INNOVATION POLICY IN THE CONSTRUCTION INDUSTRY

The Netherlands compared with several European countries

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“[…] engineers without political knowledge are like machine parts without lubrication”

— Singh, 2012

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Preface

Innovation in the Construction Industry leads to progress, on product as well as process level. Unfortunately, investment in knowledge has not been the industry's first priority in the past years. All over the world, studies have been done on how to improve this issue. In this regard, lots of studies were aimed at specific countries or specific solutions. However, a qualitative as well as quantitative comparative study may reveal new solutions and methods for improving innovation in the construction industry and could improve the innovation policy in the Dutch construction industry. This study shows ways how the Dutch construction policy makers can address this issue based on practices in other innovation-leading European countries.

Apart from the scientific added value, this topic has stimulated self-development as a broadly oriented engineer. In this way I have enabled myself to not only see things from a technical perspective, but also to place contemporary political developments into perspective. The set of skills has been stretched, touching the field of policy making. Moreover, the nature of the research, including methodology and discussion part, has been completely different from regular engineering problems, which has been offering me useful additions to problem-solving approaches.

The research has been conducted within the University of Twente in Enschede under supervision of Joop Halman and Hans Voordijk. The thesis has been the final stage of the master's program of Construction Management & Engineering at the same university and was executed within a period of a little more than half a year. I wish that this research leads to a useful and satisfying recommendations in which not only I have pleasantly concluded my master, but also the research base in innovation policy making has been thickened a bit.

I wish you a pleasant reading.

Tom Coenen

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Management summary (EN)

Innovation and the construction industry have always had an uncomfortable relationship and the percentage of money spent on research and development (R&D) is considerably lower than in most other industries. In the past few years, more and more has been discussed about increasing innovation activities in this industry. Also the call for increasing sustainability and decreasing environmental impact has contributed to this tendency. Although the Netherlands is considered as an innovative leader, the Dutch construction industry is rather fragmented and less-innovative.

Research purpose and methodology

In order to increase innovativeness of the Dutch construction industry, several other European countries, all considered innovative leaders, are studied to draw lessons from the innovation policies in those countries. Innovation policies are considered as public intervention to support the generation and diffusion of new products, processes or services, in which this study is confined to state-initiated policy measures. Innovation strategies, policies and construction policies in the United Kingdom, Denmark, Sweden and Germany are studied and compared in order to develop recommendations on improving the Dutch construction industry.

The Sectoral Innovation System (SIS) approach was used, which considers a sector, in this case the construction industry, as a dynamic system consisting of several different entities which are all dependent on each other. The sectoral patterns are influenced by four blocks, being (1) agents, interactions and networks, (2) institutional framing, (3) technology regime and (4) market demand. The role of institutional framing, consisting of context, strategies and policies, heavily influencing the other blocks. Therefore, for every of the aforementioned countries, a structural analysis was conducted, followed by an analysis of policies and their impact. This policy analysis and its focus on impact is largely based on the *Handbook of Innovation Policy Impact* by Edler, Cunningham, Gök, and Shapira (2016).

Country profiles

The Dutch construction industry is marked by a high productivity and even in the field of innovativeness it does not score particularly bad. However, the industry is largely fragmented and the links between policy makers, clients, the market and research & education institutes are weak. Furthermore, partly resulting from the construction fraud in the early 2000s, distrust between public and private parties is large. Several policies influence innovation in construction in the Netherlands. The Netherlands have a large package of R&D stimulating financial measures in the forms of direct support, tax incentives and venture capital, mostly aimed at all industries. Furthermore, the access to expertise is large with several research institutes and intermediaries. Also PIANOo and *Ondernemersplein* offer knowledge and advice on several procedural construction-relevant topics. The lack of collaboration is a large issue in Dutch construction, which is accounted for by most notably the recently initiated *Bouwcampus*. Several other initiatives exist to stimulate collaboration, among which new forms of contracting and procurement. Furthermore, innovation is, be it less than in several other countries, stimulated from the demand side with for example innovation-oriented purchasing and SBIR. However, the policy mix is not particularly integrated and several measures lack to support the whole innovation trajectory.

The UK is distinguished by a high level of market liberalization, but with a low labor productivity in construction. From the other side, for several decades, government-initiated reform initiatives have been ruling the UK construction industry, largely emphasizing collaboration, quality and transparency in the sector. The more concrete innovation policies in UK construction consist of a broad policy profile with training boards to stimulate supply of skills and several networking and cluster programs. Most notably, the stimulation of demand for innovation is large with initiatives as SBRI, *Forward Commitment Procurement* and new ways of construction procurement. The policy profile is quite balanced in the UK. However, the provision of support and knowledge during the entire innovation process is meagre.

The construction industry in Denmark is, in the Scandinavian tradition, characterized by high levels of collaboration. Although a large part of the tendency to collaborate can be traced back to culture historical roots, the stimulation of collaboration and co-creation is very active and direct. Denmark has one of the best balanced policy profiles of the countries studied, with large emphasis on connections and complementaries. Also the amount of working groups and task forces working at stimulating the construction industry is remarkable, all with a high participation rate of different groups of actors. Regarding stimulating demand for innovation, the unique *User-driven Innovation* program was launched, specially aimed at diffusion of methods for innovation, aimed at societal challenge and customer needs.

Sweden is despite of the liberal tendencies a slightly left-winged country with a large and centralized government. Similar to Denmark, Sweden strongly collaborates between all groups of actors, consisting also of the 'Iron Triangle'. Sweden's innovation agency Vinnova is unique, also incorporating a program aimed at construction: *Bygginnovationen*. Most strikingly contrasting the other preselected countries, is the large emphasis on demand-driven innovation, including pre-commercial procurement methods as well as challenge-driven innovation programs. Furthermore, the networking and clustering activities are for construction available in abundancy, which offer a proper complementary set to the direct measures. Also the centralization is remarkable, resulting in a much clearer innovation system, which enables policy makers to develop more coherent policy mixes.

Germany is Europe's largest country and is divided into smaller states. The country showed large resilience to the crisis and remained the stable power in Europe. The construction industry has since 2010 almost continuously been growing in turnover, which is exceptional compared to other studied countries. The federal system largely affects the way of policy-making as the states have large autonomy in this field. The range of policy measures is wide and balanced. The main reason is the existence of overarching strategies, which are created and managed cross-ministerial. Especially the *Neue High Tech Strategy* is a very balanced package of future goals and corresponding policy measures. Most indicators point towards a relatively high level of innovation, which can possibly be explained by the unambiguous strategies and customized policies per state.

Conclusion for the Dutch construction industry

The Dutch construction industry is in relation to the other countries not less innovative, although gaps in the policy profiles are visible. The industry is in terms of policies rather fragmented with low mutual trust, especially compared to other countries. Different ministries and agencies are responsible for different subsectors, and moreover the innovation policies are approached from other departments. Although the Netherlands have in the recent past presented some very valuable and effective policies and initiatives, the policy mixes seem to be poorly coordinated and are often stand-alone shots.

Overarching strategies are newly issued or in the making, but running innovation-boosting policies are hard to find.

The gaps as well as the strengths in policies are, even when not considering policies on content, evident. The Netherlands are one of the leaders in supporting input for innovation and R&D. Not only are these effective measures complete in terms of mechanisms, they are also more generous than in most other countries. However, the construction industry seems to make less use of these support measures than other industries. Regarding access to knowledge and expertise, the Netherlands also are outperformers, especially concerning procedural and legislative knowledge. The supply of skill lacks in the policy overview, but the market itself has set up several initiatives for training and education, such as the *BuildUpSkills* network, which was not initiated by the government, but merely supported by it. The most significant gaps are probably in the fields of standardizations and demand for innovation. The first is, especially within the civil engineering construction, important as it stimulates on one hand security and stability, and enables, when applied from a more technical perspective, larger possibilities for diffusion of innovations. Demand for innovation is very effective in stimulating innovation, especially when applied to the abundantly available direct support measures.

Recommendations

All in all, collaboration should radically increase in order to stimulate structural innovativeness. This should be between contractors and suppliers as well as with clients and knowledge organizations. A government-led clients organization may aid in fostering this. Secondly, the use of quality measurement mechanisms should be applied in the form of past-performance indicators or project team assessments. Thirdly, policy should be evaluated and the evaluations should be used in new policy making – even considering international results. The impact evaluation should moreover be split-up in the different subsectors, such as building construction and civil engineering construction. Fourth, construction policies in general should be more aimed at innovation in the Dutch construction industry. Innovation largely determines the phase of progress and it also puts the Dutch sector internationally in a better light.

In order to actually heed the recommendations, a policy profile is suggested, supplementing the existing one. First of all, the input for innovation and R&D measures should be (partly) integrated to reduce bureaucracy and increase accessibility. Especially WBSO, *Innovatiebox*, *Innovatiekrediet* and RDA are largely aimed at a comparable target group and work in a great complementing fashion. Accordingly, centralized governance of these measures could increase efficiency. Furthermore, several foreign measures are added to the Dutch policy profile in order to close the gaps.

First of all, the supply of skills is supplemented by immigrant policies to account for the expected labor shortage. Also a training board may aid in accounting for the shortfalls of skilled workers. Also, the access to expertise is well-organized in the Netherlands, but the distribution of information can be improved by publishing brief pamphlets with scientific developments. For collaboration, a clients' association could aid in improving the link between government and industry. The *Bouwcampus* is currently partly fulfilling this goal. Also demand for innovation should be stimulated more actively. User- and challenge-driven innovation programs may be suitable solutions. Also Forward Commitment Procurement can enlarge the contractor's window of opportunity for exploiting innovations. Standardization in technical aspects, processes (such as BIM) and in evaluation should also be applied to facilitate a stable and structured framework and improve future policy-making.

Samenvatting (NE)

Innovatie in de bouwsector wordt al tijden als moeizaam ervaren en ook de cijfers over investeringen in onderzoek en ontwikkeling zijn lager dan in menig andere sector. De laatste jaren is de discussie op gang gekomen om innovatie in de bouw te bevorderen. Ook de roep voor een duurzamere en groenere maatschappij heeft hiertoe bijgedragen. Hoewel Nederland in Europese studies als een van de koplopers op het gebied van innovatie wordt beschouwd, is de bouw een sector die door velen nog niet als zodanig wordt beschreven.

Onderzoeksdoel en -methode

Om de innovativiteit van de Nederlandse bouw te verhogen, zijn een aantal bouwsectoren van innovatieve Europese landen bestudeerd op innovatiebeleid. Strategieën, beleidsmaatregelen en bouwbeleid zijn bestudeerd van het Verenigd Koninkrijk, Denemarken, Sweden en Duitsland om een beeld te krijgen van de aanpak in deze landen en de punten waar zij beter op scoren dan Nederland. Aanbevelingen uit deze lessen zijn gemaakt, om zo de Nederlandse bouwsector innovatiever te maken. Voor deze studie is de Sectorale Innovatiesysteem (SIS) benadering toegepast. SIS benadert een sector, in dit geval de bouw, als een dynamisch systeem bestaande uit verschillende onderling afhankelijke entiteiten. The sectorale patronen worden beïnvloed door vier verschillende blokken: (1) middelen, interacties en netwerken, (2) institutionele inkadering, (3) technologisch regime en (4) marktvraag. De rol van institutionele inkadering, bestaande uit externe factoren, strategieën en beleid, beïnvloeden de andere blokken sterk. Voor elk van de voorgenoemde landen is daarom eerst de sectorstructuur van de bouw bepaald, waarna de strategieën en beleidspunten die innovatie in de bouw beïnvloeden zijn bestudeerd en de effecten op de bouw zijn bepaald. Deze analyse is gebaseerd op het *Handbook of Innovation Policy Impact* van Edler, Cunningham, Gök en Shapira (2016).

Analyse per land

De Nederlandse bouwsector wordt gekenmerkt door een hoge productiviteit en zelfs het innovatieniveau is goed op orde. Toch is de sector sterk gefragmenteerd en zijn de relaties tussen beleidsmakers, opdrachtgevers, marktpartijen en onderzoeksorganisaties zwak. Dit komt mede voort uit het gebrek in wederzijds vertrouwen, dat voornamelijk sinds de bouwfraude kenmerkend is geworden voor de Nederlandse bouw. De innovatie in de bouw wordt beïnvloed door verschillende beleidsmaatregelen. Een breed scala aan maatregelen die input voor onderzoek en innovatie stimuleren is aanwezig die zich richt op vrijwel alle sectoren in de Nederlandse industrie. Ook het aanbod in expert ondersteuning is groot, met verschillende instituten en tussenliggende partijen, zoals PIANOo en *Ondernemersplein* die kennis aanbieden over verschillende procedurele onderwerpen die relevant zijn voor de bouw. Samenwerking is een groot probleem in de Nederlandse bouw, waar momenteel aan gewerkt wordt door onder andere de *Bouwcampus*. Ook nieuwe initiatieven in aanbesteding en inkoop zijn gericht op verbeterde samenwerking. Eveneens zijn er vanuit de vraagzijde verschillende beleidsinitiatieven die innovatie stimuleren, zoals *Inkoop Innovatie Urgent* en SBIR. Toch is het gehele beleidspakket niet erg gebalanceerd en integraal, ook omdat enkele essentiële mechanismen ontbreken in het Nederlandse bouwbeleid.

In het Verenigd Koningrijk (VK) is de markt sterk geliberaliseerd en de productiviteit in de bouw is er betrekkelijk laag. Wel zijn er de laatste decennia verschillende door de overheid geïnitieerde hervormingsstrategieën gelanceerd, die een grote invloed hebben gehad op de bouw; grotendeels betreffende samenwerking, kwaliteit en transparantie in de sector. Concreter innovatiebeleid in de

bouw in het VK bestaat uit een breed beleidsprofiel met in het bijzonder trainingsplatforms gericht op de toevoer van vaardigheden en verschillende netwerk- en clusterprogramma's om samenwerking en co-creatie te bevorderen. Meest opvallend zijn is het stimuleringsbeleid voor vraaggerichte innovatie, bestaande uit SBRI, *Forward Commitment Procurement* en nieuwe aanbestedingsprocedures. Het beleidsprofiel is goed gebalanceerd in het VK, maar de voorziening van kennis en begeleiding gedurende het gehele innovatieproces laat nog te wensen over.

De bouwsector in Denemarken is volgens de Scandinavische traditie gekenmerkt door hoge mate van samenwerking. Hoewel de oorzaak hiervan cultuurhistorisch bepaald is, is de stimulering van samenwerking door beleid direct en intensief. Denemarken heeft van de onderzochte landen een van de best gebalanceerde beleidsprofielen met een sterk oog voor verbindingen en aanvullingen tussen beleid en actoren. Ook het aantal werkgroepen en agentschappen met betrekking tot de bouwsector is zeer groot, met een grote diversiteit tussen betrokkenen. Betreffende de aanmoediging van vraag naar innovatie is een *User-driven Innovation* programma gelanceerd met een sterke nadruk op maatschappelijke vraagstukken en gebruikerswensen.

Zweden is ondanks de liberaler wordende tendensen een sociaaldemocratisch land met een grote en gecentraliseerde overheid. Net als Denemarken hecht Zweden veel waarde aan samenwerking tussen alle groepen betrokkenen die, in het specifiek gericht op wetgevers, aannemers en opdrachtgevers, ook wel de 'IJzeren Driehoek' wordt genoemd. Sweden heeft een agentschap, Vinnova, dat specifiek op bevordering van innovatie gericht is. Ook de bouw is hier inbegrepen met het zogenaamde Bygginnovationen programma. Wat het meeste opvalt ten opzichte van de andere landen is de focus op vraaggerichte innovatie. Ook netwerk- en clusterprogramma's zijn veelvuldig te vinden in het Zweedse beleidsprofiel, die een nuttige aanvulling geven op de financiële innovatiesteun. Ook valt de centralisatie van het beleidsprofiel op, die resulteert in een gestructureerd innovatiesysteem, waardoor beleidsmakers een gebalanceerde beleidsmix kunnen ontwerpen.

Duitsland is de grootste economie van Europa en is opgesplitst in zestien deelstaten met een betrekkelijk grote autonomie; ook op beleidsgebied. Het land heeft de crisis zonder heel grote schade doorstaan en wordt economisch gezien beschouwd als een van de stabielste landen van Europa. De bouwsector heeft zelfs in en na de crisis groei vertoond. Het beleidsprofiel dat innovatie in de bouw beïnvloed is breed en gebalanceerd, hoewel meer specifieke beleidsmaatregelen vaak door de staten zelf worden bepaald. De overkoepelende strategieën zijn echter compleet en integraal en voorzien Duitsland van duidelijke doelen en een gebalanceerd beleidskader. Voornamelijk de *Neue High Tech Strategie* is een zeer gebalanceerd pakket aan beleidsdoelen en -maatregelen met een duidelijke toekomstvisie. De meeste indicatoren wijzen op een hoge mate van innovativiteit in de Duitse bouw, die mogelijk verklaard wordt door de strategieën en op maat gemaakte beleidsmaatregelen per staat.

Conclusies voor de Nederlandse bouwsector

De Nederlandse bouwsector is in vergelijking met andere landen niet minder innovatief, hoewel er duidelijke gaten in het beleidsprofiel te zien zijn. Met betrekking tot beleid is de bouwsector sterk gefragmenteerd met een laag onderling vertrouwen; ook in verhouding tot de andere landen. Verschillende ministeries en agentschappen zijn verantwoordelijk voor de verschillende deelsectoren en innovatiebeleid is weer door een ander ministerie bepaald. Ondanks dat Nederland recentelijk verschillende veelbelovende en waardevolle beleidsmaatregelen en initiatieven heeft gelanceerd, is het algehele beleidsprofiel matig gecoördineerd en zijn de maatregelen niet zelden wilde schoten in

de lucht. Overkoepelende strategieën zijn in de maak, maar werkende innovatie-stimulerende maatregelen zijn moeilijk te vinden.

De hiaten in het beleidsprofiel alsmede de sterke punten zijn, zelfs wanneer de beleidsmechanismen niet inhoudelijk beoordeeld worden, duidelijk. Nederland is een van de kartrekkers op het gebied van financiële stimulering van O&O en innovatie. Niet alleen blijken de mechanismen effectief, maar ook is de ruimhartigheid van de maatregelen groot. De maatregelen worden door bouwbedrijven echter minder gebruikt dan in andere sectoren. Met betrekking tot toegang tot kennis en expertise is Nederland ook een van de toppers; voornamelijk op het gebied van procedurele en wetkundige kennis. Aan de andere kant wordt training en opleiding van werkenden minder actief gestimuleerd, maar de branche heeft zelf enkele initiatieven gelanceerd zoals *BuildUpSkills*, die door de overheid enkel gestimuleerd wordt. De meest opvallende hiaten zijn echter te zien in standaardisering en vraag-gerichte innovatie. De eerste is, zeker in de GWW-sector belangrijk, omdat het enerzijds zekerheid en stabiliteit biedt, en anderzijds, zeker vanuit een technisch perspectief, mogelijkheden biedt voor diffusie van innovaties. De tweede is effectief voor het stimuleren van innovatie wanneer het gecombineerd wordt met de directe maatregelen, die grotendeels al aanwezig zijn.

Aanbevelingen

Al met al moet samenwerking aan de voorkant sterk toenemen om structurele innovativiteit te stimuleren, zowel tussen aannemers en toeleveranciers, als opdrachtgevers en kennisorganisaties. Een vanuit de overheid georganiseerde opdrachtgeversvereniging kan deze samenwerking grotendeels faciliteren. Ook dienen kwaliteitssystemen ingevoerd te worden in de vorm van past-performance of assessmentsessies voor het projectteam als onderdeel van de selectieprocedure. Verder dient het beleid structureel geëvalueerd te worden om toekomstig beleid te optimaliseren. Het wordt aangeraden deze beleidsimpactevaluaties op te splitsen per deelsector, waaronder GWW en B&U. Ten slotte is het aan te raden om meer innovatie-specifiek beleid in de bouw toe te passen, omdat innovatie grotendeels de vooruitgang in de sector beschrijft en Nederland internationaal gezien een voorsprong kan nemen. Om deze aanbevelingen daadwerkelijk door te voeren, is er een beleidsprofiel voorgesteld, die het bestaande profiel aanvult.

Ten eerste dient de financiële stimuleringsbeleid van O&O beter geïntegreerd te worden om complexiteit en bureaucratie in te perken. De efficiëntie van de maatregelen kunnen zo verhoogd worden van bijvoorbeeld WBSO, *Innovatiebox, Innovatiekrediet* en RDA. Verder zijn verschillende maatregelen uit de andere bestudeerde landen toegevoegd om de hiaten op te vullen. De instroom van gedeeltelijk hoogopgeleide migranten biedt een mogelijkheid om het arbeidstekort op te vullen. Ook een opleidingsinstituut voor werkenden kan omscholing stimuleren en innovatiecapaciteit van werknemers verhogen. Hoewel toegang tot expertise goed geregeld is in Nederland, kan een gestructureerde uitgaven van beknopte brochures over technische alsmede procedurele onderwerpen kennisontwikkeling op de vloer stimuleren. Om samenwerking verder te stimuleren, kan een opdrachtgeversvereniging een grote rol spelen om partijen dichter bij elkaar te brengen, al vevult de Bouwcampus nu gedeeltelijk die rol. Ook de vraagzijde van innovatie moet actiever gestimuleerd worden. Gebruikers- en uitdagingsgerichte innovatieprogramma's zoals in de Scandinavische landen blijken hiervoor geschikt te zijn. Ook de *Forward Commitment Procurement*, die tot op zekere hoogte lijkt op *Inkoop Innovatie Urgent* stimuleert vraag naar innovatie. Verder dienen standaardiserings-initiatieven opgezet te worden op het gebied van technische aspecten, processen (zoals BIM) en van evaluatiemethoden om een stabiel en gestructureerd kader te bieden voor ondernemers.

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List with commonly used abbreviations and institutions

3TU	Cooperation program between three Dutch technical universities
BBC	British Broadcasting Corporation
BIM	Building Information Modelling
BIS	UK department of Business, Innovation and Skills
BMBF	German federal Ministry of Science and Education
BMUB	German federal Ministry of Environment, Nature Conservation, Building and Nuclear Safety
BMVI	German federal Ministry of Transport and Digital Infrastructure
BMWi	German federal Ministry of Economics and Technology
CBS	Dutch public agency for statistics
CI	Construction Industry
CIOB	Chartered Institute of Building
COB	Dutch association for underground construction
CoPS	Complex Products and Systems
CROW	Dutch knowledge institute for infrastructure, public space, traffic and transport
CPB	Dutch bureau for economic policy analysis
DE	Germany
DEA	Data envelopment analysis
DFF	Danish Council for Independent Research
DFG	German research community
DK	Denmark
DTI	Danish Technological Institute
E2BA	Energy-efficient Buildings Association
EC	European Commission
EeB	Energy-efficient Buildings
EIB	Economic Institute for Construction
EM	Danish Ministry of Business and Growth
EP	European Parliament
EU	European Union
EZ	Dutch Ministry of Economic Affairs
ICT	Information and communication technology
IenM	Dutch Ministry of Infrastructure and Environment
IMF	International Monetary Fund
IPS	Intellectual Property System
ISSO	Dutch knowledge institute for installation techniques
IT	Information Technology
GDP	Gross domestic product
GHG	Greenhouse gas
HBO	Dutch system of Higher Vocational Education
HE	Higher education
HEI	Higher education institute
HMRC	UK non-ministerial department for collection of taxes and several other tasks
HLF	High Level Tripartite Strategic Forum
KAM	Knowledge Assessment Methodology
KEI	Knowledge Economy Index
KPI	Key Performance Indicator
LMI	Lead Market Initiative
M	Mega, million
MP	Member of Parliament (applicable in the UK)
NSI	National Innovation System
NL	The Netherlands

NSB	UK national standards body
NWO	Dutch national agency for applied technical sciences
NYT	New York Times
OCW	Ministry of Education, Culture and Science
OECD	Organisation for Economic Co-operation and Development
ONS	UK national statistics agency
PhD	Doctor of Philosophy (doctoral degree)
PP	Past Performance
PPP	Public Private Partnership
R&D	Research and development
R&I	Research and innovation
RCUK	UK central research council
SBI	Danish Building Research Institute
SE	Sweden
SI	System of Innovation
SME	Small and medium-sized enterprise
RGD	Empire buildings service
RISE	Sweden's largest research institute
RWS	Rijkswaterstaat, the Dutch executional infrastructure agency
RIS	Regional Innovation System
SCB	Sweden's national agency for statistics
SCC	Association for Swedish construction clients
SEK	Swedish crowns (ca. 0,102 euro)
SIS	Sectorial Innovation System
STA	Swedish Transport Agency
STW	Dutch technology association
TIS	Technological Innovation System
TNO	Dutch national research institute
TO2	Federal cooperative of the largest Dutch research institutes
TG	Task Group
TKI	Dutch consortia for knowledge and innovation
TRM	Danish Ministry of Transport, Building and Housing
TSB	UK Technology Strategy Board
TUD	Delft University of Technology
UFM	Danish Ministry of Higher Education and Science
UK	United Kingdom
UN	United Nations
USA	United States of America
UT	University of Twente
WR	German knowledge council

1 Introduction

1.1 Research background

Innovation and the construction industry (CI) have always had an uncomfortable relationship and the percentage of money spent on research and development (R&D) is considerably lower than in most other industries (Seaden & Manseau, 2001). Piles of literature have been written on innovation in construction, but the answer to the question whether the CI is innovative is completely dependent on the context. Kulatunga, Amaratunga, and Haigh (2006) argue that regardless whether the CI is innovative or not, the lack of systematic diffusion of innovations through the sector remains a concern. In the past few years, more and more has been discussed about increasing innovation in the industry.

Also the call for increasing sustainability and decreasing environmental impact has contributed to this tendency. However, in the last decades some European countries focus systematically more on innovations in the CI than the Netherlands, as we can tell from the percentage of turnover that consists of R&D activities. This relation is confirmed by Mairesse and Mohnen (2005) who state that "R&D is positively correlated with all measures of innovation output and, all other things equal, more correlated than size to innovation. Innovation is generally more sensitive to R&D in the low-tech sectors than in the high-tech sectors." Velzing (2013), however, stresses that R&D is an input indicator and no output indicator for innovation. Therefore, he argues, one should look further than R&D to give a realistic view of current innovation practices. The broader view also contains for example marketing methods and patenting (OECD, 2005). Indeed, the relation between R&D and innovation has been demonstrated, but literature shows that this relation is non-linear and therefore difficult to compare (Manseau & Seaden, 2001).

For finding causes of the lack in knowledge investment, this study takes a look at the different innovation policies in several countries and tries to use these differences in order to draw most welcome lessons for the Dutch CI. The intended outcomes may also be used in order to benchmark the different countries. The study will aim at the policy level of stimulation of innovation, rather than individual innovations. A similar study was conducted between 1998 and 2000 by Manseau and Seaden (2001) with a different selection of countries and had a strong focus on the creation of a framework. Also Miozzo and Dewick (2004) conducted a comparative study on innovation in European CIs, but their analysis was rather aimed at the micro structure and innovation policies were not individually analyzed. Furthermore, a lot has changed in the past 15 years in an economic, legislative, cultural, and technological sense which causes a lot of changes on the policy side, as the system is complex and highly dynamic.

Regarding the Netherlands, several decades ago, Jacobs, Kuijper, and Roes (1992) conducted a study on the state and economic impact of the Dutch CI. This study was largely focused on the dynamics of the industry as a whole. Since the publication of that study, a lot has changed in the Dutch CI. In those past two decades, some major changes occurred in legislation and organization structure due to internal as well as external pressures. For example the case of the collusion in the Dutch CI which was exposed in 2002, urged for quick reforms within the sector. The profit margins in the industry are meagre and competition between contractors and suppliers fierce, which resulted in disappointing outcomes of initiatives on innovation in the sector.

Meanwhile, some of the surrounding countries have been more expeditiously, which not only resulted in a more innovative climate, but in the end in an economically stronger position (Dick & Payne, 2005). Therefore, the Netherlands may learn a lot from these countries and their ways of stimulating innovation in certain areas. In 2011, the Dutch construction research institute EIB has studied the innovation in the Dutch construction industry and came unsurprisingly with a long list of barriers to innovation and recommendations on how to resolve these (Jansen & Vlist, 2011). A follow-up was presented recently by Arnoldussen, Groot, Halman, and Zwet (2016), but rather than analyzing the current state it presents recommendations on removing barriers to innovation in the CI. This study might place the EIB reports in a more international light and furthermore give additional ways of improving the Dutch construction sector. Finally, this study tries to benchmark the way and level of innovation in the Dutch industry within the European one. This might not only be useful for the Dutch industry, but also for the other countries. One might wonder why this research is aimed at improving at innovation and not at sector improvement in general. Fact is that more innovation-oriented activities within a company lead to higher profits, as is shown by for example EIB by Jansen and Vlist (2011) and TNO by Bruijn and Maas (2005). Thus, this study aims at sector improvement as a whole.

1.2 Research objectives

As stated before, the aim of this research is to find out the different construction innovation policies in several well-reputed European countries and draw, if possible, lessons for the Dutch CI. Since this is a rather vague goal, the boundaries and way of research have firstly been determined and set. As comparing the Netherlands to all European CIs is practical infeasible within the time limits of a master thesis project, some countries are preselected, next to the European Union's policies and statistics as a whole. Within those pre-selected countries, the focus has been on government policies, but sector initiatives will also be considered.

The Dutch CI is, first of all, compared to the United Kingdom's CI, as the *Brexit* may have consequences for the policy making in the CI. Furthermore, the UK has often taken the lead in reform initiatives in construction, such as the *Egan report* and the *Latham report*, which will be discussed later. Also Denmark and Sweden are taken into consideration for their outstanding reputation as drivers of innovation and sustainability. Finally, the German policies on innovation are studied, because Germany has the largest and most influential economy of the EU (European Union) (European Commission, 2015). The focus while studying those countries will be the government policies, but also industry initiatives will be considered. All these countries, including the Netherlands, are considered to be innovative leaders, which makes it useful to make comparisons (European Commission, 2017a). Moreover, these countries are all considered outperformers regarding construction productivity (McKinsley Global Institute, 2017).

The European Commission (EC), as part of the EU, headquartered in Brussels, also has a hand in international policy, legislation and stimulation of good practices and is therefore also included in the study. It will moreover give a valuable insight in the European statistics for placing the benchmark more in perspective. Furthermore, it has launched some innovation initiatives which may be interesting to take a look at. The Dutch CI will be analyzed as a whole in order to develop a broad vision of its current state. Thereafter, in a quantitative as well as a qualitative way, the most important and eye-catching statistics and policies of these countries will be gathered and analyzed. Also the innovation policies, the role of the government and the distribution of the roles and responsibilities of contractors, sub-contractors, clients and research institutes will be evaluated.

This comparative study has not been conducted in this way before; especially the goal of improving the Dutch CI is unique in its kind. First of all, market parties and government may draw conclusions from this report which may influence their policies and innovation strategies. Secondly, it may construct a basis for further research. These analyses will help to answer the main question of this research which reads as follows:

Which innovation-oriented policies are made in the construction industry of the different countries, how do the effects of these policies differ from each other and which lessons can the Dutch construction industry draw from them?

As Andersson and Widén (2005) state, "describing innovation systems of construction requires a thorough understanding of the characteristics of construction". For answering this question, therefore answers to different parts have to be gathered first. In order to achieve this, sub-questions have been drafted. These questions together will give an answer to the main research question. The sub-questions read:

1. How do governments of the preselected countries relate to each other and what are the connections with the European Commission's initiatives and policies?
2. How is the Dutch construction industry structured and how does it manage innovation policies?
3. What are the characteristics and statistics of the construction industries in the addressed countries?
4. Which role plays innovation in the construction industries of the Netherlands and the addressed countries?
5. What are the effects of the different initiatives and policies on the daily practice in construction?
6. What are the similarities and differences between the way the innovation policies are made and managed in the addressed countries and the Netherlands?

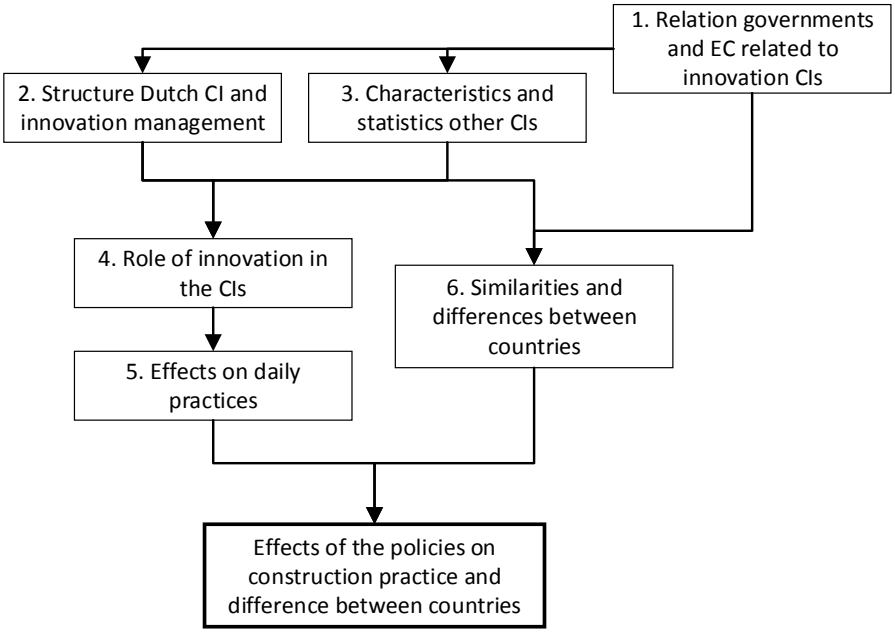


Figure 1 – Visualization coherence research questions

These sub-questions obviously do not stand on their own. They form the path to the main question which is only answered when the individual sub-questions are. To make this path clearer and determine the coherence, a flow diagram is shown in Figure 1. The numbers in the chart correspond with the numbering of the sub-questions. In order to conduct the research as a whole, the methodology per sub-question is formulated, but before these points are issues addressed, the limitations and assumptions in this study are discussed.

1.3 Limitations, delimitations and assumptions

In a nutshell, this study is aimed at an important part of the European CI and its relation to the Dutch one. One could imagine that a thorough analysis of the entire European industry in a Master Thesis project is utterly impossible. Consequently, the study is based on available reports and published literature and in a few particular cases, interviews with foreign experts are conducted. Another delimitation is that only a limited number of countries are picked for analysis based on their reputations in (construction) innovation. Potentially useful cases from other European countries may therefore be overlooked. The scope of the research is aimed at the policy level and individual projects will therefore at most be included as examples, but the focus will be entirely on the higher abstraction levels. Lastly, a policy impact analysis is conducted, but due to a strictly bound time-span and not at least lack of prior policy knowledge and econometric expertise, the impact analysis will be merely a reflection and synthesis of literature and experts' opinions.

Next to these consequences of the pre-set boundaries are there also limitations in which the researcher has little to say or pre-set about. These can be found in the researcher's linguistic limitations and willingness of governments and corporations to share information. Summarized, the research delimitations and limitations which affected the research are the following:

- The study only considers the major research reports and publications;
- The study takes only the Netherlands, the UK, Denmark, Sweden and Germany into account;
- The study aims at the policy levels and therefore, valuable case studies may be overlooked;
- The study is limited to available literature in English, German and Dutch due to the author's linguistic limitations;
- Time and the author's policy analysis-related knowledge is limited, which calls for a simplified policy impact analysis;
- The study its depth is limited to public information. Corporations may due to strategic considerations prevent information to be shared.
- Merely innovation and R&D policies are considered, while policy interaction finds place between other types of policies. These interactions are not reviewed.
- In order to determine impact on innovation of a policy as a whole, impact of a single measure has to be determined. However, time limits do not allow for individual research, so the study is limited to publicly available research reports and case studies.

Those limitations and delimitations have set the project scope and shaped the research space with its boundaries. However, limitations that cannot be controlled – called assumptions – should at least be acknowledged. This research was an expedition in itself and no clear predefined roadmap could be used leading to a satisfying, concrete solution. The main assumptions have been the following:

- The predefined countries are representative for the good practices in Europe;
- Research and data institutes such as EIB and CBS, but also the foreign ones, offer reliable data.

1.4 Terminology

This subject uses lots of ambiguous, multi-interpretable and often misused terms that deserve some special attention in this report. This varies from broad terms to jargon, wherein confinement of the terms is essential. Subsequently we will discuss the terms innovation, including product innovation and process innovation; policy and initiative; organizations, companies and institutions and construction industry.

1.4.1 Innovation

Innovation is an often used term with in every branch its own specifications. Innovation is not something tangible and is as such a rather abstract phenomenon. Sergeeva (2013) notes when trying to grasp the innovation concept in UK construction that "far from being a material entity that can be determined by variables, innovation is, perhaps, more reasonably and convincingly understood as an ongoing process of making sense". All in all, in this study, innovation in general is in line with Van de Ven et. al (2008) described as developing and implementing (successfully), based upon specific knowledge, skills and experience, something new in society. Research results, markets and institutions are not considered innovations, although they are called as such in some studies. We use this scope to denote innovation, as the policy level in which this research is conducted also applies the broadest view possible regarding innovations. Bruijn and Maas (2005) stress out that innovation processes should be considered from a system perspective which means that input factors, throughput factors and output factors should be considered when analyzing innovation, which also facilitates benchmarking.

Innovations can be distinguished in product innovations and process innovations. As Edquist and Hommen (2008) discuss, product innovations are economically speaking new – or improved – material goods as well as new intangible services; it is a matter of what is produced. In this categorization, only goods and technological process innovations are considered to be material. The other categories are non-material and therefore intangible. Thus, for example, innovations in service products are considered to be intangible innovations, as are organizational process innovations.

Furthermore, as this study will show, a diffusion of distinction is visible between innovations that are innovations new to the market and innovations that are new to the firm, or in this case countries (Edquist & Hommen, 2008). This study is aimed at the former type, as the macro scale is considered. There are furthermore several ways to distinguish types of innovation, such as radical and incremental innovations and science-based and experience-based innovations. The former group refers to the size of the innovation taken within one implementation step, fundamental change within a company versus a minor impact, while the latter distinction is based on the nature of the invention. An important note is that we take in a macro-economic sense the strong relation between level of innovations and R&D investment for granted as explained in section 1.1, although it is strictly a mere input factor. When we consider actual policy impact, the R&D investment is therefore considered inadequate as a leading indicator.

1.4.2 Policy and initiative

A policy is a set of basic principles and associated guidelines, formulated and enforced by the governing body or an organization, to direct and limit its actions in pursuit of long-term goals. In this study we mean, if the term policy is used, the national governments, as a country's innovation policy is studied as well as the EC's policies. More specific, Edquist (2001) describes innovation policy as

"actions by public organizations that influence the development and diffusion of innovations", which will be adopted in this study. This is comparable with Edler, Cunningham, Gök, and Shapira (2016) who describe innovation policy as "public intervention to support the generation and diffusion of new products, processes or services". An individual intervention is classified in a certain instrument or measure which will be described further in the methodology chapter, but for construction innovation, a public policy instrument in its broadest sense is defined as government initiated measure that influences the rate and direction of innovation by construction firms (Winch, 1999). Although several studies consider also firm's policies, this study is confined to public bodies and specifically central governments.

An initiative is a regional, industry-focused approach to workforce and economic development. It is on the contrary to policies not enforced by the government, but rather an agreement, of which the government may, but not necessarily does take part, and are sector-driven. The aim is often at a sector-wide participation in order to reach progress and development. These initiatives often go hand in hand with ambitious future goals, which can be drivers for innovation. Those initiatives are often fit in broader strategies and policies and are generally products of sector-broad cooperation.

1.4.3 Organizations, companies and institutions

Organizations are entities with a collective goal. These include governmental, non-governmental, political and international organizations. In the light of this research, it most importantly includes universities, research facilities, sector associations and companies. Companies – also called firms – are legal businesses that provide services or goods to the public. In this sentence, companies are organizations, but not the other way around.

Although the term institution may be used to indicate an organization, institution has a broader meaning. In order to prevent ambiguities, we therefore do not use the word institution when aiming at an organization, except for cases in which this word is used in a specific name, while we do use it when it refers to abstract entities, such as formal social structures. In that light, it is used as sets of common habits, norms, routines, established practices, rules or laws that regulate the relations and interactions between individuals, groups and organizations. Within the group of institutions, we distinguish hard and soft institutions, the former entailing legislation and standards and the latter ethics, norms and behavior.

1.4.4 Construction industry

The construction industry as a certain sector in each country is defined in a quite unambiguous way. However, the boundaries vary significantly per study. If in this study the construction industry is called upon, we mean the definition as presented by the standard UK industrial classification system *UK SIC* 2007, which is as follows: "This industry definition includes general construction and allied construction activities for buildings and civil engineering works. It includes new work, repair, additions and alterations, the erection of prefabricated buildings or structures on the site and also construction of a temporary nature. General construction is the construction of entire dwellings, office buildings, stores and other public and utility buildings, farm buildings etc., or the construction of civil engineering works such as motorways, streets, bridges, tunnels, railways, airfields, harbors and other water projects, irrigation systems, sewerage systems, industrial facilities, pipelines and electric lines, sports facilities etc. This work can be carried out on own account or on a fee or contract basis. Portions of the work and sometimes even the whole practical work can be subcontracted out.

A unit that carries the overall responsibility for a construction project is classified here. The repair of buildings and civil engineering works is also included. The industry definition includes the complete construction of buildings, the complete construction of civil engineering works, as well as allied construction activities; if carried out only as a part of the construction process" (Companies House, 2007). In a certain sense, we therefore take the broadest view on the definition as several studies exclude for example civil works or the hydraulic subsector of the industry. Considering this view, construction-related spending is globally responsible for 13% of the world's GDP (McKinsley Global Institute, 2017). However, regarding policy, it is important to keep in mind that building construction, civil engineering & heavy construction and services are structured very differently with different policy perceptions as a result. An elaboration on the structure of the CI is given in appendix II.

