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A STUDY OF THE
PRODUCTIVITY BENEFITS OF
SOME PROCESS CHANGES IN
THE BUILDING INDUSTRIES
OF DENMARK, SWEDEN AND
THE UK

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1. ENGLISH SUMMARY

1. The most significant changes in construction at present are to the process, and this research has built on the work of the DTU IT byg group and looked at productivity in two other countries
2. Productivity in Danish construction has not improved compared with Sweden and the UK, but is difficult to measure in relation to particular innovations. Repetition of process change has been used to justify their benefits, as well as benchmarking and a few case studies in the UK.
3. A short 3-month study has meant that only a few process changes could be studied: Standards sets of data and classification in Sweden, and partnering and use of project extranets in the UK.
4. In Sweden the IT Bygg och Fastighet development projects have shown how building owners support process change, and widely-known data systems help introduction of new technologies.
5. In the UK the experience of some large clients and contractors gives evidence for advantages of partnering and project extranets. Rethinking Construction is measuring and promoting benefits.
6. Productivity has been much studied in Denmark and DTU has researched some methods of improving it. The new Benchmark Centre for the Danish Construction Sector should provide a focus for further work
7. Benchmarking experience from M4i in UK has shown benefits from innovations in special projects compared with others. More precise types of KPI could be introduced in Denmark.
8. Basic systems of building data provide a basis for Swedish construction but take time to spread. Denmark needs better systems and project servers could help to share knowledge of these faster.

9. Involvement of building clients and long-term relationships are the basis for process change. Public/private financed projects in the UK encourage life-cycle thinking and use of extranets.
10. Extranet studies in Denmark have shown that users do not trust electronic data. Clarification of legal status is necessary. These, and other selected innovations, can then deliver full benefits.

DANSK RESUME

1. For øjeblikket sker de mest markante ændringer i byggeriet i processerne, og nærværende forskning bygger på DTU.BYG's IT gruppe's arbejde, hvor man har undersøgt produktiviteten i to andre lande.
2. Produktiviteten i dansk byggeri er ikke blevet bedre sammenlignet med Sverige og Storbritannien, men den er vanskelig at måle i forhold til den enkelte innovation. Gentagelse af procesændringer har været brugt til at begrunde fordelene ved ændringer på samme måde som benchmarking og nogle case studier i Storbritannien.
3. Undersøgelsens begrænsede længde (3 mdr) betyde at kun nogle få procesændringer er blevet undersøgt: Standard mængder af data og klassifikation i Sverige, og partnering og brug af projekt extranet i Storbritannien.
4. I Sverige har IT Bygg och Fastighet udviklingsprojekter vist, hvordan bygherrer støtter procesændringer, og at kendte datasystemer fremmer introduktion af ny teknologi.
5. I Storbritannien viser erfaringer fra nogle store klienter og entreprenører, at der er fordele ved partnering og projekt extranet. Rethinking Construction bedømmer og fremmer fordelene.
6. Produktivitet er blevet undersøgt meget i Danmark, og DTU har undersøgt nogle metoder til at forbedre den. Det nye Byggeriets Evalueringscenter vil sørge for en fokusering af det videre arbejde.
7. Benchmarking erfaring fra M4i i Storbritannien har vist fordelene ved innovationer i særlige projekter sammenlignet med andre. Mere nøjagtige KPI typer kunne introduceres i Danmark.
8. Grundlæggende systeme der håndtere byggedata udgør et grundlag for svensk byggeri, men det er tidskrævende at udbrede.
9. Inddragelse af bygherrer og længerevarende forbindelser er grundlæggende for procesændringer. Privat finansierede projekter i Storbritannien fremmer livscyklus tænkning og brug af extranet.
10. Extranet undersøgelser i Danmark har vist, at brugerne ikke stoler på elektroniske data. Præcisering af den virkelige status er nødvendig. Disse og andre udvalgte innovationer kan så give det fulde udbytte.

2. INTRODUCTION

Research in the IT byg group in the BYG.DTU institute at the Technical University of Denmark, has included evaluation of the benefits of IT systems, surveys of the use of IT in construction in Scandinavia, research on building classification systems and studies of the use and benefits of communications, particularly Project Webs. These address some of the process changes taking place in construction, enabled by the development of IT systems and experience.

Quantifying the benefits of process change, and particular systems, has always been difficult. The only measures of productivity are those for whole national industries, based on construction turnover divided by total hours of labour, with material, equipment and capital taken into account if possible. Using published data, such as that from OECD, it can be seen that some construction industries have improved their productivity more than that in other countries. Neither the United States nor Denmark seem to have increased productivity in the last 30 years, while Sweden has improved by about 80% over this period and the UK has made some progress recently.

There is much concern about this in Denmark, particularly with construction becoming more international and the report, 'Byggeriets Fremtid' [1], draws attention to the high cost of both labour and materials in Denmark. A comparison of the cost of building a virtual house showed that this would cost 700,000 DKK in Sweden and the UK and 1,200,000 in Denmark. These comparisons are not very precise, and a proposal for a research project to build similar houses in Denmark and Sweden would provide some real data.

Process change is being tried out in a number of areas, particularly those identified in the Egan Report [2]. There is now a considerable body of experience from some of these changes in the UK, through the Construction Best Practice Programme [3] and Movement for Innovation [4]. A development project in Sweden, IT Bygg och Fastighet [5] is just reporting on a number of IT related process changes and methods in building and property. These studies offer useful sources for trying to look at productivity benefits and relate these to the needs and conditions in Denmark.

This project was proposed in 2001 and a travel grant offered by the COWI foundation. The work could not start until August 2002 by which time BYG.DTU had been reorganised and had decided to withdraw from strategic IT research in construction. The scope of the work therefore had to be reduced to complete it before the end of 2002. The particular process changes selected were:

- | | | |
|----|--|------------------|
| 1. | Standard specifications | |
| 2. | Standard classification systems | mainly in Sweden |
| 3. | Other areas studied by IT Bygg och Fastighet | |
| 4. | Partnering between project teams | |
| 5. | Use of Project webs/Extranets | mainly in the UK |
| 6. | Benchmarking of performance | |

The number of companies that could be interviewed was reduced and those visited, both suppliers and users of systems linked to process change, were selected for their involvement in development or innovation projects. They were interviewed using a semi-structured checklist and their personal views, and reference to any published information, was sought. We are very grateful to the COWI foundation and to those who were interviewed or supplied data, for their assistance.

(At December 2002 £1 UK was worth 11.6 DKK, Danish Kroner and 14 SEK, Swedish Kroner)

3. SELECTED PROCESS CHANGES

Some of the most fundamental process changes being tried at present include:

- **Supply chain management** in which electronic communications and long term relationships help to ensure integration of processes carried out by different firms.
- **Public-private partnerships** in which private money is used to finance facilities for public use through the health or educational services.
- **Build-Own-Operate-Transfer (BOOT)** in which contractors or consortia tender for providing and operating a facility for many years.

These have major economic implications and are not so strongly linked to IT techniques, but they do stimulate use of project extranets, for example. They are potentially of great benefit to productivity in construction, but it requires more years of experience to evaluate these benefits, and this work should be done by researchers with credentials in economics.

The role of IT in process change is a catalytic one. Where the original contribution of IT to productivity has been based on automating certain tasks: text and drawing production, for example, it now depends upon process change for a further range of benefits. These should be both quantitative, and therefore measurable, and qualitative, by improving the service provided by the construction industry to its customers.

The reasons for selecting the process changes listed that were chosen is that they have either existed for many years or have been studied recently. Any published information has been sought in order to widen the scope of a study carried out in a limited time by one person. The longer-term tools for process change, such as the standard specifications and classifications used in Sweden, have existed for many years and are used so widely that there is little basis for comparison with working without them.

Project webs have been the subject of recent studies in Denmark and the UK. The particular work in Denmark has been done at DTU as part of the PPB housing consortium projects for the Ehrvervs and Boligministeriet [6], and for the contractor NCC and their use of ByggeWeb [7]. A detailed cost/benefit study has been carried out by Balfour Beatty in the UK, and Costain was also the subject of a case study by Salford University [8].

Partnering has been tried by several leading clients in the UK, and 'The seven pillars of partnering' [9] referred to a number of case studies which were followed up by Building in its issue of 3 April 1998 [10]. There are many years of experience and this has now moved beyond the first trial projects, which are inevitably experimental, into a regular procurement technique.

Benchmarking in construction has been most developed in the UK by the Construction Best Practice Programme and the comparisons published by the Movement for Innovation, between demonstration projects in housing and other building types [11], and general levels of performance in the industry, are real attempts to quantify benefits.

4. PRODUCTIVITY INDICATORS

Productivity is defined simply as output divided by input. This can be applied to whole industries, either as Labour Productivity, where the turnover of construction is divided by the total hours worked, or as Total Factor Productivity, in which other resources, such as material, equipment and capital, are added to labour [12]. The question then arises whether the output should be gross or value added, of relevance in construction where many products come from outside the industry.

Even if a realistic measure of productivity can be made, and the OECD publishes the best statistics for whole industries [13], identifying the contribution of individual process changes is very difficult. The Productivity Paradox [14] states that it has never been possible to prove that information technology has increased the productivity of whole industries. However most people would accept that bureaucratic businesses like banking and insurance have reduced their staff substantially while increasing their turnover. In construction a much greater value of work is now produced by fewer people, but the economic benefits to the industry have been absorbed in greater complexity of building and reduced fee and profit levels.

