation between research institutes concerning benchmarking and productivity improvements. Activities are carried out on the field of research through personal contacts between institutes as:

- Danish Building and Urban Research, Department of Process and Innovation (www.dbur.dk).
- Danish Technical University, Department of Civil Engineering, Section for Planning and Management of Building Processes (www.byg.dtu.dk).
- Technological Institute, Building and Construction (www.teknologisk.dk/byggeri).
- Aalborg University, Building Technology and Structural Engineering (www.civil-aau.dk).

In chapter 3,4 and 5 are given more information about important research, which are background for the used methods in this report.

2.3.5 Iceland

An entrepreneur as well as anyone else with the intentions to build a house can apply for a land from the local government, in order to obtain land for a building.

In areas where there is a lack of land for buildings, some local governments distribute the land through bidding. The highest bidder gets the land. Each bid, for a land owned by a local government, covers usually only a land sufficient for one building.

In the past few years it has been more common that the larger entrepreneurs buy a land from other landowners than the local government. This gives the entrepreneur often more freedom to plan the area according to his need. The local government has however to accept such planning and the planning has to be in accordance with the regional planning. It is however most common that the local government plan the building areas. The planning usually describes the number and types of all buildings, their size, number of stories, number of apartments and etc. The design of each building has to be in accordance with those decisions.

Most usually entrepreneurs build multi stories apartment buildings at their own cost to sell on the market. The Entrepreneurs sells the apartments through a real estate agent.

The buyer usually is a private person. His intentions are to live in the apartment. Hence the numbers of owners of a multi apartment building usually are as many as the number of apartments in the building. The apartments usually are delivered

completed, but the buyer can choose between different quality of floor covering, kitchen unit, cupboards and sanitary appliances and etc. For an increased quality he of course pays increased price.

For a single family house it is not uncommon that an unskilled private person applies for a land from the local community. He then contracts the designers and the skilled craftsmen needed. For industrial and office buildings, there is no method more common than other. Entrepreneurs build such buildings to sell or to rent out. The same applies for companies. They build buildings for their own use, to sell or to rent out.

A governmental fund supplies a loan to a buyer or a builder of a dwelling. The maximum loan can go up as high as 90% of total cost. Special rules apply to people with a lower income they usually get a high loan and lower interest rate. All loans from the governmental fund are annuity loans and inflation regulated. In additions banks and other financial institutions offer loans to a house buyer or a builder.

The Planning and Building Act and the Building Regulation define conditions for designers, their specialization, education and skill.

The designers usually are; Architects, Structural engineers, the designers of sanitary installations, i.e. water, heating, ventilation and the designer of the electrical installation. For more complicated houses there are in addition designers for landscaping, acoustics, fire preventions etc.

It is the designer's responsibility to secure that the total design of the house is according to laws and regulations. The design describes the house completely down to a detail. It is demanded that designers carry an insurance against mistakes.

For each building there has to be a master builder. The Building regulation demands the following; master of carpentry, master of masonry, master of plumbing, master of electrical wiring, master of painting, master of floor and wall coverings and for metal buildings a master of metalwork.

In addition a chief coordinator at the building site is demanded. The chief coordinator can be a master of carpentry, a master of masonry, a master of plumbing, an architect or an engineer. His job is to coordinate all the work done at the building site. The chief coordinator carries the first responsibility for any defects of the building. The chief coordinator has to be insured against mistakes and defects.

For new houses there is a compulsory insurance against defect with the duration of five years after the house is finished. There are no laws that directly terminate the responsibility of the designers or the entrepreneur, hence the reclamation period for mistakes and defects, can possibly be considered to be unlimited.

Administrative institutes

The Minister for the Environment has the supreme control over planning and building under the Planning and Building Act.

According to the Planning and Building Act the Planning Agency (Skipulagsstofnun) monitors the planning and gives advice on planning and building. The Agency assists the local authorities and provides guidance to them in preparing development plans. It issues recommendations for building and development permits in the

absence of a municipal plan or local plan. It reviews municipal plan proposals and provides guidance to the Minister for the Environment on the approval of municipal plans. It works with regional plan committees and guides the Minister for the Environment on the approval of regional plans. It issues statements on matters of dispute regarding planning and building.

The Iceland Fire Authority (Brunamálastofnun) produces national regulations and guidelines on both fire fighting in general as well as fire safety design of buildings. The Authority provides services to architects and engineers regarding design, inspection and approval and to the local governments by providing training, education and advice to local fire brigades in Iceland.

Local building authorities enforce the Planning and Building Act and the Building Regulation locally. A local authority issues a building permits, controls the drawings and sometimes also the calculations from the designer. Inspection on their behalf is done regularly at the building site through out all the building process. In addition to the regular inspections through out the building process a final inspection is carried out when a house is completed.

Main laws and regulations: The Planning and Building Act no. 73/ 1997, the Planning Regulation and the Building Regulation.

2.3.6 Conclusive comments

In this subchapter the house building process and connected challenges in the five Nordic countries has been discussed. Conclusion on this item is that

- the main contractors have a strong position in this sector, often covering the whole value chain, e. g. from buying land to selling the completed flats. The traditional owners, like housing organizations, act more often as partners and/or buyers of whole projects.
- *concentration*, especially among producers/suppliers of building materials, might become a menace to efficiency (cost)
- to keep market positions and satisfying results, new ways of operations are continuously tested among all stakeholders in the industry.

2.4 Productivity studies – Examples

Throughout the world, studies of productivity have been carried out for many decades by use of statistical methods and data collected national statistic bureaus. Also in the Nordic countries such studies are part of different initiatives and/or funding by government or industry, aiming to improve the “competitive edge” of the industry. The building and construction industry has also carried out efficiency studies, though not as a major strategic tool. But during the nineties and in the new centennial, with stronger growth in material costs and labour costs, it seems to be an increasing interest in such studies.

During the sixties and seventies B&C companies put much interest and effort in different types of “Working time studies”, inspired by scientific management theory (Taylor a.o.). Lots of studies have been carried out, especially concerning production of concrete structures in buildings and in civil engineering infrastructure (roads,

railways, harbours, airports, tunnelling etc). Concerning building, and especial building of dwellings with many trades involved, the methods used obvious had limitations. Studying trade-by-trade, f. ex. concrete work, carpenter work, painting etc., didn't tell "the complete story". The explanation can be that the productivity challenge - and the success of a building process - also in earlier days was closely connected to an effective *coordination* of the many different trades involved. Secondly, the study of construction activities by "following each man" was felt as "management spying" by the workers. During the eighties this way of studying productivity was tuned down, even if it still is used in some "softer" way in companies and projects. Still the majority of building and construction workers have their wages calculated based on some sort of productivity measurement (Piecework wages).

2.4.1 Statistical analysis

In 1986-89, a productivity studies based on national statistics was carried out for the B&C industry in four of the Nordic countries. Two economist researchers at Norwegian building research institute, Finn Førsund and Rolf Albriksen, had carried out a productivity study of Norwegian B&C companies (N, lit. 1 and 2). The method used was the *data envelopment analysis* – DEA. Their experience made a fundament for a similar study of four Nordic countries, showing the, not very surprising fact that the industries in the participating countries performed different, see figure 2.8. Their report discusses differences and similarities between the Nordic countries, and should still be a source of information for the managements in the new "all-Scandinavian" companies. An example: In each country was found rather high difference in the "working force productivity" between companies. Also between countries differences are observed.

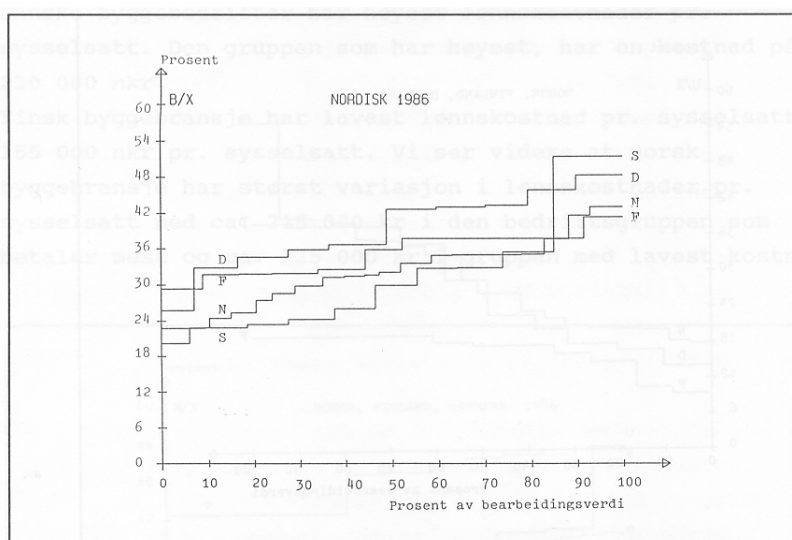


Fig. 2.8 Working force productivity (Value adding pr. employee) in companies in Finland, Denmark, Norway and Sweden. (Albriksen, R. 1989)

The diagram shall not be widely discussed her, but it must be mentioned that the actual analysis was/is studying the factors one by one (*partial* study). Thus, the low labour productivity is not telling the absolute truth about productivity. This can be illustrated by another diagram from the report, se figure 2.9.

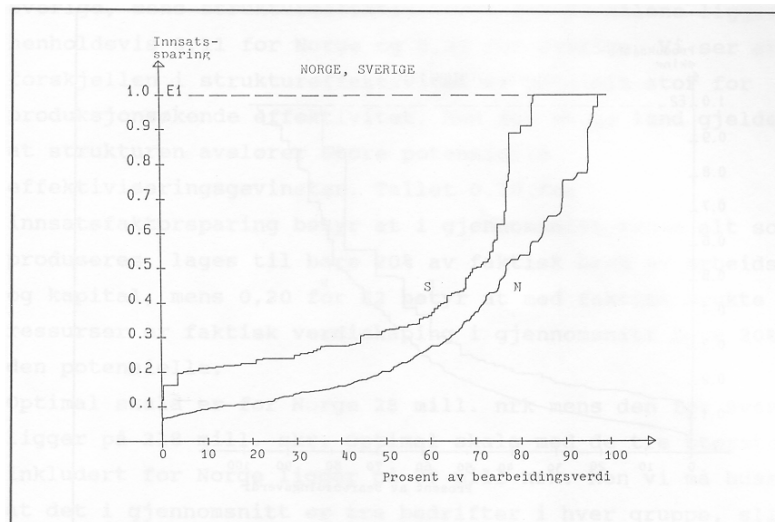


Fig 2.9 Efficiency score in Norwegian and Swedish B&C companies (Albriksen, R. 1989)

The diagram shows that the Norwegian companies of all levels had a higher potential of improvement than the Swedish companies. Unfortunately, this project was completed without any follow-ups. Consequently we do not know if this difference still exists.

2.4.2 DEA at project level

In 1996, Jan Johnsson presented his doctoral thesis at the Luleå University of technology, Division of construction Management. The thesis has the title “Construction Site Productivity Measurements”, with the sub title “Selection, application and evaluation of methods and measures” (N, Lit. 3). The author says in his preface (quote): *“My background,, had made me interested in ways of evaluating site performance. In my work, I had seen how misleading it could be when the only measures used was profit, and how negative effect this could have on motivation”*.

His basic idea was to develop a more accurate method for performance and improvement evaluation for construction projects. The thesis covers all types of construction work and a wide analysis of the different performance aspects. It will take too much time and place to comment thoroughly. Though, limiting our attention to blocks of flats, of which the thesis covers 40 units, the following can be shown, see figure 2.10.

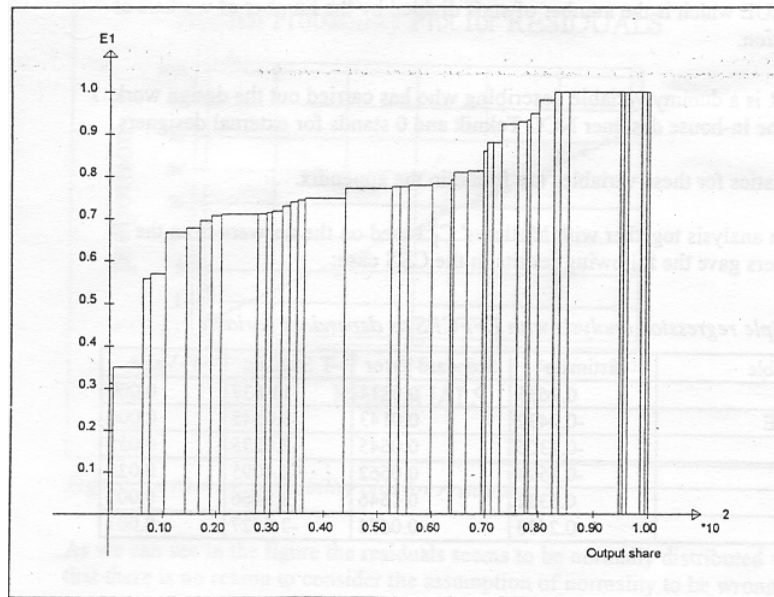


Figure 2.10 Efficiency distribution diagram (Salter diagram) for blocks of flats (using variable return on scale) (Johnsson, J 1996:185 D)

The thesis gives following comments to the diagram (quote):

- 8 projects determine the production frontier and they represent about 17 percent of total turnover⁶
- The small and the large projects are ... evenly spread in the diagram
- Efficiency for many of the projects must be considered as low (end of quote).

The thesis has, as usually in productivity studies, asked “why”. What is the reason behind measured and calculated difference in productivity (efficiency) between the forty projects. In the thesis, following can be read (quote):

“The result from the DEA together with the information from the site managers have been analysed using multiple regression. The main purpose of this multiple regression was to determine if the difference in efficiency measured with DEA can be explained by the variation in the variables we used. The identified variables that seems to be connected with the efficiency measured with DEAare:

- Change of construction time. This means that if the actual construction time was longer than the time decided in the contract, it is an indication of low efficiency. And if the actual time was shorter it is an indication of high efficiency.
- Type of contract. This means projects made with a “Design and build contract” has a lower efficiency than those with the traditional general contracts.⁷ Allowing the producers to influence the design should, according to this, be a negative step. This is something, which is in deep contrast to the development in other industries where design and production are increasingly being integrated. There is, however, a big difference between the two contract forms when it comes to compensations for changes during the construction time.

⁶ These are the eight columns to the right in the Salter diagram

⁷ (Authors comment): The legal substance of the two types of contracts (“Design and build” and “General contract”) for the very company at that time, may give better understanding of the astonishing conclusion.

- *Degree of prefabrication In the projects where important parts have been prefabricated it is mainly the structure parts that have been bought as precasted concrete. So the conclusion we can draw is that buying precasted concrete during this period was not very cost-efficient. It is possible that the opposite result would have been obtained today when we have over-capacity at the precasting factories.*
- *Design by the producer gives high efficiency, and the effect is relatively large. This means that the projects where the internal (Contractors name) had been used to carry out the design, showed a higher efficiency.*
.....
- *Disturbance reduces the efficiency. This means that serious disruptions greatly reduces the efficiency. That bad weather, strikes, delayed deliveries etc. would have negative effect is not surprising. The problem here is that it is impossible to eliminate many of these disturbances”. (End of quote).*

In the abstract, covering all the projects in the study (40 blocks of flats, 31 roads and bridges and 33 office buildings) the result of the multiple regressions is summarized like this (quote):

“..... using multiple regressions. The result was that variables such as

- *additional work orders by the client*
- *formal education and employment time of the site manager*
- *participation by workers in planning*

did not seem to have any effect for any of the types of products studied. For the blocks of flats the variables which showed a negative correlation with the result from the DEA were

- *extended construction time*
- *design and build contract*
- *major parts prefabricated*
- *serious disturbances⁸*

For the offices, variables such as

- *a large share of the work being performed by subcontractors*
- *a high proportion of the people employed being staff*

were positive, while many different persons involved in planning before the actual start of the construction were negative.

For the roads and bridges studied the positive variable were

- *in-house design*
- *a high proportion of staff*
- *many different persons being involved in planning before the start of construction work,*

The negative variable found in this case was

- *high wages to the workers”. (End of quote).*

It should be emphasised that all the projects are contracts of *one* contracting company during the period 1989 – 1992. The findings are interesting, some of them expectable and others unexpected. The thesis gives comments to each finding that makes what is immediately astonishing more understandable. Nevertheless, this work by Jan Johnsson must be deemed as of high value to the

⁸ This is a summary of the more detailed quoting earlier at the page

industry in all of the Nordic countries and should be studied and followed by new similar studies. This has not happened, probably because this is an expensive and rather difficult way of carrying out productivity studies. For the industry itself it might be experienced as too much “academic exercise”. Even in the research and development environment this way of studying productivity has been given less attention, certainly because of the difficulties in having such work funded and carried out (method, data collection etc). The Norwegian project has chosen this approach, see chapter 4.3.1.

2.5 Cost studies – an example

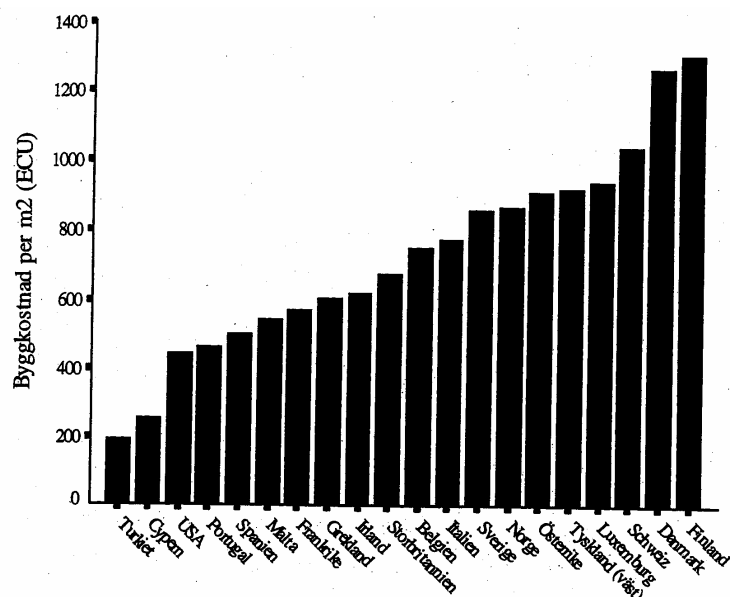
During the final editing process, the work of Lars Engebeck and Rune Wigren (N. lit 3 b) came in the focus. Without any investigation of why this work not had been given attention during the project period, it is included in this report through inserting the English Summary of the report here:

(Quote) Construction costs in the Nordic countries and Western Europe

There is a common belief that the construction costs are very high in the Nordic countries compared with other countries. This may indeed be so, if construction costs are considered in the sense total production cost including equipment connection charges for water and sewage and different kind of taxes.

The study deals with the level of construction costs in the Nordic countries compared to other Western European countries. The cost measure used here is construction cost excluding equipment, connection charges VAT and other taxes, which is roughly equal to the prices asked by the construction company, excluding VAT.

In each country an expert group estimated the cost per square meter to the developer of a dwelling in a multi-family house of normal standard in capital of the country in 1990.



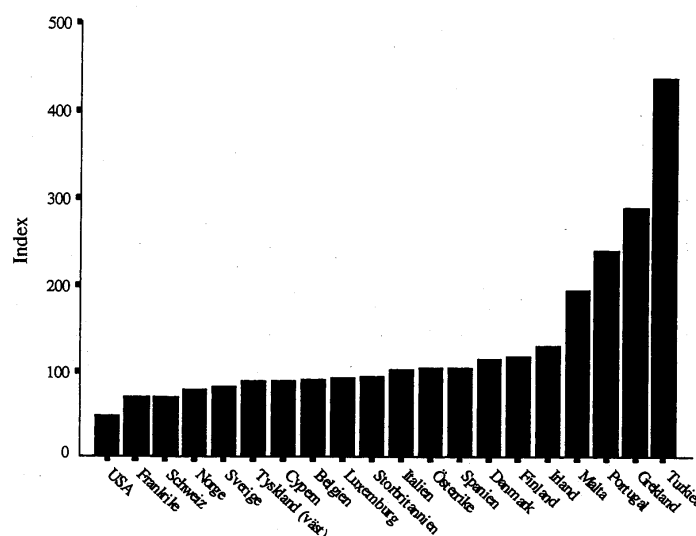
Engebeck and Wigren, Fig 1.8 Building costs per square meter in different countries 1990/1991 (ECU)

As seen in figure 1.8 Finland and Denmark had the highest normal costs in 1990/91 among the 20 countries in the study. Sweden and Norway had construction costs just above the average. It should however be born in mind that the level of production was very high in Finland and Sweden that year, and that construction costs therefore peaked during the year. In Norway, on the other hand, a downturn had already begun. At that point in time the Finish and Swedish currencies were very highly valued in relation to the ECU.⁹

There is, however, a clear tendency for countries with a relatively high standard of living to also have high construction costs. Almost 70 % of the variation in construction cost is explained by GNP per capita. Other important factors are the size of the construction market, the rate of change of GDP and inflation. What is, however, most noticeable in figure 1.8 is the very low figures for USA. The explanation could be stronger competition than in Europe, a different organisation for construction or different content of the dwelling.

The fact that construction costs are closely related to GDP per capita depends in part on the fact that wages, which are in turn related to GDP per capita, are the most important factor for construction costs. Wages in this context include not only cost for wages at the place of construction, but also wage costs included in the price of different components. GDP per capita is also closely related to the demand side as a proxy of purchase power, which in turn is related to the quality of the dwelling.

Another way of looking at the same problem is which countries have to make the greatest sacrifice to produce one square meter housing area. Figure 1.9 illustrates this when resources are measured by GDP per capita and related to the construction cost. The average of the Nordic countries is set at 100. If the index is higher than 100 for any country, that country will have to make a greater sacrifice than the Nordic country and vice versa.

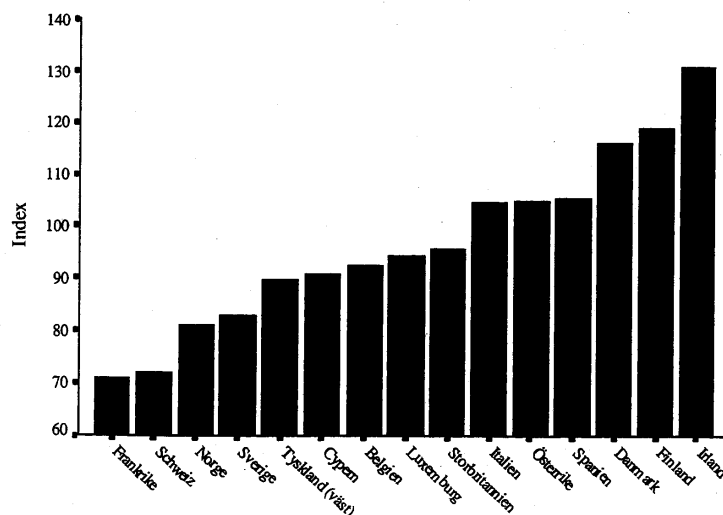


Engelbeck and Wigren, Fig 1.9 Index for the building cost's part of GDP per capita 1990/1991 (ECU). (The index value for the group "Nordic countries" is set to 100)

⁹ The ECU is the early denomination of an early common European theoretical currency that during 2003 has been replaced by the real common European currency, € ("euro").

Measured in this way the situation in the Nordic countries looks more positive. In five countries a greater sacrifice is needed to build one square meter than in Finland and Denmark. Norway and Sweden are among the five countries with the lowest “relative” construction costs. The lowest “relative” construction costs are in USA, France and Switzerland.

Naturally, USA, with its high GDP is placed well below other countries. Malta, Portugal, Greece and Turkey have the highest costs. The most remarkable feature of figure 1.9 is the small differences among Western Europe countries. When this figure is magnified, as in figure 1.10, some important differences appear. The lowest “relative” costs are in France and Switzerland, with an index of about 70. The next groupe contains Norway and Sweden, with an index of about 80. The index is about 90 for Germany, Cyprus, Belgium, Luxembourg and the UK. Denmark and Finland have high values among Western European countries.



Engelbeck and Wigren, Fig 1.9 Index for the building cost's part of GDP per capita 1990/1991 (ECU). (The index value for the group “Nordic countries” is set to 100) NB! See index scale!

The development of the total production cost in the Nordic Countries.

This study deals with the total production cost in Finland, Iceland and Norway and Sweden. Denmark was excluded due to a lack of data.

Production costs grew considerably faster than inflation in the Nordic Countries. The square meter cost, deflated by the Consumer Price Index, CPI, rose by 86 % in Sweden, 41 % in Iceland, 24 % in Finland and 16% in Norway. The average increase per year is shown in table 1.2. There are, however, great differences between different periods of time. For each country at least one period can be found when the increase in cost has been lower than in the other countries. This means that the periods of time to which the comparisons refer are important. The study concludes, however, that the increase was highest in Sweden. The average yearly increase in Sweden was over 3 % compared to 2,1 – 2,5 % in the other Nordic Countries (table 1.3).

It could be argued that deflation by CPI is not the most appropriate comparison and the Producer Price Index, PPI, is more appropriate. The trend in real production costs deflated with PPI are shown in table 1.4.