1.5 Scope

The ambiguity of different concepts used in this report and the limitations as described in section 1.3 call for a clear demarcation of the research. A clear scope is therefore of utmost importance during the entire study. First of all, innovation is already defined and includes the aforementioned product and process innovations. Organizational and institutional innovations is not aimed at when the word 'innovation' is used in this report. Furthermore, innovation is dealt with as a concept and not as an individual process or self-contained product. As a consequence, the policy level can be maintained on a high level of abstraction.

This policy level also deserves a little more attention. Rolfstam (2013) defined a hierarchy of policy levels varying from global level to individual divisions within decentralized public bodies (Figure 2). In this research, or scope will be at the national levels and the affiliated agencies. However, the interactions with the other levels should always be kept in mind, as these highly influences the policies on a national level. On one side, the European influence on for example climate targets will affect the national objectives and therefore the policies. on the other side, the autonomy of for example municipalities will influence the effectiveness of national policy.

As we discuss a specific sector, another taxonomy becomes relevant. Several policies are nation-wide applicable, including the CI and others are aimed solely at the CI. Also can this policy be specifically aimed at innovation, such as innovation as criterion within procurement, but also indirectly influence innovation such as tax incentives for R&D. Winch (1999) saw this distinction and developed the taxonomy of public policies and instruments in the construction industry (Figure 3). In this study, we focus mainly on construction-specific measures that influence innovation directly. However, if certain instruments largely affect innovation in the CI, they are also included in the analysis, as benchmarking different countries may be unrealistic as the policy profiles may differ largely in terms of this taxonomy with each a certain impact on innovation in the CI. As visualization of appropriateness, the most suitable is marked green, while the second are filled yellow and the least appropriate kind are marked red.

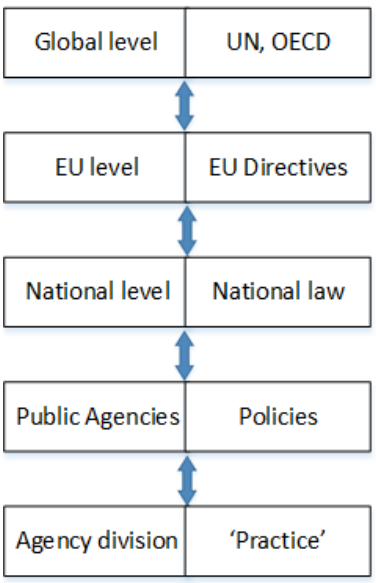


Figure 2 – Institutional level on innovation policy (adopted from Rolfstam, 2013)

	Directly aimed at innovation	**Indirectly influences innovation**
Construction-specific	Instruments explicitly aimed at innovation in construction firms or promotion of certain new construction technologies	Public policies which have an incentive/disincentive effect on innovation
General	Instruments developed for a number of sectors, which are available to construction firms	Public policies and governance structures directed towards the economy as a whole

Figure 3 – Taxonomy of public policy instruments in construction (adopted from Winch, 1999)

The scopes of innovation as well as policy will on one hand be a research limitation, as these by definition exclude other possibly influential parameters. On the other hand, however, these enable the study to keep focused on the main research objectives.

2 Research methodology

The research question is to be answered by answering the sub-questions. Since merely the impact of the different policies in different countries on innovation are mapped and the answers to these questions will be qualitative and non-binary, hypotheses will not be formulated in general. Moreover, the research in general can be described as a qualitative one. However, this qualitative approach will be complemented with quantitative statistics and is therefore to be categorized as a mixed-method research with an embedded research design. The difference in nature of those questions urges for an individual approach for each sub-question with each its own type of data.

However, the study is comparative in nature and calls for a framework in which results are presented per country in a similar and structured way. Therefore, first a framework analysis is presented in which a proper boundary structure is presented for the study. Secondly, the required data as well as the ways of collection are discussed per sub-question, whereafter the methodology is described.

2.1 Research framework

To some extent, this study may be characterized as a multiple case-study. Comparison between cases – i.e. countries – is only possible when data is researched and presented in a comparable way, which makes the study explicit. Therefore, a framework was determined in which the results are presented in a specific way. In previous innovation-oriented CI researches different frameworks have been used. These frameworks with their specific goals are discussed in appendix I. Based on these frameworks, a tailored framework is developed, founded on the Sectoral Innovation System (SIS) approach which is described below.

2.1.1 Sectoral Innovation System

A SI deals with system boundaries, actors and networks, institutions, knowledge dynamics and policy implications (Coenen & Díaz López, 2010). Considering the research questions, this is largely what will be studied in this report. Therefore, we will adopt this framework to a large extent. Andersson and Widén (2005) argue that “the effects on a macro level are that the relations between the actors of the industry are not static but vary from project to project, thus the national systems of innovation has more of an occasional character in construction than national systems of innovation in traditional manufacturing industries” and offer a sectoral approach for the CI. This is in line with the framework used by the innovation policy study as presented by Manseau and Seaden (2001). As this study is only aimed at the CI, the SIS approach will be applied. Because of the large emphasis on the innovation policies, the framework cannot be a mere copy.

Malerba (1999) describes sectoral system of innovation and production as: “[…] composed by the set of heterogeneous agents carrying out market and non-market interactions for the generation, adoption and use of (new and established) technologies and for the creation, production and use of (new and established) products that pertain to a sector (sectoral products)”. In contrast to a more conventional sector definition, a SIS considers knowledge and its structure as a key element. Furthermore, it focusses on the key aspects of firms, such as learning processes, competences, behavior and organization. Also, it places large emphasis on links and complementarities at the input and demand levels. Those interdependencies and complementarities are as such the real boundaries, rather than certain companies or types of companies. Furthermore, non-firm organizations are, as discussed before, considered as an important group of actors, which is also the case in this research.

It also considers relationships between all kinds of agents, which, as a consequence, makes contemplation of the demand agents possible and links in that way for example knowledge to certain suppliers. Finally, the SIS focusses on sectoral dynamics and transformation – an aspect on which innovation policies are often ultimately aimed.

2.1.2 Framework steps

First, a structural analysis will be conducted, consisting of an actor study involving knowledge institutes, educational organizations, industry, market actors and government bodies with supportive organizations. Also the institutions, entailing the rules of the game and constraints that shape human interactions, are made insightful. This also involves the formal policies that are likely to influence the industry, but as this research is largely about these policies, this analysis will be done separately. Furthermore, networks will be mapped, including a geographical focus and clustering and the size of these networks. Finally, technological infrastructure is mapped, showing the streams of knowledge and technology.

Of course, the data has to be collected in a comparable way. The SI-approach as discussed before has a clear view on how to use the concepts, but practical ways of analysis are not standardized yet. Hekkert, Heimeriks, and Harmsen (2011) saw this problem and came up with a manual in order to execute approach in a correct and structured way for TIS. As discussed before, the TIS approach is largely comparable with the SIS approach, so we take this manual as a starting point. By several steps, a complete analysis is done. In this study, not this complete guide is followed, as we are merely interested in mapping the industry and not in the construction of new policies. However, below all steps including the adjustments for this study are discussed in order to provide a coherent framework.

The network diagram, as mentioned above, will be constructed as described by Kuhlmann and Arnold (2001). In that way, the relations between demand industrial system, demand side, intermediary organizations such as research institutes and industry associations, educational institutes, the political system, the context and infrastructure are made clear. It also shows the place of policy making within the whole system. It shows clearly that the political system is influenced by the framework conditions and context and that this political system influences the research agenda, the intermediaries and after all the industrial system. The exact configuration of this system depends on the way the industry is structured and therefore the network will be constructed for every country individually. This network will merely serve in a heuristic fashion in order to catalyze the comparative thinking processes, rather than a normative framework.

Secondly, the phase of development should be determined according to Hekkert et al. (2011). However, they designed their study for Technological Innovations. Therefore, not a lot of attention will be given to this step. However, in relation to policy and policy impacts it might be useful to sketch the current state of the industry in order to place it in a broad context. Especially with the crisis behind and the currently still laborious housing market.

Thirdly, the system composition should be studied in order to make clear how the system is functioning. The first step in this method is the distinguishing of the ‘blocks’. In contrast to TISs, sectoral systems cannot be explained in economic product cycles and therefore the functions as described by Bergek, Jacobsson, Carlsson, Lindmark, and Rickne (2008) are not applicable. Therefore, so-called blocks are individually discussed. Faber and Hoppe (2013) discussed SIS in relation to the environmental sector in construction with a clear, relevant research framework.

The aforementioned blocks can be described as visualized in Figure 4. The agents, interaction and network describe the main conductors of changes in the sector in which also the aforementioned sector structure (step one) is described, with as most important outcome the visualization of the network. The technological regime is about the dynamic links between technologies, complementarities, artefacts and activities. It therefore is closely related to the phase of development as described in step two. The market-demand block addresses the asymmetry in information and preferences for both clients and contractors as users and a lack of skills. As such, it describes the imperfection of the market, which is the base of lots of policy initiatives as we will learn during the policy analysis. Institutional framing contains the actual policy and strategy analysis of construction innovation. The separate relation to sectoral patterns makes clear why a thorough policy analysis is not a part of the structural analysis and forms a separate entity which is codependent on the market demand, technological regime and sector structure. Step three therefore forms a synthesis of step one, two and a policy analysis.

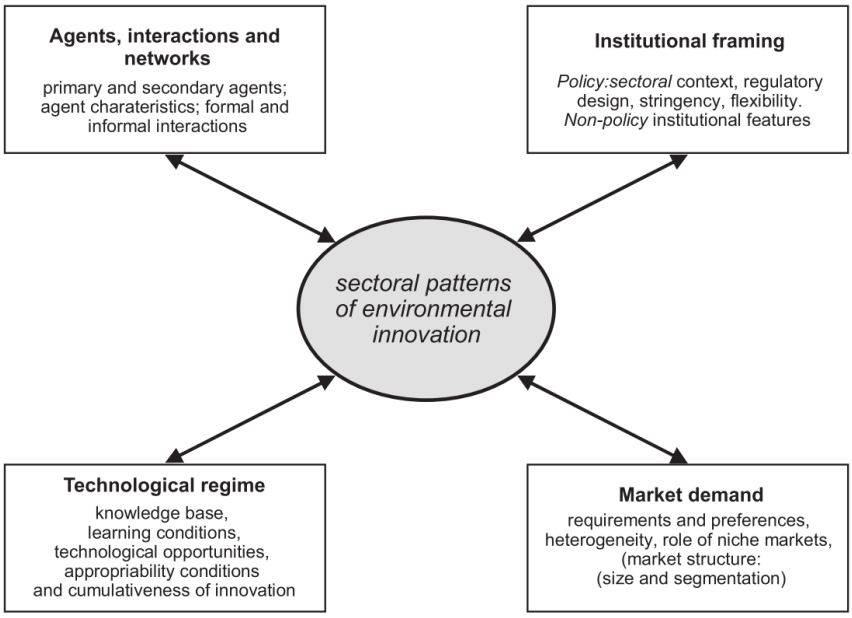


Figure 4 – Blocks in a SIS that explain the sectoral patterns (Adopted from Faber & Hoppe (2013))

The outcome of this analysis provides a basis for the fourth step. The structural cause for functional barriers should in that phase be determined. To start with, the system blocks that form a barrier are selected. Thereafter, the structural components are studied for each function, consisting of actors, networks, institutions, technology and knowledge and external factors.

Fifth, the obstacles for policy goals are to be determined based on the structural causes for functional barriers. It may be clear that this is not the main aim of this study and therefor the larges emphasis will be on step three. However, step one and two are necessary in order to start step three, but this will be kept as brief as possible. The forth step as discussed in this method will be more or less exchanged with the reflection of the innovation policies and initiatives in relation to the relations derived from step three in order to determine the successfulness and impact of certain innovation policies. Summarized, this manual is presented in a roadmap as shown in Figure 5. The step numbering of this representation will also be referred to in the next chapters of the report.

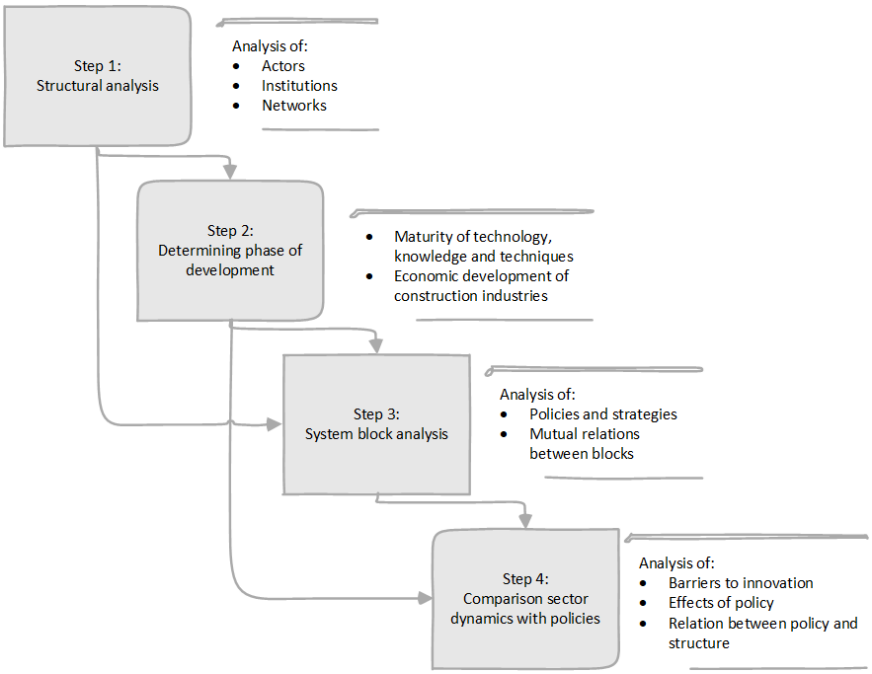


Figure 5 – Roadmap tailored SIS-approach used in this study

2.2 Data collection and research methodology

The data of this research contain of statistics, as well as qualitative policies and measures. The first group is largely obtained by national statistics institutes like CBS in the Netherlands and by analyzing research reports. The latter will be done by literature analysis and validation through face-to-face interviews with experts. Per sub-question, the more specific data aspects and methodologies are discussed below. For the sake of clearness, the sub-questions from the introduction are repeated below and the numbering corresponds with the section numbering.

1. How do governments of the preselected countries relate to each other and what are the connections with the European Commission's initiatives and policies?
2. How is the Dutch construction industry structured and how does it manage innovation policies?
3. What are the characteristics and statistics of the construction industries in the addressed countries?
4. Which role plays innovation in the construction industries of the Netherlands and the addressed countries?
5. What are the effects of the different initiatives and policies on the daily practice in construction?
6. What are the similarities and differences between the way the innovation policies are made and managed in the addressed countries and the Netherlands?

2.2.1 Influence of national and European governments

In chapter 3, the European Union and its influence on individual member states are researched. In this way, the whole system is analyzed from large (EU) to small (individual countries). First general information about the EU is given in order to provide a clear overview of the balance of power between member states. Information published by the EC is furthermore gathered. This is done by reviewing the EC's reports, which are available in abundance. These reports include qualitative as well as quantitative data in order to determine the policies and facilitate the benchmarking between

countries. Most of these EC's reports as well as the EU's reports are publicly accessible. In this report, the analysis of the EU are presented before the individual country analysis as policies of individual countries are not rarely based on European initiatives.

In this sub-question, several public roles towards the policies are examined. These consist of the governments of the pre-selected countries and the European implementing body. It is therefore useful to consider the writers, organizations and financers of the researches and publications. As the role of the different governments can largely be extracted from the literature in the previous sub-questions, specifically the reports published by the EC are studied. Also interviews are required with (innovation) policy experts in order to determine the role and the influence of the EC on the national policies on innovation in the CIs. However, these interviews are conducted after sub-question 2, 3 and 4 are answered, and are validating in nature. Globally oriented reports such as OECD reports also construct a useful addition to this part. In relation to the SIS framework, this contains as parts of step one and two.

2.2.2 Structure Dutch construction industry and innovation policies

First of all, an analysis has to be made of the trends in the Dutch CI in the recent past in order to construct a proper view of the structure of the sector. Statistics of the industry regarding economic development, investment in R&D and education are gathered in order to make the results comparable with other countries. Secondly, after the entire structure and different regulations, agencies and networks was clear, the different policies on innovation in the CI were collected; from the Dutch government as well as the market parties, including sector broad initiatives. This data made it possible to elaborate the sub-question. All this information was found online in openly accessible reports and research papers which can be found on indexing sites such as Scopus and Google Scholar.

This sub-question is answered in a descriptive way. First, the more general structure of the Dutch CI is described and in a historical way the tendencies in the industry are discussed. The SI-approach of structuring is used in which networks and agents form an important part. Also a phase of development is included which provides a view of the industry within time, especially in relation to the crisis and subsequent recovery. From this broad view, the focus is placed more and more on the innovation policies. Secondly, the Dutch innovation policies and sector initiatives are listed and described. Finally, these policies and initiatives are linked to each other in order to construct one view of the place of innovation policies in the Dutch CI. The SI manual as described before will be taken as a guide, particularly focusing on the first two steps.

2.2.3 Structure construction industry foreign countries

The data required for this question are highly comparable with the sort of data from sub-question 2. However, sub-question 2 is aimed at revealing the sector structure, while this question takes its main interests in the part about policies and industry change-oriented initiatives. These policies are collected per preselected country. Furthermore, general statistics about the economy, the place of the CI and innovation in the CI are gathered, but in contrast to the previous question, the organization of the entire sector are analyzed less in depth. All this data was found online in openly accessible reports and research papers which can be found on indexing sites such as Scopus and Google Scholar.

The different industries are solely evaluated on international oriented statistics. Therefore, merely a general view of the countries' CI is constructed. Thereafter the different innovation policies, innovation networks and sector initiatives are mapped. The result is a list of policies and initiatives per

country and a global view of its relation to the concerned CI and the country's economics. It is hereby useful to structure the assessment of each country in a similar way in order to make benchmarking possible. Just as in sub-question 2, the SI manual is used as a guide, be it in a less detailed way. Eventually, after a horizontal country analysis, a separate integrated chapter presents short comparisons of countries' characteristics. This part, as described in the conclusion of section 5.5, gives a brief overview and perspective of the different CI, including the Dutch one.

2.2.4 Role of innovation policies and initiatives

During the research, more and more information was gathered, revealing the flaws and gaps in literature and policy measures. Therefore, per country, including the Netherlands, the list of different policies and initiatives as collected in sub-question 2 is complemented. Furthermore, specific data about innovation policies, its application and its impact was gathered by interviewing experts in the different countries. This data will be qualitative rather than quantitative. The first part of the data were largely found online in openly accessible reports and research papers which can be found on indexing sites such as Scopus and Google Scholar. The experts were found through Professor Halman's contacts and references in the literature found.

The previous two questions are iterative ones, as the pile of literature is almost inexhaustible and more policies and initiatives are discovered while using new references in studied literature. Therefore, the first step is to wrap up the literature's data and finalize the lists of construction innovation policies, regulations, initiatives and networks. Thereafter, those innovation related aspects are studied more in-depth. Also experts are interviewed in order to construct an solid and up-to-date overview of the policies and its role within the CI, while the foundations are based on the published reports.

2.2.5 Effects of innovation policies and initiatives

This question succeeds more or less sub-questions 3 and 4 and mainly qualitative data was collected. First of all, this is done by reviewing progress reports and commentary reports and secondly, experts are interviewed to get their views on the matter. Also the statistical data gathered in sub-question 2 aided in determining whether policies in the histories had effect on the innovation in a certain CI. However, this was largely based on drawing parallels between literature and statistical data due to the aforementioned lack in time. New literature will – if the previous questions are answered in a proper way – not play a large role in this sub-question.

First the list of policies and initiatives is used. This list is chronologically ordered per country, followed by a quantitative as well as qualitative classification of the different policies. The actual analysis of innovation policy impact is a difficult field on which several methods are designed, each with other assumptions and aimed at other policy fields. Edler et al., (2016) have conducted an exceptionally extensive literature study on impacts of innovation policies and have formulated roughly 18 different ways of innovation policy impact analysis.

The typology used was first the policy instruments were divided into demand and supply-side. Furthermore, seven major innovation policy goals were defined: (1) increasing R&D investment, (2) augmenting skills, (3) enabling access to expertise, (4) strengthening system-wide capabilities and exploiting complementarities, (5) enhancing innovation demand, (6) improving frameworks for innovation including regulations and standards, and (7) facilitating exchange and dialogue about innovation (Edler et al., 2016). All instruments that were observed are allocated to one or more of

these goals. This categorization is presented in Figure 6 on the next page. Each category has its own subdivision and each subdivision has its own specific types. The different categories are linked to Winch's taxonomy of construction innovation as presented in Figure 3 in section 1.5. Although types of policies may or may not be directly aimed at the CI, the most construction-favorable option is shown in the figure. Needless to say, each policy is unique due to its dependency on context. Furthermore, each policy and its impact is dependent on other policies and does not stand on its own (Cunningham, Edler, Flanagan, & Larédo, 2013).

Each innovation policy will be categorized in order to construct a network of innovation policies in construction per country. As discussed before, individual policy effect assessment is infeasible, which constrains us to draw conclusion on the basis of general literature assessment per type of policy. The Compendium which is presented in the *Handbook of Innovation Impact* will help constructing a scientific basis for the conclusions (Edler et al., 2016). The structural analyses will help placing the different policies in perspective and completing the framework in order enable benchmarking.

2.2.6 Comparison between the different countries

Not a lot of new data is required for benchmarking the results, since it combines several previous sub-questions and analyses the system as presented in the framework. An important source of information, however, was aimed at validation. The findings and the conclusions drawn are assessed by experts by means of interviews. Although barely new data was extracted from literature, the experts' opinions are an important source for a robust and valid research and functions as the third pillar of triangulation. Finally, the different policies with their results are compared in a qualitative way with each other. In this way it became clear which policies are successful and which preconditions are needed to make such policies successful. Also the role of the EC on the actual innovation in the CIs is studied in this part. This sub-question answers almost entirely the main question. However, these outcomes are used to determine were opportunities of improvement are in the Dutch CI and finally to give concrete recommendations in order to improve the innovativeness of the Dutch CI.

2.2.7 Research conclusion

After applying the previously mentioned methodologies, all required information and reasoning was done. However, the main question is not yet answered in a powerful and effective way. To do so, sub-question 5 and 6 have been taken together and a clear research conclusion were drawn. This conclusion will consist of the following aspects:

- Comparison between all countries on the innovation in the CI;
- Effect of the innovation policies on the performance of the CIs;
- A resume of the most effective innovation policies and initiatives;
- The opportunities for the Dutch CI based on successful foreign policies.

This will partly consist of a conclusion and partly a recommendation. This recommendation confines itself to the Dutch CI and is aimed at making the Dutch construction sector more innovative and in the end economically more powerful. It contains concrete policies and strategies obtained from the other studied countries.

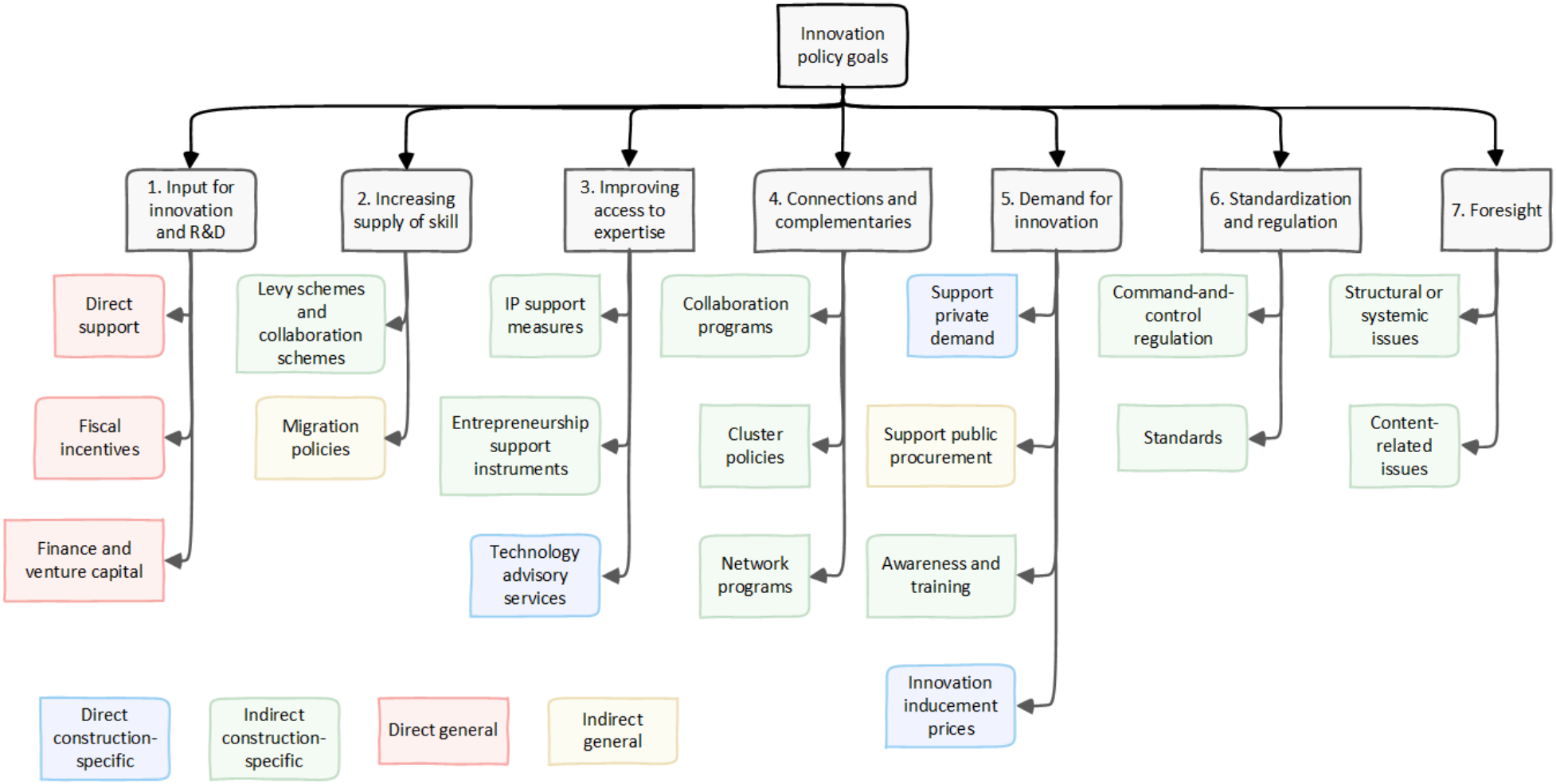


Figure 6 – Categorization of innovation policy instruments (based on Edler et al., 2016)

3 European Union

In this study, the Netherlands, the United Kingdom, Denmark, Sweden and Germany are studied, which all members of the European Union. This chapter describes the EU with its bodies relevant to construction and innovation policy.

3.1 The European Union and its bodies

The executive body is the European Commission (EC), which is also responsible for the implementation of decisions and day-to-day businesses and it furthermore proposes legislation. This implementation goes along with development of policies and visions, which are mostly initiated by the European Council, the body consisting of EU member state leaders that sets the agenda. In this chapter we will take a look at the innovation related policies that are launched by EU-related agencies. There are several reports presented by the EU and especially by the EC. The ones related to innovation and construction are published below. Merely strategic and concluding papers and studied are mentioned, while more policy-specific studies are mentioned in chapter 6. However, each of the recent publications has somehow a relation to the general 2020 strategy, which will be discussed firstly.

3.2 The strategies and platforms

Below, the different strategies are presented that directly affect construction and innovation policies in the policies of the member states.

3.2.1 Europe 2020

In 2010, a collaborative strategy was developed called *Europe 2020*. However, this was a follow-up on the much older *Lisbon Strategy*. Samardžija and Butković (2012) published the consolidation of different papers in the book *From Lisbon strategy to Europe 2020*, which perfectly explains the ins and outs of both strategies and their differences and similarities. In 2000, the *Lisbon Strategy* was adopted for a period of 10 years. The European Council has initiated this strategy and set several goals and prioritizations. In these ambitions, strengthen Europe's knowledge base to world's top and strive to an economic growth of 3% in 2010. In particular attention was paid to R&D, with the policy for every member country to spend 3% of the GDP on R&D with a significant contribution from the industry. The results, however, were disappointing and only several Scandinavian countries nearly lived up to the agreement.

From 2010, a new strategy was therefore needed and was in 2010 agreed on by the European Council, called Europe 2020. In the contrary to ten years earlier, sustainability and a 'green' economy was an important item on the agenda. Also the crisis which started two years earlier had a large impact on the strategy. In this strategy, the agreement to spend 3% of the GDP on R&D still stands tall. Regarding environment and greenhouse gasses, 20/20/20 goals are set, entailing an overall reduction of 20% of emission of greenhouse gasses since 1990, an increase in energy efficiency of 20% and an increase of 20% in renewable energy consumption. Besides, there are set national goals which are nation-specific. Also seven *flagship initiatives* were defined (European Commission, 2010). Those initiatives are the following:

- Innovation Union to improve framework conditions for innovation;
- Youth on the Move to enhance education performance;

- A Digital Agenda for Europe for improving the internet infrastructure and was adopted from the German initiative which was discussed in the previous chapter;
- Resource Efficient Europe for stimulating renewable resources and energy;
- An Industrial Policy for improving business environment, focusing on SMEs;
- Agenda for new Skills and Jobs for modernizing the labor market;
- European Platform against Poverty for ensuring social and territorial cohesion such that growth and jobs are equally shared; also amongst people who live in poverty.

For this entire framework program, a budget of 80 billion was reserved from 2014 to 2020. In order to oversee compliance and enforcement of the strategy, the European Semester was introduced, which oversees implementation in all member countries by an annually repeating procedure. This strategy is the overarching strategy and all European policies and initiatives fall directly or indirectly under this umbrella – also regarding innovation the CI. Even a large share of national strategies and initiatives are shaped in order to connect to this overshadowing program.

3.2.2 Progress reports Europe 2020

In order to monitor the whole strategy, every two years EU countries report to the EC about the progress and especially on the renewable energy goals. The EC publishes every two years a progress report in which the last one is published in the beginning of 2017. The key findings include that the renewable energy was in 2014 16% of the total energy consumption and an estimated increase of 0,4% in 2015. Although the prospects are good for the goals in 2020 to reach the 20% in 2020, but the efforts should not flag. In the transport sector, specific goals were set, but several countries have to increase their efforts dramatically to reach those goals. This is also the case for the countries selected in this study, except for Sweden, which is already over doubling the goals (European Commission, 2017b). These goals are relatively easy to measure and therefore proper monitoring is feasible. However, other goals in the strategy, such as education or business environment, are rather vague and especially preliminary impossible to measure in a comparable fashion.

3.2.3 Construction 2020 program

Construction 2020 is aimed at identifying and implementing measures that help fostering sustainable competitiveness in the construction sector in the short as well as in the medium to long term. It was launched in 2013 accompanied by a *Construction 2020 Action Plan*. In order to catalyze implementation, five key objectives were identified, being:

- Stimulating favorable investment conditions;
- Improving the human-capital basis of the construction sector;
- Improving resource efficiency, environmental performance and business opportunities;
- Strengthening the Internal Market for construction;
- Fostering the global competitive position of EU construction enterprises.

Those key objectives were assigned to *thematic task groups* (TGs) which were created in the same period as the *High Level Tripartite Strategic Forum* (HLF), which was launched in order to minor the overall implementation progress of the strategy (High Level Tripartite Strategic Forum, 2014). The first thematic group, fully “Stimulating investment in building renovation, infrastructure and innovation”, is the one that is closest to innovation policy. This is a broad pillar and includes several recommendations. From the recommendations of the HLF, one in particular is on stimulating

innovation. It recommends to support innovative *lighthouse projects* addressing various market segments and project sizes to strengthen synergies between public funds and private investors. Another relevant recommendation is to develop a quality assurance strategy specific to the respective needs of new materials, technology and services to ensure their take up by the market and insurance coverage. The latter may aid moreover in increasing innovativeness.

3.2.4 Construction and innovation strategies

As stated before, the main current strategies are all fit within the *Europe 2020* strategy while some long-term strategies were launched under the *Lisbon Strategy*; all as parts of one big strategy. The first big strategy is *Construction 2020*, which was published in 2012 by the EC. A sustainable construction sector plays a crucial role in reaching the EU's long term 80-95% greenhouse gas emission reduction objective for 2050. The required investments would contribute substantially to the competitiveness of the European construction sector. The sector has also an important role to play in adaptation to climate change and resilience to natural and man-made disasters by promoting long term disaster-proof investments (European Commission, 2012).

3.2.5 Strategy for the sustainable competitiveness

In 2012, the EC presented the communication 'Strategy for the sustainable competitiveness of the construction sector and its enterprises' to the EP in which it suggested a strategy to stimulate sustainable competitiveness in the member states' CI. Next to a state of play, concrete measures were presented in order to improve the CI, including fiscal instruments, pilot projects, improvement of the construction value chain and improvement of skills in sustainable construction. This paper was aimed at the short term as well as the long term. Most of these measures were at least partly executed and several suggestions, such as the HLF as mentioned in section 3.2.3 was initiated in this strategic paper. A comparison between de member states, however, was not included in this report.

3.2.6 Horizon 2020

Within the *Europe 2020* strategy, framework program *Horizon 2020* was developed in 2014 in order to stimulate R&D. A record amount of almost 80 billion euros reserved for R&D initiatives throughout Europe for targeted research funding (European Commission, 2014). The EC distinguishes six specific areas, being social innovation, design for innovation, demand-side innovation, public sector innovation, public procurement innovation and workplace innovation. Most tools within this policy are rather general and therefore also applicable to construction research, such as risk sharing and sustainable energy. This funding comes straight from Europe, without national interference.

3.2.7 Energy-efficient Buildings PPP

The EC has forged a PPP with the public sector as represented by the *Energy-efficient Buildings Association* (E2BA), an initiative of the European Construction Technology Platform. In the multiannual *Energy-efficient Buildings* (EeB) roadmap R&I priorities of the private sector are presented and together with the EC, KPIs and outputs are delivered (European Commission, 2013). 600 million euro is allocated in the period of 2014 to 2020 to create and integrate technologies and solutions to reduce energy consumption and GHG emissions, turn the building construction industry into a knowledge-driven business and to develop innovative and smart systemic approaches for green buildings and districts.

4 Dutch construction industry

The previous chapter gave an insight in European initiatives. However, the final objective of this report is for the Dutch CI to learn from foreign countries. Therefore, proper comparisons need to be made, especially between the Netherlands and the pre-selected countries. Hence, the Dutch CI is discussed first and most elaborate. This is conducted according the steps described in the previous chapter. Accordingly, the structural analysis, phase of development and function analysis will are addressed. First, a brief sketch of the past in the Dutch CI is given, followed by a systematic structural analysis. The structure is summarized in table form together with the other countries' CIs in section 5.5.

4.1 History and context

The Dutch CI has always been an extraordinary one. First of all, its tradition with water-related projects made it world-famous and secondly the regulations concerning collusion and cartels have until 2002 been very loose compared to other countries. In *De economische kracht van de bouw*, Jacobs, Kuijper and Roes (1992) describe the situation of the Dutch CI up to 1992 on the basis of *Porter's Diamond*[1]. The main conclusion of this study was that construction firms have the idea that innovative activities do not pay off and that in the future, the focus should be on long term strategies with respect to own employees and knowledge, integration of design and construct, an open dialogue with suppliers and buyers, rewarding of innovative initiatives, use ambitious pilot projects, increase entrance barriers by higher differentiation and quality upgrading. Rather than technological force, the sector benefits according to that study more from social-organizational innovations. These tendencies would according to Jacobs et al. (1992) lead to overall improvement for all parties within the supply chain.

4.1.1 Collusion

A real change in the industry, however, did not occur in response to this study. Although a small tendency in the right direction occurred, the focus on cost-based price competition did barely lose ground (Seaden & Manseau, 2001). This follows from the big construction fraud which was exposed in 2002. After this case, the regulations were tightened and, also under influence of foreign political pressure, the legal cartels have come largely to an end. This went hand in hand with contracts becoming tighter and thicker, which moreover influenced the procurement legislation. Dorée (2004) has thoroughly reviewed this subject and came with a set of recommendations regarding the future of the CI and ways to prevent it from happening again in the future. A tougher public sector procurement policy and the continued reliance on lowest bid prices may not contribute to the reform of the Dutch CI as intended. One-dimensional, price-oriented competition only provides a static, project-based efficiency. However, according to Dorée (2004) it neither addresses a number of organizational issues, nor resolves it the underlying pressures leading to collusion. An alternative approach allowing for a balance of competition and collaboration with a wider number of selection criteria variables would create a more dynamic, iterative competitive process over a longer timeframe. It furthermore would help in developing an innovative, efficient and profitable industry.

[1] In Porter's Diamond, presented in *Competitive Advantages of Nations* (Porter, 1990), Michael Porter links the firm's or sector's factor conditions, strategy, demand conditions and substitutes or supporting industries. In this way, the production, market, networks and economy is related to one another, with its strengths, weaknesses and structure as a whole. Also the competitiveness is considered in this way between customer, suppliers, substitute and potential entrants on the basis of Porter's theories.

4.1.2 Industry performance

A quite comparable conclusion towards the industry's performance was drawn by TNO in their 2005 report *Innovatie in de bouw*, in which the Dutch CI is classified as a low-innovative sector; a conclusion which was drawn in as good as all relevant researches (Bruijn & Maas, 2005). First of all, the amount of R&D activities is too low in the sector just as the average level of education. Secondly, the market structure forms, just as presented by Dorée (2004), a large barrier. Thirdly, the CI can be split up in different sub-sectors, such as utilities and infrastructure, which are highly variable in terms of innovation. Fourth, the collaboration with clients and users is too low for creating a stimulating working environment and fifth, the TNO report shows us that almost exclusively large companies have active R&D policies.

These researches, their recommendations and the sector's responses came to an end when the global economic and financial crisis struck the industry in 2007-2008 (hereafter referred to as 'the crisis'). Although, the CI is due to its big projects a slow reactor to the market, the crisis left a huge mark on the sector from 2009 to 2014. In *Strategie en crisis: reacties van bouwbedrijven op de economie* by Vrolijk (2010), the EIB studied over 900 Dutch construction firms in how their response to this crisis was and which strategies they applied in order to survive. The report stated that four out of five companies declared to experience difficulties because of the crisis. Two out of five companies admitted to have taken strategical measures to gain advantages over their competitors. The majority of these measures was aimed at the short-term. Implementation, however, did not go without difficulties, out of which can be concluded that a large majority did not have a straight vision in how to cope with the crisis situation. Interesting to see, on the other hand, was that the level of innovation, and especially process innovation, was during and just after the crisis higher than before, as companies are triggered to review their ways of doing business and their competitive position.

4.2 Structural analysis

Now the context of the industry on the basis of a short history review has been depicted, the current structure of the sector can be analyzed. This structural review contains in short of an actor analysis, institution and policy analysis and network analysis. When these three elements have become clear, the main industry's structure ought to be clear. This includes the relations between different actors and the role of institutions. First the different actors and networks are mapped and thereafter a more comprehensive system analysis is done.

4.2.1 Actors

Different types of actors are to be distinguished in order to give a clear view of the interrelationships and shape of the network. For the sake of consistency, the categorization of Hekkert et al. (2011) as described in chapter 2.1 is followed, which consists of knowledge institutes, educational organizations, industry, market actors and government bodies & supportive organizations.

4.2.1.1 Knowledge institutes

Knowledge institutes entail the organizations which has as primary goal to develop knowledge, transfer knowledge or both. In the Netherlands, there are several organizations that confine themselves with this mission, within the construction industry as well as cross-sectoral. Cross-sectoral, the *Netherlands Organization for Applied Scientific Research* (TNO) is, apart from universities, the largest public research organization in the Netherlands. This organization is established by law in 1932 and as a public organization, it acts independently, funded with public money. It has several main

areas of expertise, in which the built environment is an important one (TNO, 2017). Due to recent and planned cuts, the number of employees and areas of expertise have gradually decreased. However, its stake in Dutch research is still significant. TNO is united with five other big research institutes (such as Deltares) in the newly launched TO2 federation. This collaboration initiative is aimed at streamlining the research efforts in the Netherlands.

Furthermore, CBS is an independent administrative authority that publishes statistical information and analyses regarding all kinds of public interest (CBS, 2017). Also, is the *Centraal Planbureau* (CPB), which is an interdepartmental research institute that formally falls under the Ministry of Health, Welfare and Sports (VWS). It conduct research for the government on economic policy analysis, also in relation to the construction sector. Next to the CPB, the Dutch government also has a *Sociaal en Cultureel Planbureau* (SCP), focusing more on the soft aspects of national policy. Regarding the organizational side of construction, PIANOo offers as part of the Ministry of Economic Affairs (EZ) information regarding public tendering, procurement and current legislation in this field. Other than economic policy analysis, this organization researches social science policies. Despite not the entire spectrum of research and knowledge institutes is covered, the ones most relevant to the Dutch CI are discussed above. In national perspective, the research system is shown in Figure 7. It shows clearly the whole knowledge structure. However, the CI has merely a small share in this whole research base. From 2017, however, NWO became a part of STW and was after this moment financed by EZ instead of ECS (NWO, 2017). The original scheme from Janssen, Erven, Den Hertog, and Jonkers (2016) was therefore slightly altered. Of course, universities are also responsible for development and distribution of knowledge, but these are discussed separately in the next section.