Using the labour productivity figures from the OECD over the period from 1984 to 1996, it can be seen that, although productivity in the Danish construction industry fluctuates, there is little overall gain over that period, while Sweden improved by about 40 points, and the UK, since 1990, by over 10 points. This period includes the major recession of 1990 that hit Sweden and the UK harder than Denmark, and savings in labour costs were inevitable.

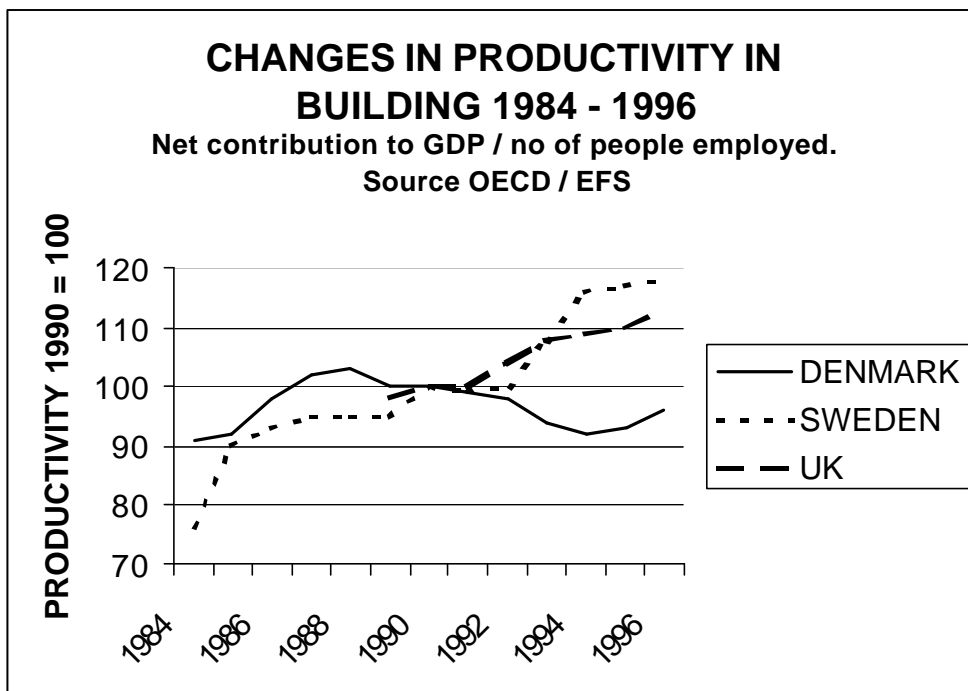


Fig 1. Changes in productivity in building 1984 – 1996. OECD

Emphasis in building procurement is moving from cost to value, and this adds another complexity to assessing productivity gain. Value can be a very subjective measure, although the Key Performance Indicators in the UK [15] provide some benchmarks for aspects of value, most useful for comparing sequential change. There still remains the value of the building to its users and even to the public. KPIs have been developed to measure design quality too, but they are quite recent and the comparative data with projects incorporating process changes does not yet exist. The quality of building in Denmark appears to be high, although it is very hard to assess the extra value of this over, say, the lower quality generally obtained in the UK.

In order to identify the contribution of particular process changes, either individual case studies must be used to represent a more general picture, or the very level of take up of new systems or techniques must be used to indicate the benefits they provide to their users. This is particularly relevant to the use of standard data and classification in Sweden where the use of the AMA and BSAB is almost universal. This brief study also takes a few case studies, and borrows from the work of others, to show the benefits achieved by a few companies using particular systems. It is not possible to project these experiences onto whole industries, but should give encouragement to those planning to introduce process changes, where the experiences of others have been good.

5. LITERATURE REVIEW

Apart from the general literature on process change and productivity already mentioned, there are a number of reports on building productivity from Denmark and the other countries being studied.

‘Productivity improvements in construction’ by Dan Petersen of SBI [16] looked at Total Factor Productivity and compared that of construction with manufacturing and public services. He used real value of output so that variations in time of the use of capital and labour were excluded. This shows manufacturing production growing by 127% between 1966 and 1992, while construction has virtually no growth over this period. He considers the quality of the output by looking at the incidence of defects in Denmark and Sweden. He also discusses the effects of innovation. There is an inability of companies to realise the benefits of their own innovations, and often these are shared with other members of a project team or may only accrue to the client.

‘Produktivitet og indtjening i byggeriet’ [17] (Productivity and earnings in building) published by Ehrvervsfremmestyrelsen in 2000 looked at individual trades and companies. It also compared Danish productivity with that of Sweden, Germany and Holland. It includes estimates of the reduction in cost of Danish buildings that would result from productivity increases of 2 – 10%. Even a 10% productivity increase was estimated to reduce costs by 4.29%, while the Swedes have achieved an average productivity increase every five years from 1965 – 1996, of 2.6%.

‘The cooperation of the future in the melting pot’ [18] by Ib Steen Olsen of the Ministry of Housing and Urban Affairs reports on the work of the New Forms of Co-operation project applied to a partnering project. It compares the results of ten projects using partnering with a traditional project using the following criteria:

1. Formulation of joint objectives for the project
2. Understanding the parties’ objectives & success criteria
3. Use of incentives eg sharing of savings, bonuses
4. Use of quantifiable benchmarks
5. Use of open estimates and accounts by all parties
6. Use of workshops as a supplement to meetings
7. Dialogue-based solution of problems & disputes
8. Contractor’s participation in design work
9. Involvement of subcontractors & suppliers in design
10. Use of multi-skilled gangs on the site
11. Keeping the same cooperation minded people throughout the project

In order to compare Danish experience of Project web with that in the UK, these criteria will also be used to provide some measure of comparative effectiveness in these two countries.

The final report of the Projekt Nye Samarbejdsformer [19] (new forms of cooperation) compares six building projects using six of the criteria listed above. Most showed substantial improvement. It also refers to some UK experience, 'Towards positive partnering' [20] in which systematic forms of construction coupled with process change produced savings of up to 60%.

References to Swedish literature were kindly provided by Niclas Andersson of the Department of Construction Management at Lund University. These include:

'Fakta om Byggandet 2001' [21] by a group representing the building industry, contains comparisons of the Nordic countries' levels of construction activity and the percentage of BNP spent on construction in OECD countries between 1977 and 1997. Denmark is the lowest with about 9% while the UK and Sweden are nearly as low with about 10%.

'Fran byggsekt till byggsektor' [22] is a report presenting the government's view and aimed at trying to change the industry from a 'sect' to an industrial sector. It suggests that substantial cost savings of up to 40% should be achievable.

'Accelerating change' [23] is the most recent report from the UK on progress with the changes proposed in the Egan report [2]. It sets targets for specific process improvements. For example, 20% of construction projects by value should be undertaken by integrated teams and supply chains, by 2004, and 50% by 2007. The target for productivity improvement is 10% and the KPI comparisons of demonstration projects with the industry norms are projected to mean that, if one third of the industry took up the process changes demonstrated, there would be a cost saving of £840 million as well as greater profitability. IT and the Internet are given a passing mention with potential benefits identified for: knowledge management, economy and speed, business relationships, product and process improvement, and technology and entrepreneurship.

6. INTERVIEWS IN SWEDEN

6.1 Orjan Wikforss, professor, Industrial economy and organisation, KTH, Stockholm

INDEK is an institution presenting the I-programme for highly qualified students in all engineering disciplines. Research and teaching of IT management in construction has moved from the civil engineering department to this institution. Wikforss has also been managing director of Svensk Byggtjänst and is on the board of the IT Bygg och Fastighet development project, the results of which will be published by the end of 2002 [5].

The national building specification, the AMA, was revised at a cost of 50 M SEK and republished by Svensk Byggtjänst in Dec 2001. It uses the BSAB96 classification system. It is now being extended into road construction and facilities management. More attention is given to the semantics than to the user interface. The use of these systems is influenced by the increase in projects led by a few big contractors, who have about half of the market, and their own systems.

The IT BoF projects were in three areas: research, standards and implementation. It has been very successful in involving property owners, but they have tended to keep to their own group. They have mapped FM processes into XML. Little software has been developed but the Industry Foundation Classes have been linked to existing products. There may have been too much emphasis on 3D modelling and IFCs in ITBoF but there has also been some good work including that on metadata. The results of the programme are being evaluated in late 2002.

6.2 Lars Haggstrom, Manager Systematics, Swedish Building Centre, Svensk Byggtjanst

Process changes being tried in Sweden include Public – Private Partnerships, such as were used on the Arlanda Express railway. Project Webs are quite widely used and may be conventional ones using file sharing with metadata, or unconventional ones linking metadata to a URL and then to the document. Building owners usually dictate the organisation of a Project Web rather than the suppliers of the service.

A version of XML, called sbXML, is linked to BSAB96, the Swedish building classification system. The Point CAD system is now using BSAB96 for its layer structure. There are a series of guidelines that are commonly adopted by clients and consultants. On product data, the EPIC initiative appears to have slowed down. Byggtjanst has a conceptual database and names can be added later. The Dutch system, Lexicon, is mainly concerned with terminology.