Production costs is a function of the quality of the dwelling, the price of the production factors and efficiency. In Sweden it is easy to analyse the development of the different factors due to the existence of a unique set of index series. If C/P is the index of real production costs, G is the index for the quality, F/P the index for real factor prices and E the index for efficiency in a certain year, then

$$C/P = (G(F/P))/E$$

Quality, or more correctly, the value of the product, (G) is a quality index containing dwelling area, construction material, insulation, equipment etc. another factor is the regional distribution of new construction. A high proportion of construction in the city regions means higher value, at least measured as production cost. Smaller dwellings means higher quality per square meter as the value of the kitchen and bathroom is spread over fewer square meters.

The index of efficiency (E) is measured of total productivity including profit.

In the Nordic Countries no such indices are available. We therefore constructed a regression model, which was tested by comparison with the Swedish data as measured by the different Swedish indices. Using this model, we were able to analyse the increase in production cost and study the effect of the different components. A test of the model of data from Sweden showed effects close to those measured by the different Swedish indices. A common model for the four Nordic Countries is worked out on page 71.¹⁰ The separate models for the different countries involve a slightly different set of explanatory variables, but the variables are highly correlated and could be used as proxies for one other.

Between 1978 and 1992 the quality of the dwelling was estimated to increase by between 13 and 36 percent (table 1.5)¹¹. The highest increase was in Norway, followed by Finland. The smallest increase is noted for Iceland. For Finland production cost rose by 58 percent between 1978 and 1992 (table 1.8).

Real factor prices increased sharply in Finland, 39 percent. The increases were lower in Norway and Sweden. In Finland and Norway there has been a considerable increase in efficiency.

Without the increase in efficiency in Finland production costs would have risen to 81 percent above the level of 1978. Now the increase was only up to 58 percent. The corresponding figures for Norway are 60 percent and 17 percent respectively.

Conclusions

The main conclusion of the international investigation of the level of construction costs and the Nordic study of production costs is that there are great differences between the Nordic Countries. The cost level seems to be lower in Norway and Sweden than in Denmark and Finland. The main reason why the nominal

¹⁰ This means page 71 in the Engebeck-Wigren report.

¹¹ The table shows increase by 13 and 36 percent is to be read as percent points.

construction cost is higher in the Nordic Countries as a group is their relatively high GDP per capita.

When the effect of GDP per capita and cultural differences in how housing is viewed are considered, there is no reason to say that construction costs are exceptionally higher in the Nordic Countries. The differences between the Nordic countries are also smaller when account is taken of differences in GDP per capita. The increase in costs over the past 25 years is, however, largest in Sweden. In all Nordic countries costs have increased due to the increased quality of the dwellings. The development of efficiency is quite similar except for Sweden. A possible explanation, suggested by the regression model, is the fact that construction volumes have changed most in Sweden during the period. (End of quote).

The Engebeck-Wigren report leaves many interesting questions, among which the major is: “Why is it not repeated based on more recent sets of data?”. There are certainly answers to this, which should be searched for in future studies of cost and productivity in construction sector.

2.5 Conclusive comments

The share of construction sector of total GNP is typically between 5 to 15 % in European countries, depending on market situation on short time span – and level of urbanisation on longer time span. The B&C industry has a considerable size. Further on, the spillover effects to other sectors in the economy are of great importance.

In each country the national statistics collects and publish lot of data about the B&C sector. The published data varies from one country to another depending of the tradition in each country. General knowledge about the productivity in building and construction industry is mainly based on national statistics and national economy figures. This gives “rough” pictures of the industry, not suitable for control and decision making at company level.

The building process (value adding chain) is described more or less similar in the Nordic countries. This should ease benchmarking activities, if all other conditions of investigation were taken care of.

Few major R&D works have been carried out when it comes to measuring productivity/efficiency. Of the two reported ones, the first is based on national statistics (“Macro data”), and as such not very suitable as basis for reliable benchmarking. The other one, the doctoral work of Jan Johnsson at Luleå University of technology in 1996, is very interesting, as it uses project data (“Micro data”) as basis for investigation of productivity/efficiency. Unfortunately it has not been followed by similar studies until the ongoing national project of Norway (2001 – 2005), see chapter 6. At the field of construction cost comparison the work of Engebeck and Wigren (N Lit 3b) is very interesting. Unfortunately, this is also a “once in the time”-project. New studies, concerning method improvement as well as substantial information about cost development in a country and comparison between countries, should be given high priority.

It exists a need of productivity information in Nordic building and construction industry. Statistical methods exist. They are used worldwide at different areas, even

at micro data level, f. ex. in banking/finance. To achieve similar statistical information about the B&C industry, the condition is to make micro data (project data) available for common statistical studies. As to now, this resource demanding challenge has not been taken. Instead there have been carried out different local price- and costs studies to simply follow the change and “explain” it in plain words.

3 State of the Art

Profitability, normally measured as earning before interest and taxes (EBIT), is the figure of ultimate importance and interest for a company in a competitive market. On the other hand, profit is partly a consequence of the market situation, and partly of the company's skill and capacity. Normally a company wish to know as much as possible about its own performance skill at any time. This has during the years lead to different types of studies of performance, or *productivity studies*, which is mainly used as denomination of these activities.

As mentioned in chapter 2, there has for years been executed some kinds of productivity studies in the Nordic countries within the construction sector. The State of the Art presentation will address the three main directions

- 1) The classical, based on national account and national statistics figures, where data sources are company level data ("macro").
- 2) The project based studies, where figures for main parts of the project cost, or price, are studied ("micro-project")
- 3) The activity based studies, where different identified activities, like producing forms for casing of concrete, producing brick walls etc. are studied ("micro-activity").

Stat of the Art is mainly direction 2, even if the other two are executed in different situations and environments. Within the direction 2 ("micro/project") there seems to be three dominant methods

- a) The "*Cost* per square meter" approach, where building projects are studied based on the main cost figure and sub-figures of special importance for understanding why the total is high or low. Example of such structuring of cost/price is shown in chapter 3.5.2.3 (Norway).
- b) The "*Price* per square meter" approach, where building projects are studied based on the main price figure and sub-figures of special importance for understanding why the total is high or low. Example of such structuring of cost/price is shown in chapter 5.2.5.1 and 5.2.5.3 (Sweden, Denmark, Iceland).
- c) The "efficiency figure" method, where statistic theory on the field of productivity is used. The most used, the Data Envelopment Analysis (DEA) used on "micro" figures is mentioned in chapter 2.2.1. In reality, the Luleå doctoral thesis represents State of the Art, though kept in chapter 2 of no other reason than the fact that the Swedish productivity studies has not proceeded along the "DEA-path", but chosen the "price per square meter path" (b). Today, this approach is represented by Norway and Finland, see chapter 5.1 and 5.3.

In his chapter we will present and discuss the resent executed and ongoing r&d activities concerning productivity/efficiency in the construction sector, after an initial discussion of the denominations at the field.

3.1 Productivity (definition)

Productivity is a way of measuring how much a sector, company or project produce by a given amount of resources – or how much resources is used when producing a given number/volume of a product. The reason for measuring productivity is to understand own production processes and learn about capacity of machinery and people. The aim is to improve capacity, as this is “part of the game” for all companies in a competitive market. When a producing organization is able to quantify how efficient resources are used, the figures can be made statistics and the statistics is the best way of having (almost) neutral and truth picture of the organization’s performance ability.

The word productivity can be defined as “capacity to produce” and will in a mathematic processing be the ratio between produced units and related use of resources, se fig. 1

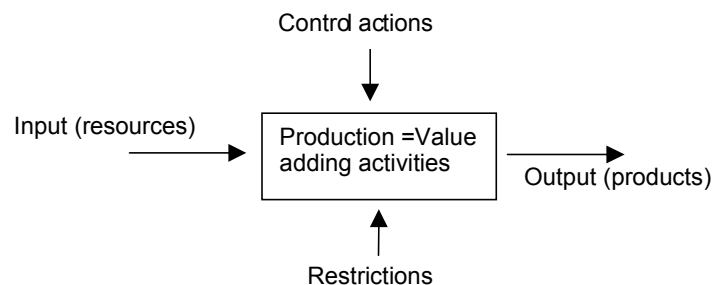


Fig. 3.1 Schematic illustration of the productivity measurement method

Measuring productivity is here done by the ration “Product value” to “Resource value”. The ratio includes measured quantity of the ordered product (numerator) and the amount of resources used (denominator), and the dedication (productivity figure) tells how much is produced by one resource unit.

$\text{Productivity} = \frac{\text{Product}}{\text{Resources}}$

Fig. 3.2 Calculation of productivity - principal

When measuring productivity one need to have a term for the product value, as well as for the resources. The product unit can be measured, f. ex, as the value of the product, as the value adding of the organisation or it can be the amount of the product produced. The resources in the tradition of productivity studies are

- Manhours and other labour costs
- Materials
- Energy
- Capital (machinery etc)

In building projects all these factors (types of variables) exists. In production of ordinary buildings “Manhours” and “Materials” are the two dominating elements.¹² The amount of each of the four factors is normally measured as costs - in the currency for each country (kroner, euro, ...).

The *product unit* might be the gross area of the building, measured as square meters (m²). By using these two variables, “the productivity equation” tells how many square meters a producing group, f. ex. a building site organization, delivers pr. actual costs of the “men and material”, like m²/sek, m²/fim etc.

3.2 Comparing productivity

An organization that by measurement appears to have a high m²/sek score is called a high- productive unit compared to earlier performance or other organizations with lower scores – or compared to some normative figures (reference number, key performance indicators). When comparing to others, or to a reference figure, each producing organization in a master sample will have an individual score called “the efficiency figure”, see figure 3.

$$E_n = \frac{P_n}{Ref}$$

Fig. 3.3 Evaluation of productivity - principal

When productivity of a number of building projects has been measured, one can have them ranked by their efficiency score, e.g. from the one with highest to the one with lowest efficiency score. By such ranking (benchmarking) much can be learned with respect to efficient production. When the reference figure is the project(s) with the highest score, this one will be given efficiency number 1,0. All the others will have efficiency number lower than the best one. This short description is the mathematical approach of benchmarking in a master sample of similar units, f. ex. units in a group of buildings.

The basic condition for carrying out a proper benchmarking by such method is that the products are comparable (“Apples compared with apples - and not with bananas”). In building production one project rarely is like another, not even when it comes to building of blocks of flats.¹³

Therefore one need to “equalize” the projects before it is possible to do a mathematical benchmarking. The statistical benchmarking method called DEA (Data Enveloping Analysis), used in many countries when studying productivity, is a

¹² The fact that both “Manhours” and (delivery of) Materials can be delivered by one or more contractors, either in individual contracts with the owner or in one main contract and the others connected through sub-contracts, is one of many aspects causing “trouble” to the data collection

¹³ In the sixties and seventies, when mass production of flats was the policy (necessity), great fields of land were developed through “copying-like” production of residential buildings in most of the Nordic countries. This is not the situation anymore. Today, the production of blocks of flats, like all other types of buildings, is mainly governed by two factors: shortage of land and the buyers/users preferences

method developed deal with the fact that units in a benchmarking objects not are identical. By use of modern data technology, the DEA increases the possibility to do benchmarking when the units in a randomly established master sample not are fully similar to each other. At least one of the national productivity projects is working with DEA in the benchmarking of building projects, se chapter 4.2 and 5.1.

3.3 Comparing prices

Advanced benchmarking can be carried out as mentioned in 3.2. This is, however, a rather expensive way of studying productivity/efficiency. There are easier ways of studying productivity, though not as precise as the DEA, see chapter 2.4.2; The Luleå doctoral thesis.

A (very) simple way of having a measurable value of *the building product* is limit the numbers of qualities (values) to one – the quality “Area”, measured as f. ex. gross area (m²). With such simplification, the efficiency number (E) in 3.2 is nothing but the inverse of the “square meter cost”, f. ex. nok/ m². In the simplest way, studying of the development of productivity can be done by putting attention to the cost pr. square meter. This is what contractors and other stakeholders in the construction sector always have done. It must be mentioned that such simplification of the product value - gross meter only - calls for high degree of “gut feeling” with respect to the (many) unmeasured qualities (characteristics) of the buildings that must be evaluated when comparing efficiency. Nevertheless, the “square meter cost” or “square meter price” is a handy way to “spot” the building project, e.g.. to tell colleagues and other B&C professionals about the “productivity”. The method is improved by breaking down the major cost, or price, figure in a sub structure, and even to a level below this, more or less similar to the structure of calculation and account system for projects. In this way, the understanding of the cost/price development *can* be followed and explained by professionals. In chapter 3.5.3, 5.2 and 5.5 this way of communicating productivity is presented. The problem is that comparing projects by these figures is not easy, since much of the differences not are given as figures Example: Functional and aesthetical standard (“quality”) of the building. In this respect, the scientific, statistic approach, like the one referred in 2.4.2, can give a more “true” picture of differences in productivity.

3.4 Other approaches to performance evaluation

Multivariable statistic methods, like DEA and other methods of regression studies (3.2) are very suitable in studying the change in performance/capacity of an organization or differences between competing organizations. Simplified methods, like registration and comparing of building component price (3.3), are a rather sensitive method and should be used only when all other important characteristics of the products (buildings) in a master sample are like.

Many organizations have their own, often simplified, ways of measuring its own performance. This can be measuring of

- The level of, or change in, “non-presence-time”
 - Level of costs of faults and rework during erection
 - Deviations from predicted production time
 - Number of complaints for customers
- etc, etc.

In later years the Balanced Scorecard idea has been taken into use, especially in UK, connected to the national improvement program “Rethinking construction”. In short, a number of performance indicators like those mentioned above have been defined as key performance indicators (KPI), measured regularly and put together in some benchmarking system, see fig. 3.4.

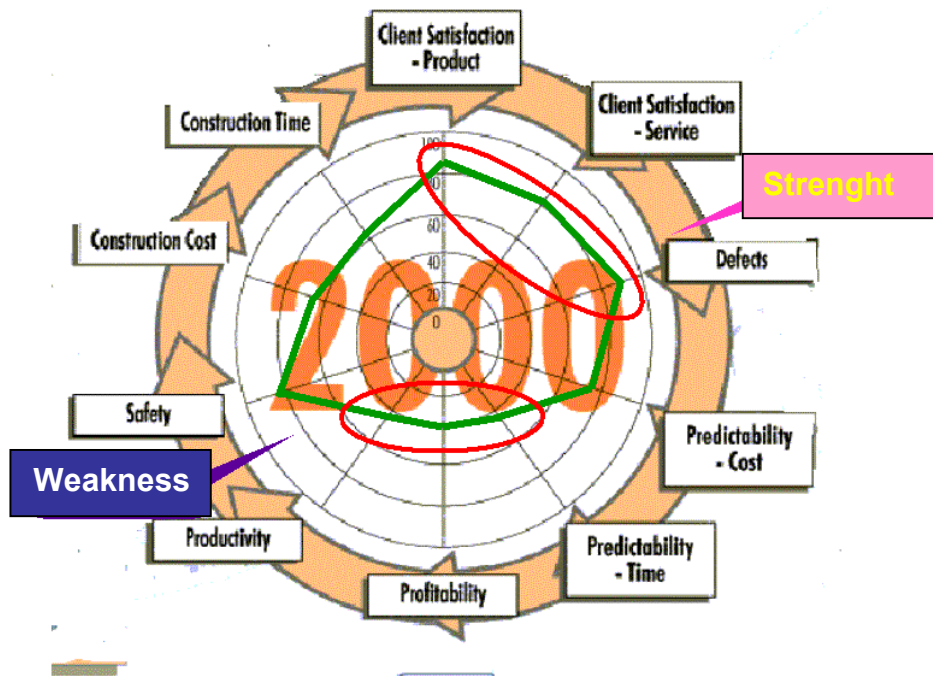


Fig. 3.3b KPI presentation sheet (illustration), showing 10 Key Performance Indicators, and one example company's results – with variations in values from “weak” (close to centre) and “strong” (far from centre). Source: BRE, England.

As seen in fig. 3.3 b, “Productivity” is one of ten indicators. It is measured as *labour productivity* at project or company levels, e.g. total cost divided by the number of working hours, and by this a figure that needs supplementary comments of type degree of sub-contractors, type of structure, degree of prefabrication, functional, technical and aesthetical standard (“quality”), etc.

3.5 Actual activities and institutions

During the eighties and nineties, the R&D activities concerning building and construction mainly put focus on quality, health and safety, environmental matters, etc. and less on productivity/efficiency. This last mentioned aspect was of course part of the discussion, but not at a research question itself, more as a background and qualification for the other areas of attention.

Different circumstances brought productivity/efficiency as such to the surface again. The industry itself pronounced the need of such research. Increasing costs for the industry causes increasing prices in the market, and the public expressed its dissatisfaction about the situation. At the same time it can be observed an understanding by political authorities in all five countries about the need of a competent and competitive national construction sector. Such acknowledgement empowered the new interest of productivity as a researchable problem, leading to different R&D activities. In this chapter are listed and given comments to different recent programs and R&D projects at the field of productivity.

3.5.2 Norway

3.5.2.1 The Econ Note 34/2000

After the report “Productivity in the Nordic building industry” (Albriksen, R 1989) was presented in 1989, the public research activities in this field were absent. In 2000, the Econ - Centre for economic analysis, presented a report with the title “Productivity in building and construction industry” (N, Lit. 4). The report used, like the normal practice has been when measuring productivity, the data from Statistics Norway, and presented the diagram shown in figure 3.4. The conclusion was

- *Productivity growth in B&C industry has been 1¼ % per year in the period 1978 – 96, slightly below what is the figure for all the Norwegian mainland industry¹⁴*
- *The figures for the construction sector has been (very) low for the whole period, and even lower in 1996 than in 1978*
- *the growth in the industry's productivity is caused by the building sector alone. The growth in building sector has been 1½ % per year, just as much as the rest of the economy.*
- *It is the category “Erection of buildings” that has caused increased productivity in B&C industry. The other categories within building sector, the category “Work in ground” and “Installations” have had rather weak growth.*

¹⁴ “Mainland industry” means all industry except oil and gas industry

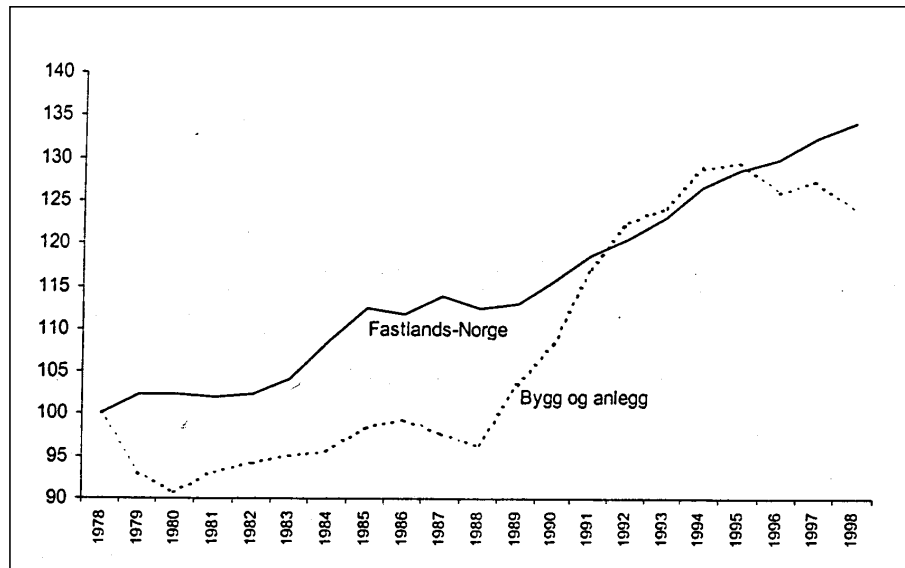


Fig. 3.4 Norway; Productivity in B&C industry 1978- 96 (dotted), and mainland industry in the same period (Statistics Norway and ECON 2000)

The early “flashing” topic in this report was the fact that the B&C graph is mostly situated lower than the industry graph. Despite the recommendation in the report, the general interpretation of the diagram is that the B&C industry does not perform as effective as the other industries. Certainly a quick glance at the diagram can give such impression. But this is not “fair”, as the report’s summery says that

- “1 In B&C industry productivity growth has been severe since 1978
- 2 The growth has been lower than the growth in the rest of mainland industry, but not substantial lower.
- 3 The growth in B&C differs strongly from the rest by the fact that almost all the growth came during the period 1988 – 94”.

In the report’s Abstract is stated: “We do emphasis that there are lots of problems/weaknesses when productivity is measured by use of those aggregated figures (i.e. Statistics Norway’s data collection), but nevertheless we regard it to be a useful start for a broader analysis of productivity development study in the trade”.¹⁵

Still, the diagram is used to show “how bad B&C industry is”, often in an introduction when the challenges of the industry shall be debated. Such “short-cut interpretations” can be explained by the lack of satisfactory statistics for the construction sector. The result is a sector with very limited true information for studying and understanding own performance and prepare for the future.

But gradually the attention has moved to the “right spot”. Unlike the total curve, the B&C curve starts a downward path in 1994-95 that seems permanent when the analysis of Econ stops at 1998. The statistic information, though based on rough figures, indicates some serious change in the frame conditions for the B&C industry. Leaders are frequently addressing the issue, expressing concern about the situation and the future. The frightening downward path of the “B&C-curve” that started in 1994-95 demands for further and better research. Will the decline be confirmed by

¹⁵ “The macro data problem” is present, more or less, in all Nordic countries”

more precise figures? What is/are the reason(s)? Is it reduced skills and reduced effort (loyalty) in the labour force, which is one of the often stated hypothesis, or is it increasing costs of materials, wages and other costs, see figure 2.2? Anyway, the problem is real and severe. “The declining development of efficiency rating” seems to be the common opinion in and around the construction sector.¹⁶

3.5.2.2 The “B&C productivity measurement tool” project (2001 – 2006)

In 2001 the Federation of Norwegian Construction Industries (BNL) decided to initiate a thorough study of productivity in the industry. Based on an initial project report (application of funding), the Research council of Norway gave birth to a project of productivity studies for the period 2001 – 2005 (2006) by funding it with 14,2 million nok, e.g. approximately 3 mnok/year. The project includes two Ph. D. theses, based on cooperation with the Universities in Oslo and Trondheim.

The project intends to establish best practice information for the construction sector, based on productivity measurement by the Data Enveloping Analysis (DEA). The project organization is established and has carried out an initial test of the suitability of DEA for the building production (2001-02). The work is given closer presentation in chapter 4.3 and chapter 5.1.

3.5.2.3 Building costs – two (three) studies

a) Introduction

There has been a common opinion, partly confirmed through registrations, that the prices of houses and flats in Norway have been escalating more than prices in general. Based on this opinion, the Local Government and Regional Department, initiated some R&D activities on this issue. Two reports have been presented during spring 2003 as basis for the Governments presentation to the parliament (Stortinget) in February 2004, named “2004 State of Art and Visions regarding Housing” (N, Lit. 5). The two reports are commented below.

Initially, in figure 3.5, is shown a non-scientific study made by an employee in one of the Norwegian house builders/developers with reference to three of the companies’ own, completed projects. Between the first and the second project there is a time space of five years, as it also is between the second and the third. (Cost- and price figures are all adjusted to level 2002 – nok/m²):

¹⁶ See fig. 2.3. Also in Finland it seems to have “happened something” in 1993-95. Similar change can be observed in Sweden, see fig. 3.16. The logical evaluations and comments to the situations are many. Few are based on better facts/data than the GNP-figures.

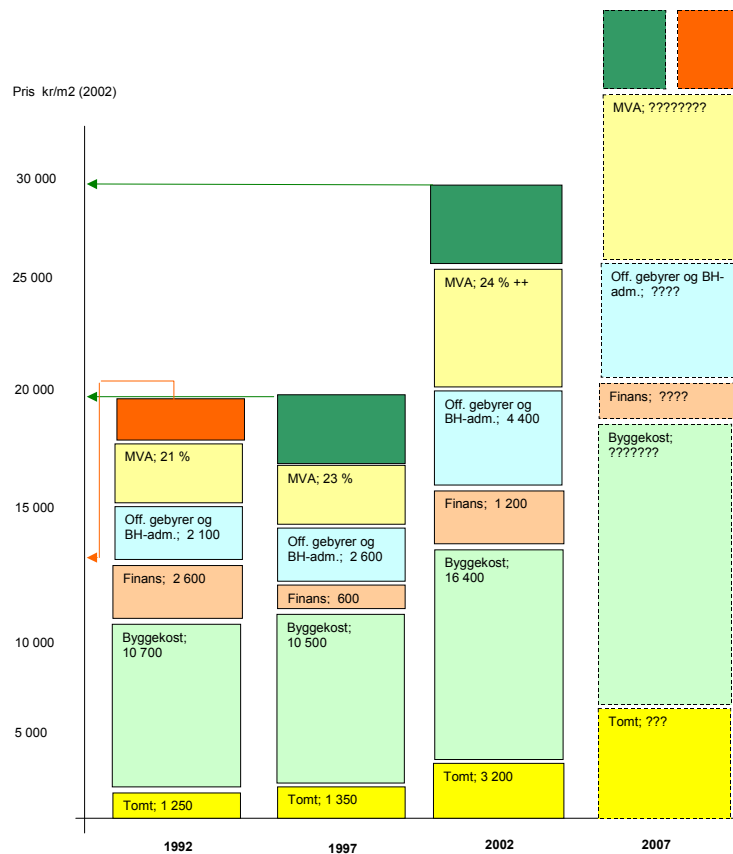


Figure 3.5 Example of costs and prices reg. development of three residential buildings 1992 – 2002, and hypothesis of future development (2007). NB! The four columns and the scale “Pris” (y) are not corresponding in details! (Source: Unofficial)

It is interesting to observe that the two cost categories that increased strongest from 1997 to 2002 are land and TVA, both approximately 140%. Also financing (100%) and owners costs (costs for permission etc) have grown strongly (69%). These are all costs outside the influence of the building companies (contractors ect). Also building costs increased severely (56%), but still not as much as the others. Of importance is that increased functional and aesthetical standard (“quality”) also is part of the growth of building costs. This means that the figures of the three objects are strictly not comparable, as discussed in chapter 3.2 – 3.3.