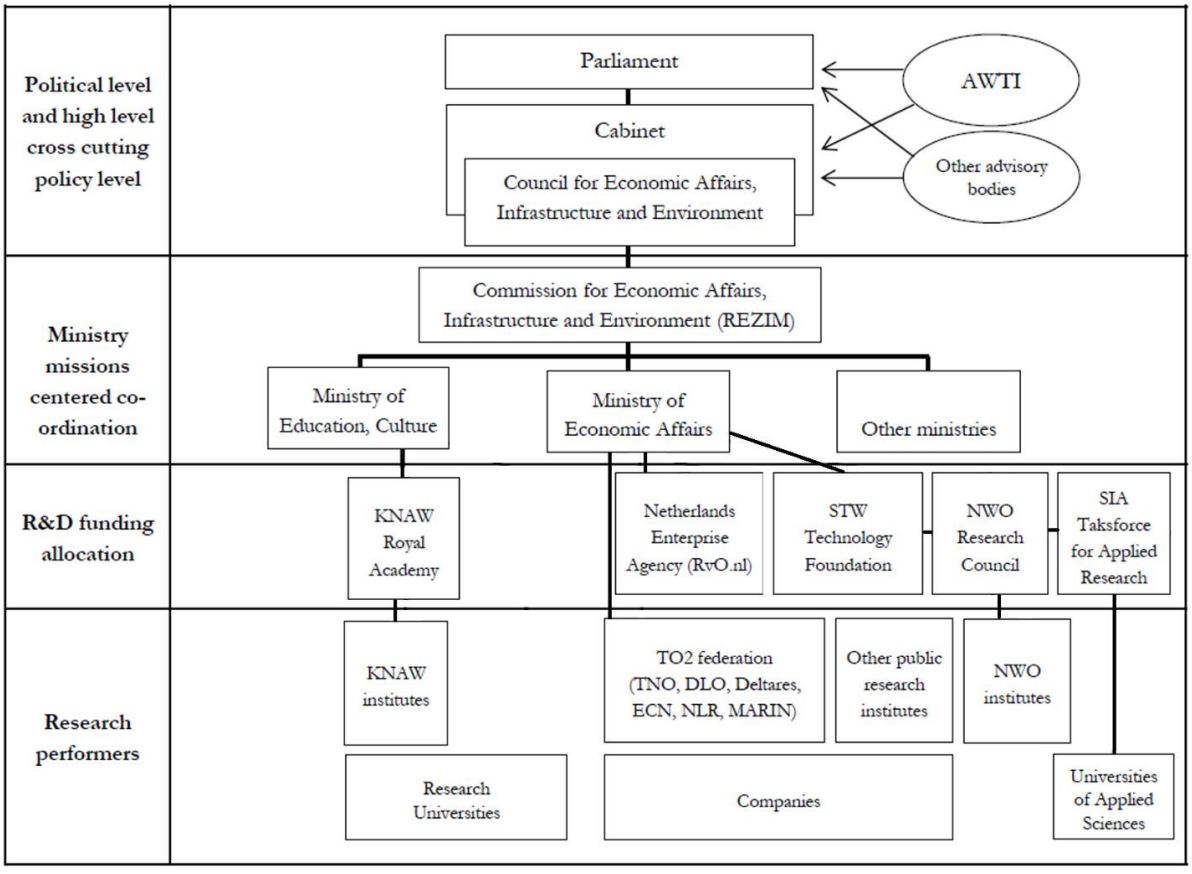


Figure 7 – Dutch national research system (interpreted from Janssen et al., 2016)

Within the sector, particularly the EIB, researches the economic aspects of the Dutch CI extensively. On its own initiative as well as commissioned by market parties and government, it studies in an independent and scientific fashion the economic and social issues within the CI (EIB, 2017). The *SBRCURnet* is an intermediary organization that aims at stimulation of innovation in the CI. It offers platforms for professionals and aims furthermore at placing current topics on the national agenda (SBR, 2016). Also STABU is an independent knowledge institute focused at supporting quality and efficiency within the lifecycle of buildings by offering structured, standardized and validated information exchange within the sector. Furthermore, Deltares is an influential research institution, but first of all it limits itself to water-related topics and secondly it is strongly focused on technical research (Deltares, 2017). Even more specialized, is for example the COB which is a knowledge institute regarding undergrounding construction. Also the CROW is an influential Dutch knowledge organization regarding traffic and infrastructural affairs. It publishes technical and organizational guidelines regarding design of infrastructure which are not legally binding, but are highly respected. ISSO does the same for installation techniques. These organizations are also known as intermediary knowledge organizations.

4.2.1.2 Educational organizations

Next to the knowledge institutes, educational educations are strongly woven into knowledge development and distribution. Also the training of (future) employees is an essential aspect. Moreover, professionals are trained by different market initiatives, such as BuildUpSkills, but as it is initiated by market parties, these institutes and networks are not discussed further. The most important educational organizations with a view to knowledge creation and innovative alumni are universities. First of all, the different departments have each their own areas of expertise who conduct research commissioned by others as well as on their own initiative. Furthermore, and no less important, is the fact that universities educate their students with certain motives. Each Master's program has its own teaching goals, which enables its alumni to work in a desired way in the industry, be it commercial organizations, governmental organizations or universities.

Within the Dutch higher education, a binary system is visible, containing research universities (called universities) and universities of applied science (called HBO). In recent years, the latter group also has been producing more and more knowledge, while the old system was mainly aimed at university research. The system as used in the Netherlands is considered as rather efficient and well-performing in various international comparisons of performance. This success has been attributed to the education reform initiatives that were undertaken during the end of '80s, being one of the frontrunners in modernization of higher education in Europe (Elken, Frølich, & Reymert, 2016). Recently, focus has shifted from equality towards increased differentiation in education. A government appointed national commission highlighted in its 2010 report the need for further differentiation in structure, between institutions and in study program profile. Performance contracts were introduced in 2012, and the first round will be completed in 2016 when it will be evaluated to decide whether this will be incorporated into the law. The idea of contracts was already put forward in 2005 and there was a test period with collective agreements in 2008-2011. The current rationale for introduction of individual contracts can be found in the following 2011 *Quality in Diversity* strategy, as the need for more institutional profiling and differentiation has been emphasized in the system (Elken et al., 2016). 7% of the teaching budget is performance based. The process is monitored by a review committee, who has provided a yearly report on progress. Currently, the system is being evaluated with an expected outcome in the course of 2017.

From the 13 regular, public Dutch Universities, 12 were in the global top 200 in 2016 according to the *New York Times* (NYT), which indicates an excellent level of higher education; especially when considering the size of the country. In the Netherlands, there are several technical universities who offer programs directly aimed at the CI, being University of Twente (UT), Technical University of Delft (TUD) and Technical University Eindhoven (TU/e). Those three universities collaborate also within the 3TU program with *speerpunt bouw*, aimed at integral knowledge development and education regarding the construction sector.

Recently this 3TU is extended to 4TU, including the agricultural Wageningen University, but this last one is not specialized in construction. The first two also offer programs aimed at a broader (construction) engineering management perspective. Also the University of Utrecht (UU), University of Amsterdam (UvA) and Erasmus University (EUR) offer Master's programs about policy making and innovation in the public sector, be it not specialized in construction. Furthermore, there are several universities, among which Rijksuniversiteit Groningen (RUG), Vrije Universiteit (VU), Maastricht University (UM), Radboud University (RU) and Tilburg University who offer programs that have common ground with innovation policies in the construction industry. Regarding research in this field, several Dutch universities stand out in particular. Respecting the CI specifically, the TUD and UT have professorships at this particular subject. Concerning the broader connection with policy, the UvA, EUR and UU published several relevant reports and papers.

4.2.1.3 Industry

The CI is a rather special branch in which the relations and interrelational expectations are unique (Noordhuis & Vrijhoef, 2011). A value chain analysis helps in making the industry's structure clearer (Porter, 1985). However, a proper value chain analysis aims at business level within a branch and within this master thesis project, that level of detail is not feasible. Therefore, a mere description of the business activities is given with the focus on the entire value chain.

In the CI, products, mainly large products, in the form of buildings and civil constructions, are built by main contractors. Clients buy those 'products' from the main contractor, who is going to fabricate it in the form of a unique project. In this project, most often the main contractor looks for partners in the form of sub-contractors and suppliers in order to get all specialized works done. Wat can and cannot be done is in the Netherlands defined in the legally binding *Bouwbesluit*. When the government is client, which is common in the heavy and civil construction works, the client cannot choose its own 'product supplier', but should apply public tendering, which is legally defined in European conventions, community law, Dutch legislation and regulations and most importantly, *Aanbestedingsreglement Werken* and *Aanbestedingswet 2016*. Although this methods increases equal chances in the sector, the focus on price often affects quality and level of innovation. Furthermore, it is often considered as a large barrier to innovation, which will be discussed later on.

The development of the industry is also visible through statistics. These statistics are largely obtained from CBS, which keeps among other things track of the spatial, demographic and economic situation of the Netherlands. In order to express the industry in numbers, the amount of employees, size of the companies, sector turnover and relative growth are studied.

First the size of the industry is expressed by means of firms, employees and turnover. Table 1 show us that in terms of employees, the specialized sector is the biggest one, from which a major part consist of installation firms, united in Uneto-Vni (CBS, 2017). Table 2, regarding turnover, confirms this.

However, the difference in amount of employees is way bigger, as the building construction sector is far more capital intensive due to the large amount of materials used. The same applies to the service sector in which labor costs comprise the largest expenses. It is striking that the group of architects and engineers is larger than the group of architects and engineers contains more employees than building construction. The main reason is that the former contains a large amount of sub-categories in which building construction workers are barely needed, such as consultancy on traffic, city planning, technical installations, environmental issues, soil survey and much more. Also project management is included in this group, which is also responsible for a considerable workforce (CBS, 2017).

Table 1 – Employees per subsector x1000 people (Source: CBS statline)

YEAR	Building construction	Heavy & Civil	Specialized	Architects and engineers
2010	105,4	58,9	213,6	114,6
2011	107,3	58,7	215,6	112,6
2012	100,1	59,9	207,1	109,6
2013	85,3	56,7	191,1	109,4
2014	81,5	55,6	181,5	112,2

Table 2 – Net turnover in million euros (Source: CBS statline)

YEAR	Building construction	Heavy & Civil	Specialized	Architects and engineers
2010	29.789	13.838	35.328	15.344
2011	31.661	14.706	36.743	15.496
2012	28.058	13.990	34.538	15.233
2013	24.967	14.453	32.970	15.126
2014	25.411	14.535	33.069	15.541

From 2010 to 2014, in particular the building construction has had a setback (Figure 8); still a result from the economic crisis. Albeit in a lesser extent, this also is the case for the specialized sector. Particularly installation is strongly dependent on the building construction subsector, which is visible in the fluctuation of a similar shape. Figure 7 shows also that the heavy and civil subsector have recovered quicker, what mainly has been the result of the fact that these subsectors are largely government-dependent instead of being reliant on private investors. The same fluctuations follow from Figure 9 which shows the amount of firms with 100 employees or more. The figure shows also that building construction firms are often the large firms, while heavy & civil and specialized companies rely, especially in relation to the turnover, much more on small enterprises. This statement is confirmed by the tendency of amount of companies, from which also the interesting conclusion can be drawn that enlisted companies consist for over 80% of freelancers, who are united in *Zelfstandigen Bouw* (ZBO). However, the big companies and larger SMEs together embody so many employees, that merely 30% of all people work in the CI as freelancers.

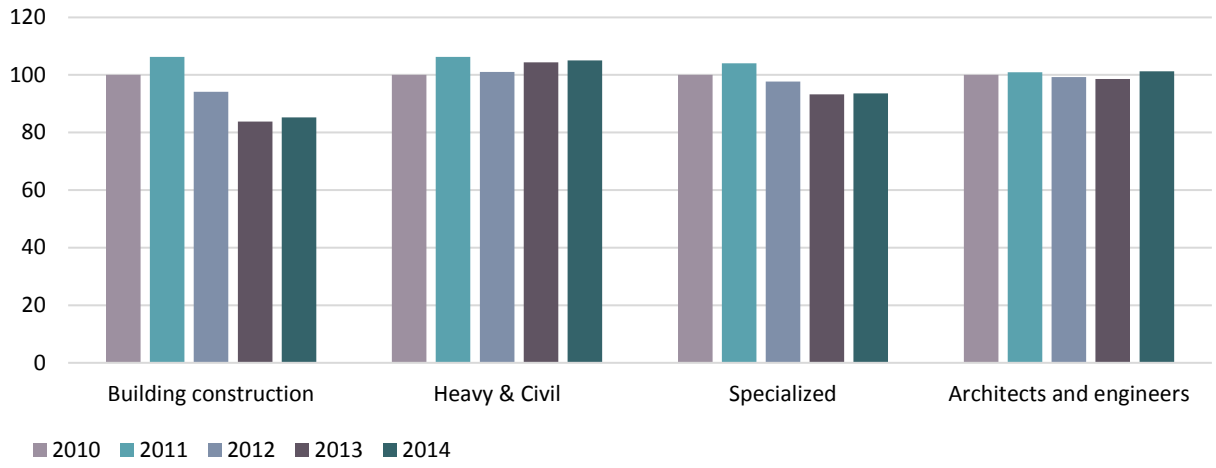


Figure 8 – Indexation net turnover from 2010 to 2014 (source: CBS statline)

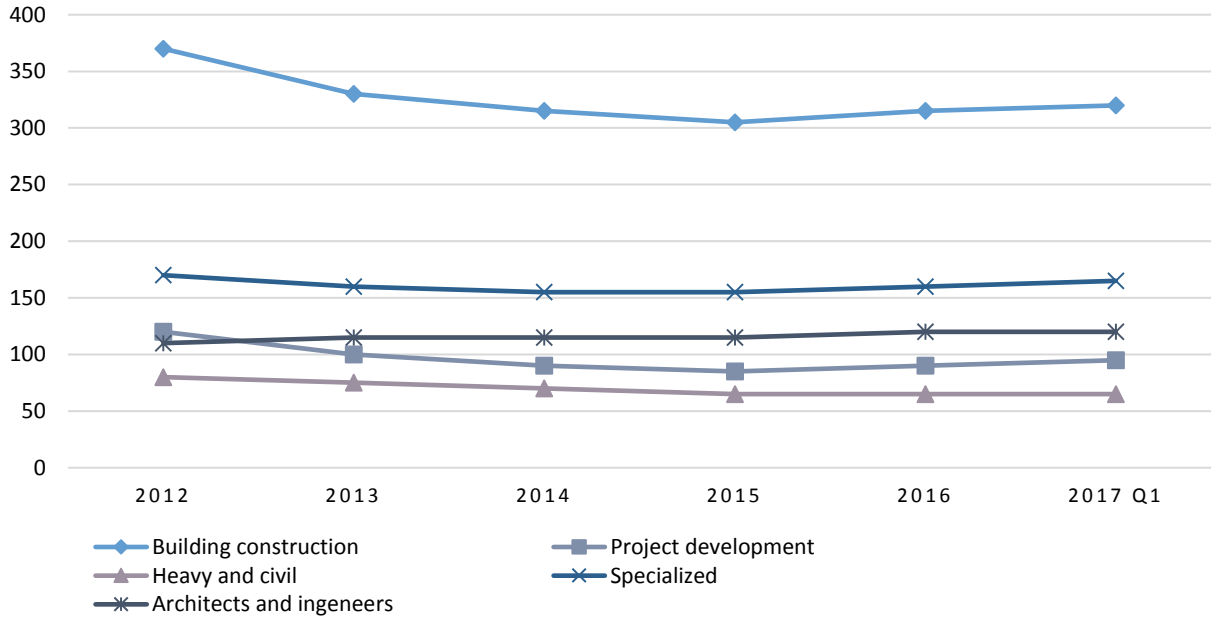


Figure 9 – Companies with more than 100 employees per subsector from 2012 to 2017 (source: CBS statline)

4.2.1.4 Market actors

In the previous section, the industry as a whole is lined out, but no less important is to discuss what the demand side looks like and how specific the products and services are. This, however, depends largely on the subsector that is considered. Therefore, in this section per subsector the clients and the users are discussed. However, it is important to keep in mind that especially the bigger firms are often active in building construction as well as infrastructure. Project developers, united in *Neprom*, are often supply-driven and therefore, they do not specifically work commissioned by a third party. Instead, it tries to sell or rent its products – usually dwellings – to private persons or organizations. Therefore, these are not discussed in a separate section.

4.2.1.4.1 Building construction

In the building construction, three major groups of clients are to be distinguished. First of all, the government bodies together with the Housing Associations, united in *Aedes*, are considered. Secondly, the project developers form a large group of clients. Finally, the group of other private clients can be

distinguished, consisting of buildings that are built for own use, being residents as well as companies. Regarding home-ownership, the Dutch pie is presented in Figure 10. The social housing sector is large in the Netherlands as becomes clear from the high percentage of rented dwellings from corporations. However, in general, still the majority of the housing stock is owner-occupied in the Netherlands (CBS, 2017).

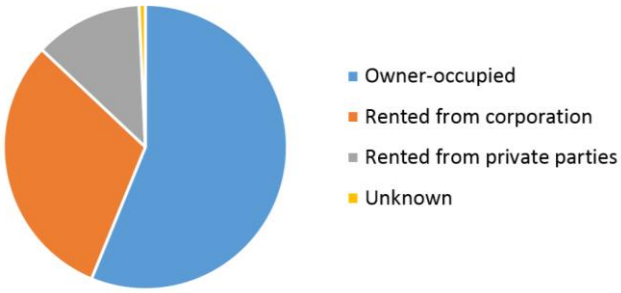


Figure 10 – Housing stock distribution by ownership in 2012 (Source: CBS Statline)

Regarding the construction of new dwellings, the pies look significantly different. Figure 11 in which building permits granted in 2016 per type of client are visualized, clearly shows that the industry players are by far the most prominent group of house builders, especially regarding owner-occupied dwellings. Housing Associations and governments form a significant group in rental housing, but this number has as a result of the crisis dropped significantly in just a few years, amplified by the 2015 Housing Law in which corporations were split-up in ones that merely act in general economic interest and the ones that do not (VNG, 2015). However, the government intends to increase the share of Housing Associations again in rental housing. Moreover, the government has a large hand in developing social housing, which leads to the large share of government and Housing Association in the houses for rent.

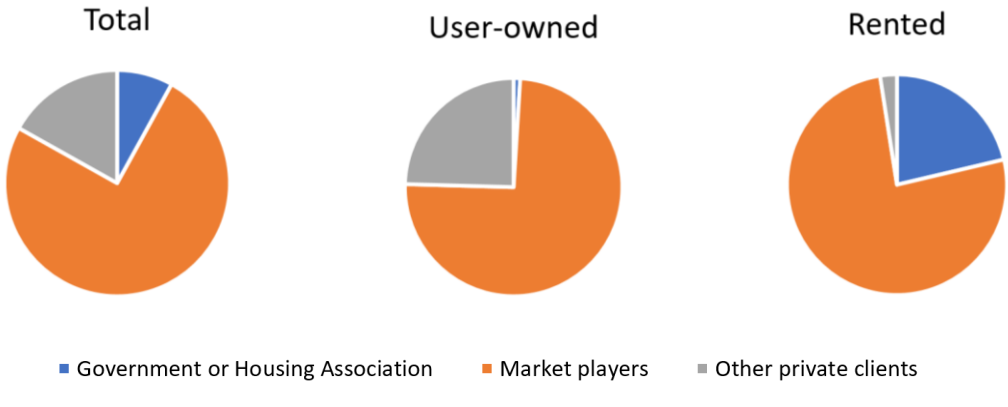


Figure 11 – Client distribution per type of housing (Source: CBS statline)

Mostly, the Housing Associations, being non-profit associations, are supported by the central government and municipalities. This support is mostly in the shape of surety on loans and for example cheap land prices. This is the reason that these two groups are considered together. From the national government, the *Rijksgebouwendienst* (RGD) handles the responsibilities regarding the maintenance and project contracting of new and existing (government) buildings. The market players are largely project developers who build and sell or rent their houses to residents. Of course, those market players are to a greater or lesser extent profit-oriented.

4.2.1.4.2 Heavy and civil construction

Most infrastructure-related projects are commissioned by the government, be it the national, provincial (IPO), municipal (VNG) or water board (UvW) body. From the national government, *Rijkswaterstaat* (RWS), the executive body of the Ministry of Infrastructure and Environment (IenM), is the most important client and project planner of the Netherlands. Several years ago, they constructed numerous projects themselves, but more and more they outsourced projects and took the role of client. The major share of heavy and civil construction are nevertheless, be it direct as well as indirect, commissioned by government bodies on any level.

4.2.1.4.3 Architects and engineering firms

Architects and engineering or consultancy firms, work by definition for secondary parties. Those clients may be in the building or heavy construction and can be public as well as private. Next to designing and engineering activities, more and more these parties also take care of other activities, such as project management. However, the government, from municipal to national level, is by far the largest client of this subsector. Interesting is the fact that of those for aforementioned subsectors, the architects and engineering firms, and so to speak the service sector, the turnover of this subsector has since 2009 increased, which was definitely not the case for the heavy and civil and building construction subsectors, which can be concluded from Figure 8 at page 26.

4.2.1.5 Government bodies and supportive organizations

Within the CI, the government plays a huge and pluralistic role. Within the whole chain a strong connection with the government is sensible, e.g. as client, legislator, policy maker, financer and so on. The Ministry of Infrastructure and Environment (IenM) is the most important department regarding infrastructural projects which also entails RWS. Also the provincial and municipal bodies are large players who are big clients for infrastructure and have a strong hand in (regional) legislation. As stated before, also in the building construction the government has an important role. This manifests mainly in subsidies regarding social housing. However, the entire industry is broader than under IenM and the Ministry of the Interior and Kingdom Relations (BZK) is responsible for construction legislation and EZ is also active in construction policy and funding of general reform initiatives. An important player is the agency for entrepreneurship (RVO), which is active in several innovation-stimulating initiatives for the market sector. Furthermore, indirectly, the Ministry of Education, Culture and Science (OCW) has a large hand in research strategies and prioritization.

The most influential construction sector association in the Netherlands is *Bouwend Nederland*, which is the industry association of the whole CI. Its main focus is on housing, sustainability, tendering and contracts, water, mobility, supply-chain management, modern HR, state pension and CBAs (Bouwend Nederland, 2017). Apart from connecting the different firms with each other and with the governmental organizations and knowledge and education institutes, it moreover conducts and commissions research in the field regarding a wide range of subjects. Furthermore, the *Aannemersfederatie Nederland* is a large branch organization that serves the interest of contractors in the sector. More specifically, for as good as every sub-branch – e.g. concrete drilling, masons, roofers and so on – organizations exist that serve the interest of those professionals. Furthermore, there are two main national branch organizations: VNO-NCW and MKB-Nederland. The former focusses largely on the big companies, while the latter is concerned with SMEs. Those two cover largely all the other branch organizations. Professional, sector-wide client associations are not found as for example in Denmark and Sweden.

4.2.2 Institutions and political and social structures

As described in the terminology section in the introduction, institution is an ambiguous concept. In this study, it is only used as social mechanisms, consisting of the patterns of behavior and the corresponding norms, laws and ways of conduct. In the legislation, policies and initiatives that move certain actors into certain behavior in the Dutch CI are discussed.

Politically speaking, the Netherlands have traditionally a more centralized government structure. In most cabinets, there was a (building) construction ministry for championing construction policies in a top-down manner. A government-led system applies to the Dutch system, although the market-driven system has become more and more prevalent. However, the role of publicly sponsored projects have been significant, as is the role of centralized regulation and policy-making (Seaden & Manseau, 2001). Consequently, socio-economic goals are achieved with a large planning and steering role from the centralized government. More recently, the construction-specific departments have largely been taken down.

4.2.3 Network

As all actors and their mutual relations are clear, the total network of the sector can be drawn. As the size makes it impossible to include all actors, it is classified in groups and schematized according to the system as presented by Kuhlmann and Arnold (2001) as discussed in the framework part (section 2.1).

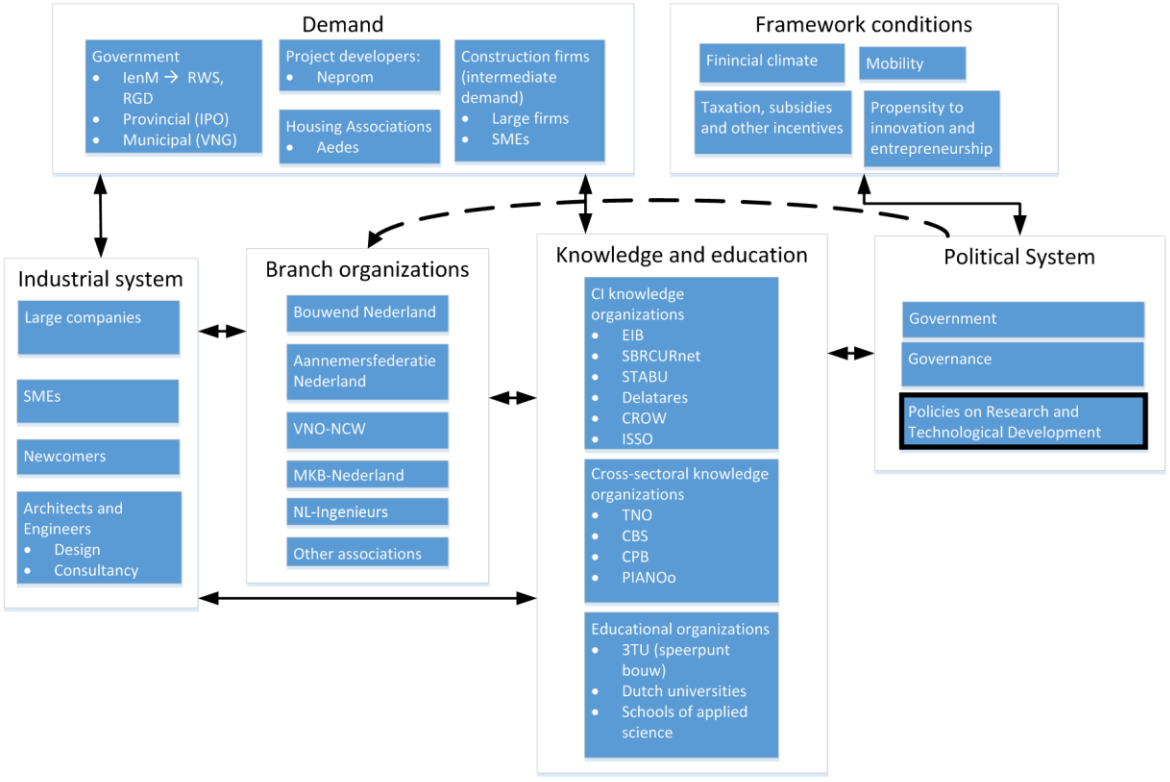


Figure 12 shows the relations between the actors and the way the political system, including the policies, influences the other actor groups. The system is dynamic and the whole network is so to say put under one institutional umbrella. This approach makes first of all analysis of the policies in relation to the other groups of actors possible and allows us secondly to benchmark the outcomes with the other pre-selected countries.

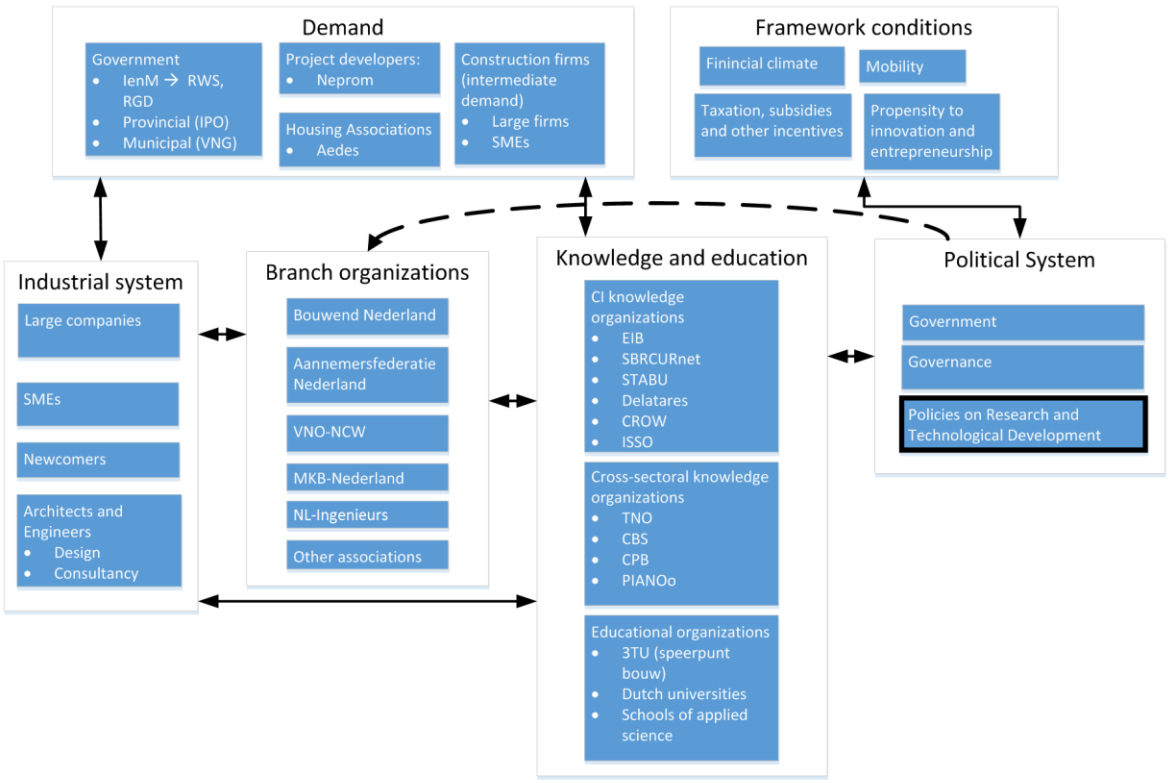


Figure 12 – Network schematization Dutch construction industry

The framework conditions heavily influence the political system. In an indirect way, it affects the whole industry. The political system has on its turn a large impact on the strategical agenda and with it on education and research. Furthermore, the sector associations react on the way of governance and different policies with their own strategies and initiatives, which impacts the industrial system. The demand side, which is next to the political system strongly represented by public organizations, is on its turn dependent on research and education and on the industry's supply. Some actors are on the demand side as well as part of the industrial system, as most contractors use sub-contractors and suppliers themselves.

Characteristic to the Dutch CI network is the strong relation between sector associations, research system and government. An Initiative as PIANOo are unique in its kind in trying to inform the industry, demand as well as supply, on tendering and procurement in a government launched initiative. Furthermore, especially in the past, the couplings within the supply side of the sector were exceptionally strong, with formerly legal competence for collusion. Although those practices are largely predicted to be from the past, the industry is still tightly bonded. Another unique aspect of the Dutch CI is the existence of the 3TU/4TU program which has connected higher education with top-notch research in relation to the industry and the market in order to become a knowledge-oriented sector. Furthermore, the stated-by-law research institution TNO is also unique as it is publicly established and largely publicly funded and commissioned.

4.3 Phase of development

The literature presented by Hekkert et al. (2011) focusses on individual technological developments. As discussed before, the way of analysis is quite comparable. However, the phase of development is

harder to grasp, as the industry has a continuous development and is never in its absolute peak. When considering the phase of development of a product as an individual S-shape (known as the technology life cycle), the phase of development of an industry is much more comparable with an economic cycle, especially as the share in GDP of the CI is relatively so large, as is its dependency on government investments. Therefore, a small economic analysis of the CI is offered for the Netherlands.

Figure 13 shows that since the crisis of 2008, a deep fall was noticed, as the turnover of the different types of companies shows. From 2013, however, the industry restored from the depression and a recovery was visible which seems to increase. Architects, however, seem to recover only very gradually and are hit the severest within the construction supply chain, while installation companies and engineering firms are back to the level of before the crisis and a similar tendency is visible for the construction firms, be it less rapid. Although the figures are positive, the recovery is not felt by all parties, even among contractors. In several subsector, contractors are still bidding below cost price, which indicates that it is still mere survival rather than growth. This heavily affects the way innovation is considered within these firms.

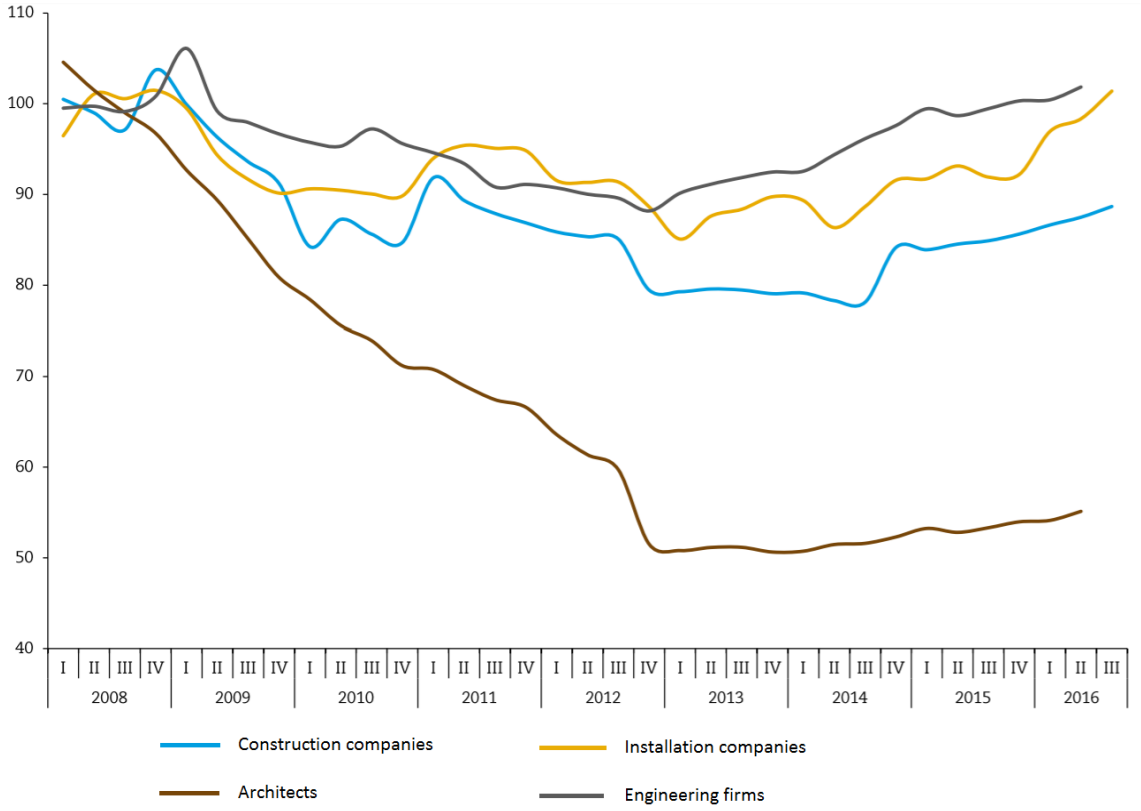


Figure 13 – Economic development of the subsectors in the construction industry (2008 = 100; source: EIB, 2016)

The firms as analyzed in Figure 13 were also asked to predict their future turnover based on backlogs and market observations. Visser (2016) concludes that all along the line an increasing amount of companies is optimistic, with the engineering and installation firms leading. After the incredible fall of architects, the expected grow is within this group the lowest, but nevertheless, an increase is expected. As contractors more and more do architectural activities in-house, the relative level of 2008 is not expected to be reached again. Also the workforce is expected to increase slightly, although a majority of the companies expect to remain stable.

5 European construction industries

The European Union as a whole was discussed in chapter 3 which contains all industries that will be presented in this chapter. The previous chapter consists of a more detailed analysis of the Dutch CI. The same will be done for the other selected industries, be it in a summarized way. Consecutively, the UK, Denmark, Sweden and Germany will be discussed. An extensive analysis of each of these countries is presented in appendix III. Finally, this chapter is summarized in the section 5.5, together with the Dutch CI in a comparative way, containing qualitative as well as quantitative characteristics.

5.1 United Kingdom

The UK has an elaborate history of initiatives to improve the CI. Innovation has in those initiatives not rarely been a theme on the agenda. First a context sketch is given which is followed by a structural analysis and brief policy assessment.

5.1.1 History & Context

By means of a recital of reform reports, the UK CI is sketched. As a starting point with respect to new construction practices in this tradition we take *Constructing the Team* (Latham, 1994), also known as *The Latham report*, following the entire history of reviewing the UK CI which traces back to the 1944 *Simon Committee Report* (Murray & Langford, 2003). Table 3 gives a short summary of these reports.

Table 3 – The UK CI on the basis of reform reports from 1994 to 2016

Report title	Author, year	Key issues
Constructing the Team	Latham, 1994	• Lack of implementation previous studies • Leading role of government • Checklist with design responsibilities • Basic contractual principles for standardization • Transparency, standardization, competence, active government and partnering & collaboration

Rethinking Construction	Egan, 1998	• Too slow implementation of Latham Report
		• Too little investment in capital, R&D and education
		• Five key drivers:
		  ○ Committed leadership
		  ○ Focus on customer
		  ○ Integrated processes and teams
		  ○ Quality driven agenda
		  ○ Commitment to people
		• Performance data for client information
		• Targets: -10% cost and -20% time in cons. projects
		• Lean construction and four process improvements:
		  ○ Product development
		  ○ Partnering within supply chain
		  ○ Project implementation
		  ○ Production of components

Modernizing Construction	Bourn, 2001	• Evaluation of Egan and Latham reports • Best practice on partnering • Value of money instead of price • Supply chain integration • Encourage innovation to remove project waste • Improve buildability and project value

Accelerating Change	Egan, 2002	• Collaboration • Partnering essential for innovation • Long-term relationships • Aim at continuous industry improvement
Modernizing Construction Review	Latham, 2005	• Improvements were made since 2001 • Less budget and time overruns
Be Valuable	Saxon, 2005	• Shift of paradigm from asset to valuable object • Recommendations for research and support action programs for value creation • Common measurement factors to learn from past

Callcutt Review	Callcut, 2007	• Housebuilding Industry evaluation
		• Public parties should focus on:
		  ○ Land supply
		  ○ Management strategies
		  ○ Customer satisfaction

Strategy for Sustainable Construction	HMGovernment, 2008	• Clarity around existing policy framework • Signal future direction of Government policy

Never Waste a Good Crisis	Construction Excellence, 2009	• Provides a review of earlier reports
		• Too slow implementation of previous reports
		• Identifies blockers of improvement:
		  ○ Short-term cycles
		  ○ Fragmented industry
		  ○ Poor supply-chain integration
		  ○ Lack of strategic commitment
		• Emphasizes collaboration and customer focus

Construction 2025	HMGovernment, 2013	• Calls for collaboration industry and government • Barriers to improvement are given with solutions

Farmer Review	Mark Farmer, 2016	• Root causes for symptoms to lack of progress:
		  ○ Survivalist structure
		  ○ Non-aligned interests
		  ○ Lack of strategic incentives
		• A set of measures for every cause is given

Altogether, the UK CI has a long tradition in reviewing itself and taking measures in collaborative researches and initiatives. Since the early '90s, there has been a call for restructuring the industry in order to make it more effective, efficient and reducing the amount of time and budget overruns. The call upon collaboration, focus on the user and supply chain integration has not faded away in the past twenty years. The final five to ten years, the suggestion for using ICT-related techniques such as BIM has become stronger and started to hold prominent places on the national construction agenda. However, the later reports all acknowledge the positive effect of for example the *Latham report* and *Egan report* and statistics show us that the amount of failures in the CI drastically dropped in those past twenty years despite of the pile of work that has to be done in order to get the industry to the desired level.

5.1.2 Industry structure

Different from the Dutch system, the UK research agenda and institute are managed from the central *Research Councils UK* (RCUK), consisting of seven sub-councils. Within the CI, the Department of Business, Innovation and Skills (BIS) is the main driver of public construction research. Also universities are an important source of research, of which the UK has several globally acclaimed ones. These universities act fairly independently and are able to set their own agendas. The funding system,

however, is currently being reformed, resulting in funding from two bodies: a single market regulator and research and innovation body (Elken et al., 2016).

The UK is a highly privatized country, which is also visible from the ownership of infrastructure, which is much more in hands of private parties than in the other researched countries. The social housing sector, on the other side, is partly nationalized which is fairly comparable to the Danish system. Several parties have called for privatization of this sector, but the practices in Germany did not show convincing results. Furthermore, the self-employment rate in the UK CI is high, even in comparison to the other studied countries. As a result, the sector fragmentation is high (Infrastructure UK, 2012). Nevertheless, the structure of the CI as a whole is quite comparable to the Dutch one.

In the UK, the share owner occupied/rented housing was in 2016 a little less than 3/2 and in 2012 more than new 150.000 dwellings were completed (ARUP, 2016). The share of social housing is only about 18%. The services subsector, containing of engineers and architects, only hold 10% to 15% of the whole construction sector in value (Brookhouse, 2014). However, this subsector is largely responsible for export products of the CI as especially architects have an outstanding reputation.

Publicly, the CI is rather fragmented. BIS has as an overarching body of several relevant agencies a large voice in construction. However, HM Treasury and Department for Work and Pensions have also several construction topics in their portfolio. Furthermore, decisions from the Department for Work and Pensions (DWP), Health and Safety Executive (HSE), Departments for Environment, Food & Rural Affairs (DEFRA), Culture Media and Sport (DCMS) and Business, Energy & Industrial Strategy (BEIS) influence the construction industry. The industry itself is also united in associations, although the participation rate is relatively low as is the bargaining power. The most significant ones are *Build UK* and *Engineering Construction Industry Association* (ECIA).