Lars believes the IFCs are not conceptual enough, however the IAI now gives more importance to classification. There is a mapping of IFCs to sbXML with text databases, and this could provide a basis for cost estimating systems.

The AMA started to be widely used in the 1950s and grew during the 1970s. After the recession of 1990, a range of middle managers in construction disappeared and the staff are now mainly older and younger, with only the older ones fully familiar with the AMA. The AMA consists of many books of work and material descriptions, and AMA nyt provides updates also available in electronic form. Each issue costs over 1000 SEK and the books can cost up to 2000 SEK each. They are not selling as well as they did for a number of reasons: there are more Total Build contracts, not all the books are available in electronic form, and offices tend to have fewer copies. The AMA is a widely used reference and provides a basis for quality control. Some parts are used in all large building projects. The number is increasing with the inclusion of road projects.

It is very difficult to estimate the productivity benefits of the AMA to the Swedish construction industry and no studies have been found. However it is so fundamental to all construction work that, if it did not exist, there would be much less common understanding of work processes. There are some reservations about it limiting design freedom and, in Denmark, the BPS system is a type specification which is less widely relied upon, but growing in usage. BSAB96 is free to use but is licensed to software developers, such as Point, at a significant rate. It is used almost as universal as the AMA but does not have tables for product classification.

6.3 Håkan Blom, Olle Samuelson, Inger Westling, Frank Janland, Tyrens Building consultancy

Håkan Blom was a member of the board of the MOPO Product Models and Processes projects in ITBoF. Tyrens is also involved with SWECO in development of a Project Server in Finland www.enterprixe.com The IT BoF project had a large part of its work related to IFCs, but modelling can be done in other ways. IT use in facility management is quite successful but employs simpler models than IFCs.

There are many construction projects using Project Webs, but also a number of suppliers of services, such as Byggnet. Often the client decides which system will be used. Users are not generally very happy since the systems are not yet very user friendly. There have also been some bad experiences and there is also some use of systems from the US and Holland.

The productivity gains from IT are hard to measure. There are even questions about the benefits of CAD. The cost of this is now almost as great as that of the office rent. Time spent on drawing is less, but any savings are needed to meet greater pressure on time and economy. The design process has not been changed by CAD. Project servers can hold common systems such as AutoCAD ADT or the IFCs. They could help with versioning over the Internet and control access to files while they are being edited by others.

A pre-study is being carried out by ISO on future standards for technical documents. In Sweden most building data is classified by BSAB, but project webs often use other systems. BSAB is used for both drawings and specifications, but often the specifications are left to the contractor.

The AMA is widely used in Tyrens. They have about 600 staff of which 250 are in the Stockholm office. They probably have about 25 copies of the main AMA books and subscribe to AMA nyt. They use the administrative parts on all projects, and also the main construction book. Most staff are familiar with the AMA and it is referred to by its clauses, classified by BSAB96. Even small builders use the AMA, which is linked to price books. BSAB can be used for cost calculations, drawing numbers, libraries and products. But only Byggtjänst uses it for product data. The benefits of BSAB and the AMA to Tyrens are that they are so widely known and referenced that they have become part of the general education of most people in the Swedish construction industry.

6.4 Kurt Lownertz, Kjell Lundberg, SWECO Connect, part of the largest construction consultancy in Sweden

SWECO uses project webs on some projects and extranets for various services, e.g. forming joint projects and for links to testing laboratories. Their first experience was in 1997. Kurt and Kjell are both members of ISO SC8 WG16 on future methods of documentation, which relates to the IFCs.

Their experience of the AMA is that it has not changed much in the last 10 years. It is a standard tool that is used on all except renovation projects. Its quantitative benefit is that it reduces the amount of writing on a project description, and its qualitative benefit is that it provides precision and links with quality systems. The problem they find is that there are too many headings and they often have to go back to the books for their explanation. It should all be put into electronic form. That which is, is available in Word templates and on the SWECO Intranet.

BSAB96 has a good reputation and should be self-financing through the AMA and other publications and services. Metadata contains classification and a table of document types is needed. This could include models as the documents of the future.

The standard on Metadata, ISO/IEC 82045 is nearly ready. Part 2 is the specification of metadata elements, which is complemented by Part 5 for application in AEC/FM. It gives the ability to describe documents as objects. Several prototypes for exchanging documents with metadata have been developed for EDM systems and project webs. . The problem is how to input the metadata. Part 3 of ISO 13567, CAD layers, is a Technical report on implementation of a range of systems.

7 INTERVIEWS IN THE UK

7.1 Martin Ong, Director of Projects Technology, and Peter Rebbeck,, Design, BAA plc

BAA is the owner of 7 large airports in the UK. Its chairman was formerly Sir John Egan who chaired the Egan report and has introduced much process change in BAA's procurement of buildings. The value of construction work is expected to reach £8 billion over the next 11 years. He presented a paper to the CICA Annual Convention [24] in which he said that their objectives in adding value to their operation are to become a well-informed client through:

- Predictability, buildability and maintainability
- Selecting consultants and contractors as framework partners
- Continuous improvement measured by Key Performance Indicators
- Involving project teams in the whole process
- Measurement of added value
- Eliminating waste through technical and process change

They have a system called AMA, Acquire and Maintain Assets, which aims to reduce costs by 10% in 2 years, produce a 30% rate of return and save time on site by up to 60%. This will be through increasing off-site manufacture from 35% to 65%. They aim to develop a common data environment and there is a single model for their largest project, Terminal 5 at Heathrow. At present they generate 3D from 2D data and need to go back to 2D when changes are made. When 3D CAD data standards are established it should be possible to use a 3D asset model throughout. They aim to fully implement object modelling through the Industry Foundation Classes in 3 years.

They use two construction portals or extranets, BidCom and BIW and about £350 million of work is on these. BidCom's Asite gives about a 3% return on its costs. They have used the KPIs to benchmark their progress after the first 5 years of framework agreements. Martin Ong believes that the client should not dictate the tools to be used, but its knowledge management and AMA.net are on their website for use by framework partners. There is a lack of clarity in the construction industry with no overall strategy document. Industry and academic timescales are not aligned and it is difficult for them to collaborate, while there is too little time spent on imbedding the result of research. He believes that project collaboration tools reduce rework and are productive, but this is difficult to quantify. However collaboration using the Asite project extranet produced a 3% reduction in costs apportioned between the extranet and partnering as shown in Fig 2.

Benefit contributors	Asite collaboration %	Common Project team %
5% reduction in design team costs	40	60
8 – 16% reduction in programme schedule	40	60
40% reduction in Early Warning Notices	50	50
10% reduced number of drawing revisions	70	30
Improved duration of drawing approvals	75	25
Reduced design work - Product Library	90	10
Use of Product Library for standardisation	100	-
Electronic Health & Safety file at the end	100	-
Transparency & improved communication	75	25
Average contribution	70	30

Fig 2. Contributions to savings on BAA project using project extranet and partnering. Martin Ong

Peter Rebbeck said that after experience of 5-year Framework agreements with their partners, they were now moving to 10-year agreements with a review every year. There is a need for long-term relationships but partners can become complacent. In relation to the points used in the Boligministeriet study on New Forms of Cooperation [19], he commented on their experience of partnering as follows:

1. **Formulation of joint objectives** – they agree objectives and identify the capabilities needed
2. **Understanding objectives and success criteria** – they pick teams on past performance
3. **Use of incentives** – there is no real sharing of risk or profit, but bonuses are paid
4. **Use of benchmarks** – Key Performance Indicators are used
5. **Use of open estimates and accounts** – these are open to all parties involved
6. **Use of workshops** – they hold these but they are largely social events to bring people together
7. **Solution of problems** – by traditional means but they are trying to move to more dialogue
8. **Contractor's participation in design** – yes from the beginning of the project
9. **Involvement of subcontractors and suppliers in design** – they nominate special suppliers and contractors hire subcontractors as early as possible
10. **Use of multi-skilled gangs** – they use a lot of multi-skilling
11. **Keep same people through a project** – their work is high profile and attracts good people.

In the future BAA expects to retain at least two project extranet suppliers and it would hope to build more structure into the documents exchanged between partners, moving towards customised solutions based on de facto standards. A recent article in Building Design [25] said that architects in the framework programme would not have responsibility for detailed design, but this would be given to construction and building services firms. This is a more similar approach to that used in Denmark where consulting engineers do much of the detailed design.

7.2 John Connaughton, Davis Langdon Consultancy, Construction Best Practice Programme

The CBPP is one of the initiatives of Rethinking Construction launched to implement the Egan Report. This also includes the Housing Forum, Movement for Innovation (M4I) and the Local Government task force. CBPP is funded separately and is fairly independent. The Davis Langdon consultancy provides support for CBPP and the CRISP construction research group. John was involved in setting up M4I and the Key Performance Indicators but they are now operated by M4I. The report Accelerating change [23] includes comparisons of KPI results for demonstration projects with industry data from DTI. They are quite crude and can be manipulated. The profitability comparisons have little value and productivity is very difficult to measure. The comparisons should also be analysed by project type.

The M4I demonstration projects are rather special ones and are self-assessed. They are offered at an early stage of the project but some do not start until the contractor is on site. Some never get published and there is much haggling over the draft reports. There is a need to get industry to change and, if these case studies can encourage them to do so, they are achieving their objectives. Accelerating change is now proposing more specific targets. Building down barriers [26] is concerned with integrating the supply chain. Prime contracting is the method for integrating teams under a single umbrella and giving suppliers more design responsibility, used by the MOD. The form of contract for partnering is PPC2000 [27]. Project extranets have been taken up quite quickly and there are about 6 major providers in the UK.