We do not know much about how productivity changed during the period. The question of major interest is “Can increased productivity in the industry reduce the growth in housing prices in the future?” The referred representative has his thoughts about this issue too, see table 3.1.

Ground	Limited supply, especially in the pressure area
Regulation	Increased/enlarged ”hidden taxation” through mixing building licence with cost of social infrastructure elements like roads, schools, church, etc.
Building costs	Grow, if not certain initiatives are carried out, i.e. R&D, industrialization, simplifications of solutions etc.
Warranty works/costs	Grow, if not authorities and the industry itself manage to change the tendency, see NBI-report no. 163

Table 3.1 Thoughts about the future of house building sector

As underlined above, this is a non-scientific listing of some data for three certain projects. Nevertheless, it reflects the reality, and put focus on the rights issues, see the “2007-coloumn”.

b) The Norwegian State Housing Bank (Husbanken) study

In spring 2003 the bank, urged by the department, brought forward a document named “Increased cost focusing?” (N, Lit. 6). The document presents facts about price- and costs growth in housing (one/few family houses and blocks of flats) in Norway as a whole, as well as for regions (break down). Further it discusses how to limit the growth of prices/costs.

It says, based on the banks own figures from applications, that price/cost in housing has increased approximately 68 % in the period 1989 – 2002, which is 5,2 % pr. year. As the figures are adjusted for inflation, the growth figures are real. The diagram below shows building cost as the dotted line, confirming the experience from the developer in section a) above.

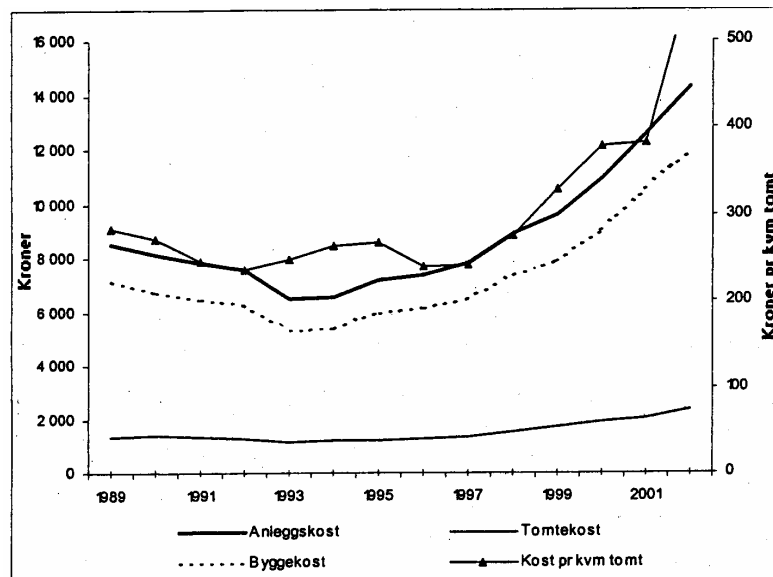


Fig. 3.6 Price and cost evolution during 1989 – 2002 (The Norwegian state housing bank)

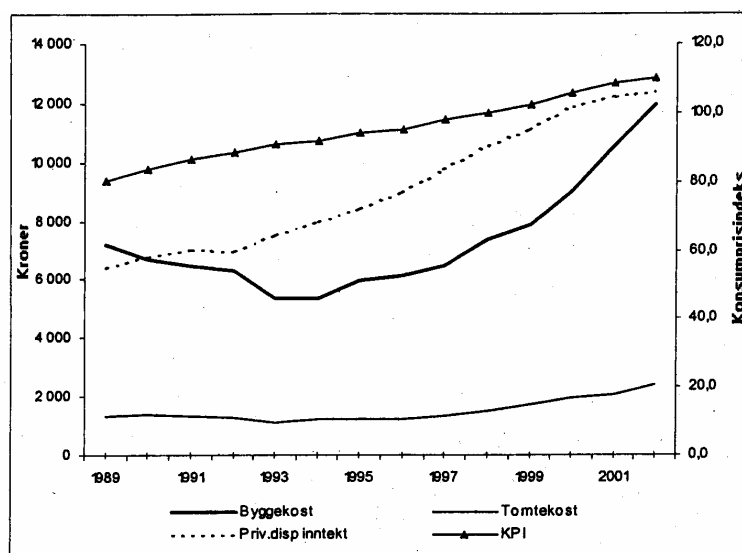
The strong growth in prices/costs to owner/developer, from 1993 –2002, approximately 82 %, which is aprx. 9% in average, calls for more investigation. See figure 2.2. What are the driving forces – the prices paid for materials, transportation, subcontractors, machinery and equipment, or is it lower productivity by the labour force?

There are some important regional differences. In Norway as a whole, the developer’s cost (contractors price) increased from 1984 to 2002 increased by 122 %. Lowest growth, 88 %, is measured in the Aust-Agder region in southern Norway. Oslo is on top with 205 %.

The report itself emphasizes the fact that the figures from the state housing bank in not very suitable for real price/cost analysis. One source of disinformation is the fact that the main samples are non-randomly. The general figure, 122%, is strongly

influenced by single/few family “large-area” houses (In 2002 the upper allowed area of one unit was 130 m²), while the Oslo figure, 205%, is influenced by the “dens” blocks of flats (In 2002 the upper allowed area of one flat was 69 m²).

Despite the reservations in the report, there is given a diagram comparing developer’s cost with the disposable private income, see figure 3.7. Especially in the period from 1999 to 2002 the developer’s cost has grown much stronger than the disposable private income. The consequence for new buyers will presumably be less to spend on other elements in the private budget.



Kilde: SSB og Husbanken

Figure 3.7 Evolution of Developer’s cost (strong line) and disposable private income (dotted line) The Norwegian State Housing Bank)

The discussion in the report about what the State Housing Bank has done, and in the future can do, to stop the escalating price of housing, is interesting. The existing practice, and different ideas are presented. The major idea is to develop a building cost monitoring department in the bank to establish better transparency and knowledge among all stakeholders. (Other ideas are mentioned, too).

c) The Econ-HoltheProject study

In March 2003 the two companies Econ and HolteProject AS together carried out a study, presented in the report “Initiative for lower costs in house building” (N, Lit. 7). The report is based on studies of the Norwegian National Accounts and Statistics Norway. It includes also an estimate carried out based on the calculation model and material and wage price database of HolteProject AS.

The report states that the market prices of older houses and flats (“second hand market”) have increased severe. The report assumes that the price of *new houses/flats* has increased similarly. Further, the report says, has *the building cost* grown considerably less than the price of used houses/flats. Consequently the growth in prices for new houses/flats must stem from three factors:

- a) An increased price of land
- b) The increased demand concerning standard (“quality”) from buyers

c) *New, cost increasing demands from authorities, to technical elements and to the administrative part*

This evaluation is based on following findings:

1) *The building cost index* for single family houses and for blocks of flats, has increased almost exactly as much as the consume price index (inflation), see figure 3.8 (As shown in chapter 2, figure 2.2, the building cost index is the price the contractor pays for materials, wages, subcontractors, transportation, machinery and energy. The input factors are weighted into to indexes, one for one-family houses and one for blocks of flats. The indexes don't include the profit of the contractor).

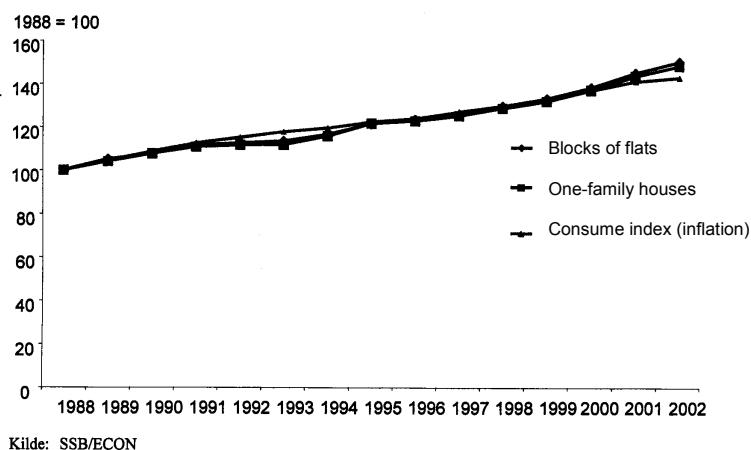


Figure 3.8 SSB Building cost indexes and consume price index 1988 – 2002; like evolution

The material costs have had a stronger growth than the wages have, though not deviating much from the total. Interesting is an observation from the national account, see figure 3.9. This shows the evolution of wages, with the interesting fact that the increase in wages in building and construction is slightly lower than the total.

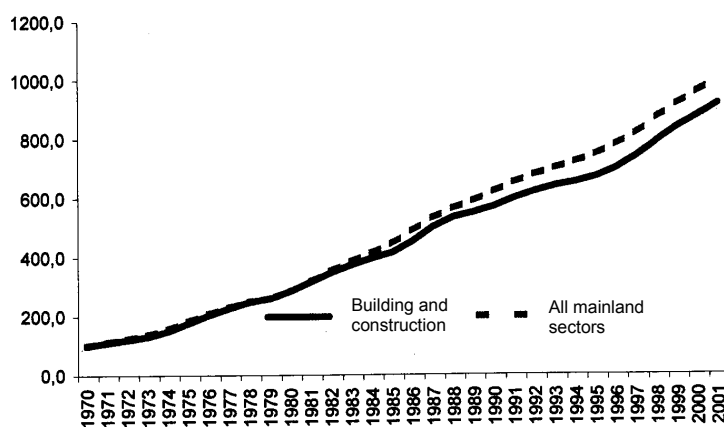


Figure 3.9 The National Account; Evolution of "Wage pr. (normalised) year", general and in B&C industry (1970 = 100)

2) *The productivity growth in the sector has been lower than it should be expected.* The conclusion is based on the usual – rather simple - way to measure labour productivity, using the figures in the National Account for the sector's production volume (turn over) divided by the total number of working hours in a year. It should not be given too much attention, i.e. because the aggregation problems can be severe. See also 3.6.2.1 The Econ note 34/2000.¹⁷

3) *The price index, both for new and second hand one-family houses, has increased much more than the consume price index. Despite this, the part of the households' total consumption spent on housing services, is almost unchanged.*

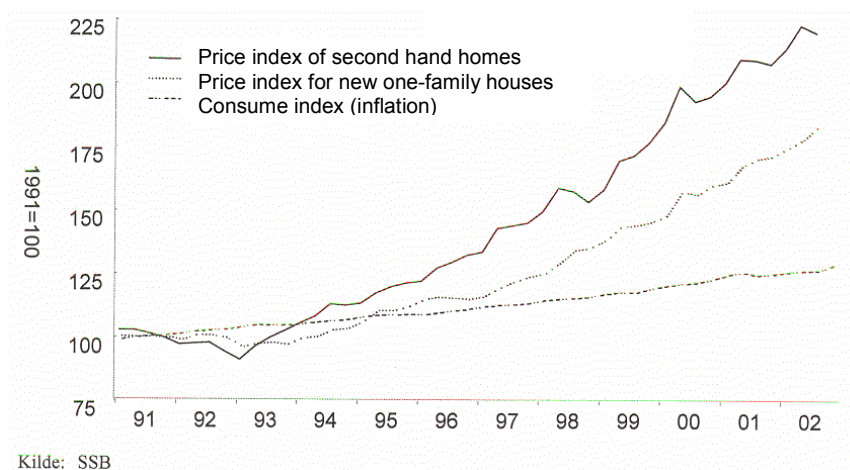


Figure 3.10 Price indexes for old homes, new one-family houses and the consume price index (1991 = 100. Statistic Norway)

The two diagrams shown in figure 3.8 and 3.9 are used to deduce the conclusion that the price-driving factors are as listed above. The second part of the thesis 3 should be seen in light of the State Housing Bank statement, see section b).

4) *Public statistics and other public sources are not suitable as basis for analyses like the one just done.*

This is said in other sources as well, and should be remembered. The result depends on the quality of the basic information. The report's advice is to produce better statistics in cooperation with the B&C industry. This is the aim of at least one of the five nations participating in the Nordic productivity study project.

HolteProject has developed and maintained a calculation model and a database of production unit cost in construction sector. This was used to produce a predicted cost evaluation for a model block of flats, see figure 3.11

¹⁷ There is no reason that the labour productivity, nor the total factor productivity, should be the same for any branch.

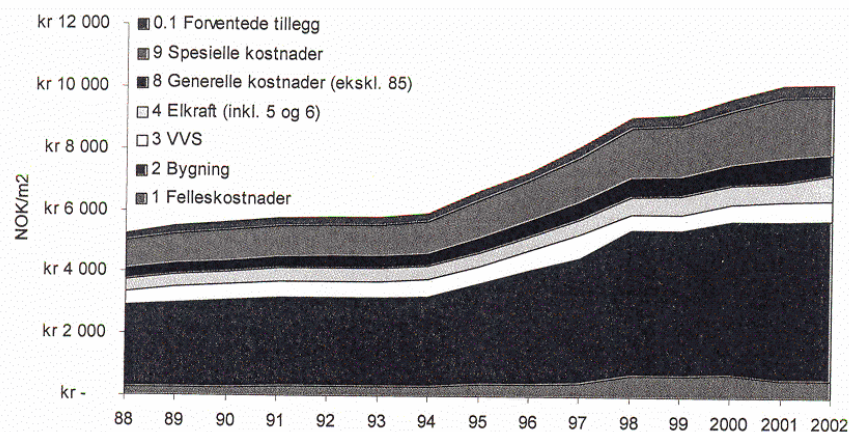


Diagram 3.11 Evaluation of predicted Project costs for blocks of flats, 1988 – 2002 (HolteProject AS)

The figure shows growth variations in the different part of the project cost. HVAC is the component that had the lowest growth (45 %), while the growth was highest in the group Electric installations (116 %). In total, the developer's cost excl. the cost of land has grown with 91 % in the period 1988 – 2002, which is 6,5 % pr. year.

The model calculations do not take into consideration the de facto *change in standard* ("quality"). But an interesting estimate is conclusively performed in this respect: Changing the point of view from 1988 to 2002, the report present the 1989 Project cost to be 46,7% lower than the 2002 cost. The figure 46,7 % is further divided into four explanatory sub-indexes:

- 1) Ordinary growth in prices (inflation): 29,7 %
- 2) Firmer/wider requirements from authorities: 7,3 %
- 3) Increased standard due to market's (buyer's) demand: 15,1 %
- 4) Other reasons: 1,2 %

Despite the no-scientific and not easy understandable deduction, this report do present this section, since the price/cost growth by this is given "flesh and blood" to the total, even if figures themselves are disputable. It is interesting to see the figures together with those in the Engebeck-Wigren report:

In Norway; the increase in construction costs 1978 – 1993, caused by increased value of the product, i.e. product standard ("quality") was 44 %. Above is stated an increase from 1988 – 2002 of $(7,3 + 15,1) = 22,4$ %. Taking into consideration the overlap 1988 – 1993, the sum of the two says that the major improvement of standard took place during 1978 – 1988, and that the growth 1993 – 2002 has been lower and seemingly only represented by the growth caused by the authorities (7,3 %). This can be in accordance to the common opinion of what has happened with the value of blocks of flats during the last 25 years. As the figures have different data sources etc. one should not try to make more out of it, but keep in mind that product value change has been calculated in two different environment, giving future studies of this very question a possible good start.

3.5.3 Sweden

Information on building types and building cost is collected from Statistics Sweden (SCB) – the official national statistic institute. Further information on their web site: www.scb.se

Dwelling types

Table 3.3 shows that half of the apartments in multi-dwelling houses are build with own management of either of the large contractor that will find the land, design the house, build and sell. For single house dwellings is the building with own management higher. For multi-dwelling houses is the houses build by contract probably most turnkey contracts or general contracts. No statistic for this is found.

House types	Number of Apartments	Own management	Contract Tender	Contract Negotiation
Multi dwellings	4633	50%	20%	30%
Group build single house	2304	66%	12%	22%

Table 3.3 Distribution of house types year 2000

Table 3.4 shows the distribution of dwelling types based on ownership. The tenant type is a dwelling for letting out. The second type – tenant-owner (bostadsrätt) is dwellings “owned” by people living there. This is not the same as full ownership, as found in most other countries in Europe. A tenant-owner association owns the dwelling. The association has the purpose for unlimited time to place apartments for the member’s disposal. The general meeting and the board make the decisions for the association. Two large organisations help in forming and administrating the tenant-owner associations – Riksbyggen (owned by the workers association) and HSB. The tenant-owner system is unique for Sweden.

Dwelling type	Number of apartments	Distribution
Tenant	1343	29%
Tenant-owner (Bostadsrätt)	3290	71%

Table 3.4 Dwelling type year 2000

Table 3.5 shows who build the houses. For tenant-owner associations can the builder be a private firm as JM and Skanska or associations of tenant owner associations as Riksbyggen and HSB. It is seen that public building of apartments is minor part.

Builders (Byggherre)	Number of apartments	Distribution
Private firms	397	9%
Tenant-owner associations	3290	71%
Public	946	20%

Table 3.5 Builders of the houses year 2000

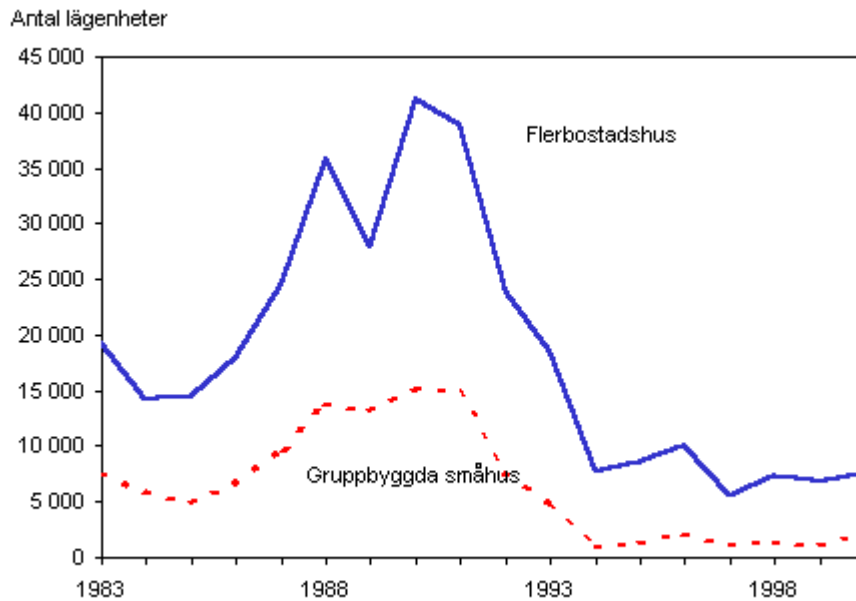


Figure 3.12 Number of new apartments in multi dwellings (flerbostadshus) and group single dwellings (gruppbbyggda småhus) 1983-2000 From SCB, BO 27 SM 0101

The buildings of new dwellings are expected to rise in the next years. In 2001 were build approximately 21000 apartments (included 7000 single family houses). For 2002 is expected build 25000 and in 2003 26000. The estimation is that there is a use for approximately 50000 apartments per year taking into account the rise in population and the need for renovation of old apartments. The working force in the building sector is expected to rise, but problems with getting new workers are not expected.

Building cost

In the statistics from SCB is the information given as the total production cost. That is the cost the building owner must pay to all the contractors. In reality is it more interesting to get the contractors real cost, but these numbers is not open for official statistics. Further information on building cost can be found in: Bostadsbyggandet och byggkostnaderna åren 1960 till 1999, Boverket, Karlskrona, 2002, ISBN 91-7147-705-5.

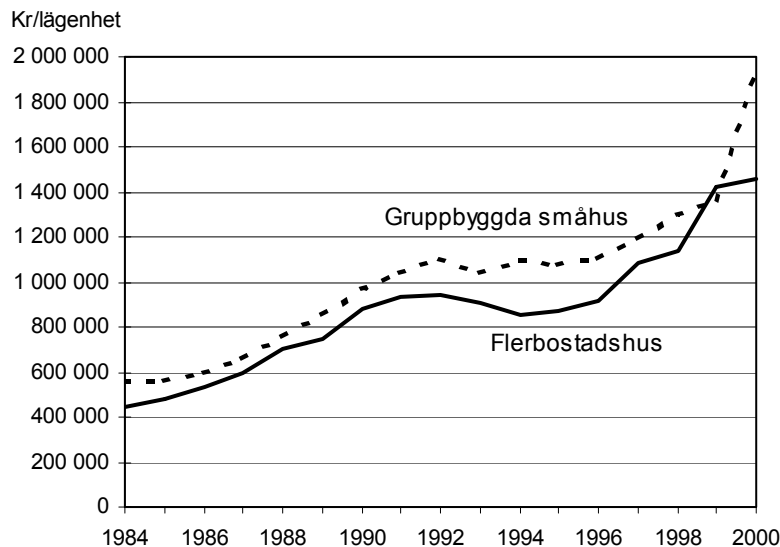


Figure 3.13 Production cost per apartment for multi dwellings (flerbostadshus) and group single dwellings (gruppbbyggda småhus) 1984-2000 From SCB.

An analysis of the building cost has also been done by the Swedish building industry and in a report “Bygger vi dyrt? - En analys av kostnadsutviklingen, Sveriges Byggindustrier, april 2003. (Are we expensive? – An analysis of the cost development in Swedish building industry”).

The official statistics includes in the total production cost, Cost of site, Fees and taxes (not VAT), Contractor costs, Consulting costs, Building owner costs, Financial costs and Value added tax (VAT). The contractor’s cost is around 70% of the total.

An analysis from 2001 shows that the total costs in a multi-family house consists of: Salary 22%, Materials 23%, Building owner cost 10%, cost of land 17%, VAT 17% and other costs 11%.

In the building process we have input prices and output prices. The input prices can be calculated by the factor price index (FPI), that is a combination of price development of the prices of the production factor (materials, work costs, machines etc.) The output prices is calculated as the building price index (BPI), that takes out the change in quality and the effect of building in different areas. These indexes have been calculated by SCB.

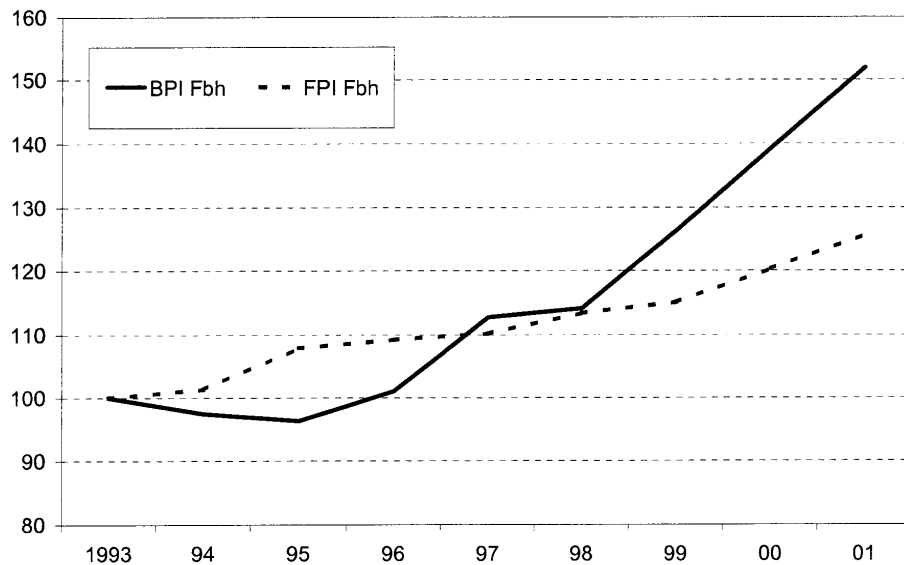


Figure 3.15 Building price index (BPI) and factor price index (FPI) for multi family houses (Fbh) from 1993 to 2001.

The BPI has a higher growth rate than the FPI since 1998. If PFI is deflated with BPI can we get an index that shows the development of the sum of profit and productivity. This is seen in diagram 3.16. The result is than that sum of profit and the productivity has increased. If we estimate that the productivity has been the same. Consequently the profit has increased with 20%.



Figure 3.16 The sum of the profit and the productivity in single (småhus) and multi family (flerbostadshus) houses. From SCB.

This assumption can be checked by using the information in the Gross domestic product (NR). Here we can also get the productivity and the profit in the building sector.