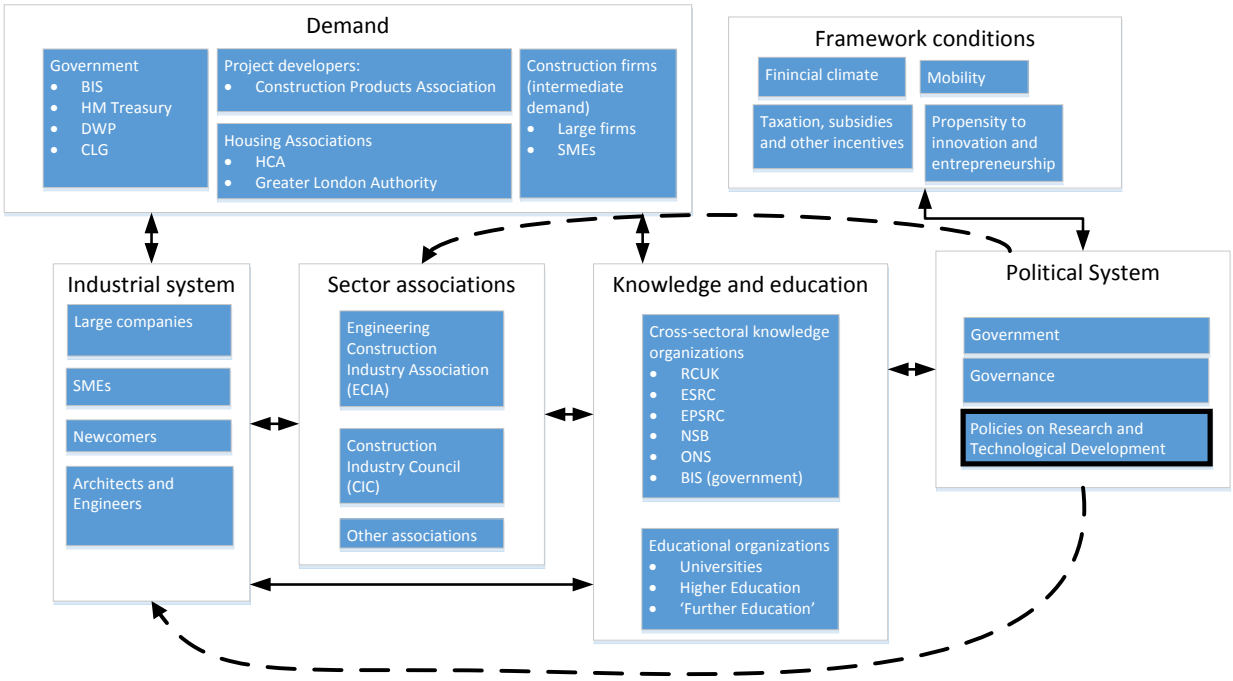


Figure 14 - Schematized network UK construction industry

The way of relation between the contractor, client, consultancies and so on is quite comparable to the Dutch CI. The most striking difference is the role of industry associations, which is less organized and relatively small in the UK. The platforms and organizations that unite the construction companies are mostly organized or at least championed by the government and the strategy documents are mostly published by the government, be it in collaboration with gurus from the industry and well-reputed universities. Therefore the relation between government and industry seems tighter than in the Dutch system. A simplified and schematized network is presented in Figure 14.

Also desire of the political system to actively improve the sector is large, which also explains the connection. Several initiatives, often oriented broader than specifically the CI, are launched by the UK government in order to remove barriers in the construction process, inform the industry and reward entrepreneurship are found. This goes hand in hand with the desire to understand best practices with regard to building processes, innovation and knowledge, as can be concluded from the broad range of publicly funded internationally recognized large-scale researches on these topics.

5.1.3 Phase of development

The phase of economic development of the British CI is one of the most interesting ones at the moment. Due to the *Brexit*, which has been definitively set into motion in March 2017, the economic situation of the coming decade is extremely hard to predict and even specialists and scientists are drastically disagreeing. Until January 2017, however, statistical data is available, which shows a graduate increase from 2013 onward, as confirmed by Figure 15. BBC's journalist Bowler (2017) has argued that house building has slowed to a six-month low because costs have increased due to a weaker currency, while the overall CI output has risen led by civil engineering. These rising input costs, may have had an effect on delays in contracts completed due to an slowed down decision making process.

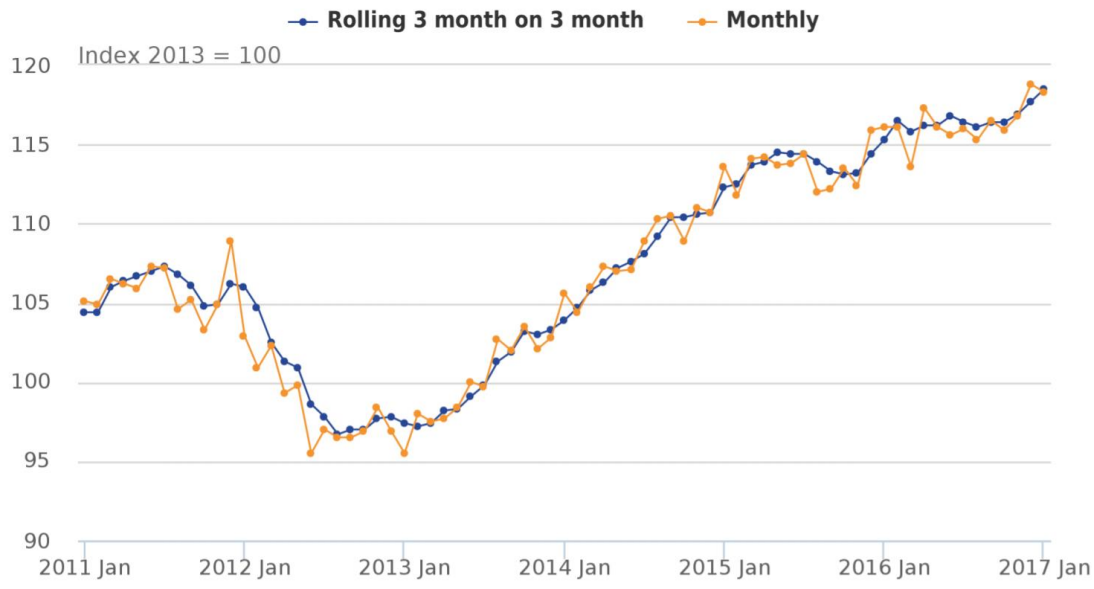


Figure 15 – Construction output in the UK from 2011 to 2017 (Source: ONS, 2017)

However, regarding the future, Jeremy Blackburn, RICS' head of UK policy has said in March 2017: "These figures reveal that the UK construction industry is currently dependent on thousands of EU workers and it is in all our interests that we make a success of *Brexit*, but a loss of access to the single market, has the potential to slowly bring the UK's £500bn infrastructure pipeline to a standstill". So

even when the economic consequences overall are a fluke, the consequences for UK construction may disappoint due to the large dependency on EU workers. It is therefore likely that, especially before the industry has stabilized, at least a few years the UK CI will encounter hard times with a silted pipeline.

About the general economic situation in the UK the opinions are divided and outcomes seem uncertain. PWC, a major assurance and tax advisory firm, annually presents economic predictions by means of scenarios. Generally it stated the following: although the market remained relatively stable after the *Brexit* vote, in 2017 and 2018 the growth slows. The services sector may remain positive, but construction is likely to suffer from lower investment levels. On the longer term, the UK economy is expected to grow around 2% again (PWC, 2017).

5.2 Denmark

Knowing the main composition of the Dutch and UK CIs, the Danish construction sector is analyzed. Danish literature shows commendable national initiatives in making the industry more sustainable, green, and innovative. Furthermore, collaboration is traditionally highly emphasized. Just as in the UK, since the '90s a considerable amount of task groups and reform initiatives were launched. During the past 15 years, a series of public policy instruments aimed at improving the low development of productivity in the Danish CI have been initiated. In recent years, focus has been put on the concepts of partnering and strategic partnerships as key drivers in the transition towards a competitive and innovative industry. In this section, first these developments are illustrated more clearly, which is followed by a summary of the structural analysis. A detailed structural analysis is presented in appendix III.

5.2.1 History and context

Among other reports, one of the most influential publications was *The future of Construction: From tradition to innovation* as published by the Building Policy Task Force in 2000. The report strongly emphasized shifts in the role of construction clients, competitiveness, collaboration and innovation. In the report, 28 proposals were presented as solutions to general problems in construction. Furthermore, a national action plan was recommended to be launched. Accordingly, the Danish government set up a separate task force to draw up proposals in this regard, as being published in *Udvalget vedrørende byggeforskning i Danmark*. Resulting, several platforms and taskforces were launched to address these problems. Haugbølle (2012a) argues that for the past few decades, construction R&D has been on the agenda on a regular basis.

In 2007, the study 'Flexible strategic partnerships in Danish construction' was published in which the objective of the research reported was to study extents and types of strategic partnerships in the Danish CI, examining inter-organizational collaboration (Gottlieb & Storgaard, 2006). The study shows that it is often problematic to realize any first mover advantages of a partnership, making it more attractive for companies to adopt existing products and production concepts rather than invest in expensive development activities. Furthermore is it shown that flexibility is seen as the primary competitive advantage in the construction sector, resulting in partnerships being created, dissolved and recreated. In the recent past, efforts are made to create long-term partnerships in order to benefit from the long-term relations, with a large-scale housing project as an excellent example.

In 2010, Denmark presented its vision for 2020 with concrete ambitions and goals, following the *Europe 2020* vision, but concentrated on Demark with its own characteristics. This vision is concrete and involves social goals such as life expectancy and trustworthiness next to for example economic

and organizational ambitions (The Danish Government, 2010). In that same year, it also published a nationwide study in order to benchmark the Danish CI, which was published in *The Benchmark Centre for the Danish Construction Sector* (Olsen, Bertelsen, Frandsen, & Haugbølle, 2010). It shows that from May 1st 2008 it has been compulsory for state clients and for housing associations to require registration of data and establishing of indicators in new projects. From 1st November 2009 it was obligatory to use indicators in selection of potential companies for design work in connection with new projects. State construction and nonprofit housing projects have acted as change agent in the use of *Key Performance Indicators* (KPIs). It has been difficult to implement this new form of evaluation and it has been necessary to adapt the KPIs and the registration of data, although a growing interest emerged in the private sector for use of KPIs but some users wish a simpler and more cost-effective system, e.g. as an integrated part of the project and company management system.

As a part of a PhD study, the institutionalization of benchmarking has shown to be a good example of the mechanisms that unfold when attempting to institutionalize a political initiative in the Danish CI (Rasmussen, Jorgensen, Gottlieb, Hesdorf, & Bonke, 2013). From the findings of the case study, this research seeks to provide recommendations on how to institutionalize new structures in the Danish CI. Until recently, it was obligatory for clients to consider benchmark and past-performance outcomes in tendering, but the current, more liberal government has withdrawn regulations in this field.

In 2011, Thuesen and Koch (2011) presented their results in *Driving sustainable innovation in construction companie*s in which *Lean Construction*, BIM and *System Deliveries* were subject to a detailed analysis, showing partly incompatible motivations and various degrees of innovation potential. It concludes that by mapping some of the most influential trends and promising niche innovations and relate these to the existing paradigm, an innovation map can act as a medium in which policymakers, interest organizations and companies can develop and coordinate future innovation activities. As is discuss later on in this chapter, this is exactly what the Danish government has done from 2012 onward.

During the 1990s and early 2000s, a range of policy reports stated that the Danish construction R&D investments were lagging behind in comparison to the OECD level (Haugbølle, 2012b). In 2001-2002, a task force on construction/housing research was established to analyze construction R&D investments who developed a roadmap for new research priorities, increased public/private R&D collaboration, improved dissemination of research-based knowledge, and reorganization of the technical support infrastructure. The survey adopted a resource area perspective, which includes the primary industry, manufacturing industry, supporting industry and service industry. These activities were all studied in the 2013 *Construction R&D investment in Denmark* report and concluded the following:

- It is complicated to draw firm conclusions on the level of construction related R&D investments;
- Public construction R&D expenditures are disproportionately low compared with other research fields;
- Private R&D investments primarily take place in the manufacturing industry;
- The R&D roadmap has not had a significant impact on construction R&D investments.

Especially this last concluding point is interesting, as the *Driving sustainable innovation in construction companies* report discussed before suggests exactly the opposite. As this last mentioned study is

published later and it considered the study which it contradicts, we assume that this later study drew the most acceptable conclusion. For a brief sketch is given of dynamics in the Danish CI, the structural analysis are conducted, as summarized below.

5.2.1.1 Network

Denmark invests for years highly in knowledge and education, which also apparent from the global and European rankings (World Bank Institute, 2009). The official research institute is the Danish Technological Institute (DTI) from which the function is highly comparable to the Dutch TNO. More construction-specific, the Danish Building Research Institute (SBI) is responsible for research-based knowledge creation and is located at the Aalborg University. In 2007, a large reorganization has taken place, resulting in large fusions between universities (Hampson, Kraatz, & Sanchez, 2014; Haugbølle, 2012b). However, the most prominent ones are still in function. These universities are moreover largely responsible for the publicly funded research in Denmark.

Although Denmark is much smaller than the Netherlands, let alone the UK and Germany, the CI structure is quite comparable to the Dutch one. However, there are some major differences. The share of freelancers is almost half and companies with more than 100 employees are scarce. This composition of companies has urged Denmark to collaborate on projects – especially large ones – for a long time. The use of consortia is common practice also the development of new techniques is done often together with other companies, private as well as public. Collaboration with foreign companies, such as the Dutch BAM has been sought in recent years, as these companies often have more experience with large-scale projects.

The crisis has severely affected the building construction, with a huge *property bubble* as a result, which has had incredible increases in prices between 2001 and 2006 as a result, from which the sector is still not completely recovered yet (Pedersen & Isaksen, 2015). The way social housing is managed is largely explainable from the fact that Denmark is a welfare state with a social socio-economic structure and a 'large' government. This is also visible from the way infrastructure is managed and procured, which is comparable to the Netherlands. Currently, large infrastructural projects are realized and several projects are still in the pipeline, which makes this subsector prosperous.

The Danish CI is largely managed by the Ministry of Transport, Building and Housing (TRM), which has several agencies under its wing, such as the road and rail directorates (TRM, 2017). Regarding (construction) research, however, the Ministry of Higher Education and Science (UFM) is responsible, which is advised by the Danish Council for Independent Research (DFF). The industry itself is united in the *Dansk Byggeri*, which is with other associations united in the by the Agency of Science launched *InnoByg* network. Next to this industry association, more specific associations play also a large role, such as Danish Architects and the engineers association. Furthermore, Dansk Industry plays a major intermediary role between industry and government. Several more initiatives and platforms are constructed directly or indirectly aimed at construction innovation. Next to public funding, Realdania is an important investor in public projects.

Unique in contrast to the Netherlands is the construction clients association (*Bygherre Foreningen*), which represents professional construction clients, public as well as private. This association is moreover an important advisory board to the government in relation to construction and infrastructure projects. This association plays an essential role in the collaboration between government as client, government as political institute and the construction market. Moreover, it has

launched together with other sector association *Værdibyg*, which publishes brief papers on how to improve construction processes and on new developments in the industry. These are publicly available (Vaerdibyg, 2017).

The Danish network is quite comparable with the Dutch one in terms of structure. The only striking point is the role of the government. In comparison to the Dutch CI, the role of the government in Denmark is broader, indicated by the non-dotted arrow in Figure 16. The public services are more than in the Netherlands nationalized. As a result, the relation between public bodies and industry are considerably tight. Furthermore, the representation of interests seems to be more centralized, which has also led to more consistent public-private cooperation.

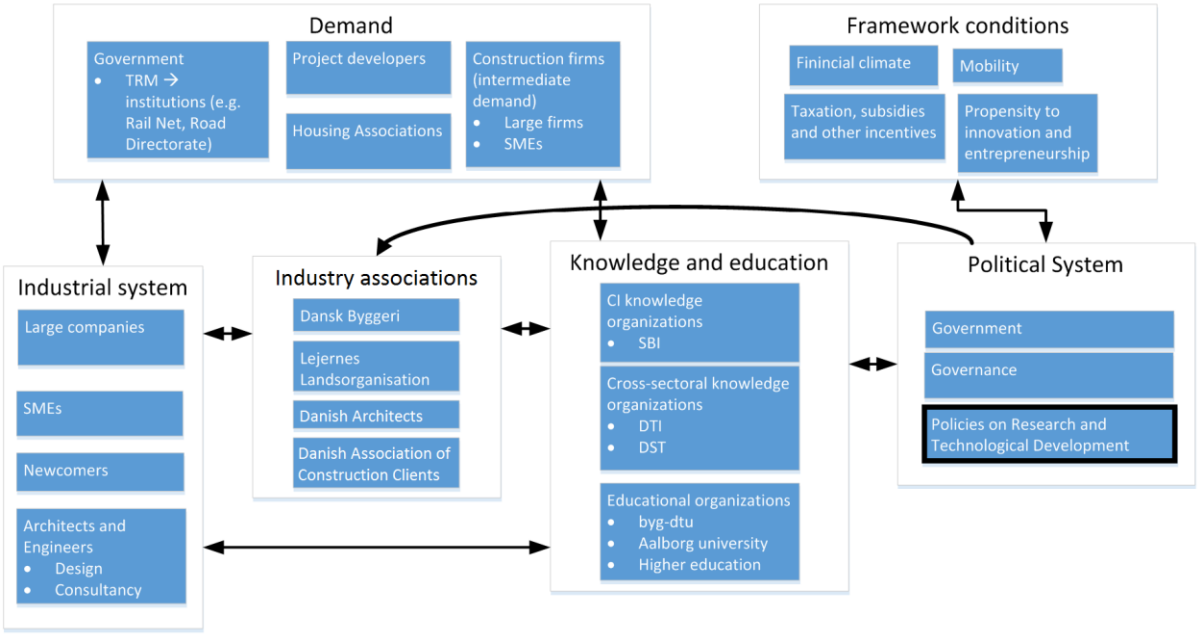


Figure 16 – Network schematization Danish construction industry

Unique for the Danish CI is the active steering on knowledge in the industry, from the government as well as within the industry. The link between education (universities) and research is tight and sector associations, especially *Dansk Byggeri* and *Bygherreforeningen*, are involved in several (government) initiatives. The government is relatively big and the TRM is responsible for a lot of agencies, such as public transport, which is reflected in centralized development of strategies and future visions.

5.2.2 Phase of development

The economic situation of Denmark is rather stable and gradually increasing since 2013/2014. Especially in the maintenance and repair market and the civil construction a significant increase is visible. The economic situation is according to *Dansk Byggeri* (2016) positive and the report reaffirms that the economic cycle of the CI is strongly related to the general economic situation. The economic growth is likely to continue in the coming years and also a recovery of the housing market is visible, resulting in an increase of new building construction. The reports expects the increase of new dwellings to be stimulated by the flow of refugees towards Europe. This goes hand in hand with a strong market for maintenance and repair of dwellings.

The civil and heavy engineering, however is less likely to grow in this tendency. The investments in state roads are significantly falling and no replacing areas are emerging. The concentration of

construction in large cities has a result that skilled workers are hard to find in the future on one hand. On the other, the CI is known as a sector in which a lot of apprentices per skilled worker are taken. In general, however, the employment has increased since 2013 and is expected to continue in the coming years. However, in a political sense, the last few years some liberalistic initiatives have been taken by slightly right-winged government coalitions. This has had an impact on loosening regulation and several procedures in construction.

5.3 Sweden

In the same fashion as the UK and Danish industry structures have been analyzed, the Swedish will be reviewed. A more detailed industry analysis is, just as in the case of the other preselected countries, presented in appendix III. First the context is illustrated, followed by a summarized structural analysis including a network representation and the phase of development in the Swedish CI.

5.3.1 History and context

Sweden passed through the global financial and economic crisis with limited damage, thanks to strong macroeconomic, fiscal and financial fundamentals and a competitive and diversified business sector (Koen, André, & Pareliussen, 2015). The Swedish economy is proving resilient in the current environment of slow-moving global growth and high uncertainty. Sweden is according to Koen, André and Pareliussen (2015) among the few countries where output is now well above its level before 2008. It has a strong comparative advantage in knowledge-intensive activities, which has stimulated growth and contained the rise in inequality over the past two decades.

The average well-being is high, and the growth is greener and more sustainable than in most other OECD countries. Public support for innovation is strong but remains fragmented and faces the challenge of adapting to an economy in which services and SMEs play a still increasing role. The OECD report therefore recommends the following actions (Koen et al., 2015). Firstly, keep up the policy for stimulating economic growth. Secondly, build stronger foundation for growth by for example simplify regulations and investment in infrastructure thirdly, it recommends to improve the skills and integrate different parties better. This also implies the collaboration between construction parties, and between for example construction firms and universities as discussed by Bröchner and Lagerqvist (2016).

Furthermore, in terms of innovation, Sweden is a reputed player (Marklund, Nilsson, Sandgren, Thorslund, & Ullström, 2003). This goes along with an attractive climate for R&D, which goes all under the umbrella of the national innovation system. Hereby is quality management important to increase overall performance (Landin, 2000). The integration of international quality management systems such as ISO 9001 have gradually increased and are more and more incorporated within companies. In Sweden, sustainability is a big, and publicly supported driver. The report *Sweden builds for the future* introduces and discusses different activities in which sustainability in planning, construction activities and property management are subject (Waldén, 2006). It shows that Sweden has ambitious visions about the sustainability and energy use in the CI. An example of commitment to these visions is the way BIM standardization is treated (Hooper, 2015). The numerous efforts in Sweden for successful implementation of BIM indicate the willingness to maintain the lead in Europe. This manifests itself in the innovation-related efforts which are discussed later on in this chapter.

5.3.2 Industry structure

In Sweden, public research is almost entirely accommodated at the universities. However, several large research institutes exist, which are largely funded by private parties (OECD, 2016b). More construction-specific, the Swedish Cement and Concrete Research Institute (CBI) has a specific research expertise. The level of average education is high in Sweden, as is the level of higher education and especially universities. Regarding construction, most notably the Chalmers University offers excellent programs, and produces significant construction research.

In Sweden, construction is responsible for 10% of the GDP and 12% of employment, of which the latter is also in relation to the other research countries very high (Vi Bygger Sverige, 2015). Just as in UK and Denmark's construction, the majority of entrepreneurs are freelancers and a small minority of the companies can be considered large. After the crisis, the amount of companies decreased, but since 2013, this amount has been recovering. This recovery is also related to the large housebuilding projects comprising 710.000 new homes within 10 years, which was launched in 2015 (SABO, 2016). The public as well as private clients are united in the Swedish Construction Clients (SCC). Furthermore, the participation rate in associations for employers as well as employees is extremely high, resulting in a strong bargaining position of the associations. The most prominent industry association is *Sveriges Byggindustrier*, which includes the large contractors, but also SMEs (Sveriges Byggindustrier, 2016).

Sweden has its own Ministry for Housing and Construction which main aim it is to maintain an effective long-time housing policy. Furthermore, the Ministry for Infrastructure and Transport largely influences the sector. Sweden maintains long-term strategies through the creation of several agencies, of which Vinnova is one. This agency is responsible for innovation policy and also deals with construction through for example the *Byginnovationen* program which is discussed elaborate in chapter 6. Furthermore, Sweden has an extensive social system and the government is relatively centralized, which results in a clear structure of construction administration.

As a result, the level of collaboration is very high – even higher than in Denmark. The words 'iron triangle' has been used for the relation between policy makers, sector associations and bureaucrats. The last few years, Sweden, however, followed the European tendency for a more liberalized landscape. Nevertheless, levels of collaboration within the construction industry, with its own knowledge and interest organizations remained very high. The use of coalitions is, just as in the Danish CI, very high, although Sweden incorporates in contrast to Denmark several big construction companies.

The network of the Swedish CI is in the context of SIs as presented in Figure 17, which was constructed on the basis of the actor analysis above. The system is rather comparable to the Danish CI and next to a close cooperation between the market and the government, the industrial system itself seeks near collaboration through branch organizations and research institutions. The government often plays a grand role in the development and organization of projects and can also be considered as the largest construction client – just as in most other countries.

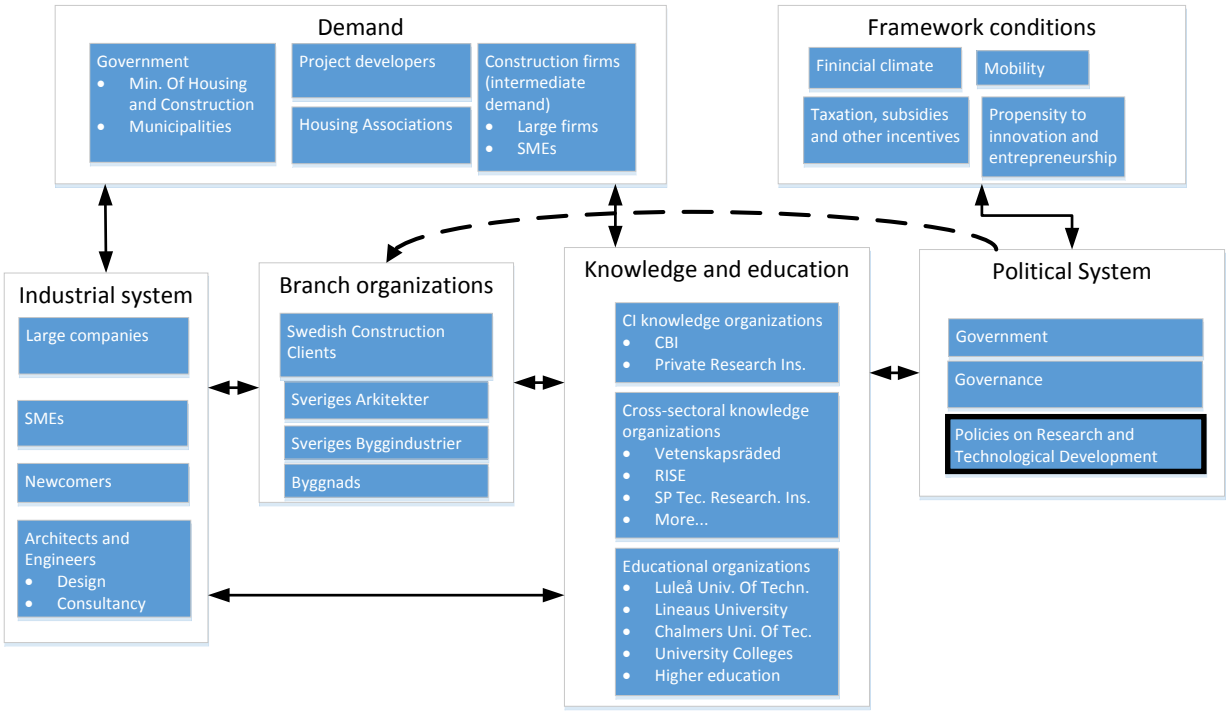


Figure 17 – Swedish System of Innovation in construction

The Swedish system, however, consists of several rather unique entities. Vinnova is the national agency that is exclusively responsible for innovation funding. This public body is also a central body for innovation policy and has tight linkages with branch organizations as well as other actors of the industry. This is indicative for the national goal of becoming a leading power as a knowledge power – also in construction. The most important research facilities are housed at leading universities which makes the link between education and research tight.

Table 4 – Economic forecast Sweden (Source: Ministry of Finance, 2016)

Annual percentage change if not otherwise stated

	2015	2016	2017	2018	2019
GDP	4.1	3.8	2.2	1.8	2.1
GDP gap[1]	-0.9	0.2	0.5	0.3	0.0
Employment[2]	1.4	1.7	1.6	0.8	0.7
Employment rate[3]	80.5	81.2	81.7	81.4	81.0
Hours worked[4]	1.0	1.9	1.7	0.7	0.7
Productivity, business sector[4,5]	3.3	2.1	1.1	1.8	1.9
Unemployment rate[6]	7.4	6.8	6.3	6.4	6.5
Wages[7]	2.4	3.1	3.3	3.4	3.4
CPI[8]	0.0	0.9	1.6	2.3	3.2

[1] The difference between actual and potential GDP as a percentage of potential GDP.
[2] Persons, 15-74 years.
[3] According to the EU 2020 target; that is, those in employment as a percentage of the population in the age bracket 20 -64 years.
[4] Calendar-adjusted.
[5] Labour productivity measured as GDP to base price per hour worked.
[6] Per cent of the labour force, 15-74 years.
[7] Measured according to short-term wage statistics.
[8] Annual average.

5.3.3 Phase of development

As stated before, Sweden went through the crisis relatively unscathed. However, the general European tendencies, such as falling interest rates, are also noticeable in Swedish policy (Ministry of Finance, 2016). The growth in GDP, however has been high in 2015 as well as in 2016. The same was visible in household consumption. This growth, however, is expected to wane in 2017. For the coming 3 years, the expected growth is shown in Table 4.

Regarding the CI, Deremar, Isaksson, Blom, and Broman (2017) have analyzed the Swedish CI in a statistical way and made some predictions about the future. A clear growth is visible in Figure 18 until 2018. In housing market, a strong increase of new dwellings is visible and expected for coming years. Renovation of buildings, however, is slightly decreasing.

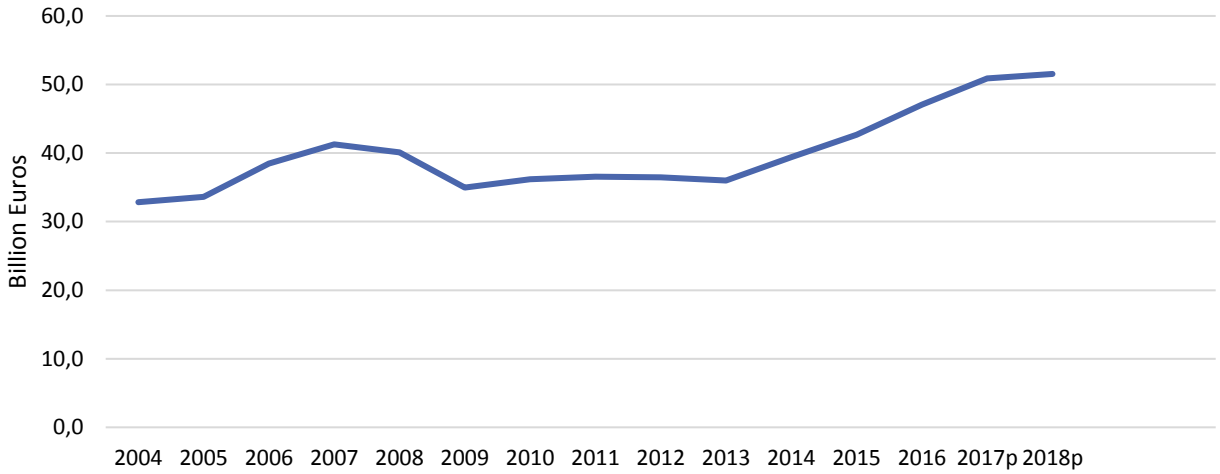


Figure 18 – Total construction investment 2004-2018 (Source: Sveriges Byggindustrier, 2017)

5.4 Germany

Germany is the largest of the pre-selected countries, in population, as well as territory. This section shows how the German CI is structured. First the context is sketched, whereafter the structure is made clear, followed by the phase of development. An elaboration on the German CI can be found in the fourth section of appendix III.

5.4.1 History and context

For the last decades, the German economy is the strongest in Europe. This is also the case for the German CI (European Commission, 2016a). The German construction sector has not suffered from the crisis as much as its European counterparts have. On the contrary, it has experienced an increase in productivity and employment, driven primarily by investments in construction of residential properties. The growth in residential construction observed since 2010 is predicted to continue, with forecasts pointing towards a significant increase in 2017. The demand for housing will according to the EC continue to increase, supported by demographic developments over the next years. This shows that the German CI is doing well in an economic sense, but the achievements in organizational industry improvement in terms of innovation and sustainability are not deductible from these statistics.

The complexity of the CIs calls for an increase the innovative capacity. For this purpose, associations, chambers, companies and the *Gewerkschaft der Wertschöpfungskette Bau* have been developing a guiding principle as a result of a one-year discussion process (Zentralverband Deutsches Baugewerbe,

2009). The discussion aimed at the importance of the CI in the economy and society, the markets of the future, qualification of the employees, innovations in the value chain construction, quality and life cycle, cooperation in the industry, legality and value management. The report in which this principle is published offers a discussion regarding the vision and offers suggestions towards policies and strategic measures to reach those goals.

The *Fraunhofer Alliance Bau* has in close cooperation with the industry and public bodies tried to find solutions for the urban future (Fraunhofer-Allianz Bau, 2012). Solutions have been sought in the life cycle approach. This includes software in the CI (BIM), Nano-technology, sustainable materials, membrane materials, the user as starting point, automated systems, safety, energy use and generation, sustainability and last but not least internationalization.

For the German CI to gain a better position in Europe, a clear political agenda for the CI has to be set. The German *Hauptverband der Deutschen Bau* (HDB), *Zentralverband Deutsches Baugewerbe* (ZDB), and *Bundesverband Baustoffe* (BBS) are defined as being the most normative organizations in these activities (BBS, Die Deutsche Bauindustry, & Das Deutsche Baugewerbe, 2014). In this *Positionspapier zu Construction 2020* that resulted from these efforts it is set forth what it should do with investments, education and training, sustainability and resources, domestic market and international affairs.

5.4.2 Industry structure

Germany has a unique system with a federal government and 16 individual states (Länder). This has huge implications on governance and policy making. However, Germany is known for its integral strategies on federal level, with large levels of prioritization. Germany has four main research institutes which are largely publicly funded. The universities have on one hand large autonomy and on the other hand they are governed by the states with their own prioritizations. Nonetheless, the federal strategies are mostly considered. The main research agenda is led by the *Deutsche Forschungsgemeinschaft* (DFG), which organizes the funding and also supports research. Regarding construction, especially *BWI Bau* is influential, mainly focusing on economic and political aspects of construction.

Germany has the largest CI in Europe with 2,2 million people employed. The crisis was not severely felt in the German CI and only a minor decrease in turnover was shown in 2012. The building construction sector has been relatively stable for in the last decade. The social housing is privatized with certain implications in organizational terms, but without large implications for construction companies. A majority of the stock is owned by landlords and housing associations and hardly 40% in Germany is owner-occupied and the social housing has dropped to a mere 6% in 2014, even considerably lower than in the UK (Knorr-Siedow, 2015). Traffic-related infrastructure has been relatively stable in the past and the expected investments are slightly increasing up to 2020 (BMVI, 2016). Infrastructure is completely publicly commissioned and owned, although a toll system is in the making. Regarding the turnover of the CI, 15% comes from the service-related companies. The architects are united in the Architektenverband (VDA) which is a powerful association which has launched several initiatives to improve the subsector.

Regarding federal administration and policy making, especially the Ministry for Environment, Nature Conservation, Building and Nuclear Safety (BMUB) is important as it takes care of the construction policies and city planning. More regarding (traffic) infrastructure, the Ministry of Transport and Digital Infrastructure (BMVI) is relevant. Concerning research and innovation, the Ministry of Science and

Education (BMBF) is active in policy making. Also in relation to construction research it develops policies and collaborates with BMUB. The industry itself is united in *Die Deutsche Bauindustrie*, which is a powerful industry association. This represents mostly the market parties in construction

Compared to the Dutch CI, there are some major differences that are not represented clearly by the network schematization as presented in Figure 19. First of all, Germany is unique regarding its federal system including states with high autonomous administrative and legislative power. Furthermore, research is organized from partly private organizations that are funded largely publicly. CI research is organized within those organizations – notably *Fraunhofer Allianz* – and also the individual universities play a large role in this research. Other national industry associations are harder to find than in most other countries. There are some so called 'Verbände', but their influence seems lower than in for example the Netherlands, let alone the Scandinavian countries.

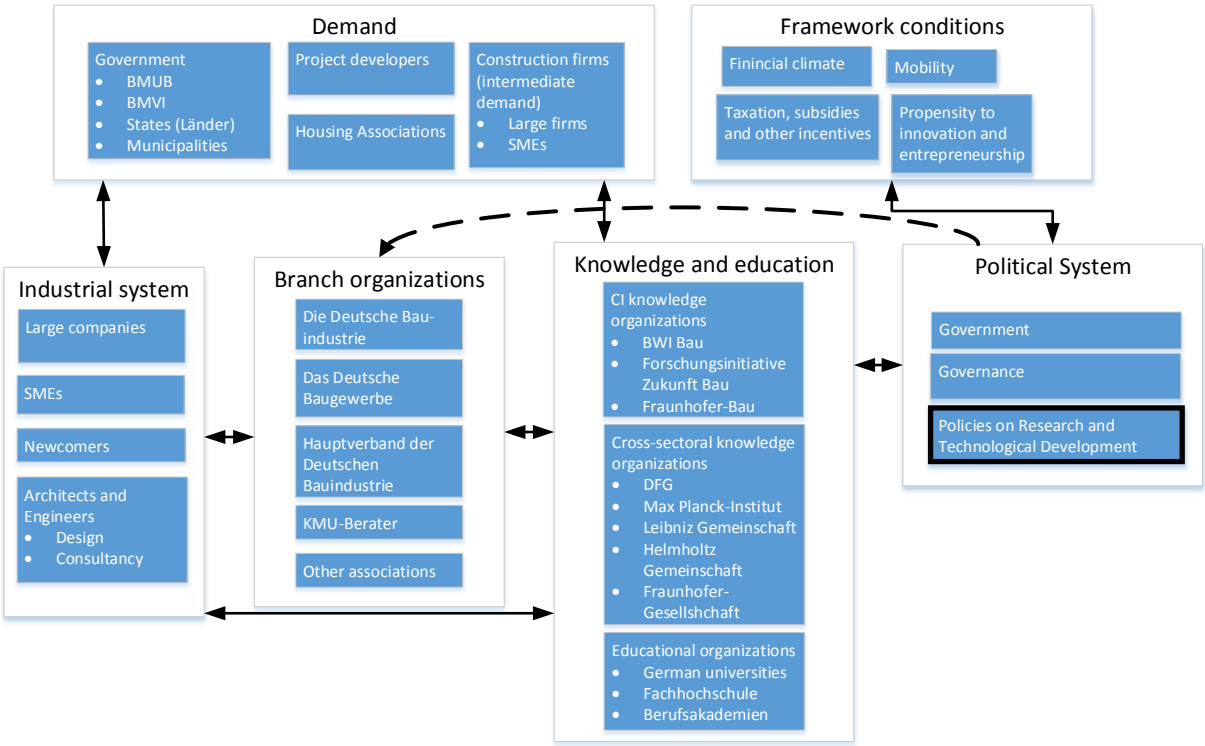


Figure 19 – Network schematization German CI

Due to the national structure, the network is in practice different than in the other four studied countries. Germany is as discussed before divided into states which have a relatively large autonomy, also regarding research and education. However, the national publicly led initiatives on innovation and construction reform are example for broad-based federal initiatives. More detailed policies, however, are made mostly by the states.

5.4.3 Phase of development

As discussed before, for several decades the German economy is one of the most stable ones. Figure 20 shows the GDP development from 2008 to 2016 and the impact of the crisis in 2009, showing the quick recovery. Over the whole line, a stable, continuous increase is visible. A stable growth is also expected for the future, up to 2020. OECD, IMF, UN and EC all expect a continuous growth around 1,7% annually, with the OECD predicting a slightly lower 1,3% annually for the coming three years.

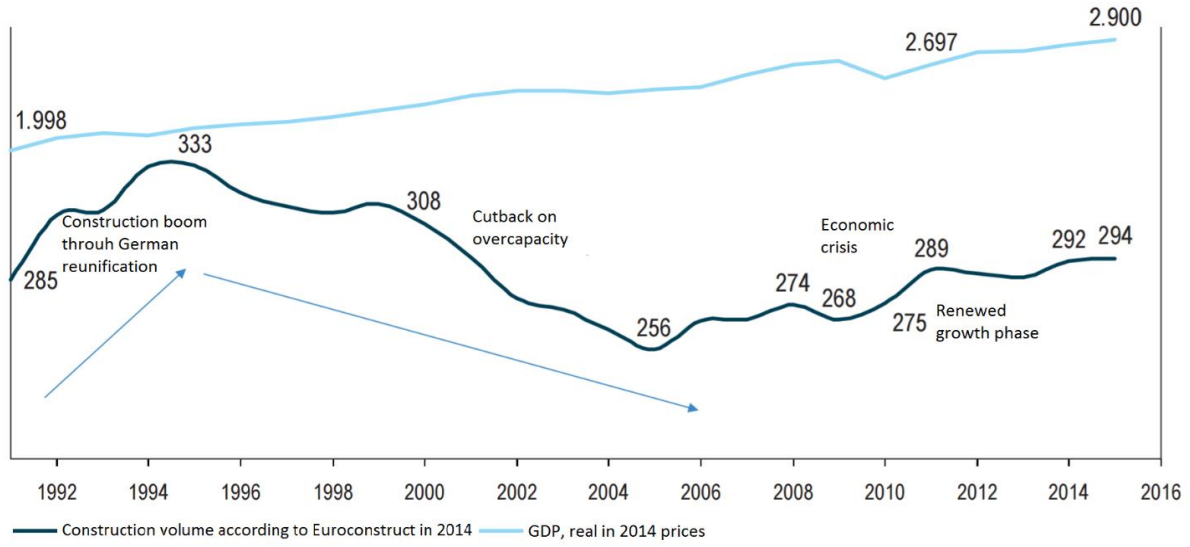


Figure 20 – Construction volume and GDP Germany (Source: Baumanns et al., 2016)

Also German Statistics Office has calculated the expected turnover of the CI in 2016 and predicted also a continuous growth for the CI as shown in Figure 21. Figure 20 shows the turnover over a longer period in which the development of the whole sector in the past 25 years is visible. The relative innocuity of the crisis in 2008 on the sector is also visible in the figure (Baumanns, Freber, Schober, & Kirchner, 2016).