7.3 Movement for Innovation. Jaki Howes, NE Co-ordinator, Ali Mafi, SE Co-ordinator

The demonstration projects are based on rather special building projects or on process-based projects such as one by a group of housebuilders. Over 400 projects have been given demonstration status but they must show innovation in product development, project implementation, partnering or production of components. Innovations are judged by measures agreed with the project team, and performance is measured by 10 of the KPIs. M4I also has regional cluster groups that review projects. Ali Mafi has been responsible for the KPIs recently but is now more involved with lean construction. He recently had a visit from the Danish Building Evaluation Centre. He explained the process of developing demonstration projects.

1. Companies submit expressions of interest
2. M4i cluster groups apply 7/8 criteria for acceptance
3. Review of innovation content by a smaller group
4. Companies apply KPIs when updated annually
5. Case history drafted by consultant and agreed with company
6. Toolkits to help others apply the experience are planned in future
7. Dissemination of case history

The KPIs most frequently used are on predictability of time and cost. Client satisfaction is also assessed. Profitability and productivity are difficult to assess for individual projects, and actual construction cost and time are the most difficult. The design KPIs are currently on trial by CIC. The Cluster Groups are the most effective element in the process and review the demonstration projects at several stages, also helping to promote process innovation. Projects are measured when at least 50% of the work on site is complete although this does include consultants' work.

The KPI process appears successful in making companies more aware of process change. The KPIs are probably not precise enough to measure any real contribution to productivity, but they do help companies make continuous improvements. A more precise measurement, possibly including the proposed toolkits, would help determine which process changes offer the most improvement. The comparison of the benchmarks for demonstration projects and the UK construction industry generally, published in 'Accelerating change' [23] Fig 3, show a significant improvement, but the demonstration projects are rather special and the accuracy of the assessments is variable.

M4I demonstration project performance compared to all construction for 2001 ⁸				
Headline Key Performance Indicator	Measure	All construction	M4I	M4I Enhancement
Client Satisfaction - Product	Scoring 8/10 or better	73%	85%	+16%
Client Satisfaction - Service	Scoring 8/10 or better	65%	80%	+23%
Defects	Scoring 8/10 or better	58%	86%	+48%
Safety ⁹	Mean accident incidence rate/100K employed	990	495	+100%
Cost Predictability - Design	On target or better	63%	81%	+28%
Cost Predictability - Construction	On target or better	50%	71%	+42%
Time Predictability - Design	On target or better	48%	81%	+76%
Time Predictability - Construction	On target or better	61%	70%	+15%
Profitability	Median profit on turnover	5.6%	7.8%	+2% percentage points
Productivity	Median value added/employee (£000)	28	34	+21%
Cost	Change compared to 1 year ago	+2%	-2%	+4%
Time	Change compared to 1 year ago	+4%	-8%	+12%

Fig 3. Comparison of KPIs on M4i demonstration projects with all UK construction in 2001.

All the partnering projects studied were initiated by the client. Of the features of new forms of construction used in the Danish report on new forms of cooperation, six were most frequently featured in the M4i demonstration projects. Sharing of savings often took the form of 50% split of savings or extra costs by the project team and the client up to agreed limits. There was little information on: 4. Benchmarks, since these were not always completed, 6, Use of workshops, 9, Involvement of subcontractors and suppliers, 10, Use of multi-skilled gangs, and 11, Keeping the same people involved throughout the project. There is now 3 years experience of benchmarking and the person most involved with this is now Katherine Mordecai. There are no demonstration projects yet featuring project extranets.

7.4 BIW Technologies. Paul Wilkinson and Steve Cooper. BIW Information Channel

The BIW Information Channel was launched in 2000 and supplies project cooperation software mainly to clients, including project extranets. It was originally a portal for building data. Its clients include Sainsbury's, a large supermarket operator, which uses prime contracting and has a limited range of project partners. BAA is another client and BIW has worked on the 5th terminal at Heathrow airport. They work with Attenda who supply extranets to BT and Microsoft among others. The Private Finance Initiative is driving the use of partnering.

Their service is based upon a relational database with metadata for the documents exchanged. They can be retrieved by any of the fields in the database. They are commissioned to manage data for the whole building lifecycle. They also have experience of using more sophisticated forms of description than drawings. At present the users' communications limit access to large building models but, when these improve, BIW will be well placed to support IFCs and other 3D models.

They have no studies of the productivity benefits of their service to customers but they provided a case study from Kajima Construction on a £10 million superstore. Use of the Project Information Channel was estimated to have saved over £12,000 on printing and postage, and the architect reported an 8% increase in efficiency. About £31,000 was saved on design team fees. BIW also provided a paper on 'Legal issues in collaboration' [28] that shows how they reassure their clients that electronic information has the same status as that on paper provided certain rules are followed. The involvement of subcontractors and suppliers in the extranets depends upon the client. BIW has been involved in over 100 projects with some clients now on their second or third project. This indicates a continuing need for project cooperation software. There are about six major suppliers of project extranets in the UK at present. It is likely that this number will reduce to two or three in future.

7.5 Balfour Beatty, major contractors. Mel Zuydam, e-commerce director

Balfour Beatty has an annual turnover of more than £3 billion of which about £2 billion is in the UK. It originally set up the Arrideo portal for e-commerce with 4 other contractors, including Skanska, but eventually decided to use an independent supplier, BuildOnline. The first of their products to be used was Projects Online, which is a project extranet. They are involved in 17 PFI contracts and have a lot of repeat business in building and civil engineering. A study was done on one of their first projects to establish the costs and benefits of using Projects Online. This project was of equivalent value to several of those studied for NCC in Denmark [29], about £20 million. There were savings from: better drawing review, reduction of duplication, utility drawings, closing out and data management, were estimated at about £24,000. This data was used to estimate savings on 10 work packages of different types. Predicted savings were £144,565 (Fig 4) against costs of £55,208, resulting in a net saving of £89,357.

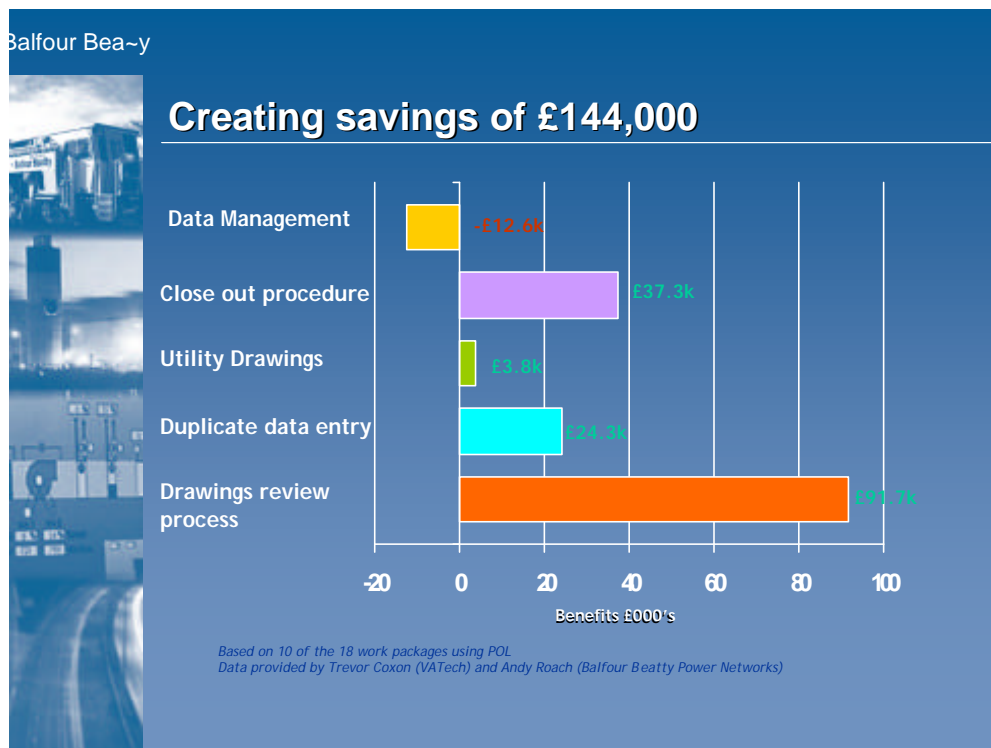


Fig 4 Savings from using Project Online estimated from 10 work packages. Balfour Beatty

Data management includes cost of storing documents and email. Costs include the licence to Build Online, training and support. Other benefits are qualitative and could not be measured. They include: client satisfaction, better team management, improved communication, resource planning, official notices, better accountability, less time wastage, lower risk, accessibility, versioning, single copies of documents. So far the documents are still printed but it is planned to distribute them electronically in future.

Balfour Beatty has now, in a single year, increased the use of Project Online to 33 projects, including 344 companies and 2400 people. There have been a total of 57,000 documents accesses. Their next plans are to introduce e-tendering, e-trading and then e-invoicing using the tools provided by Build Online. The best evidence for the benefits of project extranets is their commitment to growing usage, although this is mostly on total build PFI contracts in cable laying and other repetitive work. Mel Zuydam has carried out a detailed analysis of costs and benefits based on a clear e-commerce strategy, and this provides the best evidence for their effectiveness.

