Måle effekter av digitalisering i den norske byggenæringen

Professor Ragnhild Kvålshaugen, Senter for byggenæringen

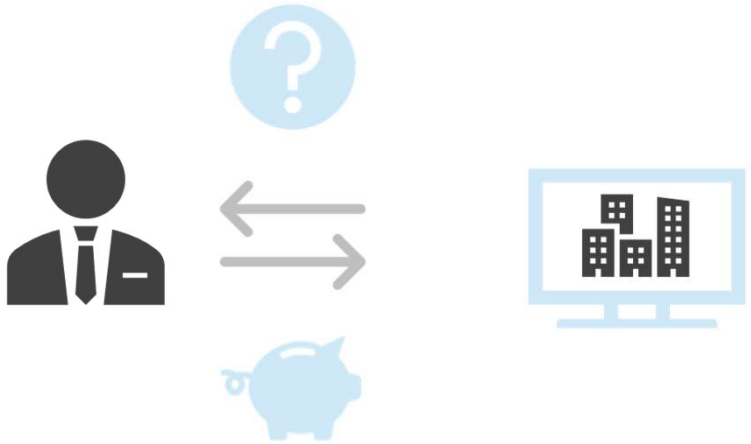
Motivasjon for studien

Mer enn 150 mill. investert i bare VDC opplæring i den norske byggenæringen

Digitalisering – løsning på utfordringer knyttet til forsinkelser, overskridelse av budsjett og kvalitetsutfordringer

Imidlertid har vi foreløpig bare anekdotiske bevis knyttet til forretningsverdi av digitalisering

Digtalt veikart (2017:6): «realisere gevinster ved å spre beste praksis om digitale arbeidsprosesser og forretningsmodeller, og måle effekten av dette.»



Forprosjektet: Litteraturstudie, utarbeide mulig forskningsdesign og oppsett for et hovedprosjekt

Samarbeid NTNU, IV og BI, Senter for byggenæringen

- Prosjektteam
  - Prosjektledelse Ragnhild Kvålshaugen (BI), Eilif Hjelseth (NTNU), Alexander Langlo (NTNU), Martin Fischer (Stanford)
  - Prosjektmedarbeider: Sergejs Groskovs (BI), Sujesh Sujan (NTNU), Petrine Djupvik-Flaa PhD student (BI), to forskningsassistenter (BI)

- Finansiering
  - Prosjekt Norge (startup finansiering – tildelt) – kr 150 000
  - Hovedprosjekt - konsortium – tilgang til data + kontantstøtte/timer
    - Vurderer å søke støtte som *Samarbeidsprosjekt for å møte utfordringer i samfunn og næringsliv* i Norges Forskningsråd – søknadsfrist 17. februar. Minimum 10% av prosjektets kostnader fra samarbeidspartnere fra næringsliv og offentlig forvaltning. Minimum 2 aktører.

Hva har vi gjort?

- Litteraturstudie
- Workshop med relevante aktører
- Presentert og diskutert med BNL og EBA
- Presentert og diskutert opplegg med Fokusgruppe A i CCC
- Diskutert med personer involvert i Digitalt veikart 2.0
- Vurderer koblinger mot Smart Construction klyngen
- Diskutert og presentert for ca 10 ulike aktører i BAE – byggherrer, entreprenører og rådgivende ingeniører
- Utarbeidet opplegg til forskningsdesign

Både praktisk og forskningsmessig verdi

- The **effects of digitalization on business performance** have occupied scholars in strategy, information systems, and other literature streams since the dawn of the computer age
  - The results of empirical studies are mixed and vary from one context to another, sometimes demonstrating positive outcomes, but other times showing negative or non-existent correlations between IT investments and business value (Sabherwal and Jeyaraj, 2015)
  - This has been attributed to underexplained causality mechanisms (Schryen, 2013), but also to a diverse measurement of variables and data quality issues (Cardona, Kretschmer, and Strobel, 2013; Lim et al., 2011)

- Construction industry typically ranks at the **bottom of productivity and digital maturity** surveys (Friedrich et al., 2011; Gandhi, Khanna, and Ramaswamy, 2016; Kane et al., 2018)
  - Construction productivity in many countries' official statistics has consistently shown negative tendencies; however, their measurement approaches have been criticized (Andersen and Langlo, 2016)
  - The low productivity reported in statistics may be driven by the redistribution of business processes away from construction and toward manufacturing and service industries due to the transition to offsite prefabrication (Ahmad et al., 2020)

- The **business value of digitalization in construction is ripe for more research** (Merschbrock and Munkvold, 2012), despite the existence of hundreds of publications on BIM (much less on VDC)
  - There is a strong belief that digitalization is central to the transformation of the industry and will eventually improve performance and productivity (Renz and Solas, 2016)

Hvordan måle?