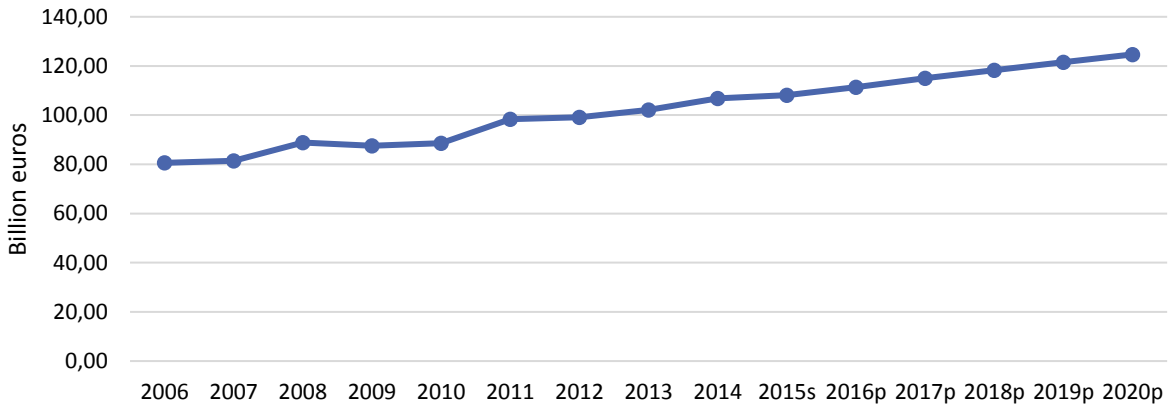


Figure 21 – Turnover German CI 2006-2020 (Source: Destatis, 2016)

5.5 Summary of structures

This chapter gives a short table-wise summary of the previous chapter. The goal of the summary is to provide a consistent overview of information in order to enable comparison and linkages to policies which will be discussed in the next chapter. The different tables correspond with the different subjects which are dealt with in the previous chapter, being the knowledge system (Table 5), educational system (Table 6), industry characteristics (Table 7), market performance (Table 8), institutions (Table 9), external factors (Table 10), network relations (Table 11) and phase of development (Table 12).

Table 5 – Knowledge system

	NL	UK	DK	SE	DE
Government-funded research institutes	TNO and Deltares united with semi-market institutes in TO2 and universities. Also research intermediaries other higher education institutes	RCUK allocates research funds. Actual research is mostly via private organizations and universities	DTI is the main and official Danish research institute. Although it is an independent institute, its relation with government is tight. Universities also play a large role in research.	Vetensaksrädet is responsible for the public research and innovation funding. Public research is largely commissioned to universities.	Research executed on a public and national basis by Max Planck Society, Fraunhofer Allianz, Leibniz Association and Helmholz Association. Individual 'Länder' arrange own research.
Privately-funded Institutes	Partly the same as government-funded. Several, united in TO2	High-level private organizations. Moderate collaboration and large focus on universities	Denmark has lots of research institutes. Funding is done with public as well as private money.	RISE and SP are two large Swedish research institutes. However, several smaller institutes are responsible for research. Vinnova's main aim is to stimulate innovation. Research is one of the means	High-level private organizations with cooperation with Universities
Construction research except for universities	EIB and individual research institutes For example Deltares for hydraulic research	Several semi-governmental organizations such as CIRIA and CITB. Also several private organizations (often linked to universities)	Regarding construction SBI is the most productive research institute.	CBI conducts a lot of research regarding concrete construction and infrastructure	Institut der Bauwirtschaft is a large player in construction research. Zukunft Bau is a program which entails construction research.
Construction research Funding	Ministry of economic affairs, Ministry of Education and culture and private funding. Furthermore EZ and IenM in specific programs	Public funding is done by seven councils united in RCUK, an independent government organization	Ministry of technology and innovation is largely responsible for funding. Also other ministries and private parties.	Vetenskapsrädet is responsible for the allotment. The Ministry of Education, Research & Culture provide the largest part of the research funding	Wissenschaftsrat advises government (Min. of Science and Education) on public national R&I funding. DFG organizes research projects.

Table 6 – Educational system

	NL	UK	DK	SE	DE
Top universities (in NYT top 200)	12	33	3	6	20
Administration of universities	Independent	Autonomous and independent	Independent. 35% is privately funded.	Autonomous, but guided by ministries	Governed by individual 'Länder'. Largely autonomous
Construction education	'4TU verband' for universities and SIA for other universities of applied science.	Universities	DTU-byg, Aalborg and other HE institutes.	Several universities and university colleges that offer construction courses	Several top universities, such as RWTH, TUM and KIT.

Table 7 – Industry characteristics

	NL	UK	DK	SE	DE
Labor productivity index 2012 (OECD, 2013)	100	80,6	98,8	90,9	96,8
DEA efficiency index in construction of 2012 (Nazarko & Chodakowska, 2015)	0,838	1,00	0,798	0,782	0,639
Building construction turnover index 2010, 2011, 2012, 2013, 2014, 2015, 2016 (2010=100)	100 106,2 94,1 83,8 85,3 n.d. n.d.	100,0 102,2 95,2 96,5 104,2 108,8 111,4	100,0 111,5 118,8 116,8 124,9 n.d. n.d.	100,0 107,0 114,4 113,6 122,0 n.d. n.d.	100,0 111,7 111,2 112,7 118,7 121,3 128,2

Table 8 – Market performance

	NL	UK	DK	SE	DE
finished dwellings (public/private) (per m citizens) (2016)	1.099/10.271 65,4/611,4	4.310/27.218 67,2/424,6	2.488/15.340 444,3/2.739	5.314/29.289 (year 2015) 539,5/2.973,5	0[1]/216.120 (year 2014) 0[1]/2675,7
Infrastructure quality ranking (EC, 2017)	Railroad: 9/26 Port: 1/23 Air: 1/28 Road: 1/28	Railroad: 3/26 Port: 7/23 Air: 7/28 Road: 12/28	Railroad: 10/26 Port: 4/23 Air: 6/28 Road: 5/28	Railroad: 16/26 Port: 6/23 Air: 9/28 Road: 11/28	Railroad: 5/26 Port: 5/23 Air: 3/28 Road: 8/28

[1]Responsibility of the 'Länder'

Table 9 – General behavior and institutions

	NL	UK	DK	SE	DE
Business behavior	Directness Distrust in other parties Low formality	Politeness Individualistic	Straight Direct Unambiguous Social contact	Directness Politeness Honesty Low power distance	Punctuality Pragmatism Relatively formal
Political system	Centralized government, semi government-led	Centralized government, market-driven	Centralized government, social-democratic	Centralized government, social-democratic	Federally constituted government, government-led
Construction legislation	Integrated in 'Bouwbesluit' and 'Aanbestedingswet'	Building Regulations and Approved Documents	Danish Building Regulations	BBR (building code)	BauGB
Employees in Unions whole sector (2014)	26%	20%	67%	70%	18%
Collective Bargaining Coverage (Source: worker-Participation.eu)	81%	29%	80%	88%	62%

Table 10 – External factors influencing innovativeness

	NL	UK	DK	SE	DE
Interest rate (oct 2013, 2014, 2015, 2016)(OECD, 2017)	0,226% 0,083% -0,054% -0,309%	0,495% 0,543% 0,570% 0,380%	0,273% 0,300% -0,070% -0,200%	0,920% 0,140% -0,440% -0,750%	0,226% 0,083% -0,054% -0,309%
Inflation (jan 2014, 2015, 2016, 2017)(OECD, 2017)	1,40% 0,0% 0,60% 1,70%	1,90% 0,30% 0,30% 1,80%	1,0% -0,10% 0,60% 0,90%	-0,20% -0,21% 0,77% 1,40%	1,34% -0,28% 0,47% 1,89%
Political compass government	Least authoritarian, neoliberal and slightly right winged	Considerably authoritarian and right winged	Moderate authoritarian, neoliberal and slightly right winged	Moderate authoritarian, neoliberal and right winged	Moderate authoritarian, neoliberal and right winged
Patent system	Unitary Patent and Unified Patent Court	Unitary Patent and UK Patents Court	Unitary Patent and Unified Patent Court	Unitary Patent and Unified Patent Court	Unitary Patent and Bundespatentgericht

Table 11 – Network characteristics

RELATIONS	NL	UK	DK	SE	DE
Demand – Industry (market)	Mutual essential dependency. Distrust each other, but try to collaborate more and more	Mutual essential dependency. Distrust each other, but relatively collaborative	Mutual essential dependency. Relatively high trust and aligned future goals.	Mutual essential dependency. Distrust each other, but try to collaborate more and more	Mutual essential dependency. Distrust is compensated with numerous initiatives
Demand – Knowledge & Education	Demand side buys knowledge. Often both governmental and close collaboration exists	Demand side buys knowledge. Often both governmental and close collaboration exists. Coordinated by RCUK	Close cooperation between government agencies and knowledge and education. Private demand side buys knowledge	Demand side buys knowledge. Often both governmental and close collaboration exists; especially through universities	The large research facilities are strongly connected with market parties, public as well as privately
Industry – Industry associations	Industry is represented by associations. Especially employers. Strong position industry associations.	Individualistic approach and wide but weak sector representation.	There is a strong industries' representation, all under the umbrella of Danish Industry, with its own, ambitious goals and policies.	Large representation of industry by industry associations.	The strong Association culture is visible in the CI and the industry representation is strong
Industry associations – Knowledge & Education	Tendencies towards collaboration. Associations now and then produce knowledge themselves, often in cooperation with knowledge institutes	Tight bonds between knowledge and education and industry associations	Industry association publish themselves, but also cooperate closely with research institutes	We could not find a tight level of cooperation	Strong relationship between the four big research institutes and associations, also concerning reform initiatives
Industry – Knowledge & Education	Educational system delivers industry's workforce and knowledge organizations deliver new insights for industry. However, interplay is limited	Strong collaboration between knowledge oriented firms and knowledge organization.	High amount of intellectual assets. The collaboration between industry and research institutes is high.	The industry develops significant knowledge itself and buys knowledge from universities and knowledge organizations.	The industry buys knowledge from the research institutes and makes use of the different services it offers (especially Fraunhofer).
Knowledge & Education – Political system	Knowledge and education improve the Dutch knowledge base. Political system decides on priorities and public funding (OCW)	Education is relatively for a large part privately funded. The universities and RCUK are independent bodies that are relatively autonomous.	Education as well as knowledge is funded largely publicly. The independency from politics is high.	The political system has a limited say in knowledge development because of the large share of university research and its autonomy.	The political system with its strategies has a strong influence on the research strategies, regarding prioritizing as well as funding.

Political system – Industry Associations	Political system negotiates with associations. Political system protects public money and associations the firm's and employee's rights.	The political system does not negotiate a lot with sector associations.	The cooperation between associations and politics is high. However, the goals set by associations are even more ambitious than set by the government.	Political system negotiates with associations. Political system protects public money and associations the firm's and employee's rights.	The political system interferes merely with associations. Of course, it negotiates terms, but the power is temperate.
Framework Conditions – Political System	Framework conditions determine political landscape and political landscape influences the context.	Framework conditions determine political landscape and political landscape influences the context.	Framework conditions determine political landscape and political landscape influences the context.	Framework conditions determine political landscape and political landscape influences the context.	Framework conditions determine political landscape and political landscape influences the context.

Table 12 – Phase of development entire construction industry

	NL	**UK**	**DK**	**SE**	**DE**
Past decades	• Collusive • Stable • International specialties, but low international orientation in general	• Reform initiatives • Early collaboration promoting initiatives	• Emphasis on sustainability • Green energy	• Knowledge oriented • Sustainability • Collaborative	• Strong economy • Broad strategies • Lead in energy policy
Handling of the crisis	• First three years were hard • Large differences for the subsectors	• Continuing housing crisis • Improving civil and heavy construction	• Heavy housing bubble • Slow recovery • Recovery civil and heavy construction	• Small impact • Early recovery • Considerable growth from 2014	• Relatively undamaged • Early and stable recovery.
Prognosis coming years	The recovery is still going on. Especially recovery services sector is going slowly	Brexit makes the future unclear. In the near future, limited damages are expected, with growth after several years	Expected growth on all sides. Housebuilding industry boost for refugee's homes. Shortage of skilled workers.	Expected increase in turnover. Also housing market is expected to grow strongly. Enormous housing projects.	Slight but stable growth in construction.
Actual developments	Confidence increases, as does the turnover and amount of employees.	The whole UK economy is currently under pressure of the Brexit. Although the actual effects are still not negative, uncertainty affects development.	Confidence is returning, but not on every aspect. Turnover and employment opportunities are from 2015 gradually increasing.	Steadily increasing construction sector. Currently, the infrastructure investments are quite low, but a new bill has ensured future investments.	Currently the sector is still growing with a strong housing growth in the recent past . The growth in the sector, however, is slow.

6 Innovation policies and initiatives

Policies are like medicines. A medicine can, when used in combination with other medicines, affect the efficacy of the other. On one hand, combined medicines can help to fight the disease, one drug might fight the side effects of the other drug or they can without any interaction be used together. On the other hand, however, an unsuitable cocktail can not only lead to diminished functioning of one drug and therefore survival of the disease, but it can make matters even worse, degenerating the body's functioning. The same goes for policies, which makes the need of a suitable 'cocktail', or policy mixtures, essential.

Attribution of effects on innovation to a single policy measure is next to impossible due to the aforementioned interdependence and unpredictability of the context. That is the second reason that the policies are considered as integral policy profiles rather than packages of individual effect analyses. Accordingly, a proper policy profile is essential and therefore the different policies are studied as integral policy profiles after the individual policies are studied per country. A note has to be made that "generalizations can only be made to a very limited extent and then with caution, and that thorough analysis of contextual conditions will always be required" (Edler et al., 2016).

Per country the different policies which affect innovative behavior of the CIs are listed and categorized. This categorization is followed by a more thorough analysis on the basis of innovation impact literature and expert's opinions. First, the European Union is briefly discussed, followed by a more detailed discussion of the Netherlands, the UK, Denmark, Sweden and Germany. For each of these countries the innovation policies are described in a convergent way, i.e. from national innovation strategy to construction innovation policy measures. In appendix IV, a table-wise summary of the different policies is offered, containing of characteristics, classification and impact estimation.

6.1 European Union

The EU, with all its institutions as discussed before, is an important player in large-scale future views and integral strategies. Regarding specific policy, it is not very active, but all the more is it in setting future goals and offer broad policy frameworks to its member states. Those frameworks are often presented in elaborate reports as described in chapter 3. However, the more specific policies regarding construction and innovation are presented in this section. The discussed initiatives and strategies are as discussed before not the main subject of this study, but the studied countries often launch policies which fit in these EU strategies. As will become clear in this chapter, many strategies are reactions on sustainability and environmental goals as for example the *Energy Efficiency Directive* (EED) and the overarching *Europe 2020* strategy.

Current innovation strategy

The general European innovation strategies were since 1984 wrapped in so called *Framework Programmes*, numbered to the 8th framework program, also known as *Horizon 2020*, which was launched in 2014. Since the first, every framework was built upon the former and grew in extensiveness from barely 3,8 billion euros to 80 billion. These funding programs mainly aim at European research and have a large emphasis on innovation. This last program has been implemented by the EC in 2014 and is planned to continue until 2020. It is responsible for implementing the R&I agenda and has a strong focus on a more sustainable Europe (European Commission, 2014).

The *Horizon 2020* program consists of three main pillars, being Excellent Science, Industrial Leadership and Societal Challenges and this whole program comes under the wider *Europe 2020* strategy. Although construction itself is not one of the themes, several sub-programs have a strong impact on construction; resource efficiency, transport and energy being examples. A more construction-oriented program, *Construction 2020*, was launched in 2012 mainly aimed at healthy competition and sustainability of constructions as well as actors' relationships (European Commission, 2012). Admitting that innovation is indirectly influenced by this strategy, innovation is not one of the focus areas.

6.1.1 Current innovation policies

For more than a decade, the European Cluster Alliance is active as an open platform to stimulate clustering for collaboration in innovative projects. It was originally launched under the PRO INNO initiative and is adopted in the new framework program. Two years later, in 2008, the *Lead Market Initiative* (LMI) was launched to unlock market potential for innovative goods and services. Sustainable construction was one of the six preselected markets in the program. From 2008 to 2011 a foresight study called *Farhorizon* was launched to align strategic and applied research with longer-term policy needs as part of the 7th framework program.

A hot topic in the policy field in the past decade is stimulation of innovation-friendly and quality-oriented procurement. In 2011, the EU published a green paper on stimulating international procurement of SMEs within Europe. This was followed by new directives in 2014 in which space was created for innovative procurement. In 2015, the simplification of regulation in order to stimulate innovation again became subject to an initiative. The so-called REFIT was a large EC-led program with the purpose to stimulate innovation through regulation. Furthermore, in 2014 Eurostars' *Eureka* was launched by the EC in order to fund international innovative projects especially aimed at SMEs. In 2016, the EFSI 2.0 was issued as a EU guarantee for mobilizing private and public investment regarding sustainability. Construction companies can claim funds for sustainability-oriented projects.

More construction-specific, some initiatives were launched, mostly not aimed at innovation as a primary goal but rather aimed at for example sustainability. In 2014, the *Energy-Efficient Buildings* (EeB) program was initiated as partnership between the *European Construction Technology Platform* and the private sector, which decide on priorities regarding energy and sustainability. It also formulates future goals and strategies regarding sustainability in building construction. Two years later, in 2016, the cPPP was launched for stimulating contractual public-private partnership in a standardized frame. This same year, the European construction regulations were revised with the aim to standardize and simplify. Also the *BIM Task Group* was installed for the stimulation of a standardized usage of BIM in construction projects throughout the EU.

6.2 The Netherlands

In the previous section, the overarching EU strategies are made clear, allowing the member states' policies to be reviewed. Regarding the different pre-selected countries, first and most elaborate, the innovation policies in the Dutch CI are studied. Starting with a discussion of the strategies and policies, a general view is sketched. This is followed by a listing and subsequent categorization of the different policies and initiatives, supplemented with a short analysis is done per individual policy measure and for the strategy as a whole. In that part, the strategy is placed into context by means of finding linkages to the structural analysis in order to give a broader view of the SIS. This is followed by an analysis of policy classes and finally an impact estimation.

6.2.1 Current national innovation strategy

The Netherlands act by an encompassing Research and Innovation (R&I) strategy consisting of (applied) research, innovation and entrepreneurship (Janssen et al., 2016). This in 2011 launched *Enterprise Policy* is primarily governed by the OCW and EZ, and occasionally other departments are involved – for instance BuZa, when it comes to attracting foreign direct investment. Regarding construction, IenM has a large say in infrastructural projects were BZK decides on building construction. Typically, IenM has a more long-term hands-off approach, whereas EZ has a hands-on approach, resulting in an interactive and cooperate intensive approach with the relevant actors. Furthermore, IenM is more responsible for infrastructure, whereas the building construction far more organized by the market itself, with BZK as official ministry. This list of ministries immediately points out the fragmentation of construction as well as innovation throughout the different departments, which, as can be read later on, results in poorly matched policy profiles. Higher education policies are typically integrated in science policy, but the rest of the education part is mostly seen as a separate policy field (Janssen et al., 2016).

The *Enterprise Policy* includes both the plans regarding generic and more specific R&I policies, although the latter initially received considerably more attention in the public and policy debate. A key principle of the *Enterprise Policy* is that the government does not steer with rules and subsidies, although the following paragraph shows that it is not entirely done this way (Janssen et al., 2016). Instead, it should ensure that companies have sufficient space to do business, to invest, to innovate and to export. This has resulted in the award of less direct funds in exchange for generous R&D tax incentives, less and simpler rules, broader access to corporate finance, better utilization of the public knowledge infrastructure by businesses and better alignment of fiscal policy, education policy, foreign policy and diplomacy with the needs of businesses. However, other aforementioned barriers still prevent construction companies to innovate structurally.

The formal longer-term policy goals are to bring the Netherlands in the top-5 of knowledge economies in the world in 2020, to increase in this same period the Dutch R&D expenditures to 2,5% of GDP, and to create *Top-consortia for Knowledge and Innovation* (TKIs). In this last point, public and private parties participate for more than €500 million, of which at least 40% is funded by the business sector in 2015. This share of funding eventually has grown to 48% with an overall participation of €800 million (Ministry of Economic Affairs, 2016). At the request of the Cabinet, several *Top Teams* were established over the course of 2011. These *Top Teams*, contributing actively to the strengthening of the new enterprise policy, are constituted by representatives from industry, research institutes and government. The government has implemented various actions based on the advice of the *Top Teams*.

Within this plan, nine *Top Sectors* were identified, consisting of agriculture & food, horticulture & propagating stock, high-tech materials & systems, energy, logistics, creative industry, life sciences, chemicals and water. In October 2015, the companies, societal organizations, research institutes and governmental authorities united in top sectors signed the new *Knowledge and Innovation Contract* for the next two years. *The Innovation Contract 2016-2017*, based on previous agreements, specifies for each *Top Sector* which ambitions were set including actions to be taken to meet the goals. Actual collaborative research efforts are largely taking place in the TKIs (Janssen et al., 2016). In 2016, it was announced that the number of TKIs would be reduced from 17 to 12. Compared to its predecessors, the *Top Sector Policy* is more formalized and particularly more integrated, even among ministries.

Next to these overarching strategies, there are several more specific ones. Regarding higher education, the strategic agenda *Quality in Diversity* was launched in 2011. It involves a long-term strategy for higher education and university research. A few years later, in 2014, the *Wetenschapsvisie 2025* was launched which aimed more at knowledge and science in general. One year later, in 2015, the HE agenda was succeeded by *De waarde(n) van weten* also aimed at an excellent higher education system. Although its impact on the CI is little, its impact on research and innovation in general is substantial. Regarding public real estate and spatial planning, the *RVB Marktvisie: Samenwerken op basis van vertrouwen* which strongly emphasizes collaboration for progress, which is a follow-up on the publication *Van kennis naar kansen: Strategische kennis- en innovatieagenda Ruimte en Vastgoed* (Rijksvastgoedbedrijf, 2017). Both papers highly emphasize innovation in the subsector.

Regarding construction, the overarching *Actieagenda Bouw* in combination with the *Routekaart Innovatieakkoord*, has become important, which incorporates a shared vision between government and industry about the future of the CI. A similar, but more extensive program was published in 2017 called the *Bouwagenda*. A large emphasis in those strategies is on collaboration and sustainability. Also themes were selected in the latter including digitalization, circularity and integrated designs. This final document is likely to play a huge role in construction innovation in the Netherlands, but due to its newness, no concrete policy measures following from this initiative are found to be analyzed. These initiatives are entirely developed by the Netherlands, but they fit into the EU policy goals, be it rather implicit. However, in contrast to previous initiatives, the *Bouwagenda* is supported by the largest sector associations, three ministries and influential political and industrial people. This broad support makes it more likely that collaboration and co-creation will actually take place structurally.

A more concrete government initiative towards construction is presented by Minister Blok, (formerly) Wonen en Rijksdienst (WR) who launched an initiative on benchmarking of the different construction companies in which also innovativeness can be made insightful. Evaluations on this measure are unfortunately not available. The benchmark has furthermore not turned out to be used practically ever since. Also *Task Force Delta Technology* (TFDT) was launched by *Topsector Water*. Seven people from the industry were employed by the government in order to advice clients, contractors and suppliers in order to speed up projects, decrease costs, stimulate innovation and develop new projects. In 2015, the IPS was tightened. Although no specific evaluation was conducted, the *Handbook of Innovation Policy Impact* suggests that when the innovators have a larger window of opportunity to exploit their innovation, they are prepared to take more risks and make higher investments. Quantifications, however, are not available on this subject.

6.2.2 Policy typology

The abovementioned strategies provide a framework for the more detailed policy measures. Firstly, the typology is presented, after which the more innovation- and construction-specific measures are discussed. The typology, adapted from Edler et al. (2016), as discussed in section 2.2, helps to make those policy measures more generalizable in order to draw conclusion on a theoretical basis. The policy measures that influence construction innovation are presented in Figure 22.

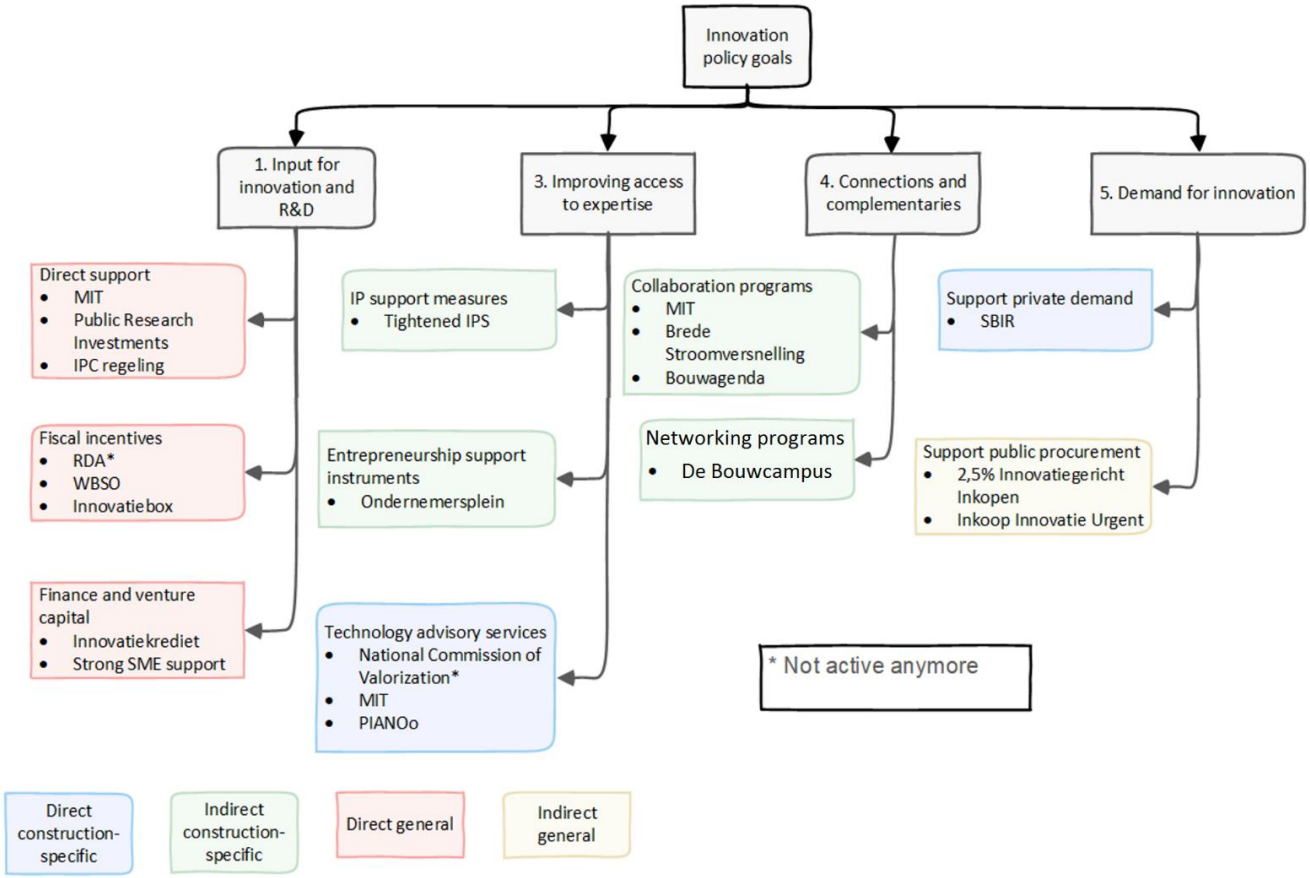


Figure 22 – Classification Dutch innovation policy measures related to the construction industry

The range of types of measures in regarding the Dutch CI is relatively limited, but the influence not less. It is clear that policy measures are mainly aimed at stimulating R&D input. Especially the (financial) share of fiscal incentives is an important set of policy tools. Furthermore, the access to expertise plays an important role in construction innovation. Most notably, the advisory services are important, as for example the national public expertise center of procurement, PIANOo, shows us, which is a rather unique organization nationally. However, the more concrete strategies and measures stem from sustainability-emphasizing and environmental impact-reducing targets and agreements rather than focusing specifically on innovation.

As noted in the methodology chapter (chapter 2), determining effects of a specific policy measure on general construction innovation is close to impossible—especially when complex, time-consuming econometric analyses are not executed per measure. Therefore, this study is confined to available policy effect reports and studies and general measure type conclusion as presented in Edler et al. (2016) their *Handbook of Innovation Policy Impact* on which the classification is also based. Also experts were interviewed to include their experiences with certain measures. Per type of class, the different policy impacts are discussed, also when no quantitative result can be given. In this way, a basis for impact estimation of policy profiles and mixes will be made.

6.2.2.1 Input for innovation and R&D

A large share of measures to stimulate innovation in general support R&D, mainly through tax incentives. Most notable are RDA, WBSO and *Innovatiebox*. Also loans were provided in the *Innovatiekrediet* scheme and the MIT and IPC measures provide direct financial support. These measures are all available cross-sectoral.

In 2013, the MIT instrument, aimed at subsidies for SME innovations was launched, which has been closed in September 2016. The promotion of innovation in SMEs is done by various kinds of tools, among which networks are set up, public organizations advise SMEs on implications with innovation and most importantly subsidies on innovative activities. In march 2017, an evaluation was presented in which the researchers claimed that the measure had as a result that publicly developed knowledge was used more effective by SMEs which resulted in an increase in innovativeness (Ministry of Economic Affairs, 2017). In the survey, it turned out that 90% of the respondents believed their knowledge about future innovations and their views on technical feasibility improved significantly. The evaluation shows that 84% of the respondents the innovation trajectory was influenced positively as a result of the MIT (Zuijdam et al., 2017). Although econometric studies were conducted which all implied a positive effect, their conclusions read that a majority of the innovation projects are still not concluded and therefore quantitative conclusions cannot be drawn. Moreover, the MIT program links those individual projects to the national strategic agendas regarding research and innovation.

Aimed at innovation collaboration, the *InnovatiePrestatieContracten* (IPC) scheme was launched, which subsidizes two-year collaborative innovation projects. In relation to innovation, it is the most important collaboration scheme in the Netherlands. This direct funding program was launched by EZ and was aimed at collaborative SME projects. In 2014, an evaluation was presented with the main conclusion that 70% of the respondents say to have participated in an innovation project because of the IPC, especially because of the additional funds. Furthermore, 60% says to innovate even more in the future (Ministry of Economic Affairs, 2014). The evaluation also shows that two-third of the surveyed SMEs says to be more profitable than before participating in the IPC. Also has the program had as a result the parties were more willing to collaborate. The funding program has taken away several barriers to innovate.

As a form of tax measures, the Dutch government has presented several rather unique policy measures. WBSO is the major scheme regarding financial tax advantages for R&D activities in the Netherlands. Companies or freelancers who invest at least 500 hours in R&D may apply for this and when granted they are qualified for tax deduction (Rijksdienst voor Ondernemend Nederland, 2017). The measure has been launched in 1994, which made the Netherlands one of the first countries to apply such a system. As a result, several evaluations were presented. The study which covers 2011-2017 will be presented in 2018, although the report on 2006 to 2010 has presented some interesting findings. The evaluation shows that the program is a large incentive for companies to conduct research and become more innovative.

As product innovation entails a large share of the construction innovation spectrum, also knowledge spill-over takes place, which enlarges the effects on innovation as a whole. The econometric evaluation is confined to product innovation as process innovations as a result of the program are according to the writers unmeasurable. Large companies conduct more private R&D instead of outsourcing and for SMEs the threshold is lowered to invest in R&D at all (Verhoeven, Van Stel, & Timmermans, 2012). Other than that, companies are willing to take a better look at other programs and incline to take more risk; especially the often risk-avoiding SMEs. Strange enough, construction companies made less use of these fiscal incentives and direct financial support than companies in other sectors. This was even in relation to the relative amount of R&D in the sector, for which a specific reason was not found (Koenen, 2016).

Furthermore, the fiscal scheme regarding tax deduction on R&D activities (RDA) was initiated. This RDA has had implications from the beginning and was despite good arguments from policy makers introduced after intensive lobbying activities. In The Hague, RDA has never been popular, as policy makers argue that the private sector itself should invest more in R&D. Although the RDA has stimulated innovation, it would moreover stimulate unfair competition. In 2016, the scheme was partly fused with the WBSO. An analysis shows that particularly young SMEs and startups, an important target group is unable to make use of the instrument as it reduces taxes on profit, find making substantial profits difficult to achieve. The CPB has analyzed the Dutch innovation policy in 2016 and concluded that although R&D was stimulated significantly, the social return was limited (Centraal Planbureau, 2016).

Related is the *Innovatiebox* that is particularly aimed at innovative activities which have either been registered as WBSO projects or produced patents. It is as such additional to the WBSO. Actual tax deduction on profit as a result of innovative activities can be acquired. An important barrier to participate in the *Innovatiebox*, however, is the fact that the production costs of the R&D have to be demonstratively recouped. This measure, which is still ongoing, was reviewed in 2015 on the period of 2010-2012. This evaluation concludes mainly that the measure is very effective, but puts a mark on the fact that as there is no proof that the reduction in corporation tax is actually used for R&I activities. An econometric analysis shows that for every euro of tax reduction, an additional 0,54 euro is spent on R&D (Hertog et al., 2015). It also states that the efficiency is very good as it is directly coupled to a statement that can be obtained through the WBSO, which highly presses additional bureaucracy.

Based at a loan, the *Innovatiekrediet* was launched in 2012 which enabled especially startups and SMEs to receive capital for R&D investment for innovations. A 2013 evaluation by De Jong, Gielen, and Van Praag (2013) was commissioned by EZ. The report shows the measure to be effective with a ‘bang for the buck’ of 1,82 euro for every euro loan. The procedure, however is quite long, and especially by rejected applications, the average downtime was more than a year. The target audience is very comparable with the WBSO, which might result in policy overlap instead of complementation. In 2018, the measure is planned to be under review again.

6.2.2.2 Improving access to expertise

Shortly after the Top Sector Approach was introduced, the Top Teams where initiated, representing the Top Sectors. In 2011, also, the *Centers of Expertise* and *Centers for Innovative Craftsmanship* were set up. Furthermore, the strategic agenda *Quality in Diversity* was presented in that year and also the *National Commission of Valorization* (LCV) was constituted, aimed at knowledge management and distribution. In 2012, the TKI approach was launched by the Top Teams. This approach contained concrete measures to stimulate research and innovation within these specific areas, mainly to offer access to expertise.

Furthermore, several initiatives are launched to smoothen information exchange and reduce bureaucracy. *TenderNet* is an example of an online service which gives market parties insights in the activities on a client-level. Furthermore, this gives the opportunity to reach a large and broad professional audience for societal problems. This theoretically stimulates innovation as also players lower in the value chain can directly suggest alternative solutions or ideas.

The *Ondernemersplein* initiative enables entrepreneurs to have all relevant public documents on a central location. The rationale is to reduce bureaucracy and improve an oversight of different measures and subsidies the entrepreneur is more intended to make use of these arrangements. However, a clear impact analysis of the *Ondernemersplein* on innovation has not been done. PIANOo is another public agency that has information provision as primal goal. Its activities consist of the organization of events and networking, the launch of innovative pilot projects and development and experimenting with new types of procurement. Another important aspect is the coupling of public organizations with fitting innovations and in this way linking the demand with the supply side.

Fortunately, an evaluation report has been written in 2014 commissioned by EZ. Its main conclusions were that PIANOo largely helped contracting authorities to improve professionalism and smoothness of procedures. The result on innovation, however, do not directly come forward from this evaluation report. However, information provided by PIANOo on for example innovative procurement is likely to have a (small) positive effect on innovativeness—even considering the harsh cuts in budget and personnel within the agency in the last few years.

6.2.2.3 Connections and complementaries

Collaboration and networking is as discussed before an important theme within the innovation strategies. The Dutch government has launched several initiatives to improve this. The MIT program is an example as can be read in section 6.2.2.1.

The *Brede Stroomversnelling* is another famous sector initiative aimed at energy neutral dwellings organized by construction firms, suppliers, social housing corporations, municipalities, energy operators and other parties, in cooperation with the government, as discussed in the previous section. It has a large basis in the energy agreement (*Energieakkoord*), which prescribes ambitious sustainability requirements for new housing. By means of pilot projects, innovation is stimulated and risk is managed and equally spread. Although innovation is not a goal in itself in these projects, the goals foster innovation. It is aimed at making rental dwellings large-scale energy-neutral and it is launched by the market in cooperation with the government. Innovative technologies in achieving this goals are stimulated. Also pilot projects are launched in the Netherlands in order to stimulate the market to come up with innovative technologies for taking the building construction to a new, low-impact, future. In 2013, the EIB has researched this initiative and strongly remark that it has a positive influence on innovation; especially because of the high amount of collaboration. It moreover has spillover effects within the sector (Hardeman & Elp, 2013).

Also the *Bouwagenda* was introduced in 2016/2017 in order to make the building construction in 2050 energy neutral, and meet the goals set in the European 2020 goals. Moreover it aims at a reduction of 50% in the use of primary raw materials and a circular use in 2050, while achieving an 10% productivity increase of the sector in 2025 by combining quality increase with cost reductions (Kamp, Schultz van Haegen-Maas Geesteranus, & Blok, 2016). This policy is controlled by the *Bouwcoalitie* of the *Bouwcampus*, in which all types of actors are included, aimed at forming an integral network within the sector. The *Bouwcampus* itself moreover acts as a network and places special emphasis on collaboration and co-creation between private and public parties and also tries to apply an integral approach by considering parties cross-sectoral. Although it could be largely seen as a strategy, it also includes concrete measures. However, as a result of the newness of these initiatives, no impact conclusions can be drawn yet and the tools presented are described too vaguely to draw conclusions based on Edler et al. (2016).

6.2.2.4 Demand for innovation

Regarding private demand, the SBIR program is a competition in which innovation is contracted by public organizations through direct competition. In June 2017, the CPB has published and evaluation of the SBIR and presented also an international comparison. It is important to note that SBIR is not construction-specific, but that the large usage of procurement makes that construction is a sector that makes SBIR suitable to construction. Regarding the Dutch SBIR, the evaluation report shows that it stimulates companies, and specifically SMEs to innovate (Centraal Planbureau, 2017). However, econometric evidence lacks. Edler et al. (2016) largely support this conclusion, although they argue that it is extremely important that procedures are followed adequately for avoiding cherry picking.

Also the launch of *Inkoop Innovatie Urgent* (IIU) is an example of an initiative of the government (particularly EZ, Commission for the Enterpreneurial Netherlands and PIANOo) in which the selection of innovative contractors is stimulated and can be seen as a demand-driven measure. This is a result of the agreement to procure for 2,5% innovation-friendly. Although it is not construction-specific, the applicability to the CI is evident. Innovation-oriented purchasing stimulates the market to innovate as it will increase their chance to execution of the project. However, the quantified impact of IIU on innovation in construction is not studied yet.

6.2.3 Policy profiles and mixes

As Edler et al. (2016) discussed, although the importance of careful policy mixture, the research base on this subject is quite thin, theoretically as well as practically. However, conclusions on several mixes were given, especially regarding specific combinations of types. This section shows whether the policies as described above can be fit into these conclusions. However, regarding stimulating research and innovation, the *Top Sector* approach seems to be balanced and attention has been paid to policy mixtures. More construction-specific, the mixture seems to be less balanced, as discussed below.

First of all, effective support of R&D should contain direct as well as indirect measures. Regarding R&D support in the Dutch CI, tax incentives are combined with direct funds in combination with specific targeting – particularly SMEs – are applied. Also the *Innovatiekrediet* offers loans for innovative projects, which are especially attractive for start-ups and SMEs. Furthermore, R&D collaboration is lightly stimulated, but several other countries take more concrete measures, while Cunningham et al. (2013) stress the effectiveness of collaboration programs as complementing direct support. However, IPC is a good example and is evaluated as successful in terms of collaborative innovation. Regarding financial measures, the general policy profile seems to be fit, but the CI turns out to make less use of these measures than other sectors.

Instruments for the support of implementation and diffusion of innovations are available in reasonable quantities and diversities, which compliments the financial support measures as described above. The policy profile as a whole, however, is leaning strongly towards the supply-driven innovation. Although some procurement initiatives make room for improvement for demand of innovation, the policy profile as a whole is still not balanced.

The *Handbook of Innovation Policy Impact* highly stresses to revise policy measures regularly in order to avoid policy measures being active that have served their purpose. The largest majority of the policy measures in the Netherlands are introduced five years ago or less. An exception is WBSO, but this program is revised regularly and kept up-to-date. As a result, the policies seem to be up-to-date and move along with the international tendencies.

All in all, it seems that Dutch policy makers do not put a lot of effort in a careful design of cross-agency policy mixes. The effects are mostly not studied and most innovation polies are implemented with their own goals. The Top-Team approach may be useful to formulate a more rationalized innovation policy profile – as a whole as well as in the CI. Also the *Bouwagenda* with the partnering *Bouwcampus* and *Bouwcoalitie* put efforts in integral approaches, but integral policy mixes that stimulate the entire innovation trajectory are not formulated as such. The *Bouwagenda* could also partly be seen as a foresight study as future societal goals play a fundamental role in the program. Notwithstanding, several combinations, such as the access-to-knowledge initiative PIANOo in combination with innovation-stimulating procurement approaches seem to be good mixes to stimulate innovation as a whole.

6.3 United Kingdom

The UK is unique in its kind regarding social institutions. The amount of collaborative reform reports is, as section 5.1.1 shows, astonishing and all those initiatives are extensively championed by public parties as well as industry individuals. First the general strategies on construction and innovation are presented which offer a framework for the later presented policy measures. The latter are analyzed on impact on innovation in the CI. Finally, a policy mix discussion is presented.

6.3.1 Current national innovation strategy

Since 2011, the UK government publishes the so called *Government Construction Strategy,* aiming at a joint strategy in order to structure the sector more and as a result reduce the cost of the public sector up to 20%. Between 2011 and 2015 the efficiency savings already turned out to be £3 billion annually (The Infrastructure and Projects Authority, 2016). Also regarding innovation several joint initiatives were launched in the past decade, but in most cases, innovation was not the main goal, but merely a tool in order to achieve goals. Rather than directly stimulating innovation, it focusses on removing barriers to it and moreover stimulating development and exchange of knowledge and collaboration (Construction Excellence, 2009; Egan, 2002; HM Government, 2013; Willetts, 2014). However, a more direct and active government role on stimulating innovation in the UK CI is presented as a 'plan B' in the *Farmer Review* (Farmer, 2016).