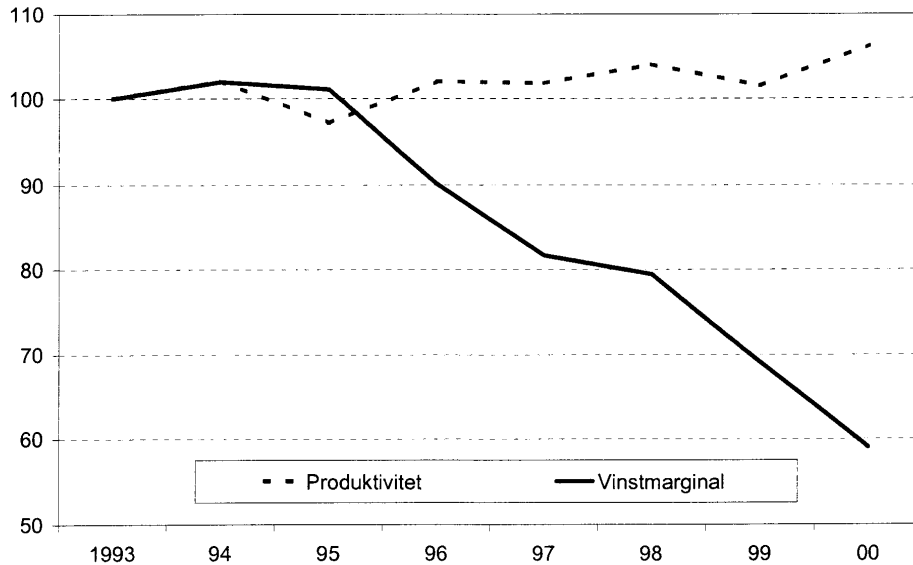


figure 3.17 Development of profit (vinstmarginal) and productivity (in running prices) in the building industry after NR. From SCB.

In this case has the productivity increased slightly and the profit has gone down by 40%.

This gives two different pictures and shows that it is not easy to use the official statistics for the building costs.

3.5.4 Finland

3.5.4.1 Building Cost Index

Presently, the official Building Cost Index refers to the general index of professional new construction. It is based on the breakdown of costs concerning blocks of flats, row houses, offices, commercial buildings and industrial production and storage facilities as well as construction volumes. In addition to the official Building Cost Index, Statistics Finland also puts out indices monitoring the development of the costs of new construction of one-dwelling houses, renovation of one-dwelling houses, dwelling repairs, facade renovation of blocks of flats and building services renovations.

From beginning of year 2001 on, the Building Cost Index has been published in revised form. The revision involves taking into account the structural changes that have taken place in construction in the 1990s as well as the requirements set by the European Union. VTT was entrusted the task of verifying that the Building Cost Index describes as well as possible construction in 2000-2005 as concerns both volume and content and cost structures. (Vainio & al. 1999)

3.5.4.2 Productivity index

The Statistics Finland is publishing sector level, annual development of productivity by an index-type indicator that does not indicate the level of productivity but changes in it. The indicator is achieved at by dividing the output (value added by the sector)

by inputs (worker hours and capital stock). Construction is divided into building construction and civil engineering - and building construction is divided into site production and the construction products industry.

The productivity of the entire building process has improved along with the developments in the production and process technology of the products industry. The fact that the end products have become more complex, and sub- and specialist contracting has gained ground has slowed down site-productivity development. (Well-Being 2003). Fig 3.18

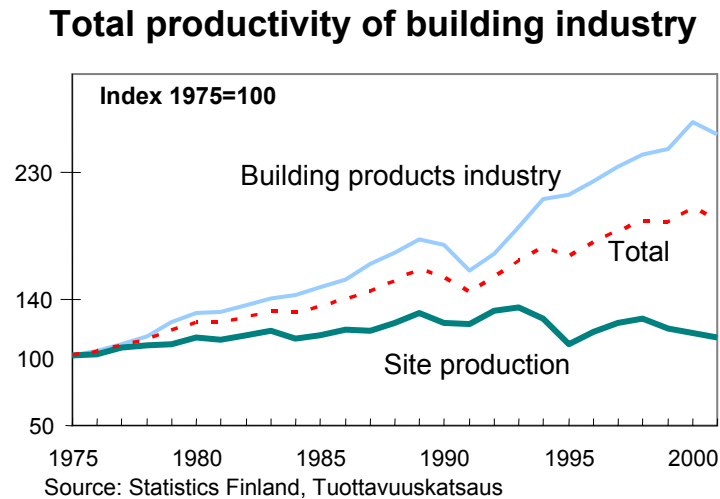


Fig. 3.18 Total productivity index of building production, index 1975 = 100. (Statistics Finland 2003)

The index-type productivity indicator based on worker hours and capital stock is strongly affected by economic cycles, if the industrial sector is capital-intensive and when the utilization of the capital goes down on recession. That is the case especially in civil engineering where the utilization of machinery and transport capacity can be sometimes low, see figure 3.19.

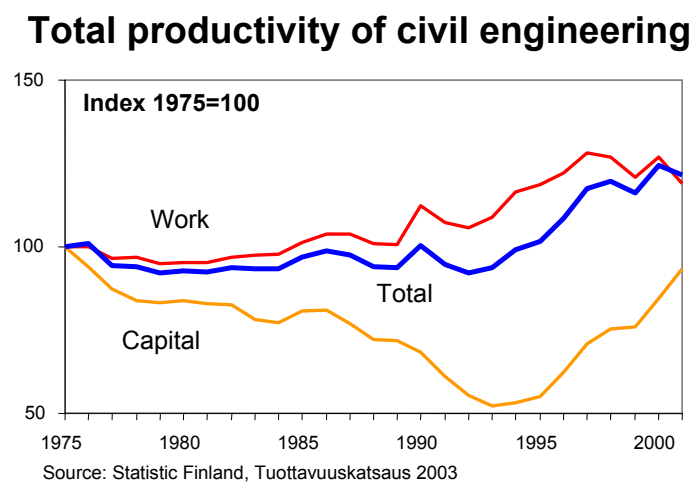


Fig. 3.19 Total productivity index of civil engineering, index 1975 = 100. (Statistics Finland 2003)

3.5.4.3 Performance measures

Helsinki University of Technology (HUT) has been studying and developing for several years the characteristics of well organised and managed construction site. HUT has published among others the measures to evaluate the performance of construction site and has measured the efficiency of site operations. The measures form a hierarchy, in which the highest level is the main objective of the site, profitability; on the second level are the causal factors, and the third level are the measures themselves. The causal factors are divided in four categories: costs, schedules, productivity and faultlessness. In addition some descriptive measures are calculated to help in the interpretation of causal measures. (Salminen 1998)

Companies need information about their performance to control their operation. Operational measures should fill the following criteria: they are possible to be calculated on grounds of presently available information, they are directed to matters essential to for the operation, and the site should be able to influence to them. (Salminen 1998)

Findings from these studies have been integrated as a part of several companies' internal reporting or operational systems.

3.5.5 Denmark

See chapter 2.3.4.

3.5.6 Iceland

There were no official programs or research projects especially oriented at the building industry in Iceland at the beginning of the Nordic productivity project. But although an official research has not been carried out, the individual companies do of course check regularly their own status concerning in this matter. A project in this field has however been organized and is expected to start during 2004.

In the past there have been two seminars about productivity in the building industry in Iceland. The first one was a NBS seminar in June 1987 and the latter one was in September 1998.

Information about productivity in the building industry as in other industries, based on official statistics, has however been published, but almost only as a part of a total survey over the industry sector as a whole. The last one was published by the Technological Institute of Iceland ("Framleidnimat" published in June 2002) in cooperation with the Federation of Icelandic Industries and the Icelandic Building Research Institute. It was prepared by the Icelandic firm Radgjof og efnahagsspar.

According to this survey the productivity of labour in the building industry was estimated to have changed annually, at average, by 2,29% from 1982 to 1991 and by 1,3% from 1991 to 2000. The average annual change between the years 1985 to 2000 was estimated to be about 2%. An average annual change in the productivity of capital, in the building industry, was estimated to be about -2,19% from 1982 to 1991 and about -0,65% from 1991 to 2000. The average annual change in the Multi

Factor Productivity in the building industry was estimated to be about 1.19% from 1982 to 1991 and about 0,82% from 1991 to 2000.

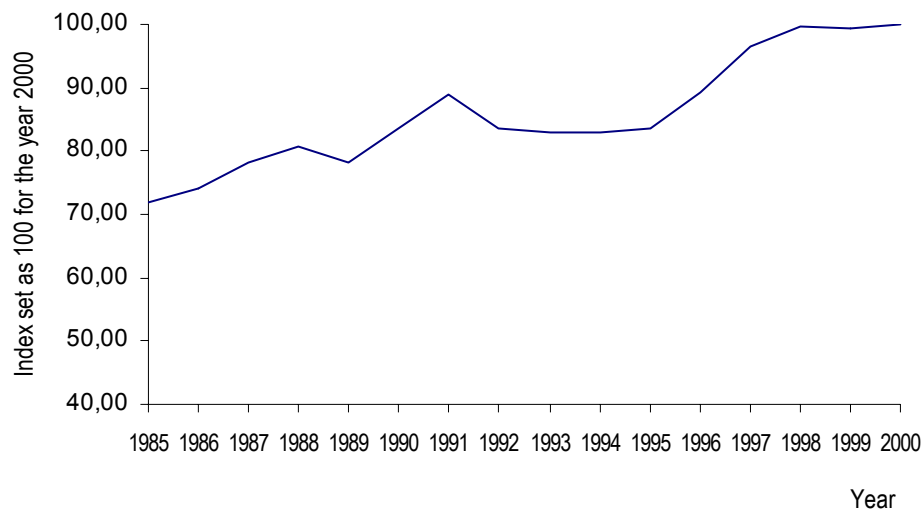


Figure 3.18 Index for the productivity of labour in the Icelandic building industry from 1985 to 2000. In the graph the index for the year 2000 was set as 100. (Source: The graph was done by the author of this chapter but based on information from the publications: "Framleidnimat" which is referred to in this chapter.)

3.5.7 Conclusive comments

The Nordic countries have a common understanding of the denominations in the field of productivity and the theory of productivity measurement. This is universal and makes future benchmarking projects possible.

Regarding measurements, the gross national account figures (GNP) and "macro" company figures are dominant as sources of information ("input"). The quality of input data, i.e. the "roughness", causes uncertainty. It is obvious that the efficiency is affected by the general development in national and international economy. But it is hard to come closer to a good and detailed understanding of the correlations. During the period 1993-95 a decline in productivity seems to occur in most of the Nordic countries. However, there are too little available data to carry out analysis on this alarming development in the observations.

Even if "the productivity problem" is given increased attention in all Nordic countries, as in Europe, the State of Art still is marked by

- lack of suitable data,
- lack of experience with suitable methods
- lack of a common, profound interest of such studies in B&C industry
- lack of a permanent productivity measurement supplier in the industry

The challenge is to have established common interest, professional environment and funding for systemized, scientific attention to the problem of efficiency in building and construction industry. National efforts exist, but even in the Nordic countries these are different and mostly of minor size and/or limited duration.

4 Methods and tools

In this chapter is presented and discussed the method and tools actual for productivity measurements and analysis in each of the Nordic countries. Basic principle is shown in the figure 3.1. To carry out productivity studies one need information of all four types of variables. This means input data, output data, facts about environmental condition and facts about the activities and priorities of the production management. In addition is needed general information of the projects, such as geography, construction period etc, etc.

4.1 The vision model

In the first workshop was suggested and discussed an active data collection with Internet questionnaires to a group of construction companies. The questionnaire should be developed in cooperation with the Nordic r&d-project members. A set of pilot interviews should be arranged with 1-5 construction companies. The researchers would do the first interviews personally with the representatives of the companies. After revision and modification, the questionnaires should be sent by Internet to a large group of construction companies in each Nordic country.

Several case projects was planned to be collected from each five countries. The case studies should be carried out on new multi storey apartment blocks.

The Internet questionnaire for the basic information and parameters for productivity should be attached to a computerized analysing system, with which the productivity benchmarking should be performed between companies in all Nordic countries. The results of benchmarking should be reported to the companies involved. Each company would receive the information of its own projects. The reported information of other companies was planned to be anonymous.

The questions was planned to be of two categories

- 1) General information of the project
- 2) Qualitative and quantitative characteristics with respect to productivity.

The information of the projects should be such that the researchers could make the analysis of differences in productivity. It was recognized as important that the definitions of the calculation data and the productivity indicators had to be precise and commensurable between all Nordic countries. Table 4.1 shows the list produced by the Workshop 2 in Tampere, as the basis for the final Internet questionnaire.

A Location of the project 1. Country and the geographic location (northern, southern etc. part of the country) 2. Regional location (capital city, major city, small town, urban, rural, city centre, central area, suburb) and address 3. Traffic conditions on site and conditions of neighbouring environment (e.g. special arrangements for safety). Special risks connected to previous (insurances)	B Systems of project management and design 1. User's needs analysis system 2. Design system 3. Tendering system 4. Procurement system 5. Execution strategy C Duration of project 1. Time of construction, name of months, and year(s) 2. Planning process, time, weeks 3. Planned time vs. actual used time, weeks 4. Budget cost vs. actual cost, currency euro
E Markets 1 Real estate (housing) markets in the district G Quality Verbal description is needed to specify the quality of the end product (apartments). 1. Performance 2. Customer satisfaction – Totally satisfied – Neither satisfied or unsatisfied – Totally dissatisfied 3. Architectural 4. Structural	F Costs 1. Currency = euro 2. Costs data need to be collected in current prices (e.g. tender price or actual costs in the year of project completion). The adjustment to constant costs (with indexes into year 2002 price level) will be done by the researchers 3. Price indexes (adjustments needed on costs) 4. Employment situation in the district 5. Supplier situation in the district (barriers, availability and control of resources and suppliers) 6. Costs data needs to be collected without value added tax (VAT 0%) 7. Taxes (explain, how the taxes influence on costs)
H Defects 1. Number and impact on the client of the defects reported in final inspection 2. Contractually agreed period for rectifying defects I Safety Number of accidents	J Physical characteristics and dimensions Private area, usable area, programmed area, m2 Flats, number, m2 Bathrooms, number, m2 Kitchen, number, m2 Bedrooms, number, m2 Living rooms, m2 Effective room/flat gross area, m2 Horizontal common areas, m2 Halls, m2 Technical rooms, lifts, m2 Corridors, m2 Total gross area, m2 Vertical common areas, m2 Stairs, m2 Lifts, number/m2

Table 4.1 Suggested variables for questionnaire for a Nordic productivity study

As the project developed, it became obvious that the task was huge. In each of the five countries there are slightly differences in understanding and/or definitions of more than a few of the factors in table 4.1. Not severe, but still differences to be handled, if a data collection should be carried out. More severe, though, was the observation that the nations and/or the involved companies had individual opinion and/or practice regarding key figures and/or how to measure them. Example: Period for rectifying defects differs between the Nordic countries as follows:

- DK Amount of defects are measured after 1 and 5 years
- SE A new law with 10 years compulsory insurance for client
- IS For new houses there is a compulsory insurance
against defect with the duration of five years after the house is finished.
- FI 1 year in general, 10 years for specified parts
- NO 2 and 3 years dependent on the size of contracts. 5 years are about to be the
new ruling condition for developers of residential buildings

Another, and more challenging difference is the way of measuring building areas. Even if there is an international standard merging¹⁸, there are mainly used local (national) standards for calculating floor area and space. These are not completely commensurable. Most extreme is may be the situation in Norway, where the State Housing Bank operates one way of area measurement, the Department of Environment another – and both deviate form the Norwegian standard 3940, which is the local “area measurement standard”.

The Nordic benchmarking should be of disputable value, if not having the same definitions for the input and output factors, even if the differences were small.

Still more challenging became the question of input variables, e.g. the cost of the resources used.

The classification of project costs was suggested to follow the classification in the Finnish Building-90 system (Talo-90), a classification system with origin in the early 1970's. The system is a comprehensive tool supporting design procedures as well as new methods of production planning and control. In Finland, parties of the construction industry have widely committed themselves to the system. The element classification is used in design, especially in specifications. The clients and contractors use the methodology in cost estimates of different accuracy by spaces, elements of construction or work sections as well as for detailed bills of quantities. The classification tables are also used in planning, scheduling and controlling the construction resources: labour, subcontracts, site equipment and purchases of building materials.

¹⁸ ISO 9836 Performance standards in buildings – Definition and calculation of area and space indicators

A Project division: Building management Building management cost entries include feasibility studies, project planning, marketing, process personnel as well as operation and maintenance manuals
B Project division: Development Development cost entries includes developer's administration, design activities, official activities, measures to manage a company or partnership and fees of joining to public services.
C Project division: Site general Site general includes costs incurred by construction activities on site, but not directly needed to install construction products in building or service elements.
D Element division: Building elements on plot Divisions from D to J are reserved for elements of construction – building elements and services elements. Division D, building elements on plot, has been separated from other elements to facilitate design, production and management of the maintenance. The external limit of elements on plot is generally the propriety. The limit against the other building and services elements is the external surface of foundations
E Element division: Substructure elements Elements of construction supporting the superstructure of building. The limit between substructure elements (E) and structural elements (F) is the lower side of footings and thermal insulation. The substructure elements include all elements under the very building. They may extend not more than 5 meters from the outer level of external wall, outside this they belong to elements on plot (D).
F Element division: Structural elements Elements of construction composed of general building products. The limit between substructure elements (E) and structural elements (F) is the lower side of footings and thermal insulation. Structural elements include foundation, structural frame elements; load bearing walls, columns, beams, floor slabs, roof structure, external and internal walls, windows, doors and finishes and equipment.
G Element division: Mechanical services elements Mechanical services elements include heating, water and sewer, air conditioning, refrigerating, gas and compressed air; fire extinguishing systems and other similar systems.
H Element division: Electrical services Electrical services include all electrical power service systems. The electrical information service systems are in division J
J Element division: Information system services Elements of information service systems include all electrical information systems as telephone, antennae, closed circuit broadcasting, property surveillance and integrated systems. The electrical power service systems are in division E.
K Project division: Project activities abroad Building projects abroad may include developer's or builder's activities, not occurring in domestic projects. These may cause varying costs depending on the country in question.
L Project division: Plot Plot cost entries include developer's costs for acquisition of the plot, which are not included in the building cost: purchase price, stamp duty tax and interest charges on the purchase price, plot rent and other plot costs during the construction time, expenditures for plot-related official activities, legal confirmation of possession and land surveying, expenditures of freeing the plot, evicting the tenants and maintenance of existing buildings, planning cost and off-site municipal engineering cost.

Table 4.2 The building classification system, Finnish Building-90 system (Talo-90)

The “Talo-90-based” draft for a project costs questionnaire seemed a good approach. It doesn't differ much from the corresponding way of structuring building costs in the other Nordic countries, and it was regarded ready for use in an electronic version of the questionnaire.

During the following workshops it became obvious that each researcher in the Nordic productivity project communicated in a strict national pattern when it comes to costs. Even if the four other nations' cost structure, or price structure, system in

principle were like the Finnish, the differences would be annoying in the data collection process. The slight differences would claim for much more time than the economy in the national projects of productivity made possible. Consequently the ambitious goals of developing and use a common tool for productivity measurement could not be reached. On the other hand the challenge and tasks in that respect are today better identified.

4.2 The realistic approach

During the autumn of 2002 and winter 2003 we made hard efforts to coordinate the two national productivity measuring projects in Norway and Finland. This seemed realistic, as the two countries representatives in the Nordic project; VTT and NBI, both had established a study based on the same statistic method (DEA). Through exchange of information, written and oral, we tried to merge the two ways of making the model operative. Finally we had to admit that it was too many details to be discussed and solved before the data collection sheet had become a common tool. But the experience is made, and new initiatives can start on a higher level and certainly with shorter distance to a successful result.

The fourth workshop recognized that the activities regarding R&D in the field of productivity differed so much from country to country that it became impossible to cooperate these. The second part of the statement in the project goal statement, see 1.3, has consequently not been achieved (*“If methods and/or equipment for the purpose are regarded as useful in the common scope, this/these shall be improved and prepared for common use”*).

The Nordic productivity project had to put all attention on the main goal, e.g. to “...carry out an overview on r&d activities on the field of productivity measurement and evaluation in building of blocks of flats in the Nordic countries”.

In the following chapters are presented and discussed the methods and tools in use or under development in the five Nordic countries.

4.3 Actual method(s)

4.3.1 Norway

The productivity study in Norway is organised in the project (program) “B&C productivity 2005”, see chapter 3.5.2.2.

For 2002-04¹⁹ the following program is planned:

- Collect data and other needed information regarding production of blocks of flats (population: 100 – 120 blocks/projects)
- Measure building site productivity by non-parametric efficiency analysis (DEA)
- Calculate efficiency number for each project and show them anonymously in a Salter diagram (see figure 2.10).

¹⁹ The original plan was to complete the data collecting process by December 2003. This has, however, shown to be too optimistic. To have the 120 units (block of flat projects) in the r&d project's database also major part of 2004 has to be spent on the collecting activities.

- Examine statistical correlations between the efficiency scores and other variables.

From the start the R&D project has emphasised close cooperation with the house builders. Almost all the major general contractors are represented. It is a challenge to develop enthusiasm for the work they have to carry out to the benefit of the research project. In the first phase, a minor group of representatives have participated in the development of a questionnaire. A lot of work has been spent on designing questions, guidelines and layout. A suitable questionnaire will have to balance between the research project's need for information and the usage of time for those who are going to provide information. The project started to collect data autumn-2003. The plan was to carry out the analysis during the autumn and report early 2004. The collection of data runs slower than expected and the 120 projects are now expected to be collected in a database by October 2004. The preparation of the analysis can partly be started when having got approximately 60 projects into the database. (This sub goal was reached spring 2004⁴).

The DEA is a method widely used in empirical efficiency and productivity analysis. Philosophy: The building process, as illustrated in figure 3.1, is a transformation of resources (materials, machinery and man hours) to products (area, volume, quality).

Management can influence the process by decisions and actions ("control variables"). On the other hand there are factors that are not easy to control for the project management. Examples: Weather, ground condition, regulation. ("Limiting clause variables").

Based on the input and output values, a DEA computer program calculates efficiency scores for the building projects, shown as bars in a Salter diagram, see figure 4.1.

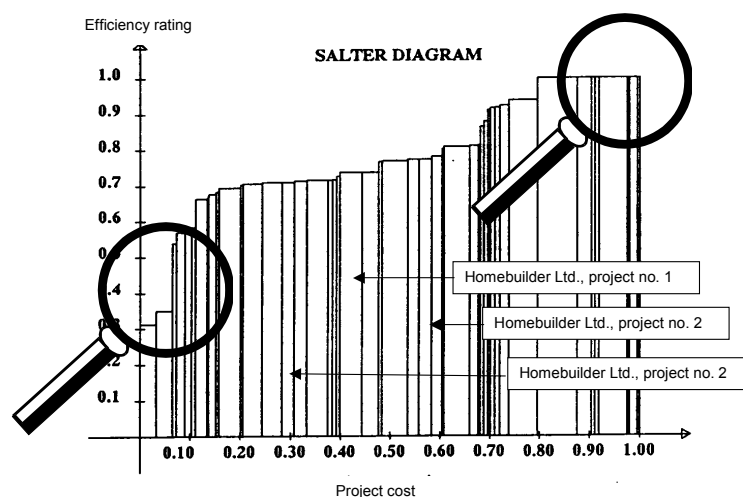


Figure 4.1 Salter diagram showing efficiency scores for a number of building projects with Best practice to the right and the least efficient to the left (Source: Construction Technology in Europe, issue 23 (2030))

The thickness of each bar represents the production cost of a project. The height measures the efficiency score, with $E = 1.0$ as Best practice. To some extent the primary variables, i.e. input and output, can give explanation to the ranking.

Example: It might be typical for the best practice projects to be of similar size (This is not the case in the illustration above).

To have better understanding of why the best are the best, a Stage 2 of the analysis will be carried out. This is a regression analysis, testing different hypotheses (the limiting clause and the control variables) against the efficiency numbers. Virtual example: Combining the efficiency score and the percentage of subcontracts in the projects, it is discovered that high efficiency scores tend to coexist with a low percentage of subcontractors. This is illustrated in figure 4.2. Such type of information, when it is true, should be valuable for the companies in their strategy development work.

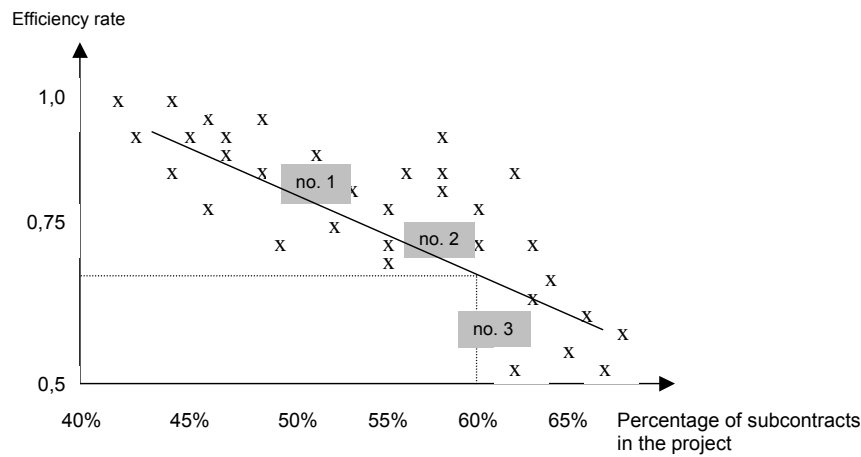


Figure 4.2 Example of how regression analyses can be presented. Here correlation between efficiency (E) and degree of production by subcontractors are given. NB! This is not a result from any real test, but only an illustration of how such results can be presented. (Source: Construction Technology in Europe, issue 23 (2030))

Behind the measuring results/ranking of the projects is a statistic benchmarking theory developed over years by international researchers of economical statistics for many countries. The Norwegian researcher, professor Finn R. Førsund at University of Oslo, has played a major role in this work. He is a team member of the “B&C productivity 2005”-project.