Research design 1
Experiment

- Select two identical projects
- Introduce VDC/BIM in one of these projects, keep all other variables fixed
- Observe and record difference in performance outcomes

- Challenges – Step 1 and Step 2
- Finding identical construction projects
- Keeping fixed many project variables not related to VDC/BIM

IMPOSSIBLE

Research design 2
Econometric analysis

- Select a large sample of projects
- Some use VDC/BIM and some do not for natural reasons, performance varies
- Perform statistical analyses and isolate the effects of VDC/BIM

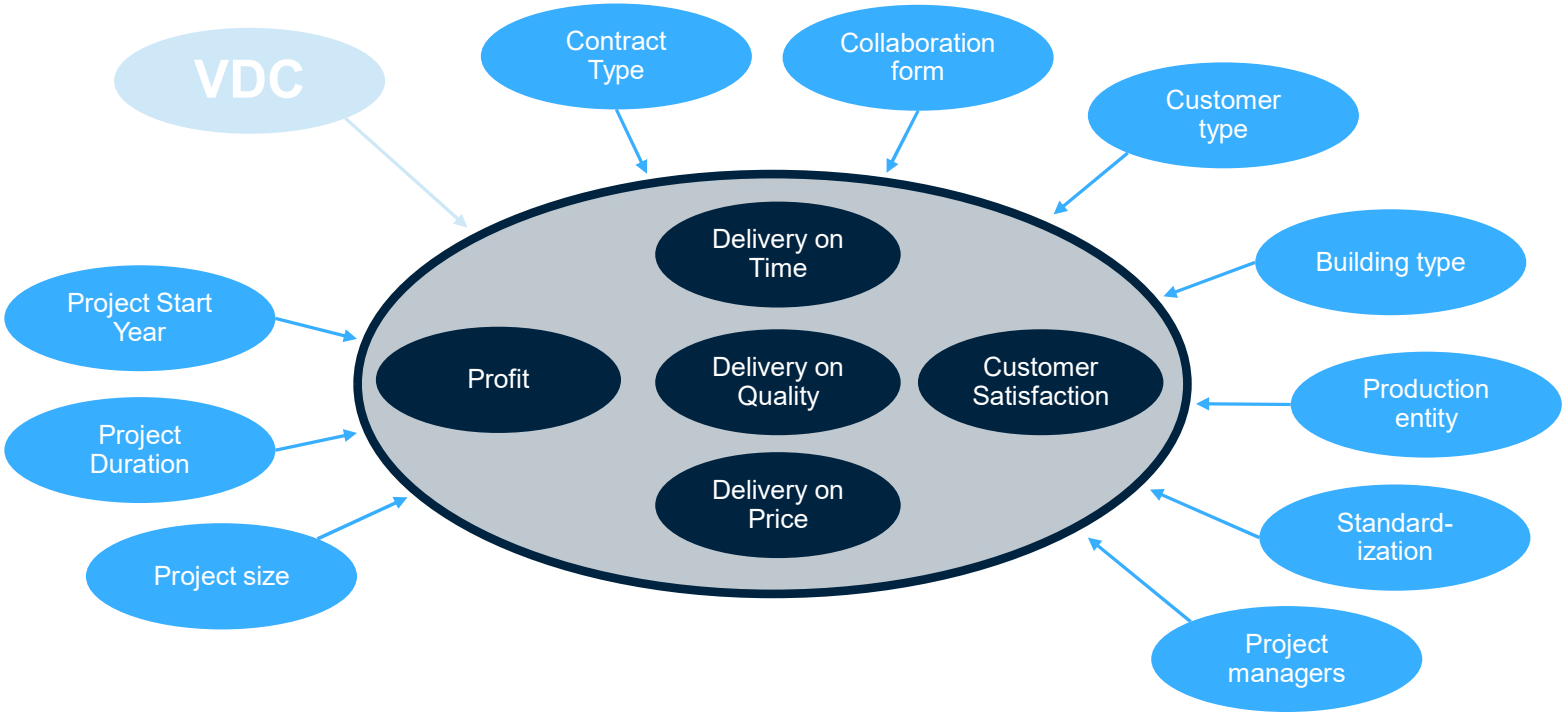
- Challenges – Step 1 and Step 3
- Availability and quality of data
- Statistical modeling on hundreds of projects and dozens of variables