In December 2014, the UK government published a *Plan for Growth* (George, 2014). Sufficiently ambitious, its goal was to make the UK the best place globally for science and business, with a large emphasis on science and innovation. Almost 3,5 billion euro will be invested from 2016 to 2021 in scientific infrastructure. The research will also be supported in this period by investigating best practices. To catalyze innovation, several focus elements are picked that will be funded and stimulated. Another goal is to participate more in global science and innovation. A year earlier, in 2013, the CIOB has presented its *Innovation & Research Strategy* regarding construction research.

Other than concrete policy measures, goals were set for the future. In 2016, the UK government has presented *Construction Strategy 2016* and *Construction 2025*, both aimed at structurally improving the CI. The former sets out a plan to develop the government's capability of being a construction client and the latter presents concrete goals for the industry in 2025. Although the reports are in terms of actions rather vague, ambitions are very clear. Goals for 2025 are, regarding the CI, to have reduced the initial and whole-life costs with 33%, to reduce the overall construction time per project with 50%, reduce the greenhouse gas emissions with 50% and reduce the trade gap between export and import with 50% (HM Government, 2013). For reaching these goals, seven key themes were distinguished,

being image improvement of the CI, focus on efficiency, sustainability & low-carbon design, BIM, whole life issues & 'soft landings', international orientation & export of talent and SMEs. The underlying ideas of this document are moreover perfectly in line with the thinking of Egan, Latham and so forth. However, these strategies were presented before the *Brexit* and as a result, the European collaboration initiatives that are called upon may be in jeopardy.

6.3.2 Individual policy measures

The strategies are made clear, whereafter the individual policy measures can be reviewed. The same method for linking policy measures to general typologies as discussed in section 2.2 as in section 6.2.2 is applied in this chapter. This typology is presented in Figure 23. This is done in order to help making the policy measures more generalizable for drawing conclusion on a theoretical basis. The measures are discussed individually and are complemented with an impact discussion.

The amount of measures in relation to the Dutch CI stands out immediately. Also the diversity in policy tools is way larger. Large emphasis in policy making is placed on connections and complementaries, showing several collaboration and network programs. Moreover, the supply of skill is actively stimulated by two designated training boards. An active attitude towards innovation in construction appears from this palette of measures.

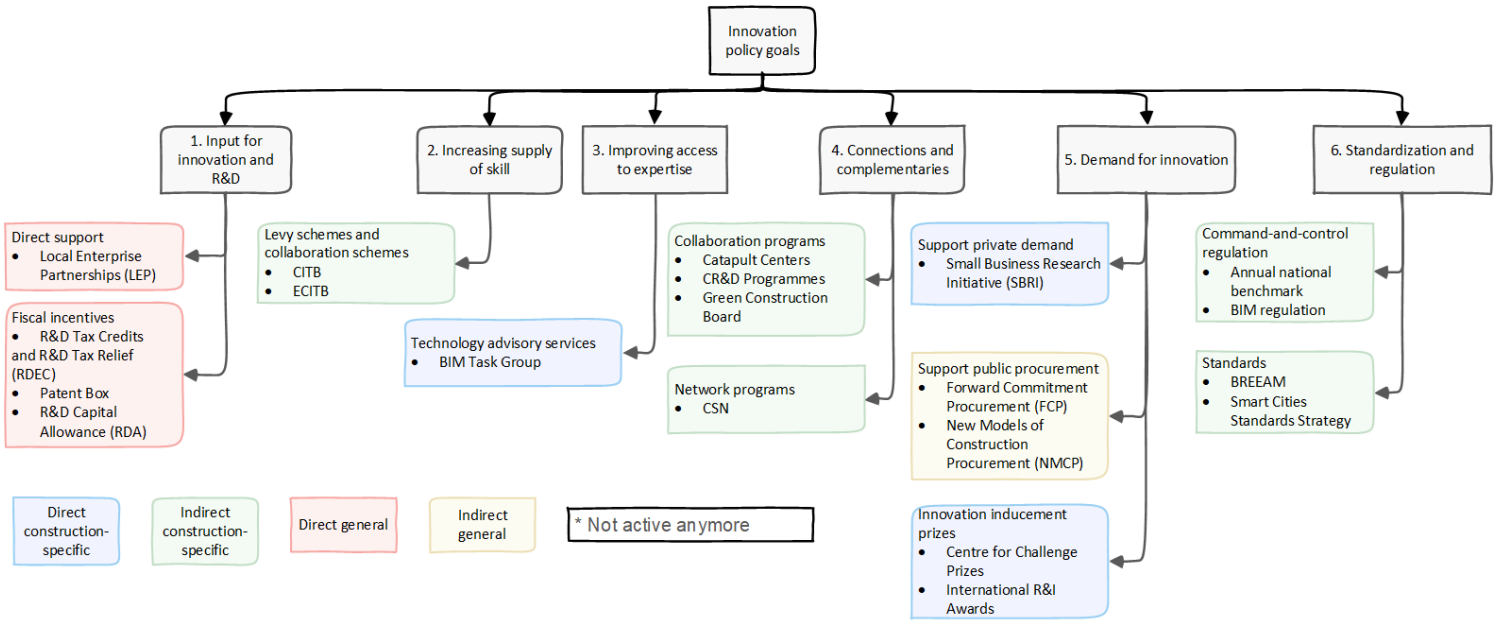


Figure 23 – Classification UK innovation policy measures related to the construction industry

In the UK the amount of policies that affect construction innovation is considerable. The study will be largely based on the study of Edler et al. (2016), as the NESTA who has commissioned this study, is located in and foremost aimed at the UK. Per type of class, the different policy impacts are discussed; also when no quantitative result can be given. In this way, a basis for impact estimation of policy profiles and mixes will be made. In the analysis, the order from the scheme of Figure 23 will be used.

6.3.2.1 Input for innovation and R&D

The aforementioned strategy and focus points have brought along several more concrete policies. R&D is, especially in the favor of SMEs, rewarded by tax incentives by the so-called *R&D Tax Credits*, aimed at increasing innovation (Willetts, 2014). Furthermore, there are several linked schemes for fiscal incentives for R&D, such as RDEC, RDA and *Patent Box*.

The *Local Enterprise Partnerships* (LEP), launched in 2014, stimulate local SMEs to innovative cross-sectoral. Although it is technically a collaboration program between public and private entities on a local basis, direct funds are allocated to companies and a large emphasis is on innovation. However, the actual impact on innovation is not evaluated; it is assumed that it has a slightly positive effect on innovation. Furthermore this measure is administered locally, resulting in a lack of national coordination and evaluation.

Regarding tax incentives, stimulation of R&D and Innovation is regularly used in the UK. First, the *R&D Tax Credits* is discussed, which was slowly taken over by the R&D tax relief in 2013. From 2016, the large company scheme which was incorporated in the tax credits, was completely taken over by the 2013 *tax relief scheme*. An evaluation of these schemes was presented by the HMRC in 2015. The evaluation suggested that for every euro of tax foregone, between 1,53 and 2,35 R&D expenditure is stimulated. Even the 1,53 is a quite reasonable additionality, which shows that the schemes are highly effective (Kringelholt Fowkes, Sousa, & Duncan, 2015).

The *R&D capital allowance* (RDA) scheme is closely related to the R&D reliefs and applies to full tax deduction for cost of capital equipment when intending to carry out R&D. As such, it can be seen as the capital expenditure equivalent to the aforementioned relief scheme. Although no particular impact analyses are being found, the expected impact is very comparable to the impact of the *tax relief scheme*. Although the target group is comparable, the difference in products makes it a useful complementary instead of overlapping measure.

The *Patent Box* is another tax incentive working according to a different mechanism. Tax profits attributable to patents and IP equivalent taxes are lowered with 10% in order to stimulated innovation. For this measure is rather new in the UK, no extensive impact analysis has yet been done. However, all directions point toward a positive effect, especially because a positive effect was also found in countries where this mechanism is used for a longer time, such as the Netherlands and Belgium. A quantitative conclusion has unfortunately not been found.

6.3.2.2 Increasing supply of skill

The UK construction industry is also known for its training boards, being CITB and ECITB. These organizations, initiated by the government, are responsible for training and advise in order to stimulate skilled labor. These agencies are aimed at training professionals and providing information. Construction employer questionnaires show that a large majority makes use of the services by these training boards and in 2014 71% of the employers had funded training for their staff (CITB, 2015). The impact on innovation, however, is unknown, but in general it is assumed that a higher level of skills goes along with an improved level of innovativeness.

6.3.2.3 Improving access to expertise

As shown in the previous section, the CITB and ECITB are also advisory services, but more is the access to expertise improved by the *BIM Task Group*. With the aim to help the industry to implement BIM thinking and usage within the UK CI, it offers help and information on the subject. This should enable firms to innovate. However, a solid evaluation on the impact on innovation has, just as the cases in the previous section, not been done and is unlikely to be done in the future, as it seems impossible to find correlations between those activities and innovativeness of firms. The CITB launched in 2005 the *Construction Network Programme* (CSN) aimed at learning and improving skills within the sector. An

evaluation of this program on innovation impact has not been found. The reason no evaluation is done is probably that these initiatives are not directly aimed at fostering innovation.

6.3.2.4 Connections and complementaries

Large emphasis has in the UK, as discussed before, been on collaboration in the industry, also in the light of innovative projects. *Catapult Centres* are strictly a networking program, but are also considered as advisory services and improving access to expertise. However, direct effect on innovation has not been determined. Next to these services, the UK has launched several *Collaborative R&D* (CR&D) programs. CR&D programs were launched in order to stimulate SMEs to work on R&D cross-sectoral. An econometric study shows a huge output additionality of these programs in an economic sense. Moreover, the participants show that 84% strengthened collaboration between firms and academics, 67% have experienced an improved access to technical and R&D skills, 59% to leading edge research and 84% to an improved technical understanding, 92% say to have improved skills in innovation and R&D and 84% positively changed their attitude towards collaboration (PACEC, 2011). Structural tendency to collaborate improved in general and more than half of the participants thought it had increased their turnover, employment and profits. 60% found the CR&D critical to the company's R&D and innovation performance. It moreover led to increased searching for funding programs, such as RDA, which was a positive, second-order effect on innovation.

The *Green Construction Board* (GCB) also largely stimulates innovation. Through providing information on sustainable building and organizing collaboration between parties, the GCB indirectly stimulates innovation. Following the general European tendency, innovation-related measures flowing from the GCB stem from sustainability-related goals. The exact impact on innovation has not been researched, but it is likely to have a positive effect, be it marginal. The CSN is under the ECITB a networking program aimed at improving skills.

The *Local Enterprise Partnerships* are part of a big initiative called *Plan for Growth* and contain numerous local partnerships of which some construction companies make use. In general these LEPs are evaluated locally, but an overall analysis was presented by the *National Audit Office* in 2016. This shows in general positive effects on turnover and job creation. However, the effect on innovation is not measured, nor estimated (NAO, 2016).

6.3.2.4.1 Demand for innovation

The demand for innovation has been stimulated in several ways. These measures are not necessarily designed for the CI, but are relevant and well-applicable. A program aimed at SMEs is the *Small Business Research Initiative* (SBRI) which aims at connecting public sector challenges with innovative ideas from industry, supporting companies to generate economic growth and enabling improvement in achieving government objectives and can be seen as a pre-commercial procurement measure. This measure is very comparable to the American SBIR which has been model for the Dutch SBIR alternative. Mostly, it was initiated to couple public challenges to innovative market solutions. As it calls for particular innovation, it directly stimulates the demand for innovation. Furthermore, spill-over effects occur as these innovations are directly implemented. The actual impact on the firm's future innovativeness has not been researched.

Regarding procurement, also *Forward Commitment Procurement* (FCP) was installed in the UK. Public authorities guarantee to buy the innovative sustainable product if the product fulfills its requirements. It is therefore a direct demand for innovation. It can be used to deliver cost effective environmental

products and services to the public sector and help to create the market conditions in which the environmental goods and services sector can thrive. A solid evaluation of the method does still not exist and all evidence stems from good practice cases (Edler et al., 2016).

The next demand stimulating measure is NMCP, which through leveraging design, materials, subcontracting, direct labor and experience uses the contractor's skills, knowledge and experience. More space is offered to innovative solutions, as the clients commits to a price and a set of rules under which the price can be achieved as final account sum (Burnand, 2014). Although the rationale suggests to be removing barriers to innovation, an actual evaluation of the procedures has not been conducted.

Furthermore demand for innovation is stimulated through several prize challenges, but as these are mere one-time occasions, no structural improvement of innovation is expected. One of the prizes is launched since 2013 by the CIOB with respect to construction in the form of *International R&I Awards*. These prizes however are awarded to individuals, often researchers, rather than companies. However, of course for these particular cases the prize has been a direct incentive for innovations.

6.3.2.5 Standardization and regulation

For a long time, the UK has been leader in developing quality standards. In 2016 also standardizations took place regarding BIM which makes the use of BIM mandatory in all public construction projects. Moreover a *BIM Task Group* was launched in 2011 to smoothen the transition towards BIM-use nationwide. This standardization was aimed at smoothening BIM implementation within companies and indirectly stimulate innovation. However, the actual impact has not been assessed and might as well be very marginal.

A famous, innovation boosting, sustainability-oriented example is the BREEAM. This quality measurement system was developed by UK agency BRE in 1990 and is still regularly updated and used worldwide. BREEAM has been developed by the UK government almost three decades ago and is about certifying sustainability of buildings. Ozorhon and Oral (2017) found among others that sustainability is a large driver of innovation in construction. Therefore it can be assumed that BREEAM had a positive effect on innovation in the sector. The quantitative correlation, however, has not been studied.

Another standardization effort is the *Smart Cities Standards Strategy* in which innovation plays a prominent role. Launched in 2012, it is set up as a holistic approach covering the standards in creating confidence in the smart cities market, helping cities to develop the capabilities for innovative infrastructure as well as ensuring that interoperability issues are resolved. Unfortunately, no evaluations are being conducted since introduction of the strategy and the relation to innovation remains unclear.

6.3.3 Policy profiles and mixes

Policy interaction is from utmost importance when considering impact of policies. Although the research base on policy mixes is thin, this section aims at providing an estimation of the impact of the policy profiles as a whole. Unfortunately, as the previous sector shows, policy evaluations in the UK are scarce, which makes a solid estimation hard.

SMEs are also stimulated by help in financing and networking. For complex systems, just as construction according to Winch (1998), Harvey, Waterson, and Dainty (2015) and Rutten, Dorée, and Halman (2009) can be specified, mere tax incentives are not enough and coordinated support is

needed. In this light, Innovation Platforms have been launched by the TSB, with operating name Innovate UK, called *Catapult Centres* with a large focus on collaboration. Next to these incentives, prize competitions are launched for innovative products or initiatives. Finally, a strong focus is placed on international collaboration in the research field and helping UK organizations to access foreign finance. However, very concrete and long-term innovation policy measures are hard to find.

In general the support to initiate innovation is quite balanced with several programs that complement the other. However, second stage measures, which help companies with market introduction are largely missing. Information services such as PIANOo in the Netherlands do not exist and it depends very much on the individual innovation program which additional help is offered next to funding measures. However, direct funding and tax schemes were used in combination, which has turned out to be effective for innovation according to Bérubé & Mohnen (2009).

Furthermore, the CR&D schemes were researched and it was found that the overlap to particularly funding schemes was significant, but the program has in general been complementary to other existing schemes, with its mode and target groups sufficiently distinctive from other schemes (Edler et al., 2016). Furthermore, a lot of companies that received direct funding later on applied for tax credits. The measures worked complementary and their outcomes were generally positive.

However, more generally related to innovation policy, several thematic programs were launched, such as the *Catapult Centres*. In themselves, they do not lead to radical innovations, but in combination with indirect measures or open support the radical innovativeness strongly increases. The UK offer several option for these additional measures, that makes them suitable combinations. Also the interplay between demand and supply driven measures should shift over time to anticipate on new emerging technologies. This mixture is, especially innovative procurement methods rather balanced in the UK.

In conclusion, the UK offers a suitable profile of policy measures in construction. However, measures aimed at information provision are sparse. The policies are consequently merely aimed at direct support and ‘aftercare’ for supported firms may structurally improve innovative capacity. On the other hand, supply of skills is uniquely stimulated in UK construction by the CITB and ECITB which is a suitable measure to make supported firms more capable of developing innovations. A note has to be made that merely innovation policies are discussed while interaction takes place between several policy fields. For example the *Handbook of Innovation Policy Impact* discusses the negative interaction between HEI block grant funding and stimulation of knowledge transfer between research and science institutes, including HEIs, and businesses. It goes without saying that these interactions affect innovation as a whole.

6.4 Denmark

The long tradition of sustainable solutions and ambitious climate goals are typical for Denmark. As chapter 5.2 has shown us, Denmark is a stable country with a high average level of education and it is considered an innovative leader for a long time. In order to get a sense of the innovation strategy in the Danish CI, first the more general innovation strategy is discussed. This is followed by more concrete innovation policies, whereupon the policies and initiatives in the CI and their impact on innovation are studied.

6.4.1 Current national innovation strategy and policies

Denmark has a long history on knowledge development and innovation. In 2012, Denmark initiated a shift of paradigm on this topic by launching a national innovation strategy called *Danmark – Løsningenes Land* (Denmark – A nation of solutions), which was accompanied by an eponymous report. The report describes the current R&I system and shows the technology push side with for example the *Danish National Research Foundation* and *Danish Council for Independent Research* and on the demand side the *Investment Funds and Development and Demonstration Programs*. Recently, several organizations have been merged for simplification and flexibilization of the innovation system. Moreover has the *Business Innovation Fund* been replaced by a *Market Maturation Fund* in which job creation and economic growth have become more important. In this strategy, education plays an important role as seed for innovative people and eventually a means to increase innovation capacity (The Danish Government, 2012).

Another goal of this strategy is the translation of knowledge to value. This is done by stimulating professional clusters, collective knowledge-based innovation programs in SMEs, simplification in innovation schemes, new ways off innovative tendering and more effective knowledge cooperation. All in all, the report presents a shift to a more demand-driven policy approach with stronger innovation capabilities in the educational sector. It moreover presents measures to increase innovation in general.

In this same period, the Danish government has published INNO+, which includes a catalogue in which focus areas are identified and prioritized in the field of research and innovation. These fields are determined in cooperation with market players and researchers. It contains six thematic areas with 21 specific focus areas. In 2014, five special areas have been selected from these focus areas, being: blue jobs via green solutions; intelligent, sustainable and efficient plant production; Denmark as preferred country for early clinical testing of new medicines; water-efficient industrial production; and innovatorium for world-class building renovation (OECD, 2016a). All recent government initiatives to promote R&I are clearly described in the report *Denmark's National Reform Programme 2016*, and in 2016, also *Danmark 2020* was launched in which clear government goals are presented for 2020.

Complementing to *Denmark – A nation of solutions*, Denmark presented *Vækst og udvikling i hele Danmark* which contained a strategy to foster regional growth, knowledge clusters and specialization. Concrete initiatives were presented in order to support collaboration, strengthen partnerships and intensify knowledge sharing. Furthermore, regarding sustainability and general reduction of environmental impact, Denmark has been leader for a long time. Long-term strategies make an important contribution. DK2050 is an economic strategy paper led by the architectural center in order to make the building industry completely green in 2050, presented in 2016. In the same year, a cluster strategy was launched in order to promote competition and collaboration.

In 2012, the Danish government entered into an ambitious energy agreement which leads up to 2020. This fitted into the ultimate goal of being completely reliant on renewable energy in 2050. The building construction takes a significant stake in this agreement. The program *Better Housing – Better Sa*vings was launched in early 2014 in which counselors helped home owners to lower energy use and making their houses more energy-efficient; all governed from the Danish Energy Agency. In this same year, building and renovation policies regarding energy savings were launched in the CI (EFMK, 2014).

Although this is not directly an innovation policy, new, innovative techniques and methods are sought in order to reach those goals.

Despite those initiatives, the actual progress up to 2016 has been lower than initially hoped for. The Danish government (2016) put the following note on the case: “The country report notes that both the strategy Towards a stronger construction sector in Denmark and the government’s growth initiatives including a proposal on the liberalization of the Planning Act, cf. the plan for Growth and Development in all parts of Denmark will be steps in the right direction, to the extent they are implemented.” This shows that the level of implementation rather than the quality of implementation has been the major obstacle to improvement.

6.4.2 Individual policy measures

The strategies are made clear in the previous section, from which several more concrete policies are developed. The policy measures are linked to the classification based on Edler et al. (2016) as presented in Figure 24. Just as in the UK CI, the wide palette of types of measures is displayed. Regarding input for R&D, the focus on direct support is easily visible.

Innovation policy measures that affect the CI are summed up in the previous section. Subsequently, the impact of those measures are discussed based on literature and experts’ opinions. Per type of class, the different policy impacts are discussed, also when no quantitative result can be given. In this way, a basis for impact estimation of policy profiles and mixes will be made.

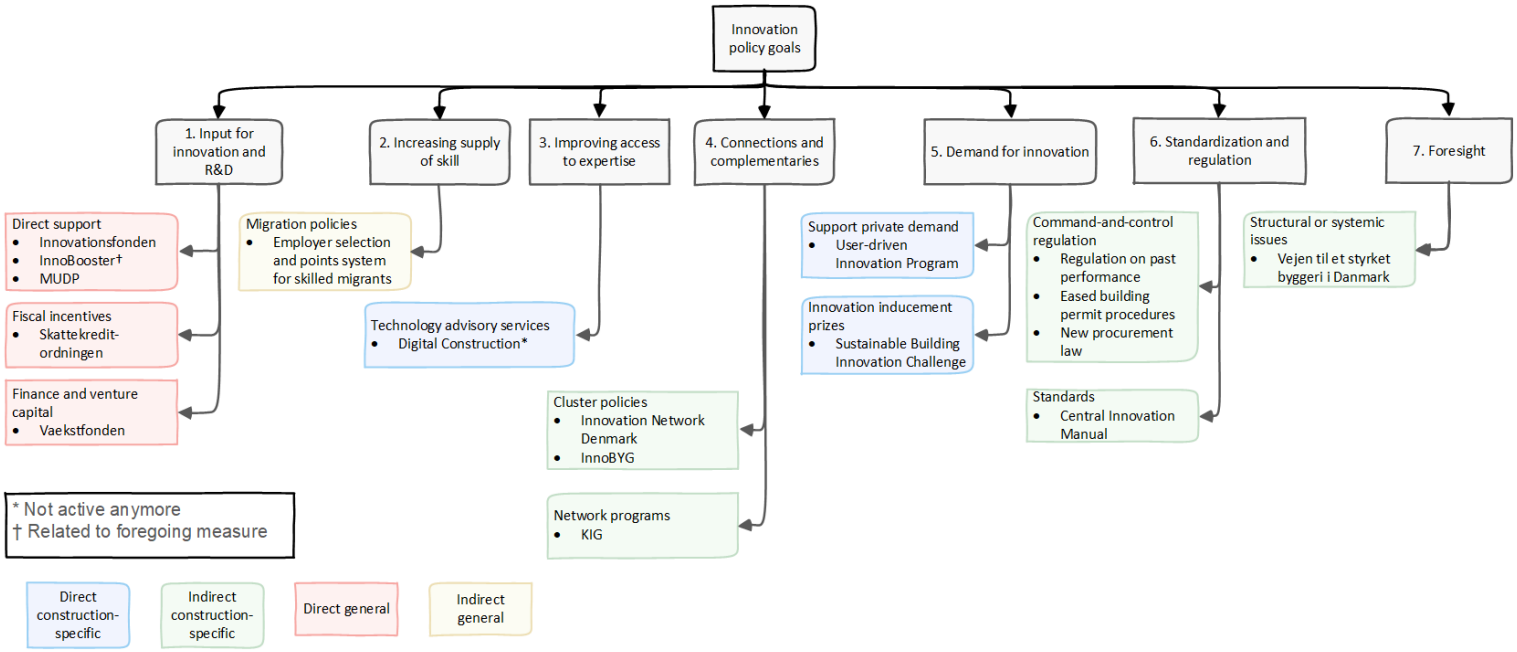


Figure 24 – Classification Danish innovation policy measures related to the construction industry

6.4.2.1 Input for innovation and R&D

Denmark is known for its high direct support. As described in section 6.4.1, in the INNO+ catalogue several focus areas in the Danish industry were picked out, followed by the highlighting of five focus areas. One of these areas was ‘Innovatorium for World Class Building Renovation’. In this light, public funds have been offered towards this subject and collaboration between education, research, market players and the government has been established in order to reach those goals from 2014 onward (The Danish Government, 2014).

In 2015, the Danish *Eco-Innovation Program* (MUDP) was launched, aimed at supporting Danish companies in development and demonstration of new eco-efficient solutions in order to meet Danish and global environmental challenges. Also ecological and sustainable construction is included in this initiative. This measure is an excellent example of innovation promoting measures as a result of targets for a green economy. As it is a very recent measure, no evaluations were conducted yet. Comparable is the Danish Growth Fund (*Vækstfonden*), which is a state investment fund for the establishment of new companies with a large focus on innovative startups. Rather than direct funding, it offers investments in companies on a state-owned basis and provides loan guarantees. This measure was already launched in 1992 and turned out to be very useful in stimulating innovation, financially as well as supporting the process (Cowling & Murray, 2013). Although the impact on construction is limited, the promotion of innovation in general has turned out to be very effective, especially regarding startups and SMEs. A similar measure is currently being developed in the Netherlands, called Invest-NL, but the exact shape is not clear yet.

In 2014, the *Innovationsfonden* (IFD) was established which also incorporated the *InnoBooster* program. In 2016, for more than 164 million euro was funded in this program. Although the main mechanism is funding innovative programs, companies can make use of a variety of instruments, including knowledge coupons and pilot projects, aimed at startups and SMEs. Research can be purchased for own employees or outsourced researchers. Moreover, the *InnoBooster* incorporates other knowledge-based help, such as support with commercialization of innovations (Udannelses- og Forskningsministeriet, 2015). Despite it is open to all sectors, its relevance to construction is significant. The first projects have only recently been concluded, so an evaluation of the program has not been conducted yet. The type of funding and additional support is regarded by Edler et al. (2016) as effective. The MUPD is also a measure of direct support of eco-friendly innovations . However, the measure was introduced in 2015 and as a consequence, no evaluations are presented yet.

In Denmark also the *Skattekreditordingen* was initiated in 2012 (OECD, 2017). It is unique as it only supports firms with liquidity problems, which makes it very applicable to startups. CPB (2014) found that the measure is highly effective and is well-implemented and the simple design of the procedure makes it easily accessible for small companies. However, the disadvantage is that also large, loss-making firms can use the instrument who are not likely to innovate quickly.

6.4.2.2 Improving access to expertise

Technology advisory service *Digital Construction* which aimed at enabling companies to use BIM and help them with the transition towards a digitalized construction process. As the use of BIM is obligatory in a large share of the projects, the addition of this program to actual innovation is hard to determine. However, the organization for sure aided companies in adopting BIM in their working processes which enabled them to develop new processes and designs.

6.4.2.3 Connections and complementaries

Denmark has been active in facilitating collaboration and organizing networks and clusters. 22 Innovation Networks were set up by the Ministry of Higher education and Science, including InnoBYG. Although concrete measures or ambition reports are hard to find, the industry has a considerable list of events, networking days and discussion platforms on innovation in construction. These events are mostly aimed at collaboration and knowledge sharing in order to develop innovations in the CI. *Coordination and Innovation Group for Knowledge in Construction* (KIG) was launched in 2009 with the aim to develop an action plan for stimulation of R&D funding through networking and

collaboration initiatives. The network is still running and offers possibilities to collaborate between contractors, research institutions and suppliers. The list of successful innovations which were aided by the network program is long (Maslesa, Thomsen, Thuesen, & Arnklit, 2014). Quantifications on the bang for the buck, however, are not available.

6.4.2.4 Demand for innovation

For several years, Denmark has been active in stimulating demand for innovation. A user-driven innovation program was launched which is largely aimed at stimulating companies to qualitatively distinguish themselves from other companies through innovation. The program has been developed in 2007 by which it was the first country in the world. Although this is more a process rather than a measurable funding, the effects were positive and several countries adopted this principle world-wide. The *Handbook of Innovation Policy Impact* also implied this demand-driven measure to be highly effective in combination with supply-driven measures.

More challenge-driven, the *Sustainable Building Innovation Challenge* was launched. Initiated by public as well as private parties, it is a competition for developing ideas that increase sustainability in the building sector and is highly aimed at materials and technology. This initiative is new and therefore not evaluated yet. There is no question that innovations will emerge from this initiative, but it is unknown whether the innovativeness of the companies as a whole increase, or whether it is a one-time effort.

6.4.2.5 Standardization and regulation

Also the plan *Growth and Development in all parts of Denmark* has been launched in 2015 in order to ensure growth in the construction sector. Simplification of rules as a means to remove barriers to construction innovation is one of the main policy tools. Next to innovation, another advantage is that bureaucracy is reduced which has a positive impact on project durations. Also legislation contributed to innovation in construction. First, in 2013, building permit procedures were revised in which simplification and decrease of bureaucracy were main aims. After that, in 2016, new procurement law was enforced which followed the EU tendency and made room for innovation.

Also, the *Central Innovation Manual* was developed for analyzing econometric evaluations of innovation policy in 2012. Systematically assessing innovation policy may offer flaws in recent policy and improving future policy. Assessing the manual econometrically will, however, be impossible due to its indirectness towards innovation in the CI.

6.4.2.6 Foresight

In public tenders, past performance has been a key aspect in Denmark for a long time. In this way, more focus will be on quality than on mere pricing. Also a Danish construction strategy was launched in 2014 called *Vejen til et styrket byggeri I Dan*mark, which provides a roadmap towards an improved construction sector.

6.4.3 Policy profiles and mixes

Denmark has been leader in a large share of new types of policy measures such as challenge- and user-driven innovation and R&D support for loss-making firms. Furthermore, the policy mixes are varied and broad. Several initiatives and strategies are launched which offer well-balanced policy mixes, being above all the *Danmark – Løsningenes Land* and *Vækst og udvikling i hele Danmark*.

Notwithstanding, the focus at construction is in these strategies small and most innovation-oriented initiatives find their background in sustainability and 'green' initiatives.

Considering the entire CI, the policy is rather fragmented. The mixture, however, is quite balanced when taking Cunningham et al. (2013) as a starting point. First of all, the direct financial measures, such as *Innovationsfonden* and *Skattekreditordningen* are strongly complemented with network and information measures, such as Digital Construction and InnoBYG. Also for example the *Bygherreforeningen* has launched several initiatives aimed at making construction firms familiar with new and best practices, such as *Værdibyg*. Access to knowledge is also provided by several government-supported research institutions, although fees are required.

Secondly, supply-driven measures such as tax-incentives are strongly complemented by demand-driven innovation policy; a shift in which Denmark was one of the leaders. According to the *Handbook of Innovation Policy Impact*, this is one of the most essential mixes for a balanced policy profile. Furthermore, these mixes are all aimed at different stages in the innovation process, which aids in streamlining the process from incentive to develop to commercialization and diffusion.

The coordination of the different initiatives, however, is rather splintered. Moreover, evaluations are not available in abundance although standards were developed to econometrically evaluate innovation policies. Therefore it remains difficult to estimate a construction innovation policy impact for the entire policy profile. Nevertheless, the international innovativeness studies, as well as the composition of the innovation policy structure suggest that the innovation policies are fairly effective.

6.5 Sweden

Even more than the other preselected countries, Sweden has been an innovative leader for a long time and emphasis on sustainability is just matter of course as the Innovation Scoreboard has shown us (appendix II). As the main industry's structure is clear, it is time to take a closer look at the innovation policies. Sweden has a clear and broad inventory of innovation reports, as well on a scientific base as in policy papers. First, the innovation strategies are discussed and thereafter the focus is placed on the CI.

6.5.1.1 Current national innovation strategy

Sweden has a long history in innovation strategies. However, we will confine ourselves mainly to the past 5 years, the present and future strategies. In 2012, the Swedish Ministry of Enterprise, Energy and Communications published the Swedish Innovation Strategy. In line with the European Horizon 2020, the strategy incorporates *Sweden's National Reform Programme 2016* in which goals until 2020 are set, well outrunning the EU's goals. The strategy is aimed at enabling people to have the capacity, willingness and conditions to contribute to innovation, prepare research and higher education for innovation and develop framework conditions and infrastructure for innovation (Ministry of Enterprise Energy and Communications, 2012). Furthermore, businesses and organizations in Sweden should obtain world-class innovation capacity, innovative and collaborative public service organizations should become legally secure and effective and obtain a high degree of quality and finally it should give the regional innovation environments international appeal.

For each of these goals, sub-targets are set in the report. Concrete measures are given in order to reach those goals and are to be found in the report. Ironically, the report suggests as the main implementation strategy to "learn from other countries' work with developing the innovation policy

and be a source of inspiration globally by means of a long-term and coordinated work to strengthen the innovation climate" – exactly the ultimate goal of this very study. In Sweden, however, the share of non-thematic research is relatively large and ends up second, just after Switzerland, although the difference with the Netherlands is not that big (OECD, 2016a). Prioritization, however, has occurred, be it in a more implicit rather than explicit topic selection. Also because of the research capacities are incorporated in universities and the universities prefer to determine their own strategies, a solid topic prioritization policy is tough.

More construction-specific, the *Bygginnovationen* program was launched in 2011, which was partly concluded in 2016. The actual results of the strategy are, however, aimed until 2026, 15 years after the launch. The strategic paper was initiated by innovation agency Vinnova and a consortium of companies to make the CI more innovative. Also the funding of the strategy and its policies is half covered by Vinnova. All in all, this should make the Swedish CI more productive and efficient and is ought to stimulate growth in employment and revenue.

Vinnova, the Swedish public innovation agency, has excellently documented the current innovation policies and the relevant statistics to support those practices. An elaborate report on their innovation strategies and ways of implementation up to 2012, with a huge emphasis on gender, can be found in *Promoting Innovation – Policies, practices and procedures* (Andersson, Berglund, Gunnarsson, & Sundin, 2012). As discussed before, Sweden has been one of the top countries in the world in terms of R&D investments, in relation to GDP – a usual way to indicate innovation capacity. By contrast to the research performed by universities, the research performed by research institutes is minor compared to other countries (Nilsson & Hellman, 2016). In 2014, Swedish investments in R&D comprised about 3,2 percent of GDP which is in Europe's top and more than a percent higher than in the Netherlands (Koen et al., 2015). OECD continually researches innovation policies in different countries. In 2016, it presented its preliminary report on Sweden. Due to the large research capacities of universities in Sweden, a main aim is to strengthen the university research and link this research to actual innovation (OECD, 2016b). The outcome is according to the 2016 OECD report that the situation is, "[…] evolving, with the relatively recent emergence of a stronger, less fragmented research-institute sector. While this phenomenon has to potential to have a significant effect on research-innovation links at an aggregate level, much will depend on the ability of the overall innovation ecosystem to accommodate it."

6.5.2 Individual policy measures

The Swedish innovation strategies as described in the previous sections are linked to the several types of policies. This synthesis is shown in Figure 25. A broad range of policies types is visible, but most strikingly, the public financial input for innovation R&D is relatively empty. On the other side, the demand for innovation is highly stimulated by for example challenge-driven innovation programs and planning grants.

The different policy measures as described are discussed on impact on innovation. This is largely done on the basis of literature, but also experts' opinions are included. First the individual measures as visualized in Figure 25 are discussed individually, followed by a policy mixture oversight. Per type of class, the different policy impacts are discussed, also when no quantitative result can be given. In this way, a basis for impact estimation of policy profiles and mixes is made.

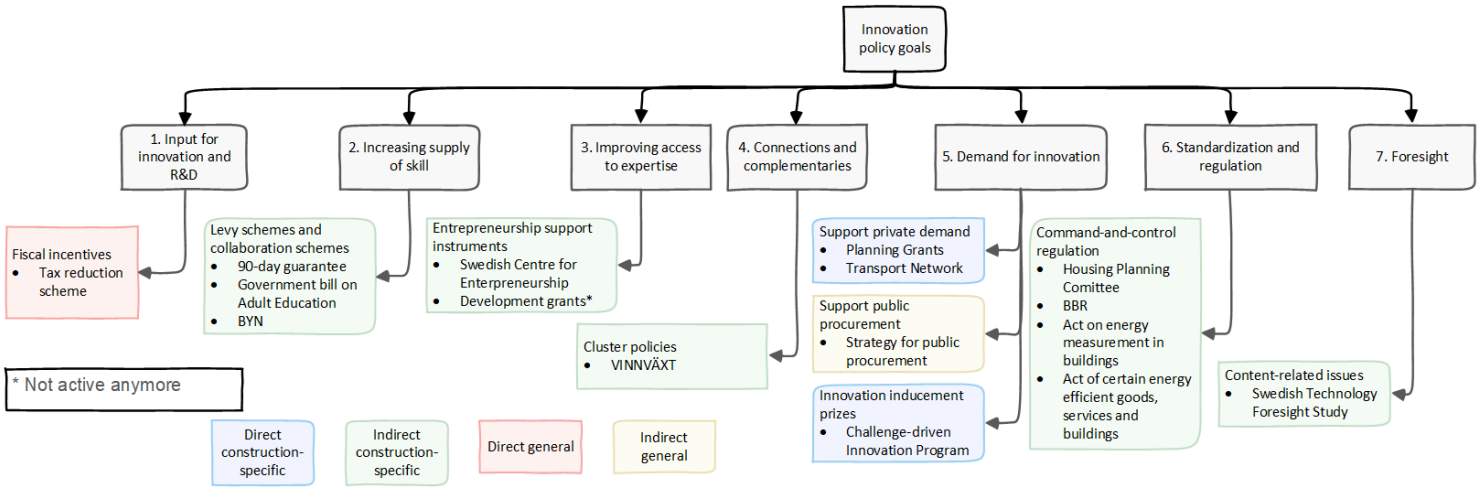


Figure 25 – Classification Swedish innovation policy measures related to the construction industry

6.5.2.1 Input for innovation and R&D

The measures regarding input for innovation are quite scarce, but contains a tax reduction scheme. Companies can claim tax reductions on R&D activities on the payroll taxes of 10% since 2014. This scheme is pretty comparable to the Dutch WBSO scheme, be it less generous. Although no particular review has been done, it is considered an effective input stimulation for innovation based on results in other countries.

6.5.2.2 Increasing supply of skill

Sweden is considered and aims to be a knowledge economy and as a means, it invests actively in life-long education and training. First of all, it introduced the rather unique 90-guarantee which was launched in 2016 and was aimed at youth between 20 and 24 years old. The effect on innovation itself remains unclear, but the measure largely contributed to a decrease in youth unemployment and an improved share in youth education (European Commission, 2017c). Furthermore it presented a government bill on adult education. Similarly as to the previous measure, the impact on innovation is not studied and remains unclear. However, training for professionals is highly emphasized in the bills and as discussed before, the level of education is positively correlated to innovation. Unfortunately, concrete effects on innovation are not reviewed yet.

The *Swedish Construction Education Board* (BYN) is also focused on training and education, be it particularly regarding construction. The board is actively working on improving skills of construction workers and engineers. Although evaluations are not available, equally to the previous two measures, improved skills are likely to lead to innovation-oriented activities. However these findings are difficult to quantify.

6.5.2.3 Improving access to expertise

The *Swedish Centre for Entrepreneurship and Business Creation* (CEBC) aims at creating and spreading knowledge about entrepreneurship in Sweden. Evaluations on this organization are not available, as are figures on impact. Furthermore, *Development Grants* were issued between 2011 and 2014. These grants contain mainly of advice and commercialization support. The additionality of the development was considered too low, as mainly large companies made us of it who also would have innovated without the grants (European Commission, 2016b).

6.5.2.4 Connections and complementaries

VINNVÄXT is Vinnova's program to stimulate regional competitiveness in an international perspective. This should, amongst other things, stimulate innovation. By rewarding best regional proposals, this instruments can also be considered as pre-commercial procurement and as such as stimulating demand for innovation. More than resulting in those single innovative 'winners', it stimulates innovation by strengthening competitiveness in the whole cluster. This helps in forming an innovative infrastructure which benefits the region as a whole. It is not placed under 'demand for innovation' type, as it should be considered broader, including supply of information, organize meetings and seminars and learning projects within clusters and nationally (Helle & Zingmark, 2015). It is a cluster program and although it is not directly aimed at innovation, innovation is highly emphasized, mainly through selection on quality and project suitability. It focusses on the high-growth sectors in Sweden, which the CI does not belong to particularly. Although concrete innovations and collaborative initiatives strongly increased in those clusters, economic evaluations of innovation regarding the 'bang for the buck' have not been conducted yet.

Sweden furthermore launched the strategic innovation areas (SIOs), with the goal to improve international competitiveness and organize interaction between the different actors in order to find sustainable solutions to global problems. It therefore puts is emphasis on collaboration as key to an healthy innovation ecosystem (OECD, 2016b). It is quite common for countries to identify science and technology based priorities for innovation, as also was shown in the cases of the Netherlands (top-sector approach), UK and Denmark. However, effects on innovation in construction are unknown.

Innovation specific, policy measures have been taken regarding the construction industry within the *Bygginnovationen* program as discussed earlier. Firstly, innovation vouchers have been introduced in which construction SMEs are offered subsidized advice and knowledge. Secondly, *Planning Grants* are issued on the mapping of regulation, legislation and IPR and the execution of cost/benefit analyses in order to show opportunities of innovation for SMEs and startups. Thirdly, development grants have been introduced within the program in order to stimulate commercialization of close-to-market products, processes and services in construction. This last measure was withdrawn in 2014 in order to focus more on SMEs and startups.