The test can, in a (very) simplified, e.g. two-dimensional way, be exemplified as follows: plotting the input value and output values in a diagram can rank a number of producing units, see figure 4.3. The producing units that deliver most products for a certain input value, or delivers a certain number of products with the lowest input value, is laying at “top of the heap”. These producing units (f. ex. building project sites) make the upper frontier of the heap. (The name DEA – data enveloping analysis – has its origin in the fact that the frontier is made visible by enveloping the number of registered units with a virtual handkerchief from above). In this way, the producing units with highest performance are identified. In other words, *the best practice* is identified.

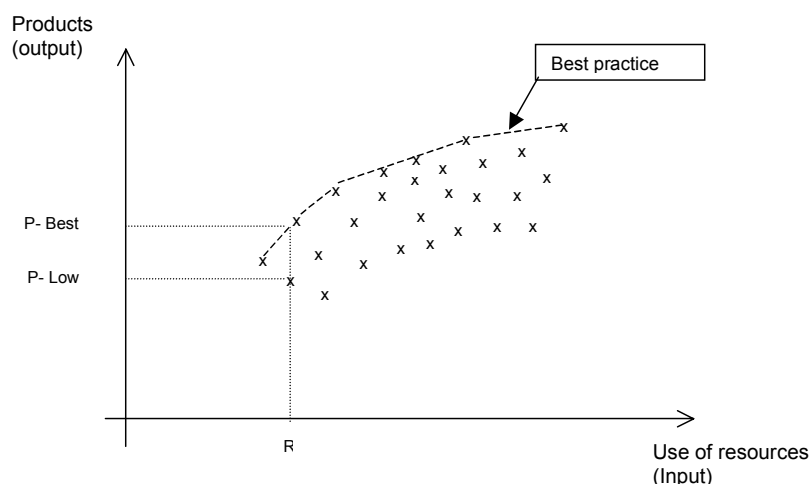


Fig. 4.3 Illustration of the DEA Best practice theory/method; Different number of products (*P-Best*, respectively *P-Low*) produced by different producing units ($x_1, x_2 \dots x_n$) with a fixed input of resources (*R*)

The theory is presented and discussed by the researchers (Førsund and Edvardsen 2000) through a more professional illustration, se fig. 4.4.

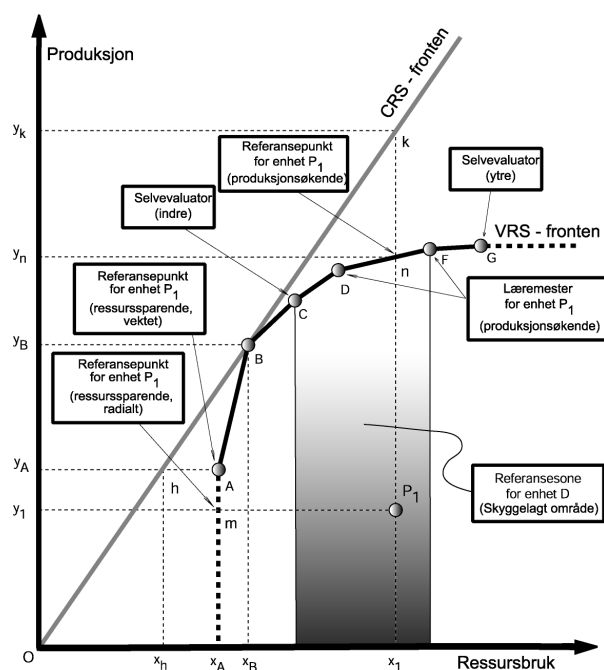


Fig 4.4 Basic illustration of the DEA Best Practice Benchmarking theory (Førsund and Edvarsen 2000)

In real life it is not possible to show the DEA method on paper. The method's characteristics are the fact that it processes an algorithm with many variables, i.e. four, five ... depending of the main sample number. The result is the Salter diagram, where producing units are ranked as result of mathematical evaluation including a sort of making the units commensurable with respect to both areas and other characteristics.

4.3.2 Sweden

The Swedish study has been based on using cost data from the client and not the contractor, as this is much easier to get. The cost data includes the total building cost and also the cost split in different parts as it is used for Swedish projects. The contractor cost is the most important of these around 2/3 of the total costs. The analysis is based on 26 cases, but we could have got many more without any problems.

The split in cost is done as described in Boverkets Byggekostnadsforum:

Cost of site

- Cost of land

- Interest on land cost to building start

- Legally registration costs

- Planning cost

- Cost of roads, water and drainage outside the building site

- Total cost of site 500-1000 Skr/m²*

Fees and taxes (not VAT)

- Fees for connexion of water and drainage

- Fee for connexion of electricity

- Fees for district heating / gas

- Payment for extra parking space

- Total fees 200-600 Skr/m²*

Contractor costs

- Building contractor

- Bricklaying

- Sheet metal work

- Floor work

- Tiles and ceramics work

- Heating and sanitation

- Ventilation

- Electric installation

- Lifts

- Control and regulation

- Site cost - roads, water and drainage at the building site

- Levelling and plants on site

- Price index change in the building period

- Extra cost for changes

- Total contractors costs 7000-10000 Skr/m²*

Consulting costs

- Architects

- Construction and geotechnics

- Heating, ventilation and sanitation

- Electric installations and lifts

- Control and regulation

- Quality control

- Other consulting costs

- Total consulting costs 300-800 Skr/m²*

Building owner costs

- Building management cost

- Cost of approval

- Insurance against building failures

Other insurances
Marketing costs
Unexpected costs
Evaluation cost for changes
Extra cost for changes
Total building owners costs 300-600 Skr/m²

Financial costs

Interest on building cost in the building period
Payment of rent of land in building period
Total financial cost 200-400 Skr/m²

Value added tax (VAT)

VAT on fees
VAT on contractors costs
VAT on consulting costs
VAT on costs
Total value added tax 2000-3000 Skr/m²

Total production cost

Total production costs 10500-16000 Skr/m²

The areas are all given as heated area BRA.

In the analyses we look at the cost variations between the projects. Based on these cases we have tried to show the data in Salter like ranking diagrams and the two-dimensional DEA-illustrations. We can show that these methods can all be used on the data from the client, either the total costs or the contractors cost. In the very simplified DEA-like approach we have used area (heated m²) as the products (output) and also shown one case where the product (output) is number of flats.

4.3.3 Finland

See chapter 5.3.

4.3.4 Denmark

The Danish study tried to put up a model for benchmarking on a more detail level than price per m² for the whole building. In the product model the building is split up in different functions, rooms and building parts that are comparable across locations, type of building and the lifecycle of the building. On each of these elements primary values and key figures for both costs, quantity and quality are defined primarily for the purpose of the building owner. The study also presents ideas for further development.

4.3.4.1 Dividing the building in main building parts – the product model

It is the experience from several studies (DK lit. 2-7) that it is difficult to compare productivity between buildings because they differ in function and content. It is also evident that the variation in price per m² indicates more than a dissimilarity in productivity. Another cause is the difference in quality, functionality and value for the end-user, which in addition is difficult to measure and evaluate. When we compare buildings in cities against building in the country (DK enclosure F) we also see a marked influence from the location. These measuring problems and variations in productivity, quality and function will grow even bigger, when we benchmark

across regions and countries, and the individual parameters will be more difficult to separate.

A solution is to divide the building in limited number of main elements that are comparable in function, quality and content and with a small variations internally in each element. The elements are in the object model mutual connected in an object hierarchy from real estate and the total building to materials as nails and screws in the smallest end.

The real estate is first split up in 'The ground and site' and 'Building and rooms'. For each type of real estate (block of flats, one family house, office building and school) a limited number of types of rooms and functions are defined e.g. for block of flats it could be:

Living rooms.

Kitchen.

Bathroom and toilet.

Corridor and hall.

Common room.

Common corridor and staircase.

At next level in the product model the building is split up in 'Building construction', 'Installation in building', 'Furnishing and equipment' and 'Common activities'. The last one is various activities which are common for the whole building and construction process e.g. design and planning activities, financing, construction site and administration. Value added tax is separated from the other accounts in a single entry.

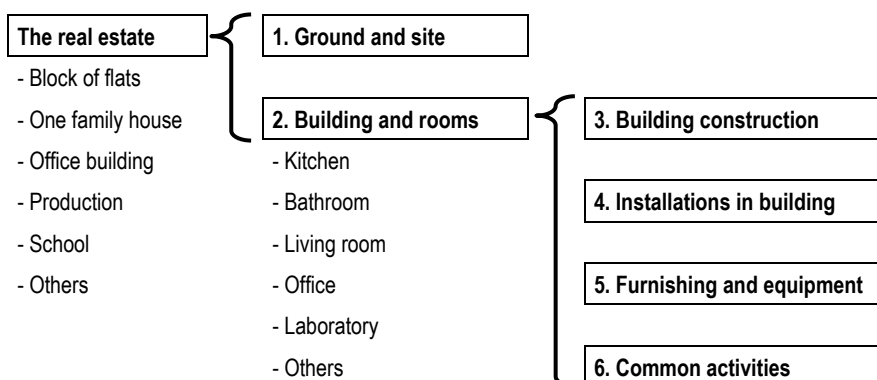


Table 4.3. In the product model the real estate is divided into comparable rooms and building parts to make a more confidence benchmarking for different functions and locations of the building. See also table 4 where no. 3, 4 and 6 in third column are subdivided further.

Each of these main building parts furthermore been split up in subparts as seen in the example in table 4.4, and each of these can again be split up in different types if it is required. These subparts is directly related to the international classifications systems for constructions parts and materials, and the real estate, the building, flats and rooms are related to the national statistic 'Building and Housing Register' (BBR).

3. Building construction	4. Installations in building	6. Common activities
- Foundation and ground floor	- Drain installation	- Construction site
- Exterior walls	- Water installation	- Design and planning
- Windows and ex. doors	- Heat installation	- Construction control
- Internal walls with doors	- Gas installation	- Project administration

- Story separations
- Ventilation
- Assurance of the project
- Roof and roof construction
- Electric installation
- Financing of the project
- Balcony
- Communication
- Other activities
- Other constructions
- Other installations

Table 4.4. Three main building parts in the product model (see table 4.3) are here subdivided in building parts, which are proposed as common for all types of buildings, functions and rooms.

In the Danish study the product model are tested at different type of real estate and constructions as seen in the four cases in enclosure D, I, J and K. There are still work to be done to find a common simple structure that fits international standards and statistics and covers the main type of buildings, functions and rooms.

4.3.4.2 Economy, functions and quality - the value model

Building and constructions are normally benchmarked by comparing price per square metre gross area of the total building as for example seen in the method in chapter 4.3.2 (Sweden). In the Danish study we have tested how a unified price could be determined for each of the main building parts and rooms and common accounts described above. In addition we have also tested some simple description of functions, standard and qualities of the correspondent building parts. The main structure in the value model related to the product model is as followed:

Economy, price, cost, profit and life cycle cost.

Design, size, volume, texture and aesthetics.

Function and applications primarily on the total building and rooms.

Technical standards on constructions and installations.

Delivery conditions. Where, when and how is each element delivered.

In the Danish study we have measured costs in relation to the quantity, size and volume for each rooms and building parts and common accounts in the product model. A unified cost parameter is calculated and used as a comparable key figures in benchmarking. In addition the quality, aesthetics, function, technical standard and delivery conditions are described in a short description. This description makes it possible to explain a deviations between key figures and can give information's on how to improve the model.

In table 4.5 examples on key figures on three different type of rooms are illustrated. A large difference is seen in the unit price on surfaces, fixture and equipment and they are respectively 629, 1.765 and 6.272 DKK per net square meter. It is also possible as an alternative to this price to add cost on constructions, installations and common activities and have a total price per net square meter for each type of room.

Rooms	Description of quality and standard	Units	Unit price	Price
Habitable rooms	Paint ceiling and walls. Inner walls of 100 mm gas concrete. Floors of massive beechwood.	2.367 m ² floor area	629	1.489 t DKK
Kitchen	Standard HTH-kitchen. 10 m ² floor area per kitchen.	400 m ² floor area	1.765	706 t DKK
		40 Kitchens	17.647	
Bathroom s	4 m ² floor area per room. Tiles on the walls and quarry tiles on the floor. Normal standard of inventory.	160 m ² floor area	6.272	1.004 t DKK
		40 Bathrooms	25.089	

Table 4.5. An example on key figures or unit price on surfaces, fixtures and equipment in three type of rooms from a new built terrace houses with 40 habitations in a 2 storeys build built in 1994, enclosure D.

In table 4.6 is given an example on key figures with reference to table 4.4 on the following three building parts: The foundation, external walls and windows and internal walls. The unit used in each example related to the specific building part, e.g. is the first unit in square meters of foundation and the second is in square meter of the surfers of the walls. The external walls and windows are furthermore divided in five subpart or types of building parts. The example shoves a variation in price per square meter from 1.260 to 4.909 t DKK per square meter and with an average at 3.472 t DKK per square meter.

It is clear from this example that the difference in price is not a dissimulation in productivity but describes a difference in standard and quality. From case to case it is therefore important to decide at what degree of detail the product model shall be described. If the unit price differ more than 10-20 % between the individual type of building parts as seen in the example for the external walls and windows a subdivision is recommended.

Building parts	Description of quality and standard	Units	Unit price	Price
Foundation	Digging and casting of concrete foundation and basement floor. Heat insulation and draining.	1.164 m ² foundation	3.376	3.930 t DKK
External walls and windows	Concrete walls, insulated and covered with bricks tiles. Windows and glass sections of steal and aluminium.	4.255 m ² facade	3.472	14.775 t DKK
Subparts of external walls	a) Walls and end walls in concrete covered with Swedish limestone.	1.045 m ² facade	4.202	4.391 t DKK
	b) Walls and end walls in concrete covered with blue subdued brick tiles.	845 m ² facade	2.373	2.005 t DKK
	c) Facade sections in steal and aluminium with sunscreens.	895 m ² facade	4.828	4.321 t DKK
	d) Walls and end walls in roof-house in steel with blue subdued brick tiles.	570 m ² facade	4.909	2.798 t DKK
	e) Walls in the basement in cast concrete on site and heat insulated.	900 m ² walls	1.400	1.260 t DKK
Internal walls	Concrete, gas concrete and gypsum on steal framework excluded surface treatments in a normal combination.	5.890 m ² walls	1.106	6.515 t DKK

Table 4.6. Examples of key figures or unit price for three examples of building parts from a new built pharmaceutical university in Copenhagen from 2002 (Enclosure K). The example for external walls and windows is in addition spilt up in five subpart called a), b), c), d) and e) and it is seen that the average unite price at 3.472 t DKK varies from 1.260 t DKK up to 4.909 t DKK depending on the type of construction.

4.3.4.3 Benchmarking between and in cases for the building owner

In the Danish study is benchmarking tested against a national statistic on public supported housing. On the other hand internal benchmarking are tested on how key figures can be followed from the first planning process to realised data at delivery at the end of the construction period and even further.

The Danish Trade and Housing Agency (Erhvervs- og Boligstyrelsen) publish every half year updated key figures on public supported housing on www.ebst.dk/Boligmarked/Nøgletal. The statistic is split up in four different locations, five different functions and type of occupants and three different type of building. The cost per square meter gross area are split in 55 different accounts under the three main accounts: Ground and site costs, construction cost and common costs. Each of these 55 accounts are specified by three levels: The lower quarter, the median and the upper quarter. In table 4.7 an example is given on family housing in municipality with a population under 50.000. More details can be seen in enclosure E and F.

Main accounts	Cost per gross area	Part of total	Sub-accounts
Ground and site costs	3.224 DKK/m ²	25,0 %	8
Construction costs	7.775 DKK/m ²	60,4%	35
Common costs	1.874 DKK/m ²	14,6 %	12
Total costs	12.878 DKK/m ²	100,0 %	55

Table 4.7. Key figures for public supported family housing in municipality with a population under 50.000. The cost per gross area are the median included 25 % VAT and from February 2003.

In the Danish study it is also tested how key figures can be compared through the building process. In these tests the deviation between budgets at different phases in the building process are compared against the realised price at the delivery at the end of the construction phase.

4.3.5 Iceland

See chapter 5.5.

4.3.6 Conclusive comments

Three main methods are in use in the Nordic counties when conducting or preparing the study of productivity.

- The Norwegian project has taken into use the non-parametric efficiency analysis method (DEA), based on whole building cost and product data.
- In Finland similar method have been evaluated, but not tested thoroughly yet.
- In Sweden and Iceland the client's price pr. square meter is the guiding method. Braking down the total price figure according to sub figures according to the calculation and/or project account systems, makes figures comparable and feasible for analysis/discussion.
- The Danish method tries to connect all costs for typical parts of a building to that very part, and by this prepare for "true element costs benchmarking" of projects (The product method).

This presentation of the different methods in use in the five Nordic countries should reveal the diversities and consequently the difficulties in combining forces and carry out a common benchmarking. On the other hand, it also demonstrate the possibility to learn form each other an possibly find a common way of carrying out productivity studies and benchmarking of building projects – if each country's productivity

research programs are given the possibility to work continuously - and continuously exchange their experience with their fellow researchers in the other Nordic countries.

5 Cases

To make the overview as substantial as possible, this chapter, (at least) on case from ongoing productivity studies has been given high priority. The synergy project members have learned that the R&D activities in each country not are addressing the same questions exactly at the same time. This is due to a lot of circumstances within each country. Even if the challenges are regarded to be the same, as it is when it comes to productivity/efficiency in construction sector, different “history”, ongoing activities, organization of R&D matters etc, are causing unlike start and finish on R&D projects on specific subjects. When it comes to productivity, none of the Nordic countries but Norway, have a considerably big project (program) on productivity studies for the time being. On the other hand, productivity questions have in different ways been part of major R&D initiatives during the last years in all the other countries. The institutions taking part in the Nordic productivity project has through projects/programs with other main focus been engaged in productivity connected R&D work. The cases are picked as examples on what is going on with relations to productivity/efficiency in each country just now. Hopefully the knowledge established through the five workshops and intermediate woke, as documented in this report, will lead to increased parallelism on important studies like productivity in the construction sector in the Nordic countries.

Due to the mentioned difference in approach, the cases are different. This will hopefully lead to questions about own approach, and widen the view concerning R&D approach, in each country.

5.1 Norway

5.1.1 Development and testing of the measuring method

See chapter 4.3. From autumn 2002 to summer 2003 the questionnaire for the building site productivity study was developed in close cooperation with the established network of house builders (contractors). During autumn 2003 a test was carried out on the method for productivity measurement and evaluation. Data and other facts about 11 completed blocks of flat-projects were collected. The intention of the test was not to do the DEA²⁰, but to test if the questionnaire was suitable for collection of the information needed in a suitable way. The test had also another aim. That was to spread information about the project and to promote the project to potential participating contractors. For the reason of the latter, a (very) simplified illustration of the ranking of the eleven testing projects was carried out. With reference to the description of the method in chapter 4.2 and the description of the simplified version, see fig. 4.4, data were put into a excel spreadsheet and processed into a scatter diagram, see fig. 5.1 below. It is interesting that the few (11) projects

²⁰ To test the suitability of the DEA as basic, statistical method, and the data programs with respect to processing data of “micro level” (projects), a study on a set of 140 completed schools had been done during spring 2002. In this case the product (output) was schools with given gross areas and users experienced functionality as schools (“quality”). The input was costs, all collected by Statistics Norway (SSB).

are scattered on the sheet in a typical way. This means that the most efficient ones form a clear frontier (dotted line), and that there are “many” unites behind (below) the frontier. We believe that a higher number of projects in the testing set would have amplified this picture.

To avoid any wrong interpretations: The figure is a *simpleminded illustration* of a multidimensional problem. In the final DEA, there will be 6 –8 variable. This cannot be illustrated in a XY-diagram, but will be presented in a Salter diagram, se fig. 4.2.

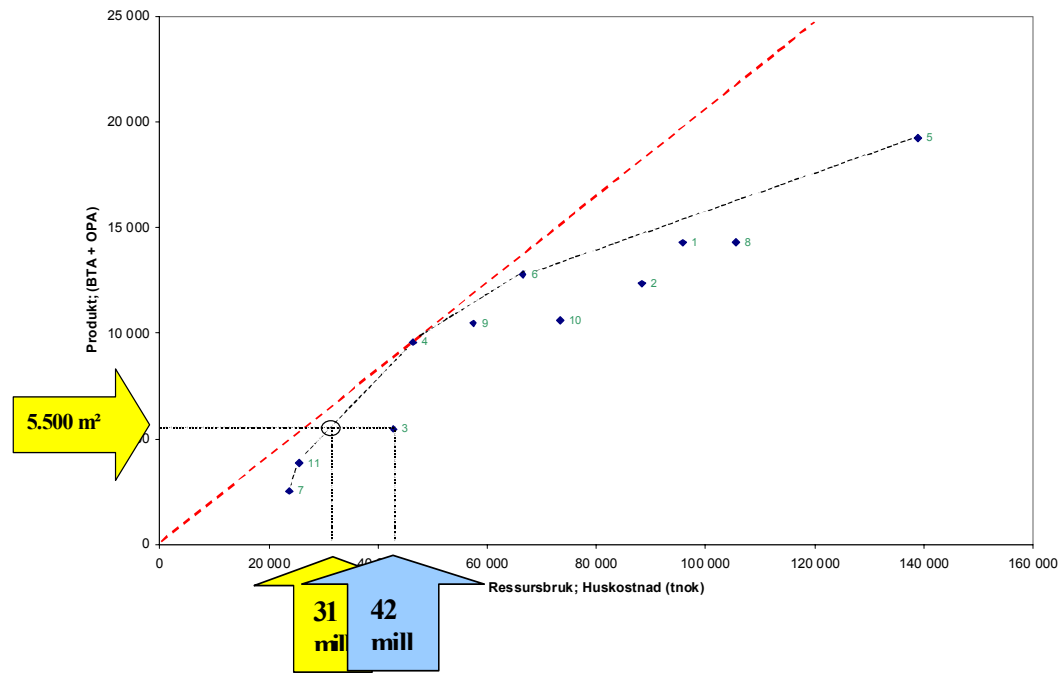


Fig. 5.1 Scatter diagram of Output ($Y = \text{Product} = \text{BTA} + \text{OPA}$) and Input ($X = \text{Resources} = \text{Contractor's cost}$, see figure 2.2) for 11 housing projects

The simpleminded illustration of the DEA of figure 5.1 shows good conformity with the theory presentation in chapter 4.2. The figure should be read like this: At the dotted frontier it would have been lots of projects, if the sample set had been made large (If we had searched for long enough). Therefore, the line between project no. 4 and project no. 11 is true. Thus we can claim there is at “5500 m2 BTA –project”, even not yet identified, that can be produced for 31 mill NOK (Norwegian kroners), at the bottom left broad arrow indicates. Behind the Best Practice frontier there is an identified “5500 m2 BTA –project” that has been produced for 42 mill nok, as the bottom right cost arrow shows. Consequently, all other conditions like, the “42-mill project” has a potential of improvement of approx. 10 million nok, i.e. 30 %.

In a Salter diagram, figure 4.2, the “31-million project” would have the position at right ($E = 100\%$), while the “42-mill project” would have been towards the left side (There might be projects with lower productivity than 70% as well, as shown in figure 4.2).

It must be repeated that the figure 5.1 is a simpleminded illustration. Here, the precondition is that all projects were very like each other, in other words that there were nothing else to compare than the gross area.²¹

One great challenge in the R&D project has been to, in a simple but exact way, to *quantify functional and aesthetic standard* (“quality”) of a block of flats. Each of the test samples has been quantified on a scale from 1 to 5, through a sub-structure of component quantification. It is not yet verified as an acceptable way of quantification, but seems promising. Comparing the standard of the buildings with the use of resources (Cost of building) in use the XY-diagram, we also have the scattered picture with a Best practice frontier, se fig. 5.2.