SOLVABLE

BI

AACSB ACCREDITED EFMD EQUIS ACCREDITED ASSOCIATION AMBA ACCREDITED

Et eksempel: Studie hos en entreprenør i Danmark



STUDY IN DENMARK

Measures and data sources

		Variable (Data)	Measure	Data source
Dependent variables	1	**Profit** (CM %)	Project's final contribution margin (consolidated from the main project and sub-projects)	Finance dept
	2	**Delivered on Time** (Yes=1/No=0)	Project delivered on agreed time or earlier (yes/no)	Project Base
	3	**Delivered on Quality** (Yes=1/No=0)	Project delivered without errors (yes: error correction date not registered)	Project Base
	4	**Delivered on Price** (Yes=1/No=0)	Project delivered to the agreed contract price or below (yes/no)	Project Base
	5	**Customer Satisfaction** (1-5)	Customer satisfaction score (average of satisfaction with time, quality, price, project, NCC, error correction time)	Customer surveys
Independent variables / controls	6	**VDC** (Yes=1/No=0)	VDC used in any phase of the project (yes: at least one VDC package used)	VDC dept
	7	**VDC Extent** (%)	Extent of VDC use in the project (% of VDC packages out of the total available)	VDC dept
	8	**VDC>50%** (Yes=1/No=0)	VDC used to a high degree (yes: 50% or more of VDC packages used)	VDC dept
	9	**Project Start Year**	Year when the project was started	Project Base
	10	**Project Duration** (# Days)	Project end date minus project start date (number of days)	Project Base
	11	**Contract type** (1-4)	Contract type belongs to one of the four categories (i.e., "totalentreprise", "hovedentreprise", "storentreprise", "fagentreprise")	Project Base
	12	**Collaboration form** (Partnering=1/Other=0)	Project uses partnering as a collaboration form (yes/no)	Project Base
	13	**Customer type** (NCC=1/Other=0)	Customer is an NCC company (yes/no)	Project Base
	14	**Customer type** (Public=1/Other=0)	Customer is a public entity (yes/no)	Project Base
	15	**Customer type** (PrivateExclNCC=1/Other=0)	Customer is a private entity but not an NCC company (yes/no)	Project Base
	16	**Building type** (1-6)	Building type belongs to one of the six major categories (e.g., commercial, housing, hospitals)	Project Base
	17	**NCC Production Entity** (East=1/West=0)	NCC's responsible production entity is located in the east of Denmark (yes/no)	Project Base
	18	**Standardization** (Concept=1/None=0)	Project is a modular/standardized building type (yes/no)	Project Base
	19	**Project Managers** (# PMs)	Number of project managers registered in the project	Project Base
	20	**Project Size** (Contract Price)	Project size: contract or target price (mDKK)	Project Base
	21	**Project Size** (Final Sales Price)	Project size: customer's final paid price (mDKK)	Project Base
	22	**Project Size** (# Internal Roles)	Project size: number of NCC's internal roles involved (project manager, design manager, estimator, etc.)	Project Base
	23	**Project Size** (# External Firms)	Project size: number of external firms involved	Project Base

Resultater fra studien i Danmark

Results (1/5)

VDC → Delivery on Time

Key takeaways:

- Probability of delivery on time appears higher in VDC projects
- Large part of variation remains unexplained, despite the significant factors accounted for in the model
- Explaining the remaining variation requires additional variables and data
  - *Examples: Production team? Subcontractors? …?*