6.5.2.5 Demand for innovation

Sweden is one of the leaders in stimulating demand for innovation. Also to abovementioned VINNVÄXT programs show this. Furthermore, *Planning Grants* are issued as discussed before. These planning grants are received mostly in the idea-generation stage, and therefore the actual correlation to innovation is difficult to determine (European Commission, 2016b). However, the grants support guidance of middle management which is considered as an effective measure to help companies to set a proper innovation and commercialization track.

The strategy for public procurement was launched very recently and an impact analysis has not been conducted. Also more general evaluation have not been done yet. However, the large emphasis on innovation makes it likely that barriers to innovation are removed in the new strategy, which will encourage innovation. The agency that implemented this strategy ensures to have thoughtfully considered past policies and learned from best practices and past failures (OECD, 2016c).

Another concrete innovation-oriented program is the *Challenge Driven Innovation* (UDI) program, which is a three-stage funding program for innovative programs for projects that are aimed at societal

problems, among which city planning and sustainable building. Through financial support to five sectors among which construction, were meant to improve in product and process innovation. For example, it was aimed at tackling societal challenges, such as city planning. It is considered revolutionary in the policy field and commentators advice to expand this program due to its successfulness (OECD, 2015). Although quantitative analyses are missing, especially regarding innovation, the UDI is already taken as an example by several other countries, implicating successfulness regarding innovation.

6.5.2.6 Standardization and regulation

Sweden recently adopted new building codes and standardizations. The first is the regulations in construction (BBR) which includes new building l. Simplification and integration have been important aspects within this BBR. Although more space is created for innovation, the actual impact is hard to determine. This same goes for the two recently adopted acts: the act on energy measurement in buildings and the act of certain energy efficient goods, services and buildings. These are adopted in 2014 and are because of the short time and indirect relationship to innovation difficult to evaluate.

6.5.2.7 Foresight

Although it is common knowledge that foresight studies help to set innovation priorities right, their actual impact and returns in innovation are next to impossible. However, the *Swedish Technology Foresight Studies* are likely to have contributed to the innovativeness, while scientific support for this claim is largely missing. General benefits, however were found in processes, enhanced networking and coordination of the R&D funding system (Edler et al., 2016).

In 2016 several more initiatives on improving the CI have been introduced. The ones that affect innovation indirectly are the following. A government action plan has been initiated called *Stimulans för ökat byggande* which comprises the development 15.000 new dwelling annually. Innovative building methods and products are encouraged in this initiative. Regarding infrastructure, the *Transport Network* has been launched as part of the *National Transport Plan*. Several funds have been allocated to large, innovative infrastructure projects, such as the high-speed rail network. In 2016 also a strategy regarding innovative and creative potential of functional procurement when specific requirements for goods or services are benchmarked. This does however not set any concrete target values for innovation-oriented procurement.

6.5.3 Policy profiles and mixes

Several policy mixes were discussed by Cunningham et al. (2013) that particularly stimulate innovation. First, direct (financial) support is most effective when internal management and market access are supported with for example access to expertise or networking activities. Sweden has relatively weak direct support of R&D input measures, but a strong support of innovation processes and trajectories. This combination is expected to foster successful innovations. The figures on innovativeness in Europe support this claim. A proper balance between direct funding and tax incentives does not apply as no extensive direct funding policy has been found. Regarding the CI, however, the Swedish government seems not to be particularly occupied with innovation.

Literature is not agreeing on the impact and interplay of demand and supply driven instruments, but Edler et al. (2016) argue that results of complementing supply and demand driven measures are very positive for public intervention in general. It states that there is a positive effect on innovation input and output for both the supply side and the innovation procurement, something Sweden applies at

the fullest. Especially because those instruments stimulate innovation in different stages, the complementarity seems successful. The *Challenge-driven Innovation Program* together with entrepreneurship supports and tax reduction schemes is a good example of a mix that covers all sides. However, a quantified analysis of the interplay is very difficult due to its complexity.

Another unique aspect Swedish innovation policy approach is the centralization and as such the thoughtfulness about policy interaction. Vinnova has published several programs or generations of strategies which include their own policy measures. Clear goals have been set and measures have been chosen to complement each other in order to reach the goals. Several unique approaches have been launched such as user involvement (which has become a world-wide standard) and the *Challenge-driven Innovation Program* which is being followed by policy makers across the world. The focus towards construction, however, has been minor in Sweden and policy mixes in this field are hard to identify.

6.6 Germany

Germany is the largest economy of the studied countries and has consequently the largest CI. De federal system, however, which split the country in several states, results in decentralized policy-making on several topics which are not included in this study. However, the centrally-developed German strategies and policies are discussed that affect innovation in the construction sector. Equally to the previous four sections, first general strategies are dealt with, followed by narrowing of the scope towards specific construction innovation policy measures and finally policy mixes.

6.6.1 Current national innovation strategy

Germany is on of EU's innovation leaders and is close to achieving the R&D expenditure target of 3% of the GDP (European Commission, 2015). However, growth is hindered by a lack of skills and finance, which calls for a new strategy. An important part of strategies to encourage innovation contain ways of enhancing knowledge, education and research. Germany adopted in 2006 a strategy for research and innovation by means of a coherent innovation policy, supporting knowledge transfer and innovation in future market, called the *High Tech Strategy 2020* (HTS 2020). In the years 2006 to 2009, two thirds of non-institutional funding of BMBF went through this strategy (Cunningham et al., 2013). Between 2012 and 2014 this strategy was thoroughly reviewed and renewed.

This integral strategy has distinguished six key stands: the digital economy and society, sustainable economy and energy, the innovative workplace, health living, intelligent mobility, and civil security (BMBF, 2014). In aiding these improvements, the German government passed a bill for heavily improvement of the data infrastructure in the whole country from 2014 to 2017. Also a e-government strategy was launched in order to improve digital interaction between government and German citizens. Despite those initiatives, the digitalization strategy has not been very fruitful until today (Gillmann, 2016). The strategy is aimed at protecting established fields rather than key competences.

The large emphasis on digitalization is also recognizable in the strategies which were launched between 2014 and 2016 being the *Digital Strategy*, *Die Digitale Agenda* and *Industry 4.0 – Digitale Wirtschaft*. All these strategies aim at an integral reform towards digitalization of the industries, government and society as a whole. This encompasses the CI, for example with the inclusion of BIM. Regarding energy, a federal strategy was launched in 2010 called *Die Energiewende*. This transition strategy directs towards a low-carbon and sustainable energy supply. New ways of energy supply are being sought in which innovation plays an important role.

More construction-specific is the BMUB strategy paper called *Reform Bundesbau – Bessere Kosten-, Termin und Qualitätssicherheit bei Bundesbauten*. Briefly, it aims at cheaper, faster and better construction. It presents several areas in which the CI can improve and the strategy paper suggests ways in which these improvements should be achieved. It also includes ways in which the government itself improves its role in order to improve the industry. It calls for several concrete policy measures, but none of these seem to be implemented yet, mainly because the paper is issued in 2016. The European Commission's (2015) *Country Report Germany* shows that R&D expenditures in the construction industry have grown with 27% from 2008 to 2012.

All in all, the current national German innovation policies are simply dividable into three programs (strategies): *Die Digitale Agenda*, aimed at a fast, but save internet infrastructure, *Die Neue High Tech Strategie* (Neue HTS), which succeeded the *High Tech Strategy* in 2014, aimed at new technologies in order to improve citizens prosperity and quality of life and *Die Energiewende*, which seeks for affordable sustainable energy production and distribution, which are described in the previous section. These programs include specific and concrete policies on stimulating innovation in certain areas. It is immediately clear that most emphasis is placed on digitalization and sustainability. On one hand, the common ground with construction is scarce, but the mutual subjects, particularly sustainable energy, materials and BIM are incorporated.

Germany annually evaluates the German research, science, innovation, entrepreneurship and education system and has published its last document in 2017 (only available in German). However, as the report itself also states, frequency, consistency and quality of individual evaluations of policy measures and resulting evidence-based policy making should severely improve for better results (EFI, 2017).

6.6.2 Individual policy measures

Also for the Germany policy measures regarding innovation in construction the linkages to the typology are visualized as shown in Figure 26. The different national strategies launched in the past 5 years in Germany have had a huge impact on policies in general and can be considered as leading for all other recent policies. Concrete and direct innovation supporting measures in construction are sparse, but all the more standardization and collaboration programs are launched. Also regarding foresight studies, Germany is an outstanding example. In contrast to the other countries, Germany prefers direct support of R&D to tax incentives, as appears from the figure.

The different policy measures as described are discussed on impact on innovation. This is largely done on the basis of literature. First, per type of class, the different policy impacts are discussed, also when no quantitative result can be given. In this way, a basis for impact estimation of policy profiles and mixes will be made.

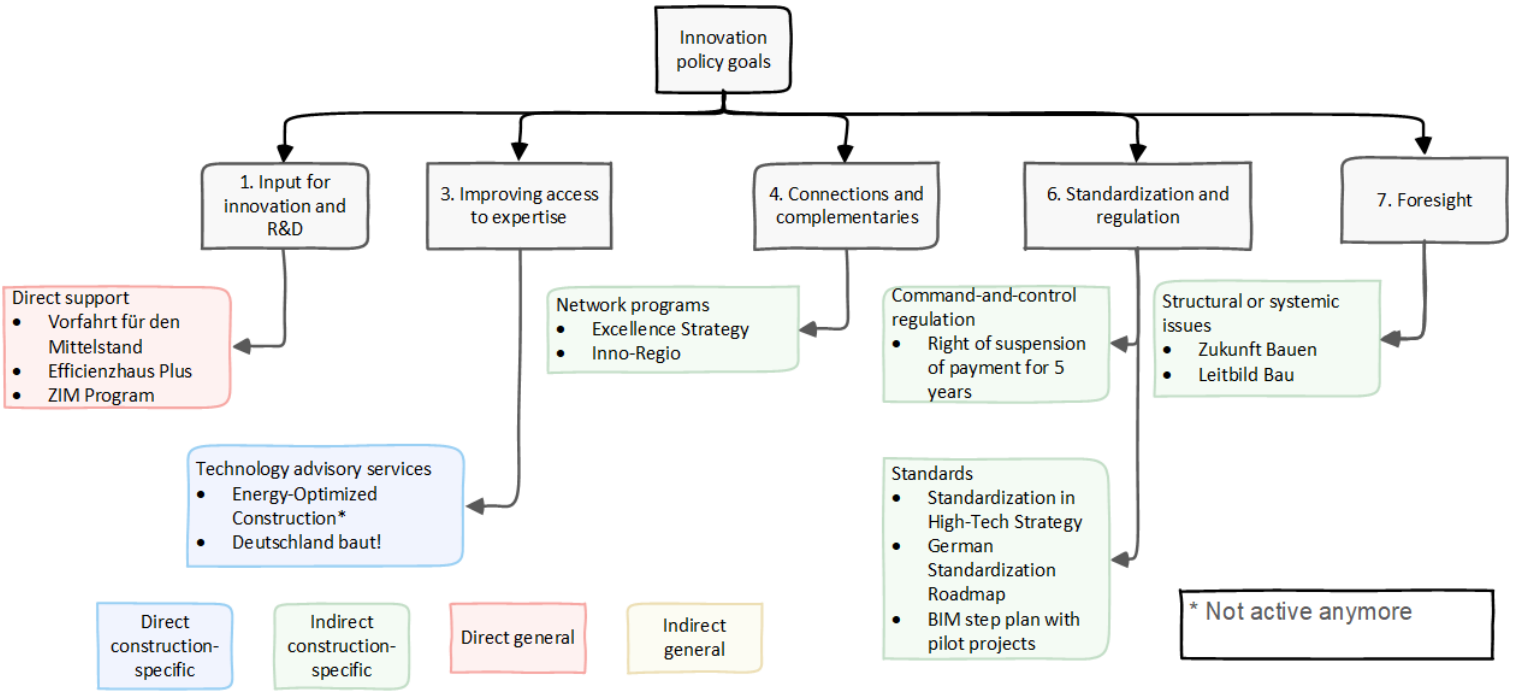


Figure 26 – Classification German innovation policy measures related to the construction industry

6.6.2.1 Input for innovation and R&D

German input for R&D is all done through direct support rather than tax incentives. In general, tax incentives are considered to be more effective, but Germany has three particular funding cases. *Vorfahrt für den Mittelstand* is a program which included direct funding. It was launched in 2016 and aimed making SMEs more innovative and is part of the aforementioned *Neue HTS*. As it is launched very recently, no evaluation has been done yet. However, in general, additionalities are high for SME-aimed policies (Edler et al., 2016).

Also pilot projects were launched in the *Effizienzhaus Plus* project. Innovative energy reduction is the most important goal and also reducing environmental impact of construction as a whole has been considered a main target. New innovations help in reducing energy usage and even produce energy (Baer, 2014). However, as such it can be seen as pilot projects, so the knowledge spillover should make it contributing to the innovativeness of the sector, although this is not evaluated yet.

Thirdly, the ZIM program was launched with rather positive effect on innovation. This program, initiated in 2015, was aimed at ambitious R&D projects within SMEs and is planned to continue until 2019. Depner, Baharian, and Vollborth (2016) analyzed the program commissioned by the MBWE until 2014 and found that 81% of the companies achieved their technological innovative goals and the funded projects showed high levels of collaboration. In 60%, companies intensified their R&D activities as a result of a single participation in a ZIM project and in 43% the R&D activities structurally improved and intensified. From the total ZIM program, between 2010 and 2016 on average 5,6% of the funding goes to construction (EFI, 2017).

6.6.2.2 Improving access to expertise

In 2013 a levy scheme for education was launched called *Deutschland baut!*. The construction initiative was launched in order to increase supply of skill. Distribution of knowledge and knowledge networking are primary tasks, but their exact impact on innovation is unknown. Although positive effects are

expected, Edler et al. (2016) note that "[…] the provision of expert technology and innovation advice also leads to significant impacts that are intangible, hard to measure or attribute, or take time to come to fruition."

The Ministry of Economics and Technology (BMWi) has launched the *Energie-Optimierte Bau* (EnOB), which comprises five areas in construction: new buildings, refurbishment, operation optimization, low-exergy technology and insulation. With a budget of 23,7 million in 2014, it is a large program in the German CI. Access to expertise was aimed at with this initiative in which knowledge was developed and distributed by public bodies. However, no specific evaluations were found on the initiative and, involving that also impact studies on innovation are missing. Nonetheless, it is generally accepted that initiatives that aim at new sustainable technologies and practices have a positive effect on innovation.

6.6.2.3 Connections and complementaries

The *Inno-Regio* was launched in 1999 and was aimed at cross-sectoral regional innovation clusters. The project was nationally funded for 255 million euros. In order to stimulate innovation, R&D was encouraged through direct funding. It is a relatively old initiative with an extensive evaluation which stems from 2002. The program involved a large number of participants resulting in several networks. Lots of innovation resulted from the program. However, the CI was not really involved and toke merely second-order advantages regarding innovation.

Germany has furthermore launched its *Excellence Strategy* which can be seen as a network and cluster program. With an annual budget of 533 million annually, it is one of the biggest innovation-related programs of Germany. It aims at improving the international competitiveness of German research across all sectors. The *Excellence Strategy* has a large impact on education and research in general. The effects on the construction are also merely second-order, as well as the effects on innovation.

6.6.2.4 Standardization and regulation

Standardization has also been an important spearhead of removing barriers to innovation in Germany. As part of the *Neue HTS*, standardization in the high-tech field has been highly emphasized. As part of the *Industry 4.0* and *Digitale Wirtschaft* the German standardization Roadmap was issued, which was lastly updated in 2016. Also implementation of BIM is included regarding construction. Moreover, a BIM step plan was launched in 2015 in order to help companies in standardization towards BIM. It mainly contains of pilot projects in order to show the possibilities to market parties and other stakeholders.

Unique in Germany is the law that public clients can postpone a share of the payment for 5 years to guarantee quality. The influence on innovation is currently unknown, but can either make contractors more careful – innovation is risky – or stimulate quality by innovations. However, no impact studies are found. The other three standardization initiatives as presented in Figure 26 are also unknown. However, it may be assumed that those initiatives contribute to a more innovative climate. Impact studies on innovation were not found, nor studies regarding the CI.

6.6.2.5 Foresight

Germany is a leader in formulating strategies and shaping the future in an economic sense. Foresight studies have been available in manifold. BMUB launched an innovation initiative regarding construction called Zukunft Bauen, which is partly led by the Fraunhofer Allianz. This initiative is largely related to sustainability and climate change. This includes a long-term plan to strengthen the German

CI, including research projects and provides long-term goals for the entire sector. These visions shape unity and certainty and result in a stable innovative climate. Zukunft Bauen particularly calls for R&D and innovation and is most likely to stimulate innovation in construction for the future. However this cannot be determined yet. The same goes for market initiative Leitbild Bau, although this is largely aimed at the architectural side of construction. However, this does not reduce the call for innovation and knowledge in the industry. Similarly, the impact on innovation cannot be measured yet.

6.6.3 Policy profiles and mixes

The previous section made clear that the concreteness of measures and availability of evaluations are rare. However, mixed policy profiles are the basis of German innovation policy making as the strategies show us. Most notable is the *Neue HTS*. Although the construction specificity is absent, the integrality of the mix is unique in the world. Next to the integrality, also the cross-governmentality is unique, especially in combination with the unified strategic vision. In contrast to for example the creation of a new agency (Sweden) or centralization, Germany bundled existing activities and created accordingly new instruments which were implemented by the different agencies and ministries. As a result, Cunningham et al. (2013) call the strategy one of the very few exceptions that are actively consider policy mixtures.

The following instruments were combined in this strategy, although not all relevant to the CI. Thematic cooperative programs, SME-stimulating programs, science-industry cooperative programs, start-up funding, innovation alliances and platforms, research bonuses (voucher scheme), regional cluster programs and innovation grants. Although a quantitative evaluation has not been done, this mix has been seen as highly effective. These instruments are recognizable from the ones mentioned above. Nonetheless, a study to policy effects in the *Neue HTS* and associated strategies has not be done thoroughly yet. However, it strikes how well the R&I policies are mixed across policy domains.

7 Qualitative comparison

The policies (chapter 6), as well as the construction industries as a whole (chapter 5) are discussed per country. In this chapter every country will be discussed with a large emphasis on innovation policy while keeping the context of the entire industry and country in mind. This is followed by a comparison of the different countries, containing a qualitative benchmark, which focusses on the impact of the different policy profiles on construction innovation.

7.1 Discussion per country

In the same order as the previous chapters, the different countries are reviewed. Consecutively, the policy profile, general impact and the link between the structure, used strategy and policies are discussed. Encompassing strategies, policies and general perceptions of innovation in construction are covered as well.

7.1.1 The Netherlands

The Dutch innovation system is studied from abroad with great interest. However, the CI has, partly because of the construction fraud, been marked by huge distrust between contractors and public clients; especially in the civil engineering sector. The consequences of this distrust drag over to the industries structure and the policy-making.

7.1.1.1 Construction within the political landscape

The Dutch political landscape has shifted in the last few decades slightly to the liberal, more right-winged side, with for example privatizations of several sectors, such as mailing and public transport as a result. Consequently, the general tendency in construction policy is to stimulate the market, and in particular suppliers, to take a leading role in innovation. The government sees itself merely as a facilitator of discussions and platforms rather than a director of innovation. A key principle, as also formulated in the *Enterprise Policy*, is that the government does not steer with rules and subsidies, although several examples exist of direct subsidies and command-and-control regulation. However, this hands-off approach has for a long time been clearly visible in the policy profile.

General strategies, such as the *Bouwagenda* and *Enterprise Policy* contain future goals – often regarding sustainability and environmental impact – and networking and collaboration facilities are offered, mostly combined with access to expertise, such as the aforementioned PIANOo. However, the market parties themselves are expected to take the lead in the innovation process. Nevertheless, in the recent past, this view is reconsidered, resulting in a more active role from the government, which is even initiated or supported by several prominent liberal politicians.

7.1.1.2 Sharing of knowledge and expertise

The politics affecting the Dutch CI are generally fragmented. The interference and division of responsibilities from several ministries is typical, which results in an unclear and a poorly coordinated policy mixture. However, we can see that in the recent past, steps have been taken towards general construction strategies. The PIANOo and *Ondernemersplein* are remarkable initiatives regarding publicly organized distribution of knowledge and information. Although evaluations are sparse on these kind of initiatives and especially the relation to innovation is no more than an educated guess, the reviews are unanimously positive as discussed in chapter 6; of course with remarks and future recommendations. Also in relation to innovation-stimulating procurement, the Netherlands are

leaders in several fields. Aforementioned institutions such as PIANOo aid in making entrepreneurs familiar with these procurement methods. The more general innovation policies, however, are far more balanced, and some measures have been used in other countries after success in the Netherlands, such as WBSO and IP measures.

7.1.1.3 Financial support to innovation

The large trust in market forces, however, does not mean that direct input of R&D is neglected. Companies, among which the suppliers, can claim direct funds for innovative projects or can apply for venture capital for such projects, but most generous are the tax incentives. Even in comparison to less liberal countries, the fiscal incentives, consisting most notably of the WBSO, Innovatiebox, IPC and MIT (moreover aimed at collaboration), offer large support and econometric studies have, by for example De Jong et al. (2013) and Hertog et al. (2015) as discussed in chapter 6, shown that these measures have been highly effective, not only regarding the particular project, but also regarding knowledge spill-over and long-term relationships between participating parties.

7.1.1.4 Policy profiles

Considering the study of Edler et al. (2016), the Dutch construction-affecting innovation policy profile shows in comparison to the other studied countries a lot of gaps. The supply of skill is despite of the shortage of skilled labor and also engineers barely actively stimulated for construction. This is not compensated for by for example active immigration policies, while the stream of migrants is currently considerable and is expected to continue in the near future, from which a significant part is well-educated. Furthermore, measures to stimulate the demand for innovation are rather scarce, but upcoming in for example the 2.5% innovation-oriented purchasing agreement, which is striking, considering the effectiveness of a balanced supply and demand-driven system and the ambition to leave increasing innovativeness to the market. However in the past few years, initiatives as *Inkoop Innovatie Urgent* and SBIR have been introduced, especially aiming at pre-commercial procurement. This shows that there are lots of opportunities to make the Dutch innovation policy profile more complementary.

7.1.1.5 Conclusion

All in all, the political system and strategies pretty much suit each other and also internationally the Netherlands score high in innovativeness (European Commission, 2017a). This seems also to be the case for the CI. Notwithstanding these positive results, the more specific policy measures regarding innovation in construction are fragmented and are not integrally designed. The main reason is that a suitable policy mix makes policy measures more effective as complementaries, especially when completely fitting the overarching strategies. Rather than forcing companies to innovate, the Dutch construction policies aim at removing barriers that obstruct innovation. Furthermore, the policies that stimulate innovation in construction stem often from general measures rather than construction-specific innovation policies. Recent initiatives such as the *Bouwagenda* aim at a uniform, more hands-on construction strategy, but the future has to show whether it will rock the industry to its very foundations or ends up as one of the many well-intended reform initiatives.

7.1.2 United Kingdom

The UK has in the past two decades been characterized by strongly championed construction reform initiatives. These attempts were certainly not in vain, as the UK sector has become more collaborative

and productivity grew substantially in the recent past. However, the link between government and private construction parties remained in most subsectors weak.

7.1.2.1 Construction within the political landscape

The UK is by far the most privatized country among the ones studied. This is also visible in the industry structure and the policy profiles. The direct government support, be it in advice and information as well as in funding, is significantly lower than in the Netherlands, but the overarching strategies are, especially in the past, way clearer and more united. These initiatives are consistently actively championed by highly regarded professors, MPs and industrial celebrities. As a result, reform initiatives are widely known and have a large impact on UK construction.

In relation to the other studied countries, the turnover of the CI has been relatively low and the labor productivity has been far below. This may explain that the UK emphasizes turnover growth more than making the industry for example more high-tech. However, the UK as a whole shows as only one of the studied countries a continuous positive figures in interest rate and inflation rates, which may indicate that the UK does not need this final instrument to counteract economic decline. However, the continuous housing crisis indicate that economic recovery is still slow, indicating the opposite.

7.1.2.2 Financial support to innovation

Direct support measures are not always as generous as in the most of the other studied countries, but they are all there, including an R&D capital allowance. Thorough evaluations of these direct support measures have hardly been conducted, which makes it hard to say something useful on the stimulating effect on innovation of the measures. On the other hand, the strategies as a whole are reviewed regularly and new strategies and reform initiatives always consider the previous ones. This becomes evident from the large amount of reform reports that have been issued in the past 25 years. Nevertheless, some clear innovation policy impact evaluations were done.

Regarding the tax incentive schemes, a positive impact was found and it was considered to be highly effective, showing a bang for the buck for the tax relief between 1,53 and 2,35. The other measures regarding financially supporting input for R&D were not quantitatively evaluated. The UK government, however, steers actively on networking and collaboration, which is in the tradition of the earliest reform reports. These collaboration initiatives look more artificial than in the historically more collaborative Scandinavian countries. Nevertheless, some fruitful results were achieved with for example the CR&D programs.

7.1.2.3 Collaboration and knowledge sharing

Furthermore, the share of employees in industry associations and collective bargaining coverage is in relation to the other studied countries low, which may indicate a need for collaboration through another route. For these initiatives, however, barely no evaluations are available, except for the CR&D program, which is not only a unique way to stimulate joint R&D, but also highly effective, with high satisfaction rates of participants. The rest of the measures to stimulate connections and complementaries also have an important place in the UK policy profiles, although the actual impact on innovation in construction is not known. Notable examples are CITB and ECITB which offer government supported education and networking activities for construction professionals.

7.1.2.4 Policy profiles

The policy profile in the UK is quite balanced and compared to the findings of the *Handbook of Innovation Policy Impact*, the mixed policies that affect construction innovation seem quite balanced. These are logical choices considering the growth strategies and political and sectoral structure. However, these measures are as good as in no case specifically aimed at improving innovation, which makes sense when being familiar with UK literature and reform initiatives that never see innovation as a goal, but always as a means to stimulate economic growth. Also, these measures are quite typical for the liberal-minded context. The relations between policy-makers, (public) clients and the market are quite weak and the distrust in each other is high. As a result, the focus on price and costs is high, although recently some initiatives were launched to shift the focus more on quality and leaving space for innovation.

7.1.2.5 Conclusion

All in all, the willingness to reform the UK CI is high and joint goals were set regularly. Although the actual targets were rarely met, the tendency has always been towards a more collaborative and quality-oriented CI. The forecast is difficult as the *Brexit* procedure has just been started, not knowing what the consequences are. Most likely, the consequences for the UK CI are not positive, as several collaboration deals were made with EU countries and the CI is dependent on a foreign (mostly East-European) workforce. However, several EU legislations and rules constitute barriers to innovation, which may be loosened after the *Brexit*, resulting in more space to innovate.

7.1.3 Denmark

Denmark is the smallest country considered. It is characterized by small firms and centralized policy-making. Collaboration has therefore been inevitable and the call for sustainability has been old and loud in Denmark, which resulted in several ways in which Denmark became one of the leaders in construction innovation.

7.1.3.1 Construction within the political landscape

The economic situation in construction is considering turnover in the industry stable and increasing in the past 7 years. Just as in Sweden, the call for new housing is large. Furthermore, Denmark has always highly emphasized collaboration; be it constrainedly, because of the small size of the construction companies. The percentage of people in unions and collective bargaining coverage is very high, which also confirms the collaborative solution-oriented culture in the northern countries in Europe. Also the focus on sustainability and a green economy is in line with other northern countries, as is the focus on R&D, which encompasses over 3% of the GDP. As discussed before, for the Netherlands, the UK and Germany, this EU target is a long way to go. In the CI, this 3% is not reached by far, although the Danish CI spends relative more than most of its European counterparts.

Denmark has been, despite of the developments towards a more liberal nation, considerably social democratic. In this system, the government plays a large, facilitating role. It moreover participates in a majority of the networks, research institutions and sector programs. Also regulation exists in large quantities, resulting in bureaucracy. On the other hand, this regulation has in several cases stimulated innovation, as for example the obligatory use of past performance in construction projects shows us. Although the results of this system were generally perceived as quality-increasing, the recent political tendencies emphasize deregulation and privatization.

7.1.3.2 Innovation strategy

The Danish innovation policies are in a lot of cases covered by overarching strategies, which are regularly developed by policy makers and market players. In the last few years, especially *Vækst og udvikling i hele Danmark* and *Danmark – Løsningenes Land* have a large stake in integral innovation policy profiles. These strategies, however, are largely aimed nation-wide rather than construction-specific. Regarding construction, the innovation policies seem rather fragmented.

7.1.3.3 Policy profiles

The policy mixes in construction are highly directed towards knowledge-oriented measures and networking and collaboration initiatives alongside the direct support measures. Literature has shown that this combination is fruitful in fostering innovation. Furthermore, Denmark was one of the leaders in applying demand-driven innovation mechanisms, which positively complements the supply-driven measures. Examples are the *User-driven Innovation Program* and the *Sustainable Building Challenge*.

As discussed above, the Danish companies are generally small. As a result, large construction projects are mostly executed in consortia. This can have some implications on innovations, as it is unclear who will profit from an invention. On the other hand, it offers the opportunity to develop construction innovations – products as well as processes – together which may increase the R&D capabilities.

7.1.3.4 Conclusion

All in all, Denmark is considered as an innovative country with large emphasis on collaboration and few barriers between public and private bodies. The high education and large research capabilities create opportunities for the development of new products and processes. Access to expertise and supply of public knowledge aids in this matter as for example in the *Værdibyg* initiative. Also demand-driven measures were applied for a long time, which stimulates innovation from another perspective. However, a broad construction strategy which encompasses a balanced construction innovation policy is lacking, which leaves space for improvement in development of integral policy profiles.

7.1.4 Sweden

Sweden's policy profile is different from the others. First of all, the innovation agency Vinnova is unique and secondly, the large emphasis on demand-driven innovation is not comparable to the other countries, except for Denmark and partly the UK. Also the diversity in tools is exceptional with a relatively small focus on stimulating input for R&D. Within Europe, the innovativeness indexes all place Sweden on top of the list (except for Switzerland, which is not a EU country), so the strategies turn out to be effective.

7.1.4.1 Construction within the political landscape

Sweden is despite the liberal tendencies a slightly left-winged country with a large and centralized government. Most striking for construction is the housing shortage. The demand for new housing is huge, which resulted in a long-term plan in which at least 15.000 new dwellings are to be built annually in the coming years as presented in *Stimulans för ökat byggande*. Experts expect that this demand will exceed the production power of construction firms and as a result, the amount of skilled laborers should be increased in a short time. This shapes largely the policy priorities in construction, as do the large infrastructural projects that are planned, such as the Stockholm Bypass. Furthermore, the share of workers who are member of unions is enormous, as is the bargaining power of these unions. Migration policies to attract skilled labor and an independent training body for construction have been established to account for this demand.

Furthermore, the inclination to collaborate is exceptionally high, with large collaboration initiatives between private and public bodies. This is also known as the *Iron Triangle*, indicating strong relations between clients, policy makers and the market. This results from the culture-historical left-winged political environment, which is despite of the recent liberalistic tendencies still visible in, for example, the strong relations for example Vinnova has with the market players.

7.1.4.2 Direct support for innovation

Vinnova has launched numerous initiatives to stimulate innovation; directly as well as indirectly. Several of these are also influencing construction and a very few are particularly aimed at the CI. The VINNVÄXT program is unique and aims at creating and stimulating regional growth within cluster by demand-driven innovation tools. Also the national innovation strategies are initiated by this agency and largely influence the course of construction – often with respect to sustainability and environmental impact.

A construction-specific Vinnova initiative is the *Bygginnovationen* in which construction companies are supported in their innovation processes by means of advice and networking in order to commercialize innovations. This is very comparable to the Danish system, although it is even more integrated. The structure is very clear, as this program falls within the Vinnova agency which falls directly under one ministry. This clarity of innovation stimulation within different sectors is completely opposite to the Dutch system in which different ministries have particular parts of the industry under their control, with each their different goals and aims.

7.1.4.3 Policy profiles

Most strikingly contrasting the other preselected countries is the large emphasis on demand-driven innovation, including pre-commercial procurement methods as well as challenge-driven innovation programs. Edler et al. (2016) highly stress the effectiveness of stimulation of the demand side of innovation and its complementary effects to the supply-driven tools. Moreover, several countries begin to follow the shift to stimulating also public demand of innovation, but momentarily Sweden remains a leader. Furthermore, the networking and clustering activities are for construction available in abundancy, which offers a proper complementary set to the direct measures.

7.1.4.4 Conclusion

In conclusion, Sweden has a deviant, but highly effective innovation system. In contrary to the Netherlands, but even more to the UK, Sweden assigns a large role to the government itself instead of merely supporting the market to initiate innovation themselves. Also the centralization is remarkable, resulting in a much clearer innovation system, which enables policy makers to develop more coherent policy mixes. This results in close collaboration between client and contractor. A remark, however, is that the population of Sweden is considerably smaller than the Netherlands, let alone Germany and the UK, which makes the industry more manageable. Evaluations on impact on innovation were hard to find on the several measures. A structured evaluation system, however, could support in evidence-based policy making.

7.1.5 Germany

Germany is Europe's largest country and is divided into smaller states. The country showed large resilience to the crisis and remained the stable power in Europe. The construction industry has since 2010 almost continuously been growing in turnover, which is exceptional compared to other studied countries.

7.1.5.1 Construction within the political landscape

The federal system largely affects the way of policy-making as the states have large autonomy in this field. Also universities and research institutes are partly governed state-wise. However, Germany has recently become renowned of the integral and broadly supported strategies which offer an excellent framework for policy-making and offer concrete measures themselves. Most notable are the *High Tech Strategy* and *Industry 4.0*.

7.1.5.2 Direct support for innovation

Specifically regarding construction, *Deutschland baut!* is an interesting initiative that increases the supply of skill which has significant positive effects when used in combination with other direct measures, such as collaborative SME support as offered in the ZIM program (Cunningham et al., 2013). More construction-specific programs, however, are mainly launched by the states. However, these are not included in the analysis. The complementary benefits of these programs are often positively reviewed, although quantifications usually lack.

7.1.5.3 Policy profile and balanced strategy

Furthermore, Germany uses a structured evaluation system of its federal policies regarding research, education and innovation. However, the individual construction policies are not incorporated in this document and the report states that individual policy evaluation should be done much more detailed in the future in order to make use of best practices. However, the range of policy measures is wide and balanced. The main reason is the existence of overarching strategies, which are created and managed cross-ministerial. Especially the *Neue High Tech Strategy* is a very balanced package of future goals and corresponding policy measures, which was highly celebrated in the *Handbook of Innovation Policy Impact* (Edler et al., 2016).

This strategy was not particularly aimed at construction, but had a huge impact on innovation policy as a whole. The states develop largely their own policies, but these have to fit within the national *Neue HTS* and *Industry 4.0*. Where other countries mainly use tax incentives to stimulate private R&D, Germany merely funds projects directly. SMEs are the most important target group of these measures and the concept of innovative pilot projects is often used. The most notable funding program is ZIM where collaborative innovation is highly emphasized with positive result and large spill-over effects.

7.1.5.4 Conclusion

All in all, the German CI is economically strong and invests above average in R&D. Most indicators point towards a relatively high level of innovation, which can possibly be explained by the unambiguous strategies and customized policies per state. Furthermore, the focus on standardization is likely to offer certainty, which theoretically increases willingness to take risks—something innovations are highly associated with. Moreover, the autonomy of the states may on one hand offer opportunities to a high level of manageability of innovation within the area. On the other hand, levels of innovation in the CIs can as a result highly deviate from state to state.

7.2 Qualitative benchmark

The previous section shows a discussion about innovation policy in the different CIs. Per discussed aspect the countries' characteristics in terms of structure, as well as policy and strategy are shown in Table 13 below. Next to general characteristics, also three more concrete examples of useful policies are presented in the table.

Table 13 – Qualitative benchmark of innovation policies in different construction industries

	NL	UK	DK	SE	DE
Trust between policy-makers, clients and market	Very high distrust since construction fraud. Recovery is very slow.	Weak ties between contractors and public clients.	Tight collaboration and relatively high trust.	Tight collaboration and relatively high trust. 'Iron Triangle'.	Interaction mostly on state-level rather than national level.
Political regard of construction	Increasing political interests. Contracting parties should take the lead.	Important topic with assigned task groups. Large history of reform initiatives.	Important, with special attention to architecture and building construction.	Large emphasis on building construction with large demand for production.	Several construction-related initiatives, but focus more on high-tech sectors.
Political focus on innovation in construction	Small focus. Recent Bouwcampus takes a little more initiative.	Minor focus. Always as a means to economic growth.	Innovation is considered important for progression.	Dedicated programs initiated by Vinnova.	Small specific focus on innovation in construction.
Focus on collaboration	Importance is acknowledged increasingly	Long tradition in call for collaboration. Still not too collaborative.	Very tight collaboration. Lots of stimulating initiatives.	Very tight collaboration. Lots of stimulating initiatives.	Collaboration is emphasized, but less than in other countries.
Focus on direct support	High focus innovation policy on stimulating R&D	Several measures on direct support, but not main focus.	Moderate focus on direct support.	Small focus on direct support. Though several measures.	Limited direct support for innovation.
Focus on knowledge and expertise	PIANOo and Ondernemersplein share knowledge	High focus on increasing skills.	High focus, with high emphasis on knowledge distribution.	Large provision for knowledge distribution.	Large focus on development and distribution of knowledge.
Policy mixture integrality	Poor matching of policies	Poor matching of policies.	Not too much focus on policy interaction.	Vinnova has a well-balanced set of innovation stimulating measures.	Very well-integrated policy mixes in strategies, although cross-sectoral.
Evaluation	No proper evaluation structure and poor usage of existing evaluations	Several evaluations of strategies. No systematic approach towards individual policies.	No proper evaluation structure and poor usage of existing evaluations.	Regular evaluation and attempts for standardization in evaluation.	Structural policy evaluations. However, measurability and standardization could improve.

Intermediaries	Several, including Bouwcampus and its spin-offs.	Several task forces and working groups.	Large role for intermediary bodies, including Bygherre-foreningen.	Agencies play an important intermediary role.	Several platforms and task groups regarding construction.
Noteworthy measure 1	R&D incentives with WBSO, Innovatiebox and RDA.	LEP for direct support to collaborative projects.	InnoBooster, a funding and support program for innovative projects.	VINNVÄXT cluster program for stimulating collaborative innovation.	ZIM program for stimulating ambitious R&D projects.
Noteworthy measure 2	PIANOo, Ondernemersplein for expertise and knowledge.	BIM Task Group for national-wide implementation of BIM.	InnoBYG, a network aimed at an innovative construction sector.	Challenge-driven innovation to stimulate innovation from demand side.	Standardization efforts in HTS.
Noteworthy measure 3	IIU and SBIR for pre-commercial procurement.	FCP for stimulating diffusion of innovation.	User-driven innovation program.	Bygginnovationen program for innovation in construction.	Zukunft Bauen for an integral approach for construction future.

7.3 Comparative discussion

Throughout all studied countries, a shift has been noted towards more liberal politics, while especially the UK has been considerably right-winged since the '80s. An important spearhead in liberal policy making is reducing bureaucracy and accompanying legislation. The approach towards stimulation of innovation is largely dependent on the way market mechanisms are considered; the more market power is emphasized, the more passively policies are applied. Especially the northern countries, being in this case Denmark and Sweden, have a remarkably more socialistic system, resulting in a bigger and more interfering government. However, it is evident that this is strongly related to the extent to which parties collaborate; especially considering the relation between private and public parties. Even associations consist in Denmark and Sweden members of public as well a market origin, resulting in the so-called *iron triangle* between policy-making entities, market parties and public clients.

Although more and more initiatives are launched in collaborative efforts, for example associations represent in Germany, the Netherlands and the UK mostly marked parties in order to increase bargaining power towards the government. The amount of distrust between groups of actors is in the latter countries higher than in the more collaborative ones. The importance of collaboration for successful innovation in construction has been stressed out by piles of literature. Although competition provides incentives to offer better, cheaper and more reliable services and products, the project-oriented structure makes market parties reserved toward taking the risk of innovation. Accordingly, the more cooperative CIs seem to be more innovative.

Moreover, the way of policy making highly affects the suitability of policy mixtures. Sweden has, for example, a dedicated innovation agency (Vinnova), which is also occupied with construction innovation initiatives, while the construction innovation policy in most countries is highly fragmented. In the Netherlands, the CI has not one particular ministry, let alone agency, which is responsible for the entire sector. This is not strange, as being client, such as RWS, requires entirely different occupations than for example developing legislation for newly built homes. As a result, policy mixes are in general not particularly well-matched.

There are two different examples which came forward from this study that have solved this problem. First, Germany has presented its *Neue HTS*, which was developed as a well-balanced policy profile and was aimed at research and innovation in all sectors. The strategy is not very specific, which leaves space to the individual states to further shape the according policies. The second example is Vinnova, which centrally steers R&I strategies, policies and initiatives. The policies it offers are well-balanced and for every stage of the innovation process support is offered, be it financially as well as providing access to knowledge and expertise. Also network and clustering activities are included in which also construction is incorporated.

Regarding support to R&D and innovation, the Netherlands have in different ways been leaders. First of all, the WBSO is one of the first tax incentives for R&D activities. This example was followed by all other countries, each with its own design. Also the *Innovatiebox* was introduced several years later aimed at actual inventions, which was adopted in different other industries. A note, however, has to be placed on the fact that at least in the Netherlands, construction firms make in relation to their turnover less use of financial R&D support measures than its industrial counterparts. The reason is unknown, but several barriers have been distinguished in multiple reports that may indicate grounds, such as the small window of opportunity due to the project-oriented structure and supply-side

reluctance to embrace new products and processes. In order to make the CI innovate, other complementary policy measures are needed, which in most cases can be used complementary to the R&D support measures.