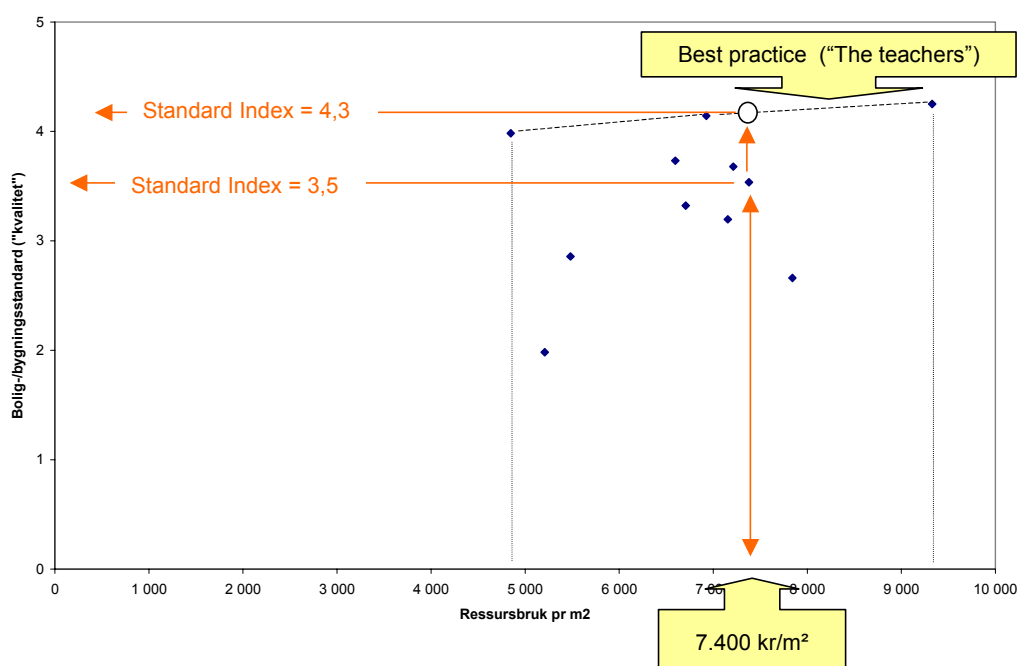


Figure 5.2 Scatter diagram of Output (Y = Standard Index of building) and Input (X = Resources = Cost of the building) for 11 housing projects

- 1) The diagram 5.2 should be read like this: The dotted frontier represents Best Practice.²² Among the 11 test projects only 3 forms the frontier, but as mentioned before, it would have been lots of projects on the curve, if we had searched for them. On the frontier is one particular project produced for 7.400 nok/m², notice the small circle on the frontier. This project has been measured (evaluated) to a standard (“quality”) of 4,3.²³ A project in the “crowd” has also been produced for 7.400 nok/ m². This has, however, only a standard index of 3,5 (see the arrow pointing on the Y-axes). Conclusion: Two projects of same square meter cost, but with very different standard, in fact as much as 30 %.

²¹ In this case, the benchmarking of productivity is identical to ranking the projects from the one with lowest to the one with highest cost per square metre.

²² The national economists use the term “Teachers” for the units on the frontier graph.

²³ In “ISO 9000-language” the word “quality” is strictly defined as deviation from quantified contractual specifications. In everyday talk, “quality” is used instead of “standard”, which is the word used to inform about the common understood value of a certain product

Many studies of productivity are carried out as the two examples given above, i.e. as *partial* studies. Such studies are often too simple, not taking into consideration the fact that “all-is-dependent-of-all”. In the building process, each decision affects many activities. An example: *Cost cutting* of floor slabs might cause *increased costs* on other parts of the process and/or product. The complication of the building process makes the interpretation of partial investigations of productivity difficult. The DEA improves the ability to have true pictures of the performance of the project by measuring the *total factor productivity*. This means that the gross area, standard index and other relevant characterizing data are computerized *together* in one operation with the Salter diagram as output. The calculation of the “all-is-dependent-of-all” theory is presented and proved over years, mainly on macro data, and is not given further comments in this report. Unfortunately, the R&D project suffers of slow data collection. The master sample of 120 projects was expected to be available for calculation in December 2003, but has still, April 2004, only reached 60 samples. Thus, the core product of the Norwegian R&D project is still to be produced, hopefully before end of 2004.

5.1.2 Interpretation of explanations

The “bottom purpose” of the Norwegian R&D project is to develop a tool for productivity analysis in general. To reach this, the residential building study is regarded suitable. Based on regularly productivity studies, the industry shall have (as much as possible) undisputable facts as basis for improvement initiatives in projects - and in companies. The first step is the ranking of projects, which indicates (anonymously) which potential of improvement each project has. The second step is search for explanations. To understand more about the circumstances at a generic level, a large number of regressions are carried out by use of modern computer capacity. The studies are based on collected information from the projects. The intention is to cover all thinkable sides of the frame conditions and controlling activities. As fig 5.3 shows, different issues are registered for the regression analysis, like

- Plot conditions (slope)
 - Ground and foundation solution(s)
 - Structure
 - Degree of prefabrication
 - Weather conditions during erection
 - The site (“production suitability”)
 - Surroundings
 - Communication with owner’s representatives
 - Organization on site
 - Wage system
 - Staff experience
 - Cooperation on site
- etc.

		Very steep	Apprx. 1:5		Horizontal	
D-01	The plot (Mark the most representative topographic characteristic)	☐	☐	☐	☐	☐
	Soil conditions - fundamentation <i>Mark the dominant situation(s) and give ev. comments in the cell to the right of your mark(s)</i>					
D-11	Rock demolition – coloumb/walls to rock	☐				
D-12	Depression of soil - banquets	☐				
D-13		☐				
D-14	Coloumb pilings	☐				
D-15	Friction poles	☐				
D-16	Othe solution (describe as good as possible)	☐				
		Ste-el	Concrete			
D-20	Prefabrikasjonsgrad - bæresystemet;		site casted	Fabi ced	Explanation	
D-21	Coloubs	☐	☐	☐		
D-22	Beams	☐	☐	☐		
D-23	Walls	☐	☐	☐		
D-24	Floors	☐	☐	☐		
	Degree of prefabrication – other elements					
D-31	Bath rooms ("cabins")	☐	☐	☐		
D-32	Fasades	☐	☐	☐		
D-33	Roofing	☐	☐	☐		
D-34		☐	☐	☐		
D-35	Stairs	☐	☐	☐		
D-36	Other elements	☐	☐	☐		
D-41	Weather conditions at site during erection					
	When <u>work in ground</u> was carried out, it was	a) heavy snowing				☐
		b) very cold				☐
		c) much/often rain				☐
		d) much wind				☐
		e) much nice weathc				☐
D-42	The condition of the site:					
		a) real good space for arrangements				☐
		b) narrow, but not any major problem				☐
	Compared to what professionals would call "an OK site", "Easy to build on", "clean site" etc, this one was typical....	c) small area for arrangements, crane, storage, parking etc.				☐

Fig 5.3 Example of frame conditions of projects – The ongoing Norwegian productivity study (2001 – 2005)

The test of this part of the tool depends on a lot more projects than the eleven in the early phase. Therefore it has not been carried out as to the moment of writing this report, unfortunately. But the information will be available in the reports of the Norwegian productivity project, during the coming years.

5.2 Sweden

The Swedish cases include 32 projects that give cost for building projects with flats mostly (27) from Boverket (The National Board of Housing, Building and Planning). This is cost data given in applications for environmental subvention funding ("Eko-bidrag").

These are cost before building is finished. It must be noted that these cases do not represent typical Swedish building cost.

The next four are from the document “Byggbkostnadsdelegationens betänkande, *Från byggsekt till byggsektor*, SOU 2000:44, 2000” and the last is the Svedala project, where we have a detailed economic description in a report from LTH: Mats Persson: *Ny byggprocess – Svedalamodellen*. The cost is the final cost after the building is finished.

5.2.1 Information from the projects

For each project is given:

- Name
- Community (town where build)
- Number of flats
- Heated area BRA m²
- Useful area BOA m²
- Start of building time – date
- End of building time –date
- Production costs divided in:
 - Cost of site
 - Fees and taxes (not VAT)
 - Contractor costs
 - Consulting costs
 - Building owner costs
 - Financial costs
 - Value added tax (VAT)
 - Total production cost

Based on these data we can calculate:

- Average size of flat (m² BOA)
- Productions cost pr m² BOA
- Production cost pr flat

This information can be presented in diagrams, see figure 5.4.

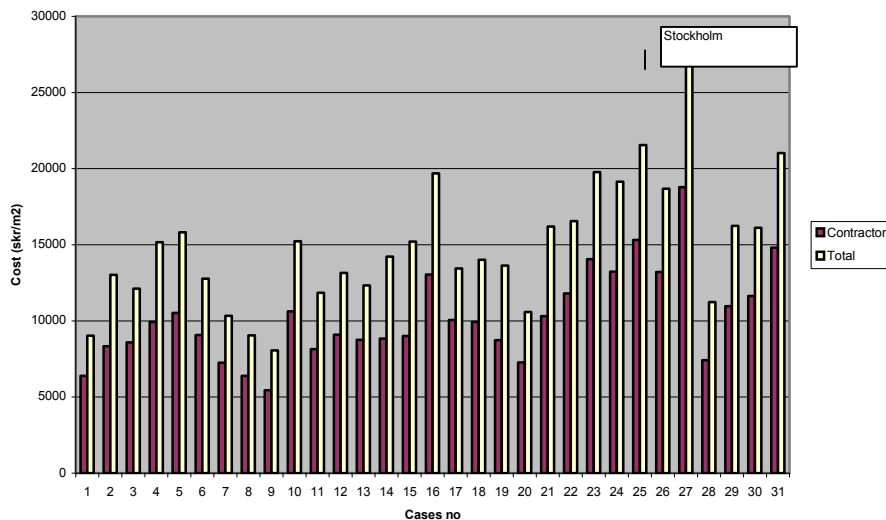


Fig 5.4 Total costs and contractor costs pr m² for 31 projects. No correction for different building year. A project in Stockholm is seen to be the most expensive.

5.2.2 Correction of the data

To reduce the variations in the data we have taken away the small student flats as these could be seen as having a special cost structure. The Stockholm case is also taken away as we only have this single case from Stockholm.

Correction has been made of the cost data using 2002 as a reference. From statistical data it is found that average price rise is 7% pr year. The correction is based on the building year.

The result is a new data file with 26 cases.

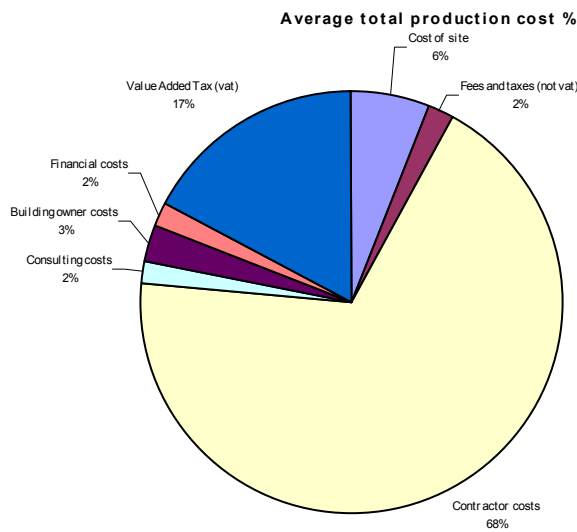


Figure 5.5. Distribution of costs – average value

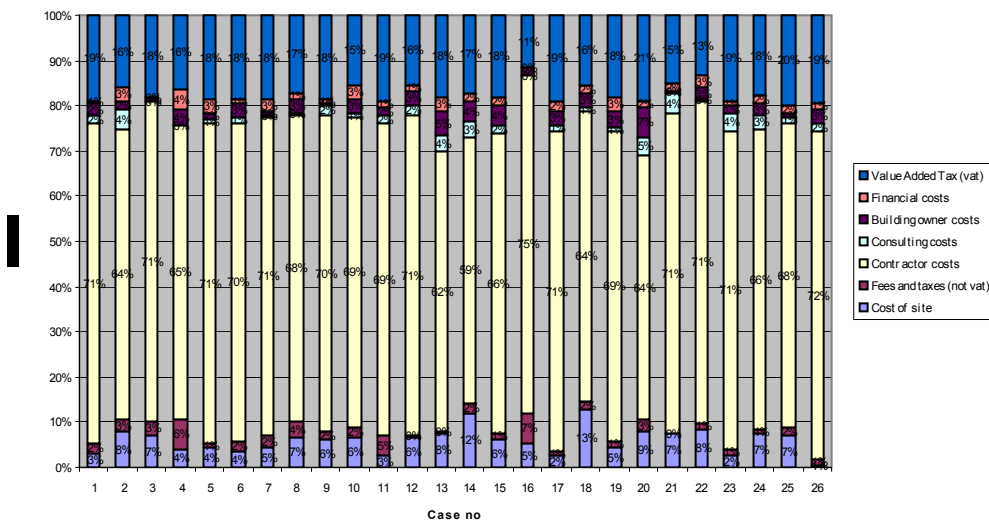


Figure 5.6. Distribution of cost for the 26 cases

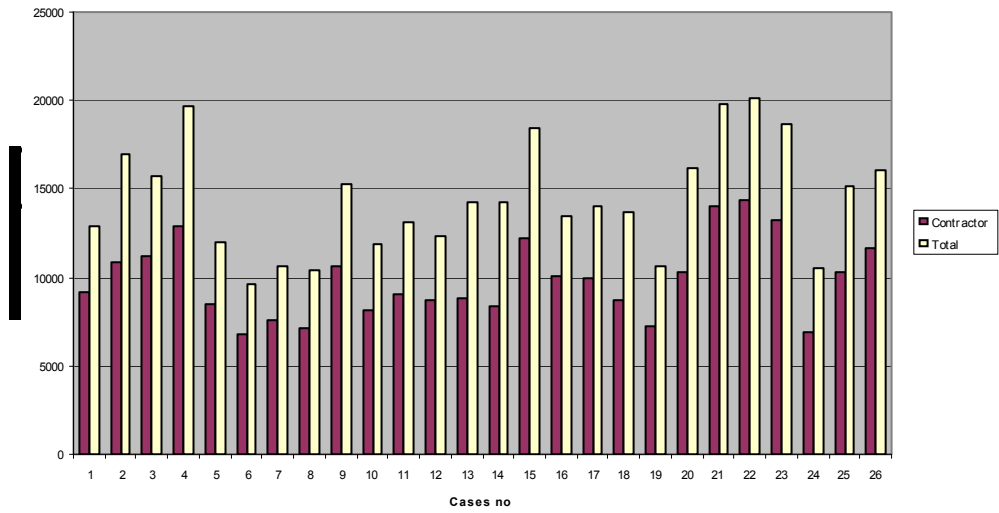


Figure 5.7 Corrected cost skr/m2

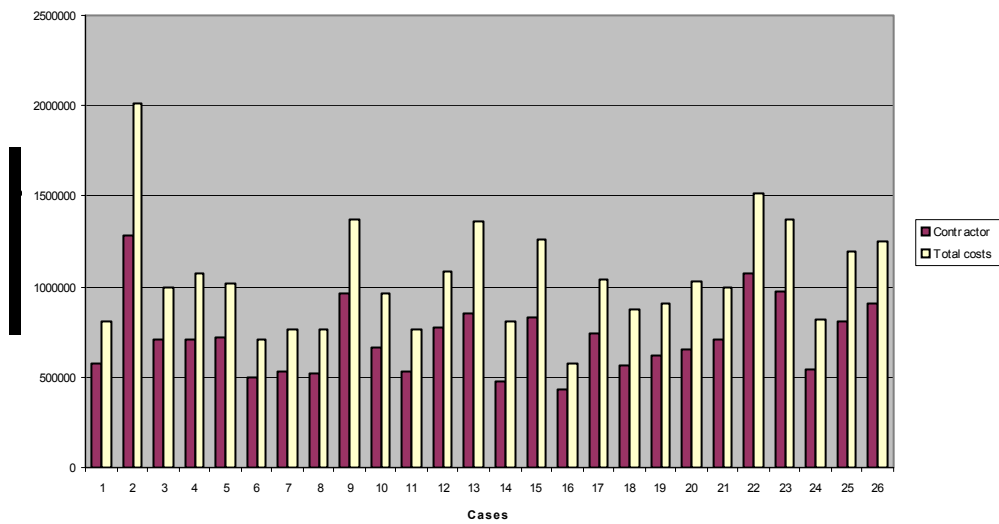


Figure 5.8 Corrected cost skr/flat

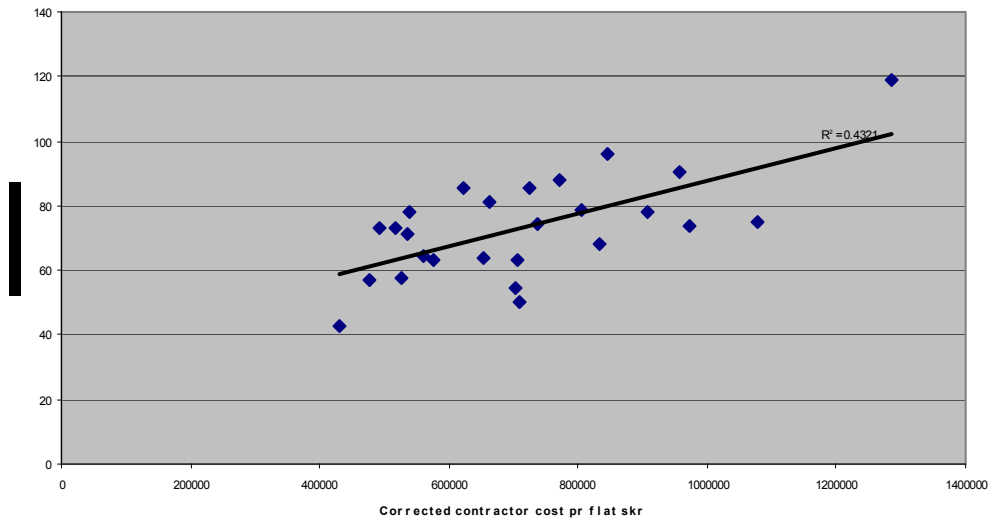


Figure 5.9. Contractor cost versus size of flat

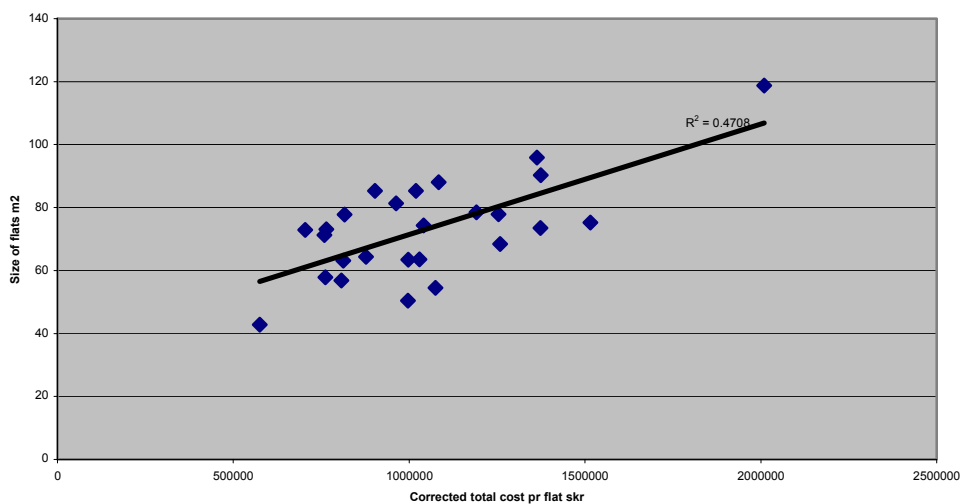


Figure 5.10 Total cost versus size of flat

5.2.3 Presentation of the results in Salter diagram

The next two diagrams show the projects sorted as with increasing costs for the project. The column width of each project is *the number of flats* in the project. There is a diagram for the contractor costs (fig. 5.11) and for the total costs, fig. 5.12. It does not look like larger projects are cheaper. The problems with this benchmarking is that a number of other factors than gross area will influence the results:

- Quality of the flats – more expensive could have better quality??
- Geography variation – large or small towns??
- Local market variation – is there few or many in the period??
- Some project can include more or less other functions as parking/stores

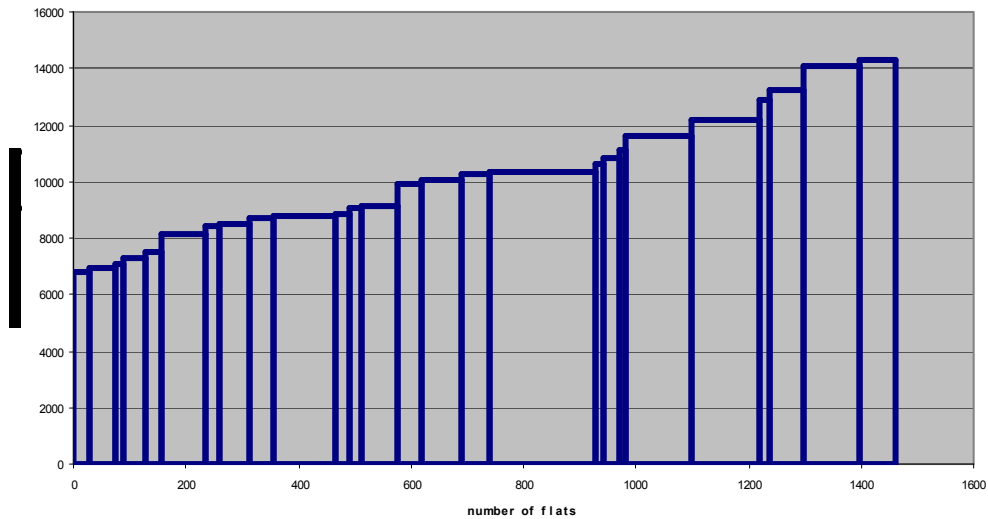


Figure 5.11 Diagram contractor cost sorted by cost. (Contractor's cost, see 4.3.2)

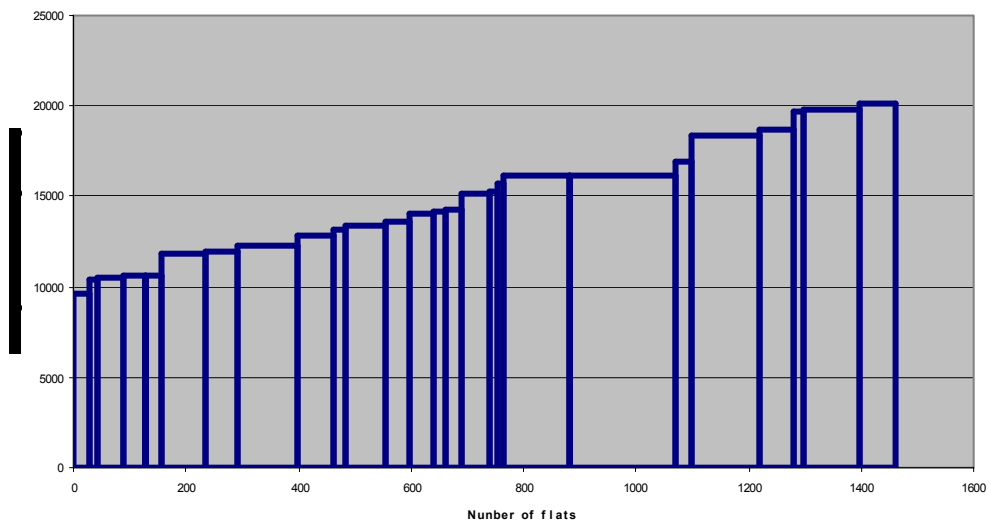


Figure 5.12 Diagram total costs sorted by cost (Total cost, see 4.3.2)

5.2.4 Splitting of the contractor cost

In some cases it is possible to split the contractor cost in different work types as HVAC, Electricity and so on.

It is much more difficult to get a detailed split in the main contract, as there is no guarantee that all costs are placed correct. For the contractor it is important to know that the total cost is under control, but maybe not the details. We can say that finding the real cost is very much depending on the culture in the firm. (Do the management accept that certain part shows loss? If not, there is a high risk that some bill are placed in another section of the account sheet, giving higher profit there).

5.2.5 Analysis of the cost data

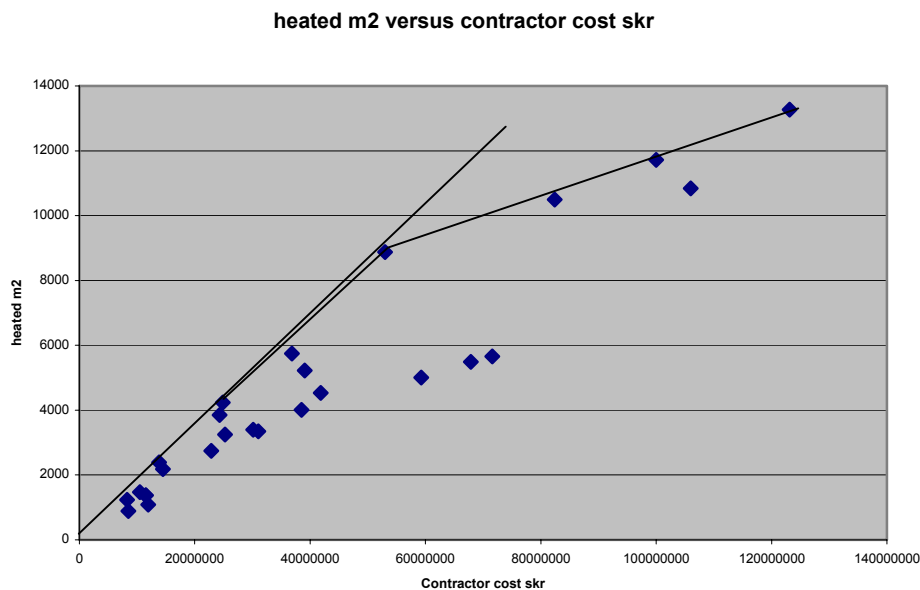


Figure 5.13 The production (heated m2) versus contractor cost (skr). The broken line shows best practice, all other factors not taken into account.