Note: Logistic regression model

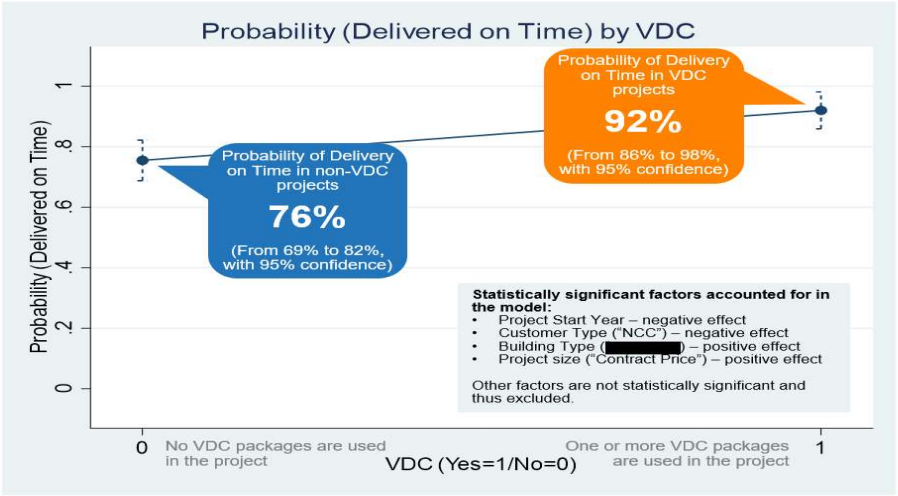
We are comparing two "average" projects, one of which uses VDC and the other does not. Projects are average in terms of the factors included in the model (see the list on the graph). The graph displays average probabilities of success in these two average projects, controlling for the effects of other statistically significant factors.

Sample size:

- 186 projects (30 VDC projects and 156 non-VDC projects)

Model evaluation:

- Significance of the complete model: **VERY HIGH** (F-test p = .000)
- Statistical significance of VDC: **HIGH** (T-test p = .009)
- Goodness of fit: **LOW** (Pseudo R-squared = .20)



Resultater fra studien i Danmark

Results (2/5)

VDC → Delivery on Quality

Key takeaways:

- Probability of delivery on quality appears higher in VDC projects
- Large part of variation remains unexplained, despite the significant factors accounted for in the model
- Explaining the remaining variation requires additional variables and data
  - *Examples: Design team? Production team? Subcontractors? …?*

Note: Logistic regression model

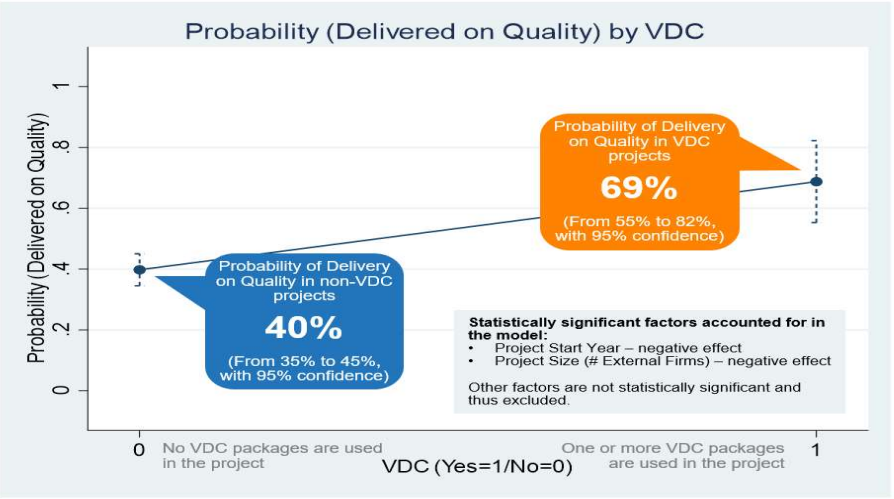
We are comparing two "average" projects, one of which uses VDC and the other does not. Projects are average in terms of the factors included in the model (see the list on the graph). The graph displays average probabilities of success in these two average projects, controlling for the effects of other statistically significant factors.