7.6 Construction Productivity Network. Benchmarking partnered social housing. CIRIA

A short note from a seminar in March 2002 [30] was based on talks by a consultant from the Construction Best Practice Programme and a supplier of software to calculate supply chain performance and apply the KPIs. One message was that KPIs need to be chosen carefully to relate to business objectives. They do not say how performance can be improved. Various KPIs can be presented in a RADAR chart to show strengths and weaknesses. About 250,000 KPI packs had been sold by that time. Contrack is a package supplied by Building Software. The housing edition helps to capture the user's, and a supply chain's, performance for comparison with other projects or externally. It is an example of a toolkit as proposed by the M4i. The benefits of using it are that it captures all performance data in one place, supports the main KPIs, allows measurement of continuous improvement and includes membership of the Housing Industry benchmarking club.

A CIRIA workshop on Electronic project collaboration in Birmingham on 7 November included experience by Liquid Knowledge of running project extranets. Relevant standards were BS/ISO 15489 on Records management and PD 0008 Legal admissibility of electronic records. Some of the benefits were in long-term storage of records, but they found that contractors were not fully committed. Chris Carter of Loughborough University reported on the EU eLegal project that will suggest how the gaps in the current legal status of electronic data should be filled by additional ICT agreements. Further information can be found at <http://cic.vtt.fi/projects/elegal/public.html>

8 STUDIES IN DENMARK

8.1 Process and Product development in Building

The PPB development project in Denmark ran from 1994 to 2001 and subsidised four housing partnering consortia to try out new methods of construction, management and communication. They built a series of social housing projects and measured the effects of process and product improvement. Two of the consortia concentrated on developing the product, with four-storey timber construction (Casa Nova) or low energy use (Comfort House), while two others focused on the process (PPU and Habitat). When the development was started, the best communication technologies were the Internet and Lotus Notes, but by the end of the project three of the consortia were trying out project webs. Most consortia involved architects, engineers and contractors, but not the clients, and Habitat involved major subcontractors and set up a company for the work.

Research on the use of IT was carried out by the ITbyg group at DTU and this was presented in the final report of the project [31]. Even in a 7-year period the technology had developed so that a consortium that had set up its IT systems early, had had to revise them twice before the end. Project webs were in their early days, but using them gave valuable experience that was later applied on other projects. DTU's research involved monitoring all communications over a two-week period on a project by each consortium. This was presented using Social Network Analysis as a diagram of messages sent and received. Non-IT communication (telephone, meetings, mail, fax) was generally used more than IT (email, project web), and the consortium that made most use of IT had no project web and sent files attached to emails.

It was not possible to estimate productivity gains for new communications on study of a short period of each project, but further work looked at the benefits of using project web. The productivity benefits of the whole range of innovations were estimated and a validation of these is still being done. The consortia's own estimates for continued use were:

- | | | |
|-----------------|------------------------|--------------------|
| • Casa Nova | Construction time –50% | Building cost –20% |
| • Comfort House | | Building cost –15% |
| • Habitat | Productivity + 15-20% | |
| • PPU | | Building cost –14% |

Actual savings on the first projects were smaller and hard to assign to particular process changes.

8.2 IT barometer surveys

Two surveys of the use and effects of IT use in building were carried out in parallel in Denmark, Sweden and Finland in 1998 and 2001 [32]. These covered a sample of architects, engineers, contractors and property owners and asked about current and future use of IT and the business benefits achieved. In Denmark in 1998 the main areas for increase in productivity from use of IT

were in design and administration – probably reflecting the wide use of CAD, word processing and database systems. In 2001 the same sample were asked in which of 7 areas had productivity increased or decreased by 5 or 15%. Administration and design were again the areas in which most had achieved 15% increase, but project and site management were close behind.

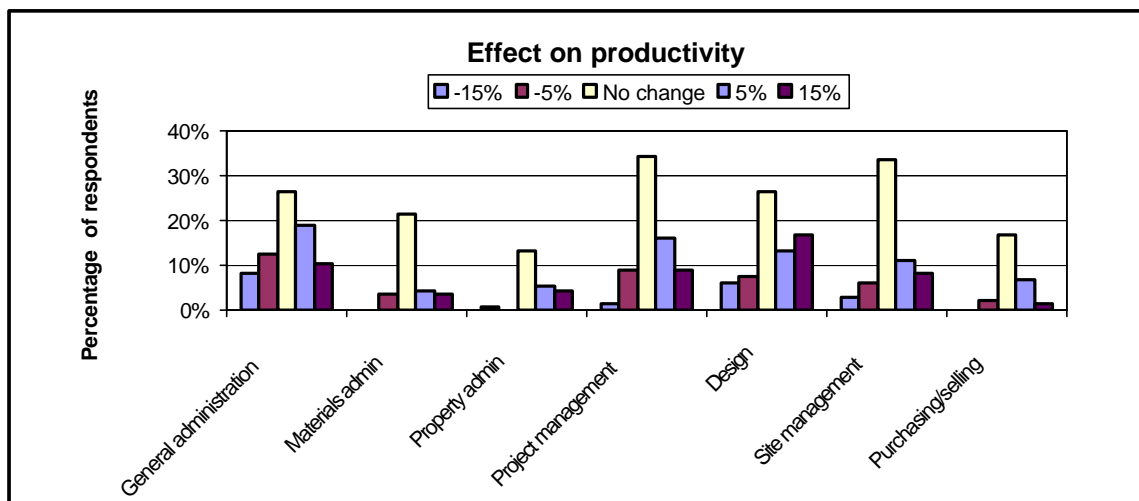


Fig 5. Effects of IT on productivity in the Danish construction industry. 2001 IT barometer.

In Sweden the results obtained from a much larger sample by Olle Samuelson of KTH, were similar but purchasing/selling added more to productivity than project management.

8.3 Interview with Ib Steen Olsen, Ministry for Industry and Housing

In order to relate the productivity gains from the other two countries to the particular needs of Denmark, sources of comparable data for Denmark were sought in addition to the studies in which DTU has taken part. Currently the two most relevant ones are: Projekt Hus, a 10 year study recently started, to use live building projects to test aspects of process change. There are a number of preliminary reports from its task groups but complete results are not expected until 2010. The other is Det Digitale Byggeri [33] (The digital building process) that follows Byggeriets Fremtid [1] (Building futures), which recommended a Centre for building IT, organisation and competence. Det Digitale Byggeri is finally a proposal for a 3-year study following rather larger ones in Sweden and Finland, to develop guidelines for public clients commissioning buildings, and develop standard 'IT bridges' between the different groups in building. Its vision includes use of a common building model, development of digital product data by suppliers, and life-cycle management using digital data. A budget of 50 m DKK is believed to be available but no time for the start of the project has been given.

A report on research in building [39] identifies 0.5 - 1% of their turnover being spent by building owners. Too much of this is on products and not enough on improving the process. The report on new forms of cooperation [19] looked at 7 building projects on which partnering was being used and to what extent 11 criteria for good cooperation had been met. These criteria have also been used to test some experience of partnering in the UK. One of the differences between Denmark and Sweden is that the three largest contractors in Sweden have about 50% of the market while the three largest in Denmark, two of which are owned by Swedish companies, only have about 15% of the market.

8.4 Use of a project web in building projects, Jan Andresen, Knud Christensen, BYG.DTU

This study was carried out with NCC Denmark on four total build projects, three of which used the project web supplied by Byggeweb. Access was provided to the logs of document up- and down-loads so that, for the one project that was completed during the study, it was possible to see who handled which documents. This gives an insight into the roles of the project team and the relative importance of different documents. The results were plotted as a sociogram and different patterns of use are compared between projects in 'Project management with a project web' [34].

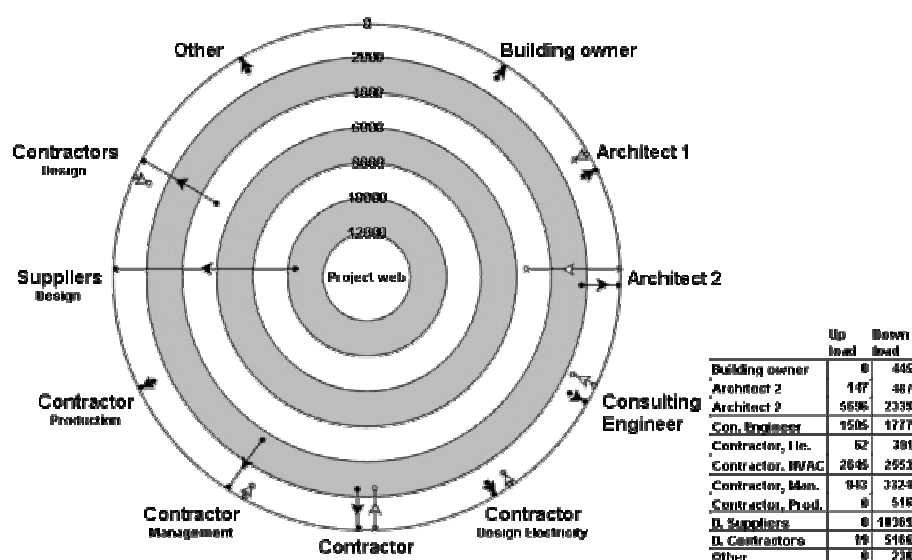


Fig. 5. Summary diagram of the building teams up- and down-loads. NCC Bruuns Project

One objective of the study was to assess the costs and benefits of using project web. The costs were established from the rates charged by Byggeweb and the learning and staff time involved by the project team. Over 5 quarters, this totalled over 1,100,000 DKK. The benefits were studied by using the 'Measuring the Benefits of IT Innovation' method developed at Salford University [35]. This estimated financial benefits at 40,750 DKK, and effectiveness benefits at a rate of 54 out of 100. There were also a number of process benefits. As an experimental project, in which traditional methods of exchanging documents (email and post) were also used, the quantifiable benefits do not yet exceed the costs. Other projects may become more effective, particularly if confidence is built up to allow process change and saving of some traditional costs.