It is interesting to evaluate the production through an area (y) – cost (x) diagram, see figure 5.13. The difference between this presentation and the Norwegian case in 5.1 is that the Norwegian case, see figure 5.1, shows costs excl. profit, while the Swedish figures include profit, in other words the clients cost. Figure 5.13 shows, as do the Norwegian case, a best practice frontier. (NB! This is, as the Norwegian case, a very “rough” evaluation of projects, not taking into consideration other variables than the heated area). - One interesting question is: “Is it important to have cost excluding profit to evaluate productivity?” - Before the answer a few more figures are presented, see fig. 5.14 – 5.16.

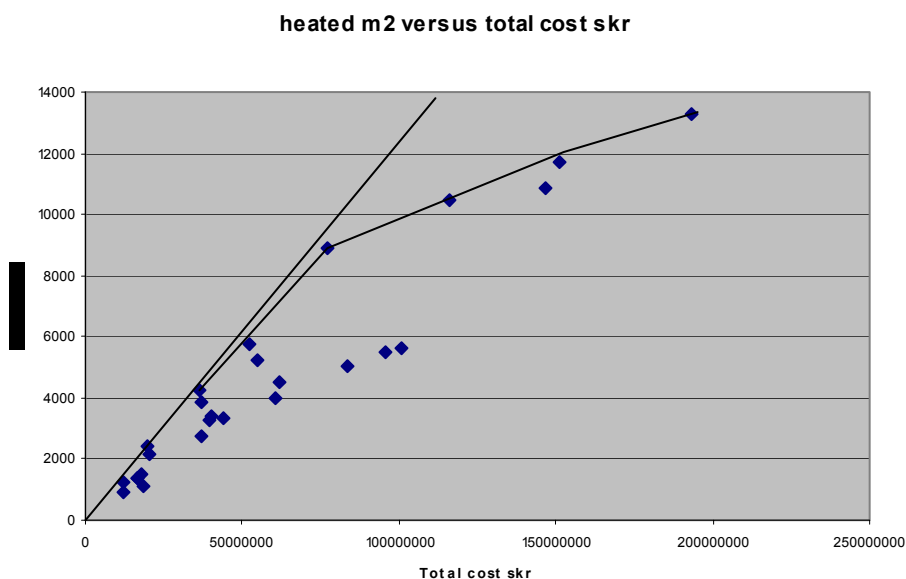


Figure 5.14 The production (heated m2) versus total cost (skr). In the figure is drawn the line of best practice, not considering any other factors than the floor area

In figure 5.14 is included all costs for the building including taxes, design, building owners cost etc. Note that this figure looks nearly the same as for the contractor costs. It is the same project that is along the line of (possible!) best practice or is lower than the line. Another interesting point is that the projects are placed approximately at the same place in the diagram. In the next figure we have compared figure 5.13 and 5.14.

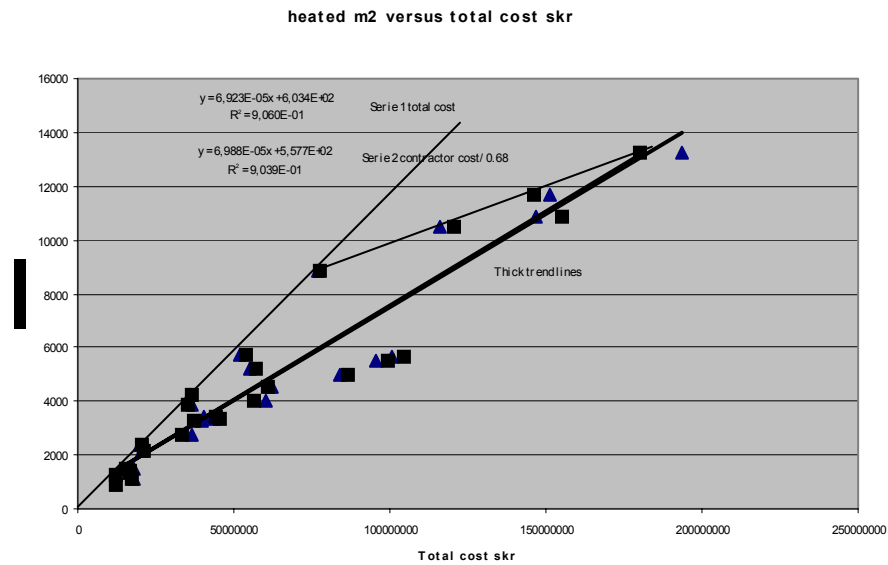


Figure 5.15 The production (heated m2) versus total costs. Series 1 is the total costs marked with triangles. Series 2 is the contractor cost divided by the average part of the total costs (0.69). Trend lines are drawn and the formula for the trend is given.

The interesting observation is that that the trend lines cannot be differentiated in the diagram – they are equal. The other important observation is that the R2 is also the same 0.906 and 0.904. So the variation is the same for both costs. In this simple illustration, having gross area as the only variable, one should not make a big mistake looking on the total costs instead of the contractors cost.

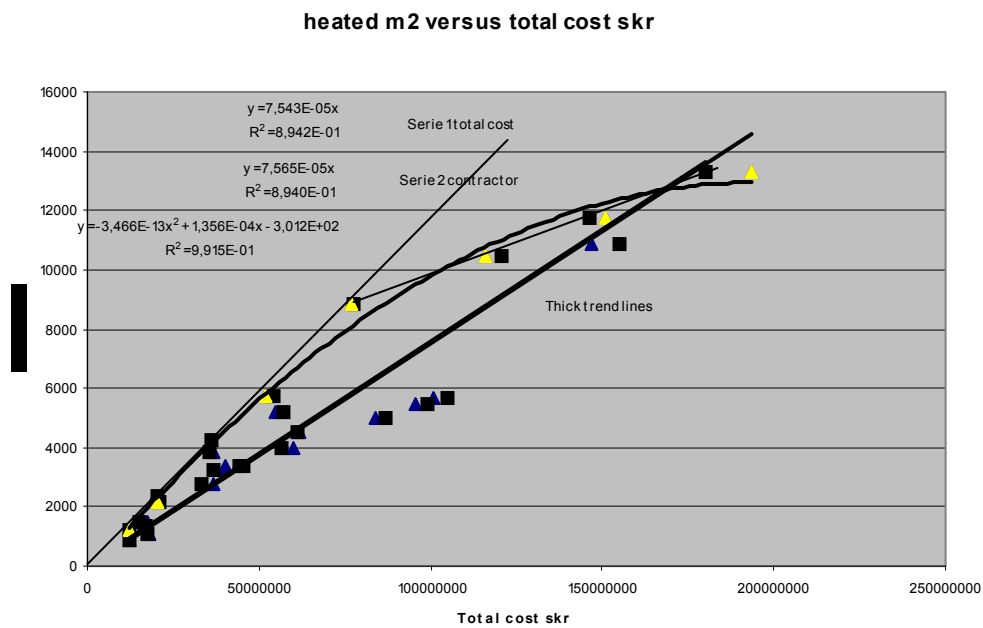


Figure 5.16 The same diagram as figure 12 with new trend lines and a frontier curve.

In figure 5.16 the trend lines has been recalculated to go trough the point 0,0. The “(possible) best practice- curve” has been calculated based only on the points along the line. The formula for the curve is found in the figure.

As underlined in chapter 5.1 this is a very simplified version of a statistical method for productivity benchmarking. As illustrated in the figures, this type of model to discuss productivity can separate the projects with “low productivity” (points below the frontier curve) from the ones with high (points on the curve). The real problem is that a number of important parameters are not taken into the calculation.

Some lacking parameters are:

- Difference in markets areas – more expensive in large cities
- Difference in size of flats
- Difference in quality of the building

These points make it very difficult to compare projects, as “productivity” cannot be found without looking at these points.

The evaluation here is based on the production in m2 heated area but we could also have used other production units in the form of number of flats or average m2 pr flat or other parameters defining what has been build.

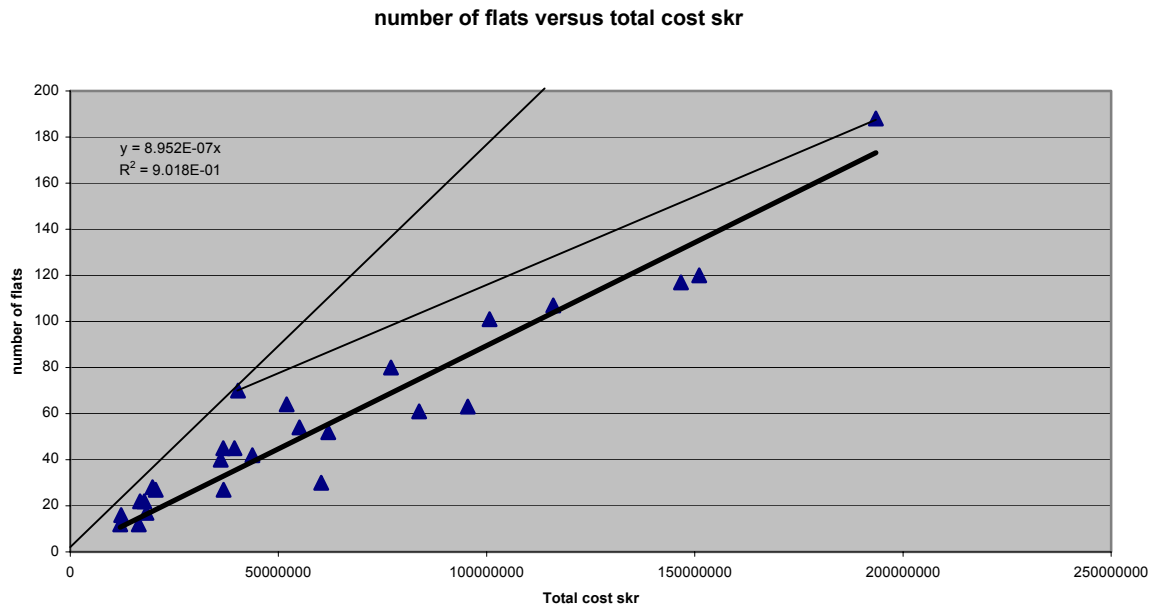


Figure 5.17. The production (number of flats) versus total costs. Series 1 is the total costs marked with triangles. A trend lines are drawn and the formula for the trend is given.

We can see that gives us a diagram that is similar to the previous with a best practice line and a spread of the points.

An important conclusion from the Swedish part is that an analysis can be done on either the total costs or the contractor costs that the owner pay. In that case you can get the information from the building owner, which might be much easier to get.

Using the data envelope analysis on client cost gives us a much better understanding of the problems with comparing projects from different areas (markets), quality of the building and size and types of flats. We are able to work with a much larger database and can look on how to compensate for these differences. The last part of the variation is from differences in profit and productivity for the contractor. After we have found this last part of the variation we could go to the last step and find out if the difference is in profit or in productivity.

5.3 Finland

5.3.1 Development tool

The main interest of a company in productivity studies is to identify the factors with impact to the productivity. Knowing these factors makes it possible to improve internal processes. By collecting information from several projects it can be possible to identify the best practices for high productivity, and transfer them from one project to another. If the reasons for difference in productivity and key factors for high productivity can be identified, productivity measuring can be important development tool for a company.

By realizing the benchmarking together with other companies, the development tool is even more effective. On the other hand, in productivity study is needed lot of very

enlightening but intimate information, which is not possible to publish. It is needed a reliable ‘third party’ to conduct productivity benchmarking, who collect the data from competing companies and give intelligent information back to them. This kind of study has been realized by six Finnish companies and with VTT as the third party expert.

5.3.2 Potential variables for productivity indicators

The general approach to the productivity is that productivity is seen as the ratio of “output” to “input” of the process. Potential input variables are *construction costs* and *used man hours*. Potential output variables are for e.g. *net floor area*, *value added* and *profit before tax and interest*. There are lot of other variables available, too, which can be used as explanatory factors like control variables and environmental variables. Control variables describe how the company successes to manage the process and they can be influenced by the company itself. Environmental variables describe under which circumstances the process has been conducted – and the company cannot influence to them. See fig. 5.18.

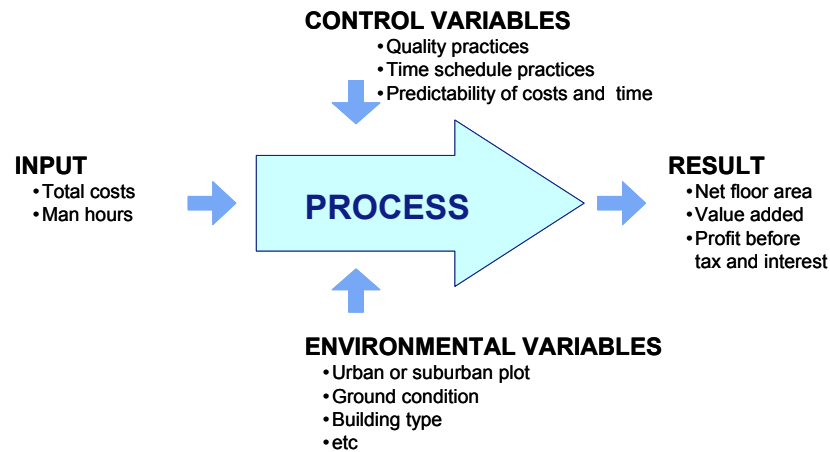


Fig 5.18 Potential variables for productivity measuring

5.3.3 Demonstration of the method

It was chosen few main productivity indicators to categorize the construction projects to the ‘good ones’ and the ‘bad ones’. One traditional and available indicator is the ratio of *gross area* to *construction cost*. Another potential indicator is the ratio of *added value per man-year* to *construction cost*. The added value of construction site is the *construction cost minus procurement cost*. A demonstration of these indicators with a sample of 12 housing projects is shown in fig. 5.19.

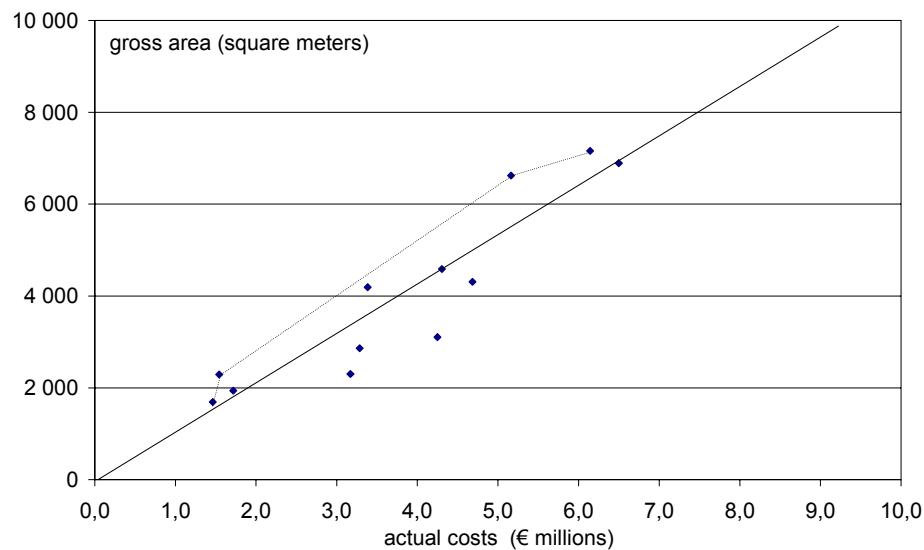


Fig 5.19 Scatter diagram of Output ($Y = \text{Product} = \text{gross area}$) and Input ($X = \text{Resources} = \text{Construction cost}$) for 12 housing projects. Cost level: year 2003.

The next step after categorizing the “good and bad projects” is to analyse, which control and environmental variables are congruent to each group. Some of the factors are such that the company can find out the best practices for wide implementation. Even if the factor is environmental, the company can pay attention to it – and to manage and control it better in future.

To keep the company-specific data confidential, the third party expert prepares company report for internal use in each company. Company specific report contains information about all the projects on general level and specific information about company’s own projects – and conclusions.

5.4 Denmark

The Danish case study is based on following four cases:

- DK case 1: Benchmarking new terrace house compared to Danish public statistic – BUR project no 6.
- DK case 2: Renewal of block of flats on Oehlenschlägergade 40 – part of a benchmarking of 88 cases in Copenhagen.
- DK case 3: Process control on renewal of block of flats on Jagtvej 30, Odense, Denmark.
- DK case 4: New-built Pharmaceutical Institute in Copenhagen.

5.4.1 DK case 1: Benchmarking new terrace house in BUR-project

The Danish case 1 is a study on cost and gross area of flats compared with public statistical data on non-profitable housing for different types and locations in Denmark.

Main accounts	Benchmark		Project DK case 1		Comparison	
	Cost per gross area DKK/m ²	Part of total	Cost per gross area DKK/m ²	Part of total	Absolute difference DKK/m ²	Index per benchmark
Ground and site costs	3.224	25,0 %	2.266	19,7 %	-958	70,3 %
Construction costs	7.775	60,4%	6.898	59,9%	-877	88,7%
Common costs	1.874	14,6 %	2.345	20,4 %	466	124,8 %
Total costs	12.878	100,0 %	11.509	100,0 %	-1.369	89,4 %

Table 5.1. Benchmarking of the three main accounts from DK case 1 against public supported family housing in municipality with a population under 50.000. The benchmark are the median from the national statistic, and all costs are included 25 % VAT and from February 2003 (enclosure G).

In table 5.1 is given an example on benchmarking the three main accounts from DK case 1 against Danish public statistic. The total cost of DK case 1 is 89,4 % of the benchmark, which is the average value of a population equal to DK case 1. It is also seen from the last column that ground and site cost is 70,3 % of the benchmark, and common cost is 124,8 % of the benchmark.

In table 5.2 an example is given on benchmarking three different building parts still from DK case 1: Foundations, external walls with windows and internal walls with doors. From the last column is seen that foundation is 55,0 % of the benchmark, and external walls are 102,5 % of benchmark. The benchmarks are the average value of a population equal to DK case 1.

Building parts	Benchmark		Project DK case 1		Comparison	
	Cost per gross area DKK/m ²	Part of total	Cost per gross area DKK/m ²	Part of total	Absolute difference DKK/m ²	Index per benchmark
*incl. windows						
Foundation	643	5,0 %	354	3,1 %	-290	55,0 %
External walls*	1.231	9,6 %	1.262	11,0 %	30	102,5 %
Internal walls	1.260	9,8 %	830	9,8 %	-430	65,9 %

Table 5.2. Benchmarking three examples of key figures from different building parts from DK case 1 against public supported family housing in municipality with a population under 50.000. The benchmark are the median from the national statistic, and all costs are included 25 % VAT and from February 2003 (enclosure G).

The experience from DK case 1 can be described in the following dots:

All key figures could only be calculated as cost per square meter gross area and not per actual unit for each building parts as assumed in the method description.

The data from DK case 1 is from 1992 and not original specified to the public benchmarking system that was introduced later.

A short description as recommended in the method was not available both in DK case 1 and for the data from the public statistic.

Dividing in building in rooms and building parts has not the certainty as wished, and it had been easier if the right specification had been used from the beginning in the case.

As a whole the method was acceptable and can be recommended for further developments of benchmarking.

5.4.2 DK case 2: Renewal of block of flats in Copenhagen.

The Danish case 2 is part of a study in Copenhagen on 88 renewal of block of flats and the building owner's benchmarking on cost, area, size and renovation level on main building parts. More details can be seen in enclosure I and DK lit. 5.

In the 88 different renewal cases in Copenhagen data on costs per units were collected on 20 different building parts or common accounts. For each building parts the type and renovation level was described and the average value for cost per unit and the corresponding standard deviation was calculated for equal types of renewal. The data from the study has afterwards be used as benchmarks in other renewal projects (DK lit. 10).

The report (DK lit. 5) shows a lot of interesting results. For most of the building parts there was no change in cost over the period of 8 years and the standard deviation was as high as 25 % to 50 %. But renewal of windows has another interesting profile.

In the renewal of windows 78 out of the 88 cases have got new windows and of these the total cost per new installed window have decreased by 30 % from 1987 to 1994. In table 5.3 the exact figures shows a cost reduction from 624 DKK/m² to 436 DKK/m² gross area (in July 1995-prices, DK-index 138 and without VAT). In the same period the standard deviation was reduced from 25 % to 17 %. It is concluded in the report that the improved productivity is caused by a industrialization of the production process both in the factories and on site. It is in addition assumed that an industrialised process with a higher productivity also have a reduced variation in price.

Type of renewal	Cases		Cost per unit	Standard deviation
New windows 1987-90	27	31 %	624 DKK/m ²	25 %
New windows 1991-92	31	35 %	500 DKK/m ²	21 %
New windows 1993-94	20	23 %	436 DKK/m ²	17 %
Other type of renewal	10	11 %	-	-
Total	88	100 %	-	-

Table 5.3. Cost on new windows in three periods in renewal of block of flats in Copenhagen. The costs are in Danish kroner per square meter gross area without VAR and in July 1995-prices (DK-index 138).

Another interesting result was the discussions of the applied units in the calculated key figures of the different building parts. Normally the cost figures are divided by the total gross area as seen in table 10, but if we for instance will compare the cost of renewal of the roof between building at different storeys we must use an other unit. In the report is for this example proposed the unit 'DKK/m² of covered roof area', and the two comparable costs for the period 1987-92 are respectively 568 DKK/m² gross area and 2.759 DKK/m² covered roof area.

In table 5.4 is given an example on benchmarking four selected building parts from the DK case 2, Oehlenschlägersgade 40, Copenhagen with the key figures from the study on renewal of block of flats in Copenhagen. The deviation between the DK case 2 and the benchmark can be seen in the last column, and we can compared the relative deviation with the standard deviation of the benchmark. It is seen that bathroom and kitchen are respectively a little bit higher and a little bit lower than the average benchmark value (about half a standard deviation). Especially the new roof

construction in DK case 2 differ a lot from the benchmark and the relative deviation is seen to be three times the standard deviation.

Building parts	Benchmark		Case 2	Deviation
	Cost per unit	Standard deviation	Cost per unit	Case 2 per Benchmark
New bathroom	52.198 DKK/room	31 %	62.011 DKK/room	119 %
New kitchen	40.050 DKK/room	37 %	34.489 DKK/room	86 %
New heating system	423 DKK/m ² gross	26 %	676 DKK/m ² gross	160 %
New roof construction	2.759 DKK/m ² roof	33 %	5.412 DKK/m ² roof	196 %

Table 5.4. Comparison of DK Case 2, Oehlenschlägersgade 40, Copenhagen, with the key figures from the benchmarking on renewal of block of flats in Copenhagen (DK report 5 and enclosure I). The costs are in Danish kroner (DKK) without VAR and in July 1995-prices (DK-index 138).

The experience from DK case 2 can be described in the following dots:

It is possible to make benchmark on renewal of buildings in the same way as for new built houses, and it is important that the cost are divided in the same type of building parts or common accounts .

The benchmarks on the 20 different building parts or accounts can be used in estimating the cost on coming renewal projects.

Normally the standard deviation is around 30 % but on industrialized building parts as windows it can go down to 17 %.

In the future development more data must be collected regular and the units of key figures and the definition of each building part or common accounts must be fixed in a common national or international standard.

5.4.3 DK case 3: Process control on renewal of block of flats in Odense.

The DK case 3 is a study of cost and process parameters to control the planning and construction phases for different levels and parties in the process of renewing block of flats. More details can be seen in enclosure J and DK lit. 3.

In the study key figures are compared with benchmark from the study in Copenhagen and in addition realized figures are compared with budget figures on cost, quality, quantity and procedures. For instance 71 % of the descriptions of standard and quality have been changed under the construction period and 99 % of the procedures have been changed in the same period. The budget for costs of materials were 3 % higher than the realized cost and the budget for wages were 15 % lower than the realized cost. It was interesting to observe that the individual deviations from the budget for wages were several times higher than for materials. On some accounts the budget was exceeded by more than 100 %. It was concluded from the report (DK lit. 3) that all contractors in the project have less competence in controlling time consumption than consumption of materials.

The experience from DK case 3 can be described in the following dots:

The benchmark from Copenhagen can be used in comparison of key figures on the individual building parts for the Odense project.

The deviation between budget and realized figures on the individual accounts were very high but as total most of the contractors have a positive balance in economy.

It was possible on each building part to make a clear linkages between the economy of the contractors and the total economy of the project seen from the building owners point of view.

It was difficult for the contractors to deliver figures on both wages, cost of material, quality and procedures divided in building parts especially for realized figures.

There were also a lack of performance in handling more than a few parameters in controlling the process.

It was concluded that future developments should focus on reducing the number of failures and deviation from budgets and that the productivity can be achieved only through simple and not too advanced process control and benchmarking systems.

5.4.4 DK case 4: New-built Pharmaceutical Institute in Copenhagen.

The DK case 4 is a study on cost, area and size parameters the building owner will use in planning and evaluating of new office- and laboratory building. More details can be seen in enclosure K and DK lit. 11.