Sample size:

- 183 projects (28 VDC projects and 155 non-VDC projects)

Model evaluation:

- Significance of the complete model: **VERY HIGH** (F-test p = .000)
- Statistical significance of VDC: **HIGH** (T-test p = .005)
- Goodness of fit: **LOW** (Pseudo R-squared = .34)



Resultater fra studien i Danmark

Results (3/5)

VDC → Customer Satisfaction

Key takeaways:

- Customer satisfaction appears higher in projects that use VDC to a high degree (>50% of VDC packages)
- Very large part of variation remains unexplained, despite the significant factors accounted for in the model
- Explaining the remaining variation requires additional variables and data, as well as a larger sample of projects
  - *Examples: Relationship management approach? Personality? …?*

Note: Linear regression model

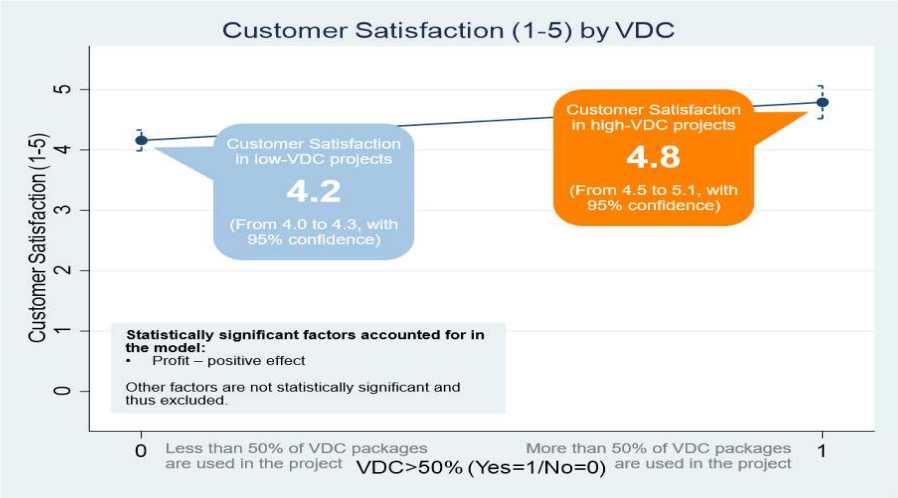
We are comparing two "average" projects, one of which uses VDC to a high degree and the other uses less or none at all. Projects are average in terms of the factors included in the model (see the list on the graph). The graph displays average customer satisfaction scores in these two average projects, controlling for the effects of other statistically significant factors.

Sample size:

- 79 projects (11 high-VDC projects and 68 low-VDC projects)

Model evaluation:

- Significance of the complete model: **VERY HIGH** (F-test p = .000)
- Statistical significance of VDC: **VERY HIGH** (T-test p = .000)
- Goodness of fit: **LOW** (R-squared = .23)



Resultater fra studien i Danmark

Results (4/5)

VDC → Profitability

Key takeaways:

- Profitability appears lower and more dispersed in VDC projects
- Large part of variation remains unexplained, despite the significant factors accounted for in the model
- Explaining the remaining variation in profit requires additional variables and data
  - *Examples: Project manager characteristics? Risk pools? …?*

Note: Linear regression model

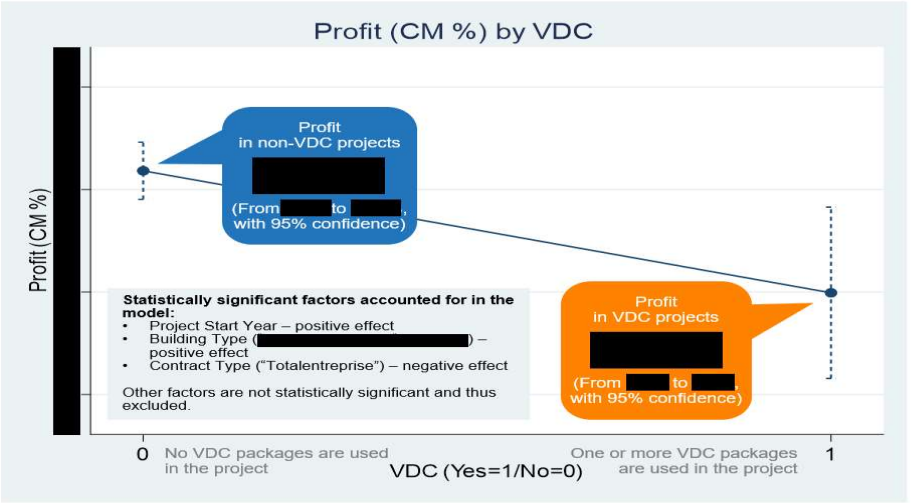
We are comparing two "average" projects, one of which uses VDC and the other does not. Projects are average in terms of the factors included in the model (see the list on the graph). The graph displays average profits in these two average projects, controlling for the effects of other statistically significant factors.