In recent years, the demand-driven innovation programs have become more popular. Classic examples are the issuing of prizes for the best innovations, but new, often procurement-oriented, measures have been implemented. In all countries, these measures have been applied, but the Scandinavian countries are leaders on several of these initiatives. User-driven Innovation is one of these Danish examples in which innovation is a significant part of procurement criteria. Also Challenge-Driven Innovation in Sweden and the SBIR and SBRI initiatives in respectively the Netherlands and the UK are excellent examples, all falling under the header of pre-commercial procurement. Next to these direct measures, also more indirect measures are introduced in the demand side. For example, the Dutch government has agreed on procuring 2.5% of the projects and projects aimed at innovative products or processes, from which more specifically the IIU emerged.

The influence of European strategies, standardization efforts and regulation is applicable to all countries considered. However, some countries clearly develop their policy designs more in line with European initiatives then others. In the UK, barely parallels can be found in their national strategies, while for example the *Neue HTS* is highly woven into EU initiatives. Also Denmark and Sweden often follow the tendencies as presented by the EU and in many cases kick it up a notch, with for example the environmental and energy-related targets. The Dutch strategies are also often presented in line with EU strategies, although several targets affecting sustainability and according innovation were politically not lived up to.

The different strategies and measures all show different emphases to stimulating innovation in construction. Some of these measures are very effective and stimulate innovation to a great extent. However, this does not necessarily mean that implementation in another country is fruitful. The different structures have different cultural-historical backgrounds and the attitude to other groups of actors differ highly from country to country. For example, in Sweden, all construction companies pay a fixed amount to a general construction research council, which determines how the money gets spent on different innovation topics. A somewhat milder, but in a sense similar mechanism was used in the Netherlands. In culturally more liberal countries, companies would never agree to it, as it is unclear whether the companies reaps the rewards or the competition. Furthermore, the size of the company highly influences the way it is managed. For small countries, centralized policy-making is easier, with better balanced policy mixes as a result. However, centralized strategies such as the HTS in Germany, but also the newly presented *Bouwagenda* in the Netherlands are proper answers to this problem.

8 Conclusions and recommendations

In this chapter conclusions and recommendations are presented. Both are aimed at the Dutch construction industry, of course considering the analyses of the four other countries. First, the conclusion is presented, considering brief conclusions on the innovation policy in construction and successful foreign policies with their implacability in the Dutch construction industry. Secondly, recommendations are presented, based on these conclusions and the comparative discussion in chapter 7. This chapter contains two kinds of recommendations: the ones directed to Dutch policy makers and the ones directed to construction policy researchers.

8.1 Conclusion

The Dutch construction industry is in relation to the other countries not less innovative, although gaps in the policy profiles are visible. As discussed in chapter 6, several recent initiatives are presented to bridge the gaps. However, some structural problems regarding innovation in the Dutch construction industry are not solved with those initiatives. Although innovations are presented in a considerable phase, diffusion of these innovation remains problematic. Based on the industry structures, innovation-affecting strategies and policies, as analyzed for the Dutch sector as well as for the UK, Danish, Swedish and German construction sectors, should be changed in order to achieve those goals.

8.1.1 Dutch innovation policies in construction

The main conclusion which can be drawn from the previous chapter is that the Dutch construction industry is in terms of policies rather fragmented with low mutual trust, especially compared to other countries. Different ministries and agencies are responsible for different subsectors, and moreover the innovation policies are approached from other departments. Although the Netherlands have in the recent past presented some very valuable and effective policies and initiatives, the policy mixes seem to be poorly coordinated and are often stand-alone shots. Overarching strategies are newly issued or in the making, but running innovation-boosting policies are hard to find.

The gaps as well as the strengths in policies are, even when not considering policies on content, evident from the Dutch construction innovation diagram as presented in Figure 22 in section 6.2. The Netherlands are one of the leaders in supporting input for innovation and R&D. Not only are these effective measures complete in terms of mechanisms, they are also more generous than in most other countries. However, the construction industry seems to make less use of these support measures than other industries. Regarding access to knowledge and expertise, the Netherlands also are outperformers, especially concerning procedural and legislative knowledge. The supply of skill lacks in the policy overview, but the market itself has set up several initiatives for training and education, such as the *BuildUpSkills* network, which was not initiated by the government, but merely supported by it.

Resulting from the distrust, collaboration seems to be labored and projects not rarely end up in court. This shows that the Dutch construction industry is still not completely recovered from the extensive construction fraud almost 15 years ago and its continuously tightening of procurement legislation. Several initiatives are aimed at restoring trust and enhance collaboration, from the market as well as from the government, but in contrast to for example the Scandinavian countries, the Dutch construction industry is not structurally picking the fruits from collaboration yet. However, recent initiatives which are backed up intensively by all kinds of stakeholders in construction are launched as is most notably apparent from the *Bouwagenda*. Results must be awaited, but just the large coalition

of prominent parties is promising. However, a note has to be placed on the fact that this collaboration is absolutely essential for other policy measures, such as pre-commercial procurement and MIT, to work.

The most significant gaps are probably in the fields of standardizations and demand for innovation. The first is, especially within the civil engineering construction, important as it stimulates on one hand security and stability, and enables, when applied from a more technical perspective, larger possibilities for diffusion of innovations. The second gap is very effective in stimulating innovation, especially when applied to the abundantly available direct support measures. These significant gaps, however, do not mean that in the other fields policy effectiveness cannot be improved studying other countries.

8.1.2 Foreign success stories

Governance of innovation policy is closely related to the way collaboration is organized. Mainly three possible solutions have been emerged from the countries studied, namely: firstly, the development of ministry-transcending strategies, such as the German *Neue High Tech Strategy* with clear comprehensive links to other policy domains, secondly the founding of dedicated innovation agencies, such as the Swedish Vinnova and thirdly collaboration between ministries to develop policies, which is partly the case in the Netherlands. For particularly the first two possibilities, high levels of industry involvement and collaboration in policy development is essential for making it successful. Slightly different, but with similar integration results, is the Scandinavian approach in which clients are united and act moreover as an advisory body to the political side of the government, as is the case in for the Danish *Bygherreforeningen*, but also in several agencies. Currently, the *Bouwcampus* partly fulfils this role in the Netherlands, but does not actively steer with innovation policy, nor does it represent specific groups of actors. Rather, it provides more or less a forum to connect all parties and their ideas.

From a culture historical perspective, the launch of a dedicated agency may not be applicable in short notice, especially because the us-them perception is larger in the Netherlands between public and private organizations than for example in Sweden. An overarching, industry supported strategy, however, may be an option. Particular awareness should be paid to the composition of policy mixes, with special attention to the balance between pre-commercial procurement and R&D support measures, and between support of R&D and measures to support commercialization and diffusion of innovations. The High Tech Strategy is in this light a good example, although it is not directly aimed at construction. The *Bouwagenda* is in some ways comparable, but lacks in policy specificity and integrality. Despite the fact that the government is stimulating the demand for innovation more and more with policies as *Inkoop Innovatie Urgent*, the Dutch public sector may learn a lot from how the Scandinavian countries and the UK stimulate demand-driven innovation.

More policy-specific, the other studied countries show some interesting policy measures. First of all, the UK Local Enterprise Partnerships have turned out to be effective in directly stimulating innovation as well as supporting collaborative innovation. Regarding collaborative innovation, also the UK *Collaborative R&D* scheme appears to be effective. In a broader sense, the Danish InnoBYG networking program has also facilitated numerous collaborative projects in construction. Regarding stimulating demand for innovation, other countries have shown interesting policy measures. In the Denmark, the demand was aimed at the users in the User-driven Innovation Program and Sweden as well as Denmark used societal challenges as starting point for demand for innovation. Furthermore, the UK has launched several new ways of guaranteeing large-scale purchasing before the actual procurement

phase, which offers large windows of opportunities for contractors to exploit their innovations. The UK has furthermore shown a unique way of stimulating supply of skills by construction-dedicated training boards. Regarding standardization, Germany has shown several initiatives, which offer stability for firms, such as *German Standardization Roadmap* and efforts in the *Neue HTS*. Moreover, Germany is the only country of the ones considered that regularly evaluates its policies and strategies.

8.2 Recommendations

The conclusions show, next to strengths, gaps or shortcomings in the Dutch policy profile and weaknesses of the industry as a whole. The first section of recommendations aims at the actual goal of this report, to wit presenting lessons from construction innovation policies that can be applied in the Netherlands. This is split-up in general recommendations and a proposal for a policy profile for stimulating innovation in the Dutch construction industry, which is presented in the second section. The last section aims at limitations and shortcomings of this research that should be addressed in further research.

8.2.1 General recommendations on innovation policy in construction

It may seem stating the obvious, but the thirty-year-old call for collaboration is not without a reason. In this matter, the Scandinavian countries are way ahead of the Netherlands, but also regarding the UK and Germany. Particularly the collaboration between clients, public as well as private, is useful for stimulating demand for innovation, but also research and education institutes play an important role. Recently some serious initiatives have been introduced in this direction, but the sincere mutual trust to establish a culture of collaboration and co-creation lacks in the Netherlands. Collaboration largely reduces cost and time overruns, as parties anticipate on problems and solving them together. Because, market parties are willing to overcome problems together with other parties, space is created for innovative solutions. A government-led clients association may largely aid in tightening the relations between government and market. However, there are voices arguing that the construction industry is still not recovered and contractors are taken without profit margins. As long as that issue is not fixed, collaboration for innovation remains troublesome.

More policy-specific, the other studied countries have shown some measures with great potential for the Dutch construction industry. Although this topic remains controversial, use of past-performance in tendering has proven to be useful in some cases, especially when using Key Performance Indicators and making use of an independent project evaluation board. The disbelieve in this system, however, is not strange, as it is likely to increase bureaucracy, cases taken to court and wrongful exclusion. However, it is highly recommendable to test a party's capabilities and intentions before starting large projects and also reputation-building of contractors may increase overall quality. Sweden and Denmark, but also the UK, show useful examples for using benchmarking and past-performance in tendering. Instead of evaluating past results, also assessment of the current team is an option, which is currently discussed in the Netherlands. However, this leaves barely space for contractors to exploit good reputation. Nevertheless, the assessment is definitely preferable to the lack of such a system.

Strategies are presented regularly, all expressing an integral view. Also evaluations are available on these reports, although consisting mostly of qualitative figures rather than quantitative econometric analyses. Moreover, considering the newly presented reports, the evaluations of the old ones seem barely considered as a clear overlap is visible between successive initiatives; the *Bouwagenda* as follow up of the older *Kennisboom van de bouw in bloei!* as an excellent example. Individual measures,

especially construction-specific, are evaluated barely. For developing solid strategies, based on best practice cases, it is of the utmost importance to regularly and systematically review policy measures and strategies, preferably in a standardized and therefore comparable way. Furthermore, evaluations regarding general innovation policies should also be split-up in different sectors, including construction, as applicability of measures differs highly per sector; illustrated by for example the low usage of R&D tax incentives by construction firms.

Finally, stimulating innovation in construction seems not to have a high priority in policy-making. First this is striking, as the industry accounts for a substantial part of the GDP, and secondly because the CI is significantly lagging behind other large industries. While other countries, with Sweden as an excellent example, see innovation partly as a goal itself, as innovation is related to progress in general, the Netherlands do not seem to pay too much attention to it. The most innovation policies stem from environmental or entrepreneurial origin. However, the countries who regard innovation higher, are also countries with more progression in construction methods and products. Not only can this be relevant to the sector itself, but also the export of construction knowledge, services and products is likely to grow.

8.2.2 Policy profile proposition

Considering the solutions to the shortcomings as shown above, some concrete examples from foreign CIs are presented to construct a comprehensive policy profile. In a similar fashion as the different policies are analyzed, the proposed policy profile is presented. This is shown in Figure 27 and consists of existing as well as newly proposed measures. The **blue** boxes are currently active Dutch policies and the **green** ones are proposed as additions to the current strategy.

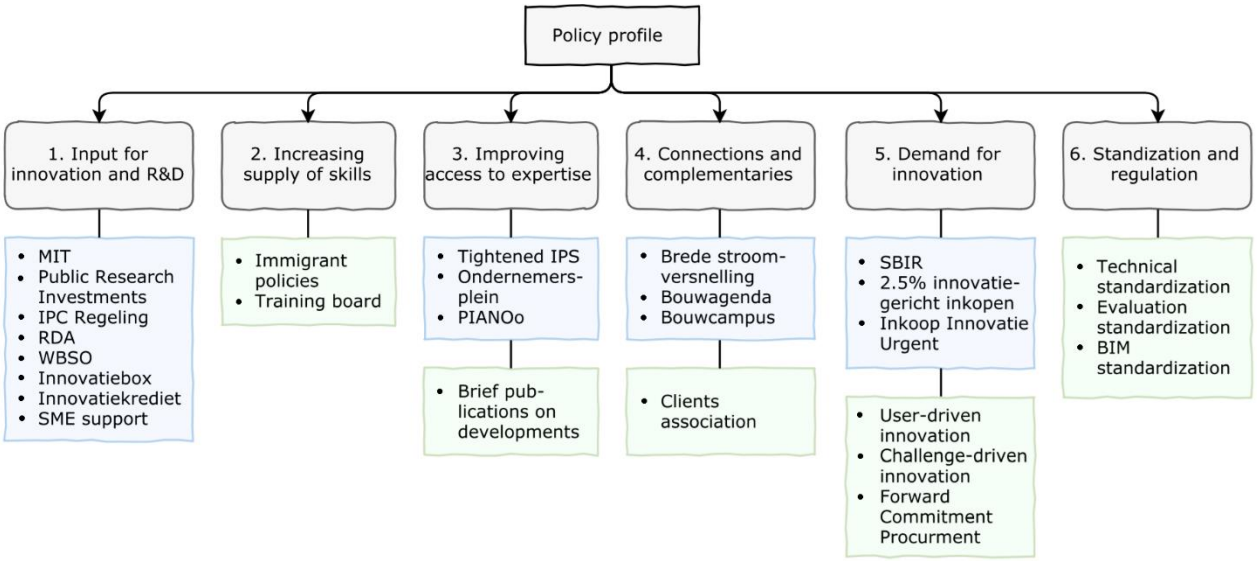


Figure 27 – Proposed policy profile for stimulating innovation in the Dutch construction sector

8.2.2.1 Additions to the policy profile

The input for innovation and R&D is well-represented in the current policy profile with an outstanding balance in measures. However, a majority, such as RDA, WBSO, *Innovatiebox* and *Innovatiekrediet*, are aimed at similar target groups. Integration of these measures decreases bureaucracy and improves the clearness of the structure. Interestingly, the participation of construction companies is low, which may be studied in further research. Active measures for supporting supply for skills is lacking in the current profile. Although the market-initiated *BuildUpSkills* exists, an extension which is linked to

networking organizations such as the *Bouwcampus* may stimulate a more organized training board. Furthermore the stream of partly well-educated refugees has recently and is still coming to the Netherlands. In combination with proper and specific education, they could play an important part in filling up the labor shortages on the construction sites as well as in the knowledge-oriented jobs.

The access to expertise is well-organized in the Netherlands with several organizations that provide technical as well as procedural expertise. Although reports on developments in the sector and progress in scientific studies are published regularly, the readability and usability for SMEs and freelancers is meagre. The Danish *Værdibyg* approach may be a solution. This partly government-led spin-off of the clients association publishes in a regular fashion short pamphlets on construction developments – technical as well as procedural – that may be useful for companies and link to the overarching sector strategy. This lastly mentioned clients association does moreover lack in the Dutch construction sector. Although the *Bouwcampus* partly fulfills this role, the association as the Danish *Bygherreforeningen* more clearly represents all clients, including private clients and plays moreover an intermediary role towards policy makers and the industry. This clients organization may be complementary to the *Bouwcampus* and can in organizational terms be integrated because of the large overlap in function. It can moreover play an important role in supporting collaboration and even co-creation.

The demand for innovation is only be partly represented in the Dutch innovation policy spectrum. However, user-driven and challenge-driven innovation has turned out to be effective in different countries as the aim is almost exclusively at stimulating innovation for societal challenges. Another effective way to stimulate demand for innovation is the *Forward Commitment Procurement* as used in the UK. The contractor has in this way certainty on exploiting innovations, which encourage investments in R&D. It moreover can be used in large-scale projects which stimulates the building of consortia which stimulates collaboration. This upscaling is essential for diffusion of innovations.

Standardization efforts also largely benefits innovation. This can be done in several ways. First of all, technical standardizations can take place in specialized field, as this eases collaboration. This is mainly the case for dimensioning, but also other aspects can be standardized. Of course, there is always an argument that standardization leads to monotony, but this is not always the case. Especially the relation between architecture/design and engineers is regularly tested by esthetics on one side and applicability and modularity on the other, for which standardization can be a solution. As discussed before, the use of policy evaluations is weak. Standardization in evaluation systematics and command-and-control regulation on the approach and use of regular policy should be applied in order learn from past policies and applicability in other policy fields. Finally, standardization in processes should take place to align the supply chain, from suppliers to clients and users. Standardization in the use of BIM is extremely suitable in this case, as digitalization of knowledge, design, project management and risk management is inevitable. Several countries have already used BIM task groups to smoothen the transition towards nation-wide BIM usage in construction. Needless to say, this standardization in BIM and other process-related cases should go hand in hand with access-to-expertise related measures.

8.2.2.2 Strategy improvements complementing policy profile

Next to these concrete measures, some basic policies should be applied, which are not easily captured in one of the boxes in Figure 27. First of all, as much measures directly aimed at construction as possible should be designed, launched, executed, monitored and evaluated from one single ministry, agency, task force or strategic center. Especially the policy design should be done centralized or in co-

creation in order to oversee policy interactions. Preferably, also consider related policy fields, such as sustainability, energy, land use, spatial planning and city planning when the design is elaborated.

Secondly, an overarching monitoring and evaluation system should be launched and maintained in order to keep the policy profile dynamic and enable it to be optimized to structural sector dynamics. It is also important to manage the evaluation results in order to make sure it is used in future policy making. The *Bouwagenda* together with the *Bouwcampus* give excellent opportunities for this approach, as these initiatives are backed by the entire assemblage of actors. Thirdly, high standards should be asked in job descriptions. Although it is a common phenomenon that clients are afraid to set standards too high for the fear of competition distortion, it is the only way to make market parties excel in quality and innovativeness. High ambitions from the government are needed to reach the ambitious goals on sustainability and energy-use, which should be translated in the contracts in order to stimulate sector innovativeness.

8.2.3 Further research

In chapter 1, the limitations, delimitations and research scope are discussed. Obviously this has consequences on the thoroughness and extensiveness of this study. In order to account for those gaps, the following recommendations are made for further research. Needless to say, close to all recommendations are consequences of limited time in this master thesis project.

First of all, the industry structures are determined on the basis of available literature and figures, supplemented with minor changes as a result of comments of experts. However, the 'industry feeling' is better represented by local residents. Accordingly, the research could be heavily extended by appointing a researcher in for example all EU countries which will increase the accuracy of the conclusions. Also several useful construction innovation policy measures may be overlooked as a result of picking a selection of countries, for where this further research could account for. It moreover takes away the linguistic barriers which are opposed to a single researcher.

Secondly, this study has approached the policy profiles on a rather abstract level. As a result, the individual measures are not analyzed on a very detailed level, let alone econometric impact studies. Partly overlapping with the recommendations from the previous section, it might be useful to develop first of all a standardized way of policy impact analysis and furthermore all individual policies and strategies. For example, several designs of tax incentives for R&D exist, but which is the most useful in what situation cannot be deducted from literature. Next to the benefits of the ability to use best practices, it also highly increases the reliability of policy mixture analysis. In the end, developing a 'perfect' policy mix is the ultimate goal, but only extensive lessons from past policy impacts allow this.

Thirdly, the parties involved in this study are very limited. Ideally, from every group of actors, people with a clear overview should be involved for every country, including large contractors, suppliers, clients, intermediary organizations, services firms, policy makers and academics. Partly these groups of actors should be considered in different subsectors as perception of innovation policy in private housing may be entirely different from for example large infrastructure construction. Fourthly, repeating this study for example once in every five year may give more structural insights in problems and opportunities to construction innovation policy. Moreover, recommendations from this study may be reviewed in the subsequent reports in order to monitor progressions and preparedness to change of the sector. Of course, the construction industry has been known as a very conservative sector, so for example annual evaluations will not be necessary.

9 List of experts

This thesis is written on the basis of available literature and discussions with experts. Without these experts' opinions, the report would not have the current quality. These experts have been helping me on gathering information, offering feedback and providing new insights, for which I am very thankful. The list of experts is presented below.

• Ben Spiering	De Bouwagenda
• Ib Steen Olsen	DTU
• Jan Bröchner	Chalmers University
• Jelger Arnoldussen	EIB
• Lennie Clausen	Realdania
• Majorie Jans	De Bouwcampus
• Niels Bruus Varming	Trafik-, bygge og Boligstyrelsen
• Simon Kofod-Svendsen	Realdania
• Stefan Kuhlmann	University of Twente
• Sten Bonke	DTU

10 Literature

Amann, W. (2015, November 24). Privatising UK social housing won't work - just look at Europe. *The Guardian*. Retrieved from https://www.theguardian.com/housing-network/2015/nov/24/privatising-uk-social-housing-associations-europe

Andersson, N., & Widén, K. (2005). Construction Innovation Systems - a Sector Approach. In *Combining Forces - Advancing Facilities management and Construction Through Innovation* (pp. 203–213). Lund: VTT. Retrieved from http://www.irbnet.de/daten/iconda/CIB6270.pdf

Andersson, S., Berglund, K., Gunnarsson, E., & Sundin, E. (2012). *Promoting innovation - Policies, Practices and Procedures* (Vol. 8). Stockholm: Vinnova. https://doi.org/10.1108/eb015723

Arksey, H., & Morée, M. (2008). Supporting working carers: Do policies in England and The Netherlands reflect "doulia rights"? *Health and Social Care in the Community*, *16*(6), 649–657. https://doi.org/10.1111/j.1365-2524.2008.00791.x

Arnoldussen, J., Groot, P., Halman, J., & Zwet, R. van. (2016). *Innovatie in de bouw*. Amsterdam.

ARUP. (2016). Towards the delivery of a national residential energy efficiency programme, (May).

Baer, O. (2014). *Das Effizienzhaus Plus in Berlin – eine Analyse*. Dresden.

Baumanns, T., Freber, P.-S., Schober, K.-S., & Kirchner, F. (2016). *Bauwirtschaft im Wandel - Trends und Potenziale bis 2020*. München.

BBS, Die Deutsche Bauindustry, & Das Deutsche Baugewerbe. (2014). Wertschöpfungskette Bau: Fundament für vitale wirtschaftliche Aktivitäten.

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., & Rickne, A. (2008). Analyzing the functional dynamics of technological innovation systems : A scheme of analysis Analyzing the Functional Dynamics of Technological Innovation Systems : A Scheme of Analysis **. *Research Policy*, *37*(37), 407–429. https://doi.org/10.1016/j.respol.2007.12.003

Bérubé, C., & Mohnen, P. (2009). Are firms that receive R & D subsidies more innovative ? e. *Canadian Journal Of Economics*, *42*(1), 206–226. https://doi.org/10.1111/j.1540-5982.2008.01505.x

Bird, A., & Ladyman, J. (2013). The Haldane Principle and the Significance of Scientific Research. *Social Epistemology Review and Reply Collective*, *2*(7), 14–22.

BIS. (2013). UK Construction: An economic analysis of the sector. *Department for Business Information & Skills*, (July), 43.

BMBF. (2014). Die neue Hightech-Strategie: Innovationen für Deutschland. *Bundesministerium Für Bildung Und Forschung*, 60. Retrieved from https://www.bmbf.de/pub_hts/HTS_Broschure_Web.pdf

BMBF. (2016). *Bundesbericht Forschung und Innovation 2016*. Berlin: Die Bundesregierung.

BMUB. (2014). German Federal Urban Development Law - the Federal Building Code. Retrieved March 17, 2017, from http://www.bmub.bund.de/en/topics/city-housing/urban-development-law/federal-building-code/

BMUB. (2017). Säulen der Forschungsinitiative Zukunft Bau. Retrieved March 14, 2017, from http://www.forschungsinitiative.de/forschung/programm/

BMVI. (2016). *Verkehr und Mobilität in Deutschland*. Berlin. Retrieved from https://www.bmvi.de/SharedDocs/DE/Publikationen/G/verkehr-und-mobilitaet-in-deutschland.pdf?__blob=publicationFile

Bortolotti, B., & Milella, V. (2006). Privatization in Western Europe Stylized Facts, Outcomes, and Open Issues. *Working Papers*, (I). Retrieved from http://ideas.repec.org/p/fem/femwpa/2006.124.html

Bourn, J. (2001). *Modernising construction*. London. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Modernising+Construction#0

Bouwend Nederland. (2017). Organisatie. Retrieved January 23, 2017, from http://www.bouwendnederland.nl/organisatie

Bowler, T. (2017). How has the economy fared since the Brexit vote? *BBC*. Retrieved from http://www.bbc.com/news/business-36956418

Bräuninger, D., Heymann, E., Möbert, J., Peters, H., Rakau, O., & Schneider, S. (2016). *Focus Germany - 2016 GDP growth: External headwinds & domestic tailwinds*. Frankfurt am Main.

Bröchner, J., Josephson, P.-E., & Kadefors, A. (2002). Swedish construction culture, management and collaborative quality practice. *Building Research & Information*, *30*(6), 392–400. https://doi.org/10.1080/09613210210159866

Bröchner, J., & Lagerqvist, O. (2016). From ideas to construction innovations: Firms and universities collaborating. *Construction Economics and Building*, *16*(1), 76–89. https://doi.org/10.5130/AJCEB.v1i1.4668

Brookhouse, S. (2014). *The Architect and the Construction Industry*.

Bruijn, P. J. M., & Maas, N. (2005). *Innovatie in de bouw*. Delft.

Bruijn, P., & Maas, N. (2005). Innovatie in de bouw, 110.

Burnand, V. (2014). *Cost Led Procurement Guidance*. *Cabinet Office*. London. Retrieved from https://www.gov.uk/government/publications/cost-led-procurement

Bygballe, L. E., & Ingemansson, M. (2011). Public policy and industry views on innovation in construction. *IMP Journal , The*, *5*(3), 157–171.

Byggherre. (2016). About the Swedish Construction Clients. Retrieved March 6, 2017, from http://www.byggherre.se/om-oss/in-english-dold-sida/

Callcut, J. (2007). *The Callcutt Review of housebuilding delivery*. London.

Carlsson, B., Jacobsson, S., Holmén, M., & Rickne, A. (2002). Innovation systems: analytical and methodological issues. *Research Policy*, *31*, 233–245. https://doi.org/10.1016/S0048-7333(01)00138-X

Carter, K. (2007). *Construction Skills - The role of the educational supply chain*. Edinburgh.

CBS. (2017). Organisatie. Retrieved January 12, 2017, from https://www.cbs.nl/nl-nl/over-ons/organisatie

Centraal Planbureau. (2016). *Kansrijk Innovatiebeleid*. Den Haag: CPB. https://doi.org/10.1017/CBO9781107415324.004

Centraal Planbureau. (2017). *Analyse en internationale vergelijking sbir*. Den Haag. Retrieved from https://www.cpb.nl/sites/default/files/omnidownload/Notitie_Analyse_en_internationale_vergelijking-sbir.pdf

CITB. (2015). *Summary Annual Report 2013-2014*. Retrieved from http://www.citbni.org.uk/CITB/files/27/271d2191-5be2-4664-b7f2-e9e4d37936d5.pdf

Coenen, L., & Díaz López, F. J. (2010). Comparing systems approaches to innovation and technological change for sustainable and competitive economies: An explorative study into conceptual commonalities, differences and complementarities. *Journal of Cleaner Production*, *18*(12), 1149–1160. https://doi.org/10.1016/j.jclepro.2010.04.003

Companies House. (2007). *Standard industrial classification of economic activities (SIC) 2007*. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/455263/SIC_codes_V2.pdf

Construction Excellence. (2009). *Never waste a good crisis: A Review of Progress since Rethinking Construction and Thoughts for Our Future*. London.

Cowling, M., & Murray, G. (2013). *Evaluation of the Danish Growth Fund*. Copenhagen.

CPB. (2014). *A Study on R&D Tax Incentives Annex: Good practice cases*. The Hague, NL. https://doi.org/TAXUD/2010/CC/104 CPB

Cunningham, P., Edler, J., Flanagan, K., & Larédo, P. (2013). *Innovation policy mix and instrument interaction*. *NESTA Compendium of Evidence on the Effectiveness of Innovation Policy Intervention*. Manchester. Retrieved from http://www.innovation-policy.net/compendium/

Danish Technological Institute. (2017). About. Retrieved February 15, 2017, from https://www.dti.dk/about

Dansk Byggeri. (2016). *Forecast for the Construction Sector*. Kopenhagen.

De Jong, P., Gielen, M., & Van Praag, M. (2013). *Evaluatie Uitdagerskrediet en Innovatiekrediet*. Den Haag.

Deltares. (2017). Deltares. Retrieved January 16, 2017, from https://www.deltares.nl/en/

Depner, H., Baharian, A., & Vollborth, T. (2016). *Wirksamkeit der geförderten GuE-Projekte des ZIM*. Eschborn, Germany.

Deremar, J., Isaksson, F., Blom, L.-J., & Broman, A. (2017). *Byggkonjunkturen hamrar sig fast*. Stockholm. Retrieved from https://mb.cision.com/Public/882/2225725/bda16322f6edcfb9.pdf

Designing Buildings. (2016). Government departments responsibility for construction. Retrieved February 8, 2017, from https://www.designingbuildings.co.uk/wiki/Government_departments_responsibility_for_construction

Destatis. (2015). Construction Industry. Retrieved March 14, 2017, from https://www.destatis.de/EN/FactsFigures/EconomicSectors/Construction/Construction.html

DFG. (2017). General Assembly. Retrieved March 13, 2017, from http://www.dfg.de/en/dfg_profile/statutory_bodies/general_assembly/general_assembly_list/index.jsp

Dick, J., & Payne, D. (2005). Regional sectoral support: A review of the construction industry, SMEs and regional innovation strategies across Europe. *International Journal of Strategic Property Management*, *9*(2), 55–63. https://doi.org/10.1080/1648715X.2005.9637527

Djurssa, M. (1994). North European business cultures: Britain vs. Denmark and Germany. *European Management Journal*, *12*(2), 138–146. https://doi.org/10.1016/0263-2373(94)90004-3

Dorée, A. G. (2004). Collusion in the Dutch construction industry: An industrial organization perspective. *Building Research & Information*, *32*(2), 146–156. https://doi.org/10.1080/0961321032000172382

Drever, E., & Doyle, M. (2012). *Survey of Employment by Occupation in the Construction Industry*.

DST. (2017). Data for Research. Retrieved February 27, 2017, from http://www.dst.dk/en/TilSalg/Forskningsservice

Dubois, A., & Gadde, L. E. (2001). The construction industry as a loosely coupled system–implications for productivity and innovativity. *Paper for the 17th IMP Conference, Oslo, Norway*, (September), 9–11. https://doi.org/10.1080/01446190210163543

Edler, J., Cunningham, P., Gök, A., & Shapira, P. (2016). *Handbook of Innovation Policy Impact*. Edward Elgar Publishing Limited.

Edquist, C. (2001). The Systems of Innovation Approach and Innovation Policy: An account of the state of the art. *DRUID Conference, Aalborg*, 12–15.

Edquist, C., & Hommen, L. (2008). Small Country Innovation Systems, (August). https://doi.org/10.4337/9781847209993

EFI. (2017). *Gutachten zu Forschung, Innovation und technologischer Leistungsfähigkeit Deutschlands* (2017th ed.). Berlin.

EFMK. (2014). Government Building Policy. Retrieved March 1, 2017, from http://old.efkm.dk/en/climate-energy-and-building-policy/denmark/construction-in-denmark/government-building-policy

Egan, J. (1998). *Rethinking construction*. Norwich. https://doi.org/Construction Task Force. Uk Government

Egan, J. (2002). *Accelerating Change–A Consultation Paper by the Strategic Forum for Construction*. Londen.

EIB. (2017). Economisch Instituut voor de Bouw. Retrieved January 16, 2017, from http://www.eib.nl/

Elken, M., Frølich, N., & Reymert, I. (2016). *Steering approaches in higher education - Comparing Norway, Sweden, Finland, the Netherlands and UK*. Oslo.

European Commission. (2006). *Country Profile: Germany - Private sector interaction in the decision making processes of public research policies*. Brussels.

European Commission. (2010). *Communication from the Commission, Europe 2020*. Brussels. https://doi.org/10.1007/s13398-014-0173-7.2

European Commission. (2012). *Construction 2020: Strategy for the sustainable competitiveness of the construction sector and its enterprises*. Brussels. Retrieved from http://www.merrionstreet.ie/wp-content/uploads/2014/05/Construction-Strategy-14-May-20141.pdf

European Commission. (2013). *The Energy-efficient Buildings PPP: research for low energy consumption buildings in the EU*. *European Union*. Brussels.

European Commission. (2014). *HORIZON 2020 in brief*. Brussels: European Union. https://doi.org/10.2777/3719

European Commission. (2015). *Country report Germany 2015*. *Commission staff working document*. Brussels. https://doi.org/10.2765/72726

European Commission. (2016a). *Construction Sector - Country profile Germany*. *European Commission*. Brussels. https://doi.org/10.1016/j.jsr.2008.02.007

European Commission. (2016b). *Construction sector - Country Profile Sweden*. Brussles. Retrieved from http://www.hse.gov.uk/statistics/industry/construction/

European Commission. (2016c). *European Innovation Scoreboard 2016*. Brussels.

European Commission. (2017a). *European Innovation Scoreboard 2017*. *Europena Commision - Innovation/SMEs Programme*. Internal Market, Industry, Enterpreneurship and SMEs. https://doi.org/10.2873/571375

European Commission. (2017b). *Renewable Energy Progress Report*. Brussels. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52017DC0057&qid=1488449105433&from=EN

European Commission. (2017c). *Youth Guarantee country by country*. Brussels.

Faber, A., & Hoppe, T. (2013). Co-constructing a sustainable built environment in the Netherlands-Dynamics and opportunities in an environmental sectoral innovation system. *Energy Policy*, *52*, 628–638. https://doi.org/10.1016/j.enpol.2012.10.022

Farmer, M. (2016). *The Farmer Review of the UK Construction Labour Model: Modernise or Die*. London. Retrieved from http://www.constructionleadershipcouncil.co.uk/news/farmerreport/

Fraunhofer-Allianz Bau. (2012). *Bauen für die Zukunft - Zukunft für den Bau*. Valley.

Gao, S., & van Lente, H. (2008). Comparing Approaches to Systems of Innovation: Confronting to the Chinese Telecommunication Sector. *Globelics Academy, Tampere, 2-13 June 2008*, 2–13. Retrieved from https://smartech.gatech.edu/handle/1853/43533

George, O. (2014). *Our plan for growth: science and innovation*. London. Retrieved from https://www.gov.uk/government/publications/our-plan-for-growth-science-and-innovation

Gillmann, B. (2016). „Digitale Wüste in deutschen Amtsstuben“. *Handelsblatt*. Retrieved from http://www.handelsblatt.com/politik/deutschland/innovations-strategie-in-deutschland-digitale-wueste-in-deutschen-amtsstuben/12975044.html

Gottlieb, S. C., & Storgaard, K. (2006). Flexible strategic partnerships in Danish construction. In *Association of*

Researchers in Construction Management, ARCOM 2006 - Procs 22nd Annual ARCOM Conference (Vol. 1, pp. 415–424). Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-84861168263&partnerID=40&md5=4ce0c6557ed9c9e16f0895a9d1e23ae6

Government of Sweden. (2017). Transport and Infrastructure. Retrieved March 7, 2017, from http://www.government.se/government-policy/transport-and-infrastructure/

Hampson, K., Kraatz, J. A., & Sanchez, X. (2014). *R&D Investment and Impact in the Global Construction Industry* (1st ed.). New York: Routledge.

Hardeman, S., & Elp, M. Van. (2013). *De Stroomversnelling*. Amsterdam. Retrieved from http://www.eib.nl/pdf/de_stroomversnelling.pdf

Harvey, E. J., Waterson, P., & Dainty, A. R. J. (2015). Applying HRO and resilience engineering to construction: Barriers and opportunities. *Safety Science*. https://doi.org/10.1016/j.ssci.2016.08.019

Haugbølle, K. (2012a). *Construction R & D investments in Denmark*. Aalborg.

Haugbølle, K. (2012b). Construction R & D investments in Denmark.

Hekkert, M., Heimeriks, G., & Harmsen, R. (2011). Technological Innovation System Analysis. *Technological Innovation System Analysis*, (November), 16.

Helle, M., & Zingmark, A. (2015). *Monitoring Smart Specialisation Strategies Emilia-Romagna*. Bologna. Retrieved from http://s3platform.jrc.ec.europa.eu/documents/20182/149513/Swedish+presentation+in+Bologna_final.pdf/dac6a08c-a02c-4dc6-9b71-30ea241eec9b

Hertog, P. Den, Vankan, A., Korlaar, L., Erven, B., Janssen, M., & Minne, B. (2015). *Evaluatie innovatiebox 2010-2012*. Utrecht.

High Level Tripartite Strategic Forum. (2014). *High Level Tripartite Strategic Forum - On follow-up actions on the Communicatino and Action Plan Construction 2020*. Brussels.

HM Government. (2008). *Strategy for sustainable construction*. London. https://doi.org/8731/2k/6/08/NP URN 08/973

HM Government. (2013). 2-Construction 2025. Industrial Strategy: Government and industry in partnership. *UK Government*, (July), 78. https://doi.org/HM Government.

Hobday, M. (2000). The project-based organisation: an ideal form for managing complex products and systems? *Research Policy*, *29*(7–8), 871–893. https://doi.org/10.1016/S0048-7333(00)00110-4

Hofstede, G. (1980). *Culture's Consequences: International Differences in Work-Related Values*. Beverly Hills, CA: Sage.

Hofverberg, E. (2014). National Funding of Road Infrastructure: Sweden. Retrieved March 7, 2017, from https://www.loc.gov/law/help/infrastructure-funding/sweden.php#_ftn1

Hooper, M. (2015). Bim standardisation efforts - The case of Sweden. *Journal of Information Technology in Construction*, *20*(October 2014), 332–346.

Hughes, A., Kitson, M., Bullock, A., & Milner, I. (2013). The Dual Funding Structure for Research in the UK : Research Council and Funding Council Allocation Methods and the Pathways to Impact of UK Academics, 167. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/181652/bis-13-545-dual-funding-structure-for-research-in-the-uk-research-council-and-funding-council-allocation-methods-and-the_pathways-to-impact-of-uk-academics.pdf

Infrastructure UK. (2012). Infrastructure Cost Review - Technical Report. *Annual Report 2011-12*, (April). Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/192589/cost_study_technicalnote211210.pdf

Infrastructure UK. (2014). *Investing in UK Infrastructure - The Infrastructure Pitchbook*. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/357135/infrastructure_pitchbook_28072014.pdf

Jacobs, D., Kuijper, J., & Roes, B. (1992). *De economische kracht van de bouw*. Leusden: SMO.

James, S. (2011). Review of Education Capital. *Crown Copyright*, *22*(23), 63. Retrieved from http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=yrovftj&NEWS=N&AN=00002311-200802130-00055

Jansen, F. J., & Vlist, A. J. van der. (2011). *De winst van innoveren*. Amsterdam. Retrieved from http://www.eib.nl/pdf/de_winst_van_innoveren.pdf

Janssen, M., Erven, B., Den Hertog, P., & Jonkers, K. (2016). *Country Report 2015: The Netherlands*. Seville: European Union. https://doi.org/10.2791/57401

Kamp, H. G. J., Schultz van Haegen-Maas Geesteranus, M. H., & Blok, S. A. (2016). *Kamerbrief Bouwagenda*. Den Haag.

Keohane, N., & Broughton, N. (2013). *The politics of housing: Introduction*. *National Housing Federation, Social Market Foundation*. https://doi.org/10.1007/BF02695951

Knorr-Siedow, T. (2015). *Social Housing Germany Experiences and Current Issues*. *Brazil-EU Dialogue Seminar on Low Income Housing Finance and Subsidies. 24-25 September 2014.*

Koen, V., André, C., & Pareliussen, J. (2015). *OECD Economic Surveys Sweden*. *OECD*. OECD. https://doi.org/10.1787/eco_surveys-jpn-2009-en

Koenen, I. (2016). Bouw profiteert matig van innovatieportjes. Retrieved from https://www.cobouw.nl/bouwbreed/nieuws/2016/7/bouw-profiteert-matig-van-innovatiepotjes-1017883

Kofner, S. (2011). *Housing Market and Housing Policy in Germany*. Osaka, Japan.

Kringelholt Fowkes, R., Sousa, J., & Duncan, N. (2015). *Evaluation of Research and Development Tax Credit*. London.

Kuhlmann, S., & Arnold, E. (2001). RCN in the Norwegian Research and Innovation System Background report No 12 in the evaluation of the Research Council of Norway, (12), 43.

Kulatunga, K. J., Amaratunga, R. D. G., & Haigh, R. (2006). Construction innovation: a literature review on current research. *Research Institute of Built and Human Environment*, 654–662. Retrieved from http://usir.salford.ac.uk/9886/

Landin, A. (2000). *Impact of Quality Management in the Swedish Construction Process*. Lund.

Latham, M. (1994). *Constructing the team: joint review of procurement and contractual arrangements in the United Kingdom construction industry*. London. https://doi.org/10.1017/CBO9781107415324.004

Latham, M. (2005). *Improving Public Services through better construction*. *Forum American Bar Association*. London.

Lundvall, B.-Å. (2005). National Innovation Systems - Analytical Concept and Development Tool. *DRUID Tenth Anniversary