8.5 Byggeriets Fremtid

This report is on the future of building [1] and was produced by a joint task force of the building and industry ministries that, shortly afterwards, became combined. Its concern about the low productivity of Danish building was the starting point for this current work, and it recommended, amongst other things, the establishment of a Building Evaluation Centre [36] and a Centre for IT, Organisation and Competence. The first of these has now been established and discussion of the second continues.

A working group of industry representatives produced a report called 'Det digitale byggeri' [33], the digital building industry. This focussed on two main areas: development of guidelines for public clients and development of standard 'IT bridges' between the different groups in building. Public investment in building, either through central or local government, is still very high and the government could set an example to other clients on methods of procurement and introduction of

innovative methods. The 'IT bridges' are standards and methods for representing building and exchanging data, and a number of existing initiatives could help to deliver these: classification systems, such as those due to be proposed by the Centre contract on building classification at the end of 2002 [37], 3D models possibly based on the Industry Foundation Classes [38], and new forms of e-business which could take advantage of the XML language on the Internet.

8.6 Byggeriet i Vidensamfundet

This is a report proposing a new research strategy for the Danish building industry produced for the Industry and Building Ministry in 2002 [39]. Denmark currently spends less per worker in construction on research than most other countries in Europe, Japan or the US. The report is concerned with wider issues than this study but has some relevant recommendations, particularly for universities that are reducing their capabilities in building management and process change. It identifies a number of important areas: the market, value, the client's role, facility management, building management, education, the building process – IT and logistics, and industrialised components. It recommends a building innovation fund and innovation consortia. It suggests a need for reviewing the financing of building research and for more PhDs, research professors and a research school. On education, it recognises the danger of non research-based courses and suggests developing knowledge production centres with the Building Evaluation Centre [36]. It proposes increasing annual spending from DKK 35 million in 2003-5, to 115 million in 2008-10. It also suggests there is a need to review the building process and to do more research on realising the strategic benefits of IT.

9 EVALUATION OF BENEFITS

9.1 Feasibility of measuring productivity

Had this research been carried over the whole year originally proposed, it would have been possible to interview more end users and collect case study material. This might have allowed some more precise analysis. However, measuring productivity is difficult enough for whole industries and, to do it for individual companies, or particular process changes, requires much more detailed work. In the three months available for this study it was more effective to talk to key people who have an overview of process change and to collect any statistics available as well as analyses done by selected companies. One of the criteria that can be used to assess the success of a process change, from the point of view of the company using it, is whether the companies persevered with it over successive projects. There may be various reasons for this: the need to repeat an experiment to allow human experience to catch up with technological change, the imprecision of measurement techniques, such as benchmarks, to establish success or failure, or the traditional approach of making changes for their own sake and never measuring the effect.

9.2 Accuracy of benchmarking

The best evidence from multiple projects available comes from the Key Performance Indicators applied to demonstration projects by the Movement for Innovation [4] in the UK. These have been monitored for four years on a growing number of building projects involving process changes from the Egan agenda [2]. This agenda is more about getting the UK construction industry to think about changing its processes than about precise measurement. Both the CBPP and M4i people who commented on this admitted that precise measurement is difficult and that the reports produced involve a certain amount of discussion with the companies which are responsible for their own figures. The work that has been done has been effective, particularly in getting the

cluster groups to share their experience. The effect on continuous improvement over the first three years, included in the progress report, Accelerating change [23], and over the first four years, Fig 6, shows improvements in most main areas measured.

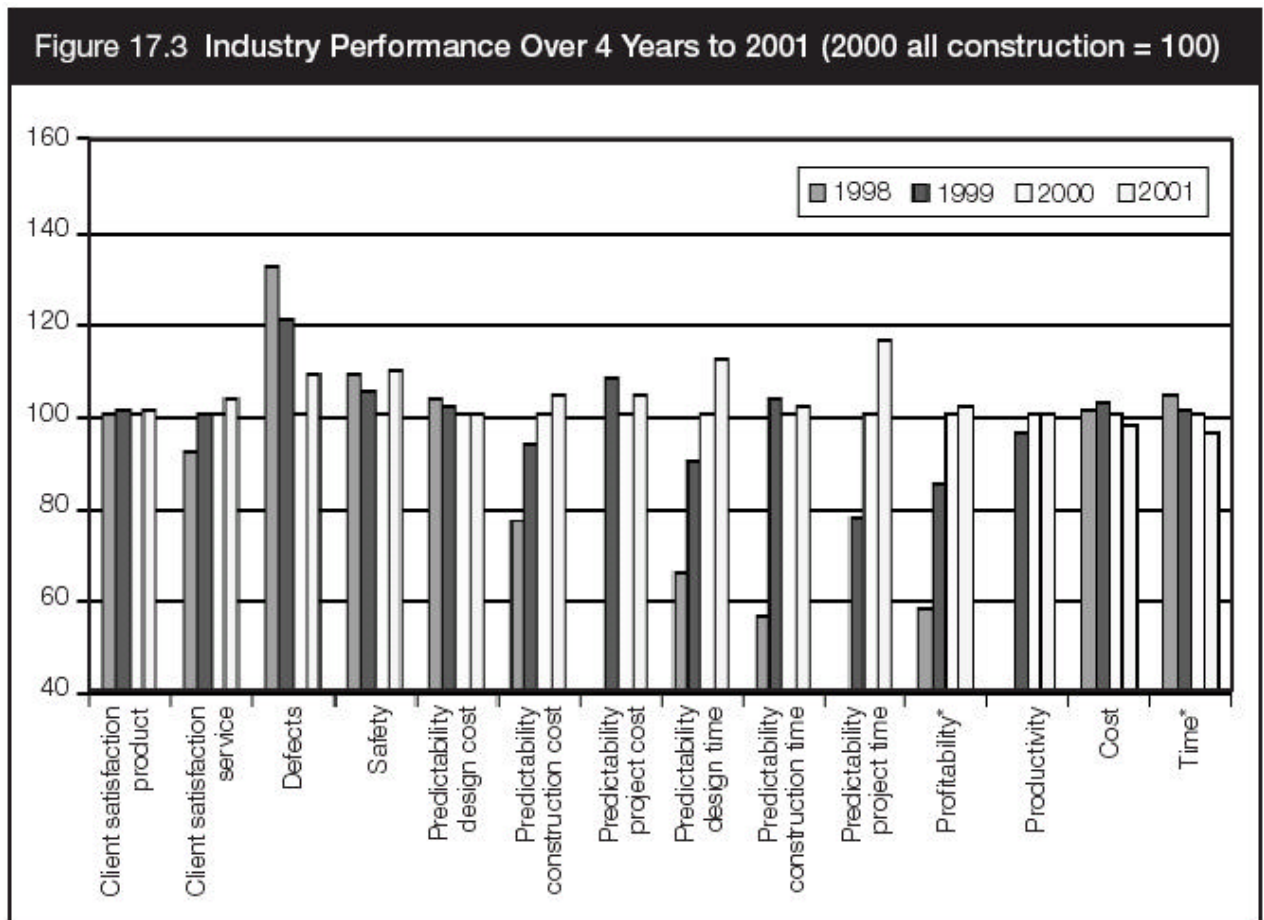


Fig 6 Main benchmarks for the UK construction industry over 4 years. Base is 2000 = 100. DTI

There is only data on productivity for the last three years during which the median added value per employee has risen from £27,000 to £28,000. For the M4i demonstration projects up to 2001, the value was £34,000, an enhancement of 21%. These demonstration projects are rather special ones put forward by their clients or contractors and used to promote their awareness of process change. Many of them are privately financed, or PFI, projects in which the bidding process often involves claims about use of new techniques. However the precision of the measurement process, particularly for time, cost, productivity and profitability is not great owing to the variables involved in the targets for these. However, even a small increase in performance could have a significant effect on an industry worth £60 billion in 2001 at 1995 rates. Danish construction is worth only about one tenth of this but, with higher labour costs, increases in productivity should have a proportionally greater effect.

The Danish Centre for Building Evaluation is planning to introduce benchmarking but its objectives are probably rather different to the Rethinking Construction emphasis in the UK. More precise measurement applied more rigorously to more typical building projects would enable the process changes that are most effective to be identified. At the same time, process change needs to be promoted in Denmark, and the work done in the UK sets an example for effectiveness. Although the results individually are confidential, much more analysis of the database of KPIs by type of process change, or by type of building, could be done when more examples are collected.