Sample size:

- 211 projects (30 VDC projects and 181 non-VDC projects)

Model evaluation:

- Significance of the complete model: **VERY HIGH** (F-test p = .000)
- Statistical significance of VDC: **HIGH** (T-test p = .008)
- Goodness of fit: **LOW** (R-squared = .26)



Resultater fra studien i Danmark

Results (5/5)

VDC → Delivery on Price

Key takeaways:

- Probability of delivery on price appears lower in VDC projects
- Smaller part of variation remains unexplained, despite the significant factors accounted for in the model
- Explaining the remaining variation requires additional variables and data
  - *Examples: Project scope? …?*

Note: Logistic regression model

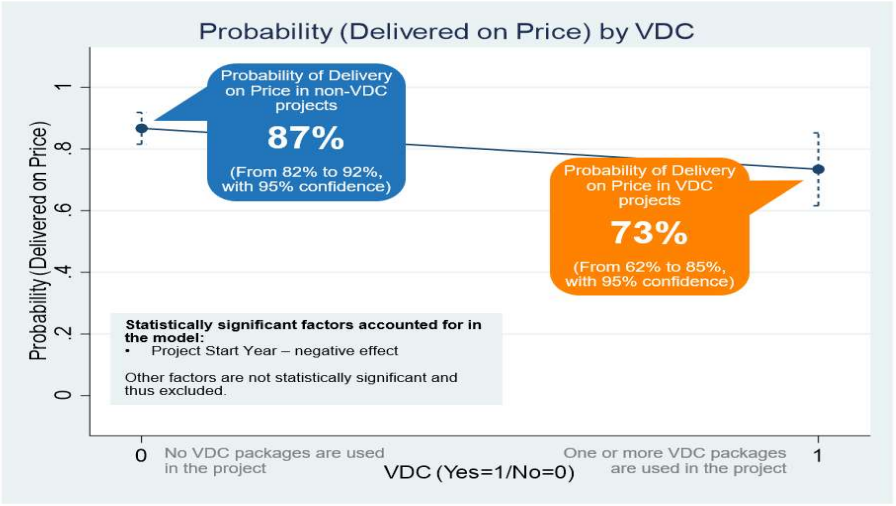
We are comparing two "average" projects, one of which uses VDC and the other does not. Projects are average in terms of the factors included in the model (see the list on the graph). The graph displays average probabilities of success in these two average projects, controlling for the effects of other statistically significant factors.

Sample size:

- 254 projects (30 VDC projects and 254 non-VDC projects)

Model evaluation:

- Significance of the complete model: **VERY HIGH** (F-test p = .000)
- Statistical significance of VDC: **ACCEPTABLE** (T-test p = .032)
- Goodness of fit: **HIGH** (Pseudo R-squared = .59)



Hva får deltakerne tilbake?

- Analyse av egen prosjektportefølje for å forstå effektene av digitalisering og opplæring i VDC og Lean

- Beslutningsgrunnlag for å gjøre målrettede investeringer i digitalisering og tilhørende opplæring
  - Investeringer – hvilke teknologier gir positive gevinster
  - Porteføljestyring av prosjekter – hvilke prosjekter er lønnsomme og mindre lønnsomme
  - Prosjektledelse – bemanning og underleverandører

- Invitasjoner til deltakelse på workshops og presentasjoner av trendene som er observert i bransjen basert på funn i studien

BI

AACSB ACCREDITED

EFMD EQUIS ACCREDITED

ASSOCIATION OF MBAS ACCREDITED