The so called 'Blokmodel' for describing the building in a limited number of building parts and rooms seen from the building owners point of view is tested on an other type of building than housing. In addition a method for making a simple budget early in the planning process is compared with collected figures at delivery. The early budget is both given for the individual types of rooms as total cost per square meter net area and on the individual construction and installation parts as unit cost for different standard and quality levels.

The experience from DK case 4 can be described in the following dots:

It was possible to describe an office- and laboratory building after the same basic system as used on new built and renewed housing, and normal calculation principles are use as benchmarking as no real benchmark was available.

It was possible to correlate the rooms and the main building parts in the 'Blokmodel' with the more detailed SfB-classification which contractor's normally use in Denmark.

The early budgets at different detail levels are given both on cost, quantity, quality and delivery parameters and the same structure is used through the process to delivery and adjustments and realised figures can easily be compared.

In Denmark we have no common accepted definition of type of rooms and net area and it must be defined in the future development if benchmarking on room level can be possible.

The future development must also contain a more visual illustration of the benchmarking and the simulation principle in 3D or 4D which help the end-user to understand the planning and delivering process better. The general principles in the 'Blokmodel' must be implemented in the building sector under control of the building owner.

Further development and network for dissemination

In Denmark two different direction for improving productivity are in progress: One has focus on the big contractors and benchmarking process control and the other has focus on the building owner and added values on the final product - new built or renewal of buildings.

As seen in figure 5.20 the construction companies have primarily focus on construction parts and to deliver to the building process, and normally the process thinking are from the detail product level towards more main product. The building owner acts oppositely, e.g. has primarily focus on the total building and function on rooms, as he is a deliverer to the end-user and the contractor is his sub-deliverer.

Both are in a way squeezing the consultants from two sides in the fight for controlling the market. Quietly the production industry are pressing the construction companies by moving part by part of the site production to industrial production with more added values.

The Benchmarking Centre for the Danish Construction Sector (www.byggeevaluering.dk) has their main focus on benchmarking big contractors and process control. In DK lit. 8, 12, 13 and 14 they have proposed a number of key performance indicators which the contractors can apply in improving competitive performance. Up to 1.000 different figures are defined and recommended to the contractors and the public authorities as basic for a future key figures system.

Their models are primarily built on general economical theories and they tried to form a mathematical correlation between figures of results and figures of causes. Figures of results are e.g. predictability on price, profit and time or figures on working environment and safety as well as damages, failure, defects and the customer's experience of process and product. To present benchmarking they have proposed different illustrations as distribution function, radar diagram and column diagram. Their fix point is no doubt the construction company and how they deliver construction parts cheap and quick to the building owner with a maximum profit under a certain planning conditions.

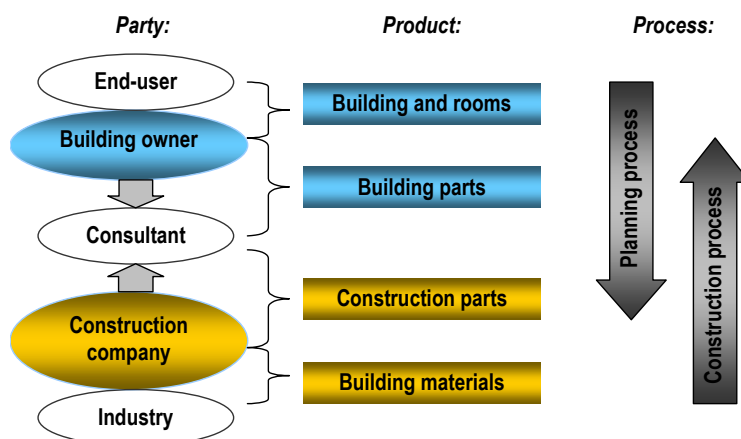


Figure 20. In Denmark there are two directions for improving productivity and benchmarking: Building owner and construction company. They have different focus on products and are squeezing consultants from two sides.

From the description of the experiences from the four cases above the following development are proposed for the future Danish research:

- To form a common accepted national or international standard for benchmarking productivity key figures (PKF) with focus on the building owner and added value for the total building, rooms and main building parts.
- To form a common accepted national or international standard for benchmarking key performance indicators (KPI) with focus on the construction process, the performance of the contractor and deliverance of construction parts to the building process.
- To finish the common description of a limited number of type of rooms, building parts and common accounts which are comparable and parts of the 'Blokmodel'.
- To introduce a net area definition in Denmark and to finish the definition of the units in the key figure definitions for the individual building parts.
- To define different standard levels for functions, standard and quality and industrialization levels which could explain the differences in prices on building parts.

To support and disseminate the development results it is proposed to continue to build up more innovation networks. The Danish Building and Urban Research will in the future continue to form a more formal innovation network consist of professional building owners and with focus on the whole facilities management process. On the other hand the institute will follow up on the relevant development activities proposed in DK lit. 14 and 15 and among these, how the development can be disseminate through the public system for education. To this purpose case studies and benchmarking of productivity can be a helping tool.

5.5 Iceland

As stated in chapter 2.2.5, there are no official statistics about building costs or costs of individual building projects available in Iceland, except from what is presented in the Icelandic Building Index. Currently, there are no ongoing projects in the field of productivity in the construction industry, which could be used as an example in this chapter. Our aim with the discussion in this chapter is, therefore, to provide further information about the Icelandic building market. We give a comparison between Icelandic projects – four apartment buildings of a common type in order to initiate discussions in this field, as well as further comparisons between countries, as discussed in Chapter 4.

The information shown here is collected from individual construction firms and from some of the buyers of apartments. For this presentation we have collected information about the cost of four different projects. The cost presented is the total cost for each building.

The buildings

Building 1 is an apartment building, seven stories high, with a total of 25 apartments. Four apartments are on each floor, except on the top floor. The apartment on the top floor is one large penthouse apartment, with a total area of 215 m². On all other floors, the size of the apartments is approximately between 80 m² to 130 m².

The total size 3.026 m².

The size of all apartments 2.603 m²

The size of common areas 38 m²

The size of corridors, stairs and elevator 258 m²

The building is centrally located and has to be considered to be of a relatively high standard (“quality”).

Building 2 is an apartment building in Reykjavik, situated in a new subdivision in the suburbs. There are six apartments in the building, each with five rooms. The house is two stories high. Each apartment has a private entrance; hence there is no common area. All apartments are of equal size. The gross size of each flat is 120 m². The total gross area of the building is 720 m²

Building 3 is an apartment building in Reykjavik, situated in a new building area in the suburbs. There are eight apartments in the building, four with five rooms and four with three rooms. The building is two stories high. Each apartment has a private

entrance; hence there is no common area. The total gross size of the apartments varies from 90 to 110 m². The total gross area of the building is 808 m².

Building 4 is an apartment building in Reykjavik, situated in a new building area in the suburbs. There are 50 apartments in the building, all with two rooms. The building is multi-story building.

The total size 4.482 m².

The size of all apartments 2.838 m²

The size of vertical common areas 263 m²

The size of horizontal common areas 1.381 m²

Building 4 has two elevators, 3 staircases and common halls for recreational activities. Corridors are relatively large. In addition, there is a common garage (parking house) for all flats. The garage is not included in this presentation.

The standard (“quality”) of the buildings

Building 1 is a building of a relatively high standard. It is centrally located in a very popular area. All material and workmanship is of high quality. In this building, special care was taken to ensure extremely good sound insulation between all apartments.

Buildings 2, 3 and 4 have to be considered as similar regarding the substructure, the finishes, and the standard of material and workmanship. As an evaluation, the standard can be considered to be between average and above average.

The design of Building 2 and Building 3 is almost the same. The difference between them is essentially only the size of the apartments. In both cases there are no common areas, since the entrance is directly into to each apartment (from balconies on the upper floors).

In Building 4 all the apartments are relatively small, with the average size of about 60 m², and each apartment has only two rooms. The common area in this building is relatively large. There are two elevators and three staircases in the building. The inhabitants have access to a large garage (car park). However, the garage is not included in this comparison.

The design of this building, with large corridors, elevators, and a car park will probably increase the total standard of this building compared to Buildings 2 and 3, although the standard of the material and workmanship has to be considered similar.

The cost

All the buildings were built in the years 2000 to 2003. To adjust all the prices to the same date, the Icelandic Building Index was used. The Icelandic Building Index is calculated once a month, and in addition to this monthly calculation, an average Index for each year is published. For this comparison, the average Index for the year 2002 is used.

The following tables show the costs of the buildings. The tables refer to the price per m² of a building, and the price per m² of flats. In both cases, this reference applies to the gross area. The gross area of the house is defined as that contained by, and

including, the outer walls (all floors included). The gross area of a flat is measured from outside of an outer wall and from the middle of a common wall.

All prices are in Icelandic kronur (ISK), and in January 2004, one Euro was equal to 86.58 ISK. Prices in this presentation do not include all cost, since the cost of land is not included. The price of land varied between these buildings. For Building 1 it was ISK 11.547 per m² of the flats, for Building 2 it was ISK 16.916, for Building 3 it was ISK 3 8.382 and for Building 4: ISK 18.965.

	Building 1		Building 2	Building 3	Building 4	
	ISK/m ² house	ISK/m ² flats	ISK/m ²	ISK/m ²	ISK/m ² house	ISK/m ² flats
Design	4.221	4.856	5.639	5.894	5.013	7.917
Excavations and fyll	3.939	4.533	2.506	3.405	3.231	5.102
Rawbuilding (found. and superstr.)	29.872	34.371	36.338	41.126	39.657	62.630
External finishes	32.452	37.339	16.290	17.812	15.373	24.278
Internal finishes	31.514	36.260	26.471	32.547	28.941	45.706
Sanitation, water, sentral heating.	11.630	13.382	5.325	5.959	5.614	8.867
Electrical installations	10.927	12.572	5.388	6.549	6.617	10.450
External works	3.517	4.047	3.047	3.533	3.119	4.926
Constructions site cost	7.269	8.364	2.976	3.143	2.278	3.598
Total cost per m ²	135.340	155.724	103.980	119.968	109.843	173.472

Table 5.5 Cost per gross square meter of flats and gross square meter of house

	Building 1	Building 2	Building 3	Bulding 4	Average all buildings	Average bld. 2,3 and 4
Design	3,1%	5,4%	4,9%	4,6%	4,5%	5,0%
Excavations and fyll	2,9%	2,4%	2,8%	2,9%	2,8%	2,7%
Rawbuilding (found. and superstr.)	22,1%	34,9%	34,3%	36,1%	31,9%	35,1%
External finishes	24,0%	15,7%	14,8%	14,0%	17,1%	14,8%
Internal finishes	23,3%	25,5%	27,1%	26,3%	25,6%	26,3%
Sanitation, water, sentral heating.	8,6%	5,1%	5,0%	5,1%	5,9%	5,1%
Electrical installations	8,1%	5,2%	5,5%	6,0%	6,2%	5,6%
External works	2,6%	2,9%	2,9%	2,8%	2,8%	2,9%
Constructions site cost	5,4%	2,9%	2,6%	2,1%	3,2%	2,5%
Total	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Table 5.6 Cost as % of the total cost per gross square meter for each of the houses

	Building 1	Building 2	Building 3	Bulding 4
Design	100%	134%	140%	119%
Excavations and fyll	157%	100%	136%	136%
Rawbuilding (found. and superstr.)	100%	122%	138%	133%
External finishes	211%	106%	116%	100%
Internal finishes	119%	100%	123%	109%
Sanitation, water, sentral heating.	218%	100%	112%	105%
Electrical installations	203%	100%	122%	123%
External works	115%	100%	116%	102%
Constructions site cost	319%	131%	138%	100%
Total price per m ² of flats	130,2%	100,0%	115%	106%

Table 5 7 Comparison of the cost per gross square meter of house. The prices of the building with **lowest** price for each category is set to 100%

As stated above, the Buildings number 2 and 3 are built in such way that there is no common area. The inhabitants walk directly into the apartments (from balcony on the upper floors). Since the gross area is defined as from the outside of an outer wall, the total gross area of all apartments is equal to the gross area of the house.

The gross area of Building 1 is 3.026 m². The total gross area of all apartments is 2.603 m² or about 86% of the total gross area of the house.

The gross area of Building 4 is 4.482 m². The total gross area of all apartments is 2.838 m² or about 63% of the total gross area of the house.

Therefore, the buildings all differ in gross area. They also have to be considered somewhat different in standard ("quality"). Hence, their price per square meter differs.

The building with the highest quality in material and workmanship, Building 1, has the highest price per gross square meter of the building.

The Building number 4 is special in that all apartments are relatively small, compared to the other buildings, and they are all with two rooms. In addition, there are large common areas in this building. This building has the highest price, per gross square meter of apartments.

The building with the lowest price, Building 2, has six apartments, all with the same appearance, and all with five rooms. Building number 3 does not differ very much from building 2. The main difference being that there are eight apartments in this building: four with five rooms, and four with three rooms.

	Building 2	Building 3	Bulding 4	Building 2	Building 3	Bulding 4
Design and preparation	5.639	5.894	5.013	112%	118%	100%
Excavations	940	1.179	1.225	100%	125%	130%
Fyll	1.566	2.227	2.005	100%	142%	128%
Formwork	12.687	14.407	14.036	100%	114%	111%
Reinforcement	3.916	4.453	5.570	100%	114%	142%
Concreting	9.555	10.740	10.248	100%	112%	107%
Windows and entrance doors	6.579	7.596	6.684	100%	115%	102%
Roof	3.603	3.929	3.119	115%	126%	100%
Sanitary installations	1.096	1.244	802	137%	155%	100%
Water and central heating	2.819	3.143	2.674	105%	118%	100%
Sanitary appliances	1.410	1.572	2.139	100%	111%	152%
Electrical installations	5.388	6.549	6.617	100%	122%	123%
Plastering	2.976	3.274	2.005	148%	163%	100%
Interior walls (not concrete)	3.446	4.453	2.228	155%	200%	100%
Metalwork	1.253	1.375	1.426	100%	110%	114%
Painting	4.856	5.632	6.238	100%	116%	128%
Internal doors and cupboards	7.205	8.382	7.798	100%	116%	108%
Floor coverings	4.856	6.287	6.238	100%	129%	128%
Clay tiles	1.880	3.143	3.008	100%	167%	160%
External cladding	13.157	14.669	12.031	109%	122%	100%
Balcony finishes	3.133	3.143	3.342	100%	100%	107%
Construction site cost	2.976	3.143	2.278	131%	138%	100%
External work (roads etc.)	3.047	3.533	3.119	100%	116%	102%

Table 5.8 In this table a further breakdown of the information for buildings 2,3 and 4 is shown. All prices are per gross square meter of building. The prices of the building with lowest price for each category is set to 100%

Conclusions regarding the Icelandic case

In this comparison, the building cost per gross square meter of apartments, and gross square meter of the building is used. It is quite reasonable to compare building cost in this manner, but comparison of this kind can, of course, only tell us that one building is more expensive than another and by how much.

In this case, Building 3 is about 15% more expensive than Building 2, even though both buildings are fairly similar. All the finishes in both buildings are exactly the same, and they were chosen for this comparison because of how much they were alike. Buildings 1 and 4 differ more, both from each other and also from Buildings 2 and 3.

Based on this comparison, we have to conclude that the project, Building 2, is a good project, probably the best one of these four, considering the price only. On the other hand, if we were looking only for standard ("quality") of material and workmanship, we probably would choose Building 1, since its standard has to be considered well above average.

The question we are dealing with in this report involves productivity, benchmarking, and comparison of the building industries between countries. Of course, the comparison shown here is not sufficient to compare the entire building market in one country, to the entire building market of another country. To do so, the sample needs to be considerably larger and more detailed methods have to be used.

This comparison shows the prices and the difference in prices between common apartment buildings in Iceland. It does not take into account the profit or the entrepreneur's or developer's outcome for each building, since the comparison's main intentions are to supply general information about the building market, in order to initiate further comparison between countries.

5.6 Conclusive comments

The cases are different, but two main types can be defined:

- The Norwegian-Finish, describing development and early testing of a scientific, statistical measurement method
- The Swedish- Icelandic-Danish, describing collection and processing of costs/prices.

Each case should be studied separately. They have their individual quality and detailed information that can inspire other to improve own r&d activities on the field. The cases emphasize the width of the field of productivity studies. The overview should make the preparation of a future Nordic r&d project of productivity easier. The preparation of such a study should be started by a discussion of direction. Before new project presumably will be launched, the experience presented in this report will be supplied by new experience on the different methods presented. This might ease the evaluation and the decision, and hopefully increase the possibility of suitable and useful benchmarking in Nordic building and construction industry.

6 Main conclusion

The Nordic productivity project has discussed productivity in the five countries, aiming to present the lot and to propose common activities. In this chapter we will inspect the achievement in relation to the defined goals as they were emphasized in chapter 1.3. In the first part we will discuss the “degree of success”. In the final part we will discuss how to have the experience from the project available and useful to building and construction industry in the Nordic countries.

6.1 Ambitions and goals

The main goal was to

- 1) *“Carry out a survey on R&D activities on the field of productivity measurement and evaluation in building of blocks of flats in the Nordic countries.*
- 2) *If methods and/or tools for the purpose are considered to be useful in the common scope, this/these shall be improved and prepared for common use.*
- 3) *Likewise, if there are identified local initiatives of obvious productivity improvement effect, the project shall spread information about this throughout all the five countries”.*

The three specific tasks have been addressed in this report are

1) The survey of R&D activities

Regarding productivity as a scientific item, a mathematic or an economic value to be measured and analysed, almost nothing has been done in the field of Building and Construction the last ten years. It might have happened that some scientific method has been used inside a single company, but nothing has been observed published since the University of Luleå Thesis in 1996 (Johsson 1996). - Caused by the concern of seemingly strong growing prices in housing, both governments and industry in each country has during the last few years paid more attention to this matter. As a consequence the word productivity is more and more being taken into use by the different parties, and some studies have been carried out. The most visible one is the Swedish study “Skerpning gubbar” (Boverket/Modig 2003), where prices of residential buildings are listed and remedies of lowering the prices are discussed. Some pilot projects are included, and the effect of different cost lowering initiatives is discussed as case studies.

2) Methods and tools for common use

The project verifies that there are different methods/tools in use in the five countries. The suitability with respect to neutral measurement of productivity has been discussed in chapter 3. The conclusion is that even if there had been revealed one outstanding method, recommended for common use, there will be a number of technical and practical challenges to exceed.

- The first one is the difference in project account systems even within one country, which makes it hard to have comparable cost figures for building projects.
- The second one is the differences in measuring/defining building areas

- Thirdly there are a lack of methods when it comes to measuring functional and technical standard of buildings
- And finally the different possibility to get complete information from developers and contractors

The Norwegian R&D project, which still is in the phase of developing and testing a method, seems to cope with most of these hindrances, but it is still too early to tell if this can be the “all-Nordic-productivity-measurement-method”.

3) Local initiatives of obvious productivity improvement effect

Many initiatives are taken into use to improve productivity in each country. The problem is that it is mostly based on intuition (“gut feeling”) and not on qualified measurement of efficiency due to difference in certain technical or managerial conditions. On governmental level in each country, there have been established similar programs, as in other European countries, to improve competitiveness. Over the last twenty years “Quality” has been the mantra, and certainly it has been a substantial initiative to improve productivity in many companies. The problem is still that the effects are difficult to measure as long as no measuring tools are available.

At company level lots of different initiatives are taken to improve productivity. Some examples:

- Reorganising the organisation
- Improve the production machinery and equipment
- Cost control management at all levels
- Introduce encouraging wage system
- Build a stimulating work place environment
- Education of staff
- Etc., etc.

In each company it is from time to time possible to measure the effect of an initiative by measuring the cost “before and after”. How exact the measurement method is doesn’t matter as long as it suits the actual company. For a common, multinational purpose a more scientific method for improvement measurement still is wanted.

R&D making it possible for the industry to study its own performance in a systematic way, and through this identify the most cost-reducing or profit-increasing initiatives, should be useful. As such, we believe that the Nordic synergy project and this report also is one step in the continuous work of building a more productive and competitive industry in the Nordic countries.

6.2 Network for productivity

The aim was to “*Establish a network for productivity research in the Nordic countries, based on the contacts established through focusing the building of blocks of flats*”. – In the synergy project five R&D institutions have represented the five countries with long history in the field of building and construction research. In a majority of the country cooperation with considerable house building companies has been central during the project period. The contact established between the five institutions, and the cooperation between the researchers and the house builders,

must be a potential for future productivity studies in the Nordic countries as a whole or in each country.

6.3 Sub-goals

6.2.1 Organizing of the production

“Identify the difference and/or similarities when it comes to the organizing of building of blocks of flats, and discuss how the productivity is affected by the different aspects”. – This issue is discussed in chapter 2.3. The conclusion is that one obvious difference between Sweden and the other countries is that multi-dwelling resident buildings in Sweden is mainly owned by tenant-owned associations and governmental connected institution (Bostadsrättsförening) while the situation in the other countries is that these type of dwellings are individually owned, like most of the dwelling houses are. Despite the difference, one cannot observe any strong difference in productivity. But again, as long as there isn't a suitable tool for measuring available, it is hard to say exactly.

Similarities are many, and seem to increase together with the “nordicfication” of the building industry. Ten years ago, the typical situation was that a contractor operated within one country. Today more than three building companies are operating in at least in three of the five countries, and such development seems to continue. The “unification” in methods is slowly evolving. Generally, the main picture is the increasing volume of “turn key” contracts with the contractor as the key stakeholder. Within this concept there are many nuances, both technical (f. ex. “prefabrication”) and organisational (f.ex. “Partnering”). All such initiatives have increasing productivity as their main goal. Unfortunately there are no systematically registrations published, but the University of Luleå thesis (Johnsson 1996), showing correlations between productivity and the way building of residential blocks are carried out. The Norwegian R&D project addresses this type of issues and might, when completed give impulses to similar studies in the other countries.

6.2.2 Prepare development of measuring methods

“Prepare development of measuring methods for productivity on blocks of flats in Nordic b&c industry - and propose improvement initiatives with respect to productivity”. - As discussed in chapter 4, the main preparation carried out by the Nordic synergy project is the discussion and identification of differences between the countries with respect to how

- The building project costs are structured
- The floor area is measured
- To define and measure the functional and technical standard of a building

When the next project about common Nordic productivity studies is launched, the work can start directly on the issues mentioned, as well as on the experience from the ongoing Nordic projects. If the Norwegian r&d project ends with a suitable tool, the next project really should benefit on this experience. The improvement initiative in all countries should be to provide information in field of productivity studies, both in the Nordic countries and other part of the world.

6.2.3 Prepare benchmarking

“Prepare for benchmarking between building and construction companies in all the Nordic countries - and develop productivity indicators for the blocks of flat production in the Nordic countries”. - As mentioned above, the Nordic synergy project has given information on the field that by it self forms a preparation for benchmarking. Unfortunately, the tool is not yet completely developed. When one certain method has proved its ability, an across-the-borders measurement can be organized and the first Nordic benchmarking on productivity of housing can be carried out. Until a method is developed and tested, no real key indicators can be defined, as the test and regression analysis will have identification of suitable key indicators as its main goal.

6.4 Information and dissemination of the project experience

6.3.1 Local information

This report makes the basis for further communication of the project and common experience. The representatives from each country will communicate the results and ideas from the project when participating in arrangements in own country and abroad. Whenever possible, they will submit information about the work of the Nordic synergy project of productivity to the building and construction industry in own countries.

6.3.2 The CIB Symposium 2005

In June 2005 the International Council for Research and Innovation in Building and Construction (CIB) is going to have an international symposium in Helsinki. Building economy, Performance concept in building and Organization and management of construction are subjects for the conference. Thus the questions related to the work carried out by the Nordic synergy project are focused, and all the five representatives in the project plan their presence.

6.3.3 Website(s)

This report will be available on the website of Nordicinnovation. Links are established to each of the five institutions websites. The Reference list indicate some other institutions involved in different types of R&D work concerning performance evaluation and improvement in building and construction.

6.5 Thoughts about the future

The Nordic synergy project (P00099 Productivity in building and construction industry”) has revealed the lack of sufficient statistics in all Nordic countries when it comes to the building and construction industry. Figures to calculate the productivity of a building project are not available. As long as no methods are in common use, this might look unimportant. On the other side, it might well happened that such a method can be established, and if so, the need of dataset will be high.

The building and research industry is of major importance in all country, as it supports all different needs in an industrialised country – from the multi professional service to other industry to development and maintenance of the entire infrastructure in the community. It is important that the society can get proper information about

the industry. Likewise it is important that the industry knows itself and it's own capacity. Thus statistics and scientific methods for survey and measurement of performance should be well developed and in use. This is not the situation today. It must be improved, and the Nordic productivity project emphasises this. In the Nordic countries there are good communication and tradition for cooperation between different groups in society. Thus further cooperation, based on open information about production cost figures, can put Nordic productivity studies in a leading position in an international perspective. The completion of the synergy project, conceived and blessed by Norinnovation during the years 2001 - 2003, should therefore as soon as possible been followed by a new project on the field. Thereby local activities can be stimulated. The result for common activities can show "best practice" and in many ways support Nordic building and construction industry as competitors wherever the companies are competing.

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