9.3 Time needed for assessment

The four years over which the KPI data has been collected are a relatively short time but the main aim is continuous improvement. The Accelerating Change report set specific targets to be met by 2004 to meet political needs. These include the use of integrated teams on projects worth 20% of the total by value by 2004, and 50% by 2007. It also proposes developing toolkits to help companies assemble integrated teams and apply process changes. This is as long as most such initiatives last before new ones replace them. However more fundamental process changes take much greater length of time.

The Swedish adoption of standards for building classification and work descriptions have developed over the last 50 years and are now part of everyone's education and experience. The danger is that they are taken for granted and the necessary resources for maintaining them do not continue. Svensk Byggtjänst has provided a good service over many years and, if the proposal for a new classification system is to be equally effective in Denmark, it needs a commercially viable support operation. Whereas targets can be set and monitored over a short period, and this may work for introducing new technologies, the more fundamental question of supplying well-organised building data is a long-term need without which the technological systems will not deliver results.

9.4 Specific process changes studied

There are many changes being tried in construction in one country or another. The particular focus of this study is on those in which IT plays a significant part, either by providing well-organised data on which new systems can operate, or by reorganising the process and using new tools for improving communications. The benefit of having a well-organised framework for building information, as in Sweden, is that, when new technologies such as the IFCs and XML appear, it is easier to see how these relate to the existing data and could be introduced. This is what the IT Bygg och Fastighet [5] project has shown, and Sweden will be able to make use of these new technologies more quickly as a result.

In the UK the processes studied were partnering, and one of the supporting technologies for this, project extranets. The government initiatives, which set up process change organisations under Rethinking Construction, have been helpful in benchmarking and publicising these. They have not yet had demonstration projects specifically on project extranets, so they have not been able to isolate the productivity contribution of these. This research has therefore had to interview a few users and suppliers of extranets and take a commitment to continuous use as evidence of benefits.

9.5 Other changes taking place

Connected with the changes being studied are some more fundamental ones that encourage the introduction of new technology, but which are driven by political and economic change beyond the scope of this study. These include the Private Finance Initiative, Build Own Operate and Transfer (BOOT) and supply chain management. The growth of e-commerce is addressing the last of these, and the first two provide the stimulus for longer-term thinking and therefore process change in the UK. E-commerce has been through a difficult period since the dot-com bubble burst, and the initiatives which have survived should now grow in a more controlled manner, but will take time to show their full benefits.

In Denmark, where costs of labour and materials are significantly higher than in the other two countries studied, the benefits of technology might seem to be small compared with the potential

for exploiting the difference between labour rates here and in the rest of Europe. However this is outside the scope of this study and, any productivity benefits that are achieved here, will result in a greater saving of resources than in countries, such as those about to join the EU, where labour can cost one tenth that of Denmark.

9.6 The role of building owners

The recent report, *Det Digitale Byggeri* [33], stressed that public projects should be used to demonstrate process change. Denmark has a high proportion of publicly funded work but much of this is through local government, the Kommunes, and they, at the time of the PPB housing consortia, showed reluctance to get involved in partnering or project webs, or to accept standard forms of FM data. The Byggherreforeningen could extend this experience to large private clients, but there are fewer of these than in the UK. There several organisations representing clients have existed for some time but they appear to be reluctant to get too close to companies in construction and have maintained a separate existence within the Rethinking Construction initiative. In Sweden, the original introduction and wide take up of the BSAB in the 1970s was due to its adoption by the organisation managing all public property. Commitment by a lead client of this type is needed to encourage adoption of such standards, and Denmark still has a large public involvement of this type. In the UK most of the applications of project extranets were initiated by client organisations according to BIW Technologies, one of the main suppliers of these. Awareness of the benefits of process change, which now exists among large clients in the UK, is needed by clients in Denmark.

9.7 Measurement of project webs/extranets

In Denmark project webs, as they are known, are supplied to the construction industry by one main company, Byggeweb. In the UK and Sweden there are several suppliers and, although competition is good, confusion can arise when using different protocols on different projects. There are also project webs set up by individual companies, but the experience of Balfour Beatty, who originally set up an e-business portal with four other contractors, is that such a service needs independence. They use BuildOnline that operates across Europe and has substantial resources. They expect the number of such suppliers to reduce to 2 or 3 in the UK construction industry. Measurement of usage and benefits of project web was started in the PPB housing consortia but, at that stage, usage was experimental. DTU carried out research for NCC in 2002 and had access to the logs maintained by Byggeweb [7]. These provide much data about uploads and downloads on different types of document and can be used to see which documents are most used, typically CAD drawings, and who is most active. In this case the total build contractor paid all the costs, but continued to operate the traditional system, printing and sending all the drawings by post. This may have been to meet legal requirements or just as part of the process of change. In the event it was difficult to show financial benefits, although there should be qualitative benefits when the projects are completed in terms of faster work and fewer errors.

In the UK, BAA has the greatest experience of project extranets, as they are called there, and estimates that their use of Asite and partnering gives about 3% saving on its costs. They also use BIW Technologies and, at Sept 2002, had put about £350 million of work through these suppliers. They are committed to process change, having been led by Sir John Egan, and their continued use of partnering and extranets is good evidence for the benefits they obtain. The best evidence was provided by Balfour Beatty who found savings of about £24,000 on a £20 million cable laying contract, in spite of the drawings also being distributed on paper. This was used to estimate future savings on 24 projects and, by Sept 2002, they had 33 contracts running on Project Online. BIW

Technologies maintain that there are no legal problems using electronic documents correctly and so there should be additional savings when all partners learn to rely less on paper documents.

9.8 Levels of cooperation

To try to obtain some comparison of levels of cooperation by users of partnering some companies were asked to comment on the list used in the New forms of cooperation project in Denmark [19].

L = low M = medium H = high	Danish study		UK examples	
	Traditional	Cases	M4i	BAA
Joint objectives	no	H	H	Agree objectives and identify skills needed
Know objectives	no	M	H	Teams picked on past performance
Use of incentives	no	M	H	No profit sharing but they pay bonuses
Use benchmarks	no	L	L	Key Performance Indicators
Open accounts	no	H	H	Accounts open to all parties
Use of workshops	no	M	-	Yes, but mainly for social purposes
Problem dialogue	no	H	H	Traditional methods, but more dialogue
Contractor design	no	H	H	Yes, from the beginning
Supplier design	no	L	-	Suppliers nominated, subcon appointed early
Multi-skilling	no	L	-	Yes, they use this a lot
Same staff	no	M	-	Yes, they attract good people

This limited comparison on different types of building does not have great significance, but indicates that the main differences are the greater use of benchmarking by BAA, and the greater use of dialogue to solve problems in Denmark. There is also more design by suppliers and sub-contractors, and more multi-skilling in the UK where there is more flexibility in the use of labour.

9.9 Future developments

The technologies underpinning the process changes being studied are evolving all the time, and experience of their use is spreading. New developments mentioned by those interviewed include the change in project webs from shared filing systems to project servers containing more advanced descriptions of buildings, standards and classification frameworks. A report from DTU 'Vejledning i evaluering af projektweb' [40], listed the possibilities for enhancing the basic system in order to evaluate different services in 2001. A Swedish / Finnish cooperation in this area, Enterprixe [41], was referred to by the Swedish partner, Tyrens. The possibilities for introducing better forms of representation and data coordination are provided by a shared resource, such as project web. The lead consultant or contractor, or the client, who pays for the service, can use such a facility to impose standards on the whole project team.

The suppliers of project web services have an opportunity, which some are taking, to add value and provide a structure for the data they manage. Too many new developments in construction technology are slow to be adopted. These include 3D models, metadata standards and classification systems. If these are built in to a project web then project partners are obliged to use them. A problem arises if each project adopts a different set of models and standards but, if in Denmark, there remain one, or a few, suppliers of project web services, these could encourage use of common standards. Another problem is in getting smaller companies to take up the innovations tried by the larger ones. Project webs involve growing networks of partners and should eventually be used on smaller and smaller projects and involve smaller companies.

New technologies that have remained unused for many years often achieve success when linked to other, more widely used, technologies. The short message system on mobile phones did not become successful until young people started to use mobiles on limited budgets. Perhaps the project web, or project server as it may become, will be the catalyst for some real process change.

10. RECOMMENDATIONS FOR DENMARK

The sources studied and organisations interviewed have been limited in number but they have generally been leading users and suppliers of innovative systems, and those who have collected data in the different countries studied. The objective was to see which of the particular process changes studied had been found beneficial and whether these would be appropriate for the Danish construction industry. There are several similar initiatives in Denmark and other groups, such as the Centre for Building Evaluation and the Ministry for Industry and Housing, are also studying experience from other countries.

As well as using the latest opinions collected from these sources, the recommendations result from only the five years that the author has working in Denmark and benefits from discussions with colleagues in DTU and Danish companies. He also has also 40 years' experience of the UK construction industry and 30 years' working with IT. The quality and organisation of the Danish construction industry seems high and the use of new technology is very advanced, but the smaller size of the Danish industry and its clients and contractors, limits the opportunity for experimenting with process change. Productivity has not improved since 1970 and labour costs are high, but the potential gains from process change, coupled with new technologies, are even higher and the greater experience of productivity improvement elsewhere should be applied selectively in ways that will maximise benefits.

10.1 Productivity measurement

Productivity measurement of specific process changes is difficult and, apart from the results of the KPI benchmarking in the UK and some individual case studies, there is little hard evidence at present. On the other hand, the fact that, in all three countries studied, companies are repeating their use of Project extranets, for example, is evidence in itself that they believe benefits are achievable. There are techniques for measuring these, as Jan Andresen's research at DTU shows [42] and, if companies want to quantify expected benefits, the most suitable of the many available methods should be chosen.

10.2 Benchmarking

Benchmarking has now been in use in the UK for 5 years via the Key Performance Indicators, and the recent exercise in comparing results on demonstration building projects with those for the

whole industry, present the desired picture. Allowance should be made for the demonstration projects being rather selective and the companies supplying the data being concerned to promote their innovations. However repetitive use of the many KPIs now available makes users think about process change and helps them to achieve improvements over a series of projects. One of the most effective services of M4i seems to be their focus groups where participants actively share experience and learn from each other.

If a similar use of benchmarking is to be set up by the Benchmark Centre for the Danish Construction Sector, it should certainly aim for greater accuracy in order to try to get absolute measures of performance improvement. This would allow the most beneficial process changes to be given priority. Accuracy may be difficult to obtain but evidence from a variety of types and sizes of building projects, collected under more controlled conditions with participating companies obliged to publish results, even if they are not good, should enable a database to be established and sorted to show where the best improvements were found by type of innovation and size of project.

10.3 Assessment time

Collecting sufficient amounts of benchmarking data takes time but, over the 10-year duration of a development project like Projekt Hus, this should be possible. Time is also needed for establishment of standard structures for building data such as those used almost universally in Sweden. The advantage of most people in the construction industry having some familiarity with BSAB and the AMA is that they form part of a common framework for communication at a time when networking enables data exchange between all parties on a building project. Such a framework may be felt to limit creativity, but a good classification system, such as that starting to come out of the Danish Centre Contract on Building Classification [37], should be open ended and allow for the most unconventional of buildings.

Another advantage of having established sets of data and structures for information, is that it is easier to relate these to new forms of structure that are coming out of international developments in building modelling and communication protocols. The Swedish IT Bygg och Fastighet work has included studies relating Swedish methods to IFCs, XML and the ISO 12006-2 standard for building information.

10.4 Project extranets

Partnering is another process change studied in all three countries. Of these the UK experience seems to be greatest, while Denmark has the advantage of having one main supplier of project webs, the technology that supports partnering. In the UK and Sweden, the variety of extranet suppliers can cause confusion when different protocols are used on different projects. The potential for adding structure and software to the services offered by extranet suppliers, making them into project servers, is enormous.

As with many other previous technological advances there are some that are easy to introduce, automating existing tasks such as drafting, for example, and others that are much harder and for which the financial returns take much longer, such as 3D modelling. Project extranets appear to have been widely accepted and could be the vehicle for offering standard sets of data and increasingly sophisticated forms of representation – from 2D and alphanumeric documents to 3D models with integrated objects. Such project servers could help to bring about the major process changes that have been technically possible for some time, and to transfer them from the larger firms down to smaller project partners, eventually penetrating most of the Danish construction industry.

10.5 Integration and lifecycle data

In addition to those studied, there are also some more fundamental process changes that stimulate the use of new technology. Almost all the uses of project extranets in the UK are requested by the client in privately financed projects or by the lead contractor. The architects and the engineers may be the most active users of them since the documents exchanged are mostly drawings, but the commitment of the whole project team needs to be ensured by the project leaders. These same leaders could, in future, insist upon exchange of building objects with attribute and performance data, so that better forms of representation would lead to more integration.

The longer-term involvement of project teams with their buildings results from the Private Finance Initiative and Build Own and Operate strategies in the UK. This gives greater significance to lifecycle and facility management data. Over a building's lifetime, the cost of the original design and construction process is a minor part of the whole, and the needs of long-term maintenance and management should take precedence in defining the model that is handed over. For this data to be useful over at least the 25 years of most BOO contracts, it should conform to standards such as: classification systems, product and process models, IT exchange protocols and many others.

10.6 Building owners and partnering

The role of the building owner has increased in importance in the degree of involvement in the building process, and this is reflected in the UK and Sweden more than in Denmark. The IT Bygg och Fastighet projects in Sweden had a large proportion of their funding from property owners and managers. The process changes referred to in the previous section are driven by some of the major client organisations. In Denmark the Bygherreforeningen has yet to get fully involved in process change and the standards needed to ensure that owners and users get the data they need in the form they need it. There is little evidence from the research on project web use in Denmark that the building owners looked at many of the documents, and few project webs are set up early enough for the owner to input the brief to the extranet. In future, if building owners become more active users of project webs, they will be able to select and define the form of data they need when they take over a building, as well as monitoring the progress of design and construction.

Partnering is critical to introducing process change over a longer period than one contract. BAA in the UK has completed one 5-year period of its Framework Agreements and has now moved to 10-year periods with annual reviews. Balfour Beatty's successful introduction of project extranets is mainly on repetitive maintenance contracts for railways and electrical installations. There is still some reservation about the legal status of electronic documents and some exchange will still have to take place on paper, but users of extranets must learn to print fewer of the less significant documents. The eLegal project will define additional agreements needed to cover liabilities from electronic transfer but, generally, extranets provide a much more accessible history of document exchange provide their suppliers are still in existence or the data has been archived correctly. Denmark has an advantage in having one main supplier of project webs in construction at present, and the number of such suppliers in the other countries is likely to reduce. Although a little more competition in Denmark might be an advantage, for common standards to apply to all suppliers would help users and, since the merger of Byggeweb in Denmark with Byggnet in Sweden, maybe these standards are becoming more international.

10.7 Different levels of cooperation

Comparative measures of collaboration in building projects are not very precise but the 11 criteria used in the New Forms of Cooperation project in Denmark [19] were tried in the UK on the M4i and on BAA, a leading client. The main differences are the greater use of benchmarking in the UK, which the Evaluation Centre already plans to build on, and the greater use of dialogue to solve problems in Denmark. This is an important characteristic of Danish construction, its comparative openness and willingness to share experience. This is vital for the relationships built on trust that are needed for true partnering and sharing of data. Perhaps one limitation in Denmark is the cost and apparent inflexibility of labour. The advantages of a highly skilled workforce are offset by the reluctance to use multi-skilling and to involve suppliers more in the design process. One case study for M4i in the UK suggested that true partnering should not require any contracts between the project team at all, something any construction industry might find hard.

The comparison of the KPIs between the M4i demonstration projects and the UK construction industry at large from Accelerating Change [23] look good, but the demonstration projects are rather special ones and the objective of Rethinking Construction is to promote process change. After a period of using benchmarks in Denmark, provided they are more rigorously applied, it should become apparent which process changes are producing the greatest benefit, and for more effort to be put into these. Some are likely not to show any benefit and this would give a more realistic picture.

10.8 Final comparisons

It may seem arrogant for someone with only a few years' experience of the Danish construction Industry to suggest where future effort in construction research and development should be directed, but sometimes an outsider can have a clearer view.

The major changes in building at present are in the design, construction and management process. The product, as designed by the excellence and imagination of Danish architects and engineers, is often innovative and there continues to be development of new materials and techniques. However the greatest need in research and education is to manage the changes that are happening in procurement and representation of building data, and take advantage of integration and information exchange enabled by IT. This is not only important for the productivity of the Danish construction industry, which could be threatened by cheaper services and labour from an ever more open European market. It is also important for reducing building costs by greater efficiency in using the high quality resources available. A high cost industry has more to gain from process change.

The most useful experience from Sweden is the wide awareness and use of well-organised data although it is impossible to measure the productivity from this except by looking at the 80% increase in general productivity over the last 30 years, some of which must be due to good data. What is apparent is that introducing new technologies and methods of organising building data is much easier when there is a well-defined system in existence. The IT Bygg och Fastighet projects have shown how this can be done.

From the UK comes what comparative measures of the effects of process change are available. They may not be very precise but there is a growing awareness of the need to change and some good evidence for the effectiveness of project extranets where clients drive the use of partnering and other process changes.

Denmark can certainly build on the experience from the UK Rethinking Construction initiative and perhaps develop more precise benchmarking to convince companies of the need to change. Better-organised data cannot be created quickly, and Denmark already has some good sets of building data, but the results of the Building Classification Centre Contract [37] are just beginning to emerge and, if they are fully developed and promoted, they will still take many years to spread. Project webs, which are starting to be used quite widely, could offer a means of speeding up this process, by incorporating the drawing structures developed by the CAD user group, ibb, or offering more ambitious product models. The Digital Building project will provide an opportunity to try out object modelling technology now demonstrated effectively in the VERA programme in Finland [43]. The Projekt Hus networks and successive test projects should provide a sufficiently lengthy development period for applying benchmarking and collecting the sort of data presented in Accelerating Change [23] in the UK.

The opportunity to benefit from process change is here, and some evidence of its effectiveness is presented in this report, even if it is largely based on companies repeating their use of innovative systems. What productivity data there is, is largely anecdotal and cannot be applied to whole industries or even to particular types of process change. However all companies should consider what is being achieved in leading projects in different countries and consider how applicable the experience is to them or the project teams in which they work. The construction industry is becoming more international and very competitive, and only the process changes that are shown to be effective should be implemented.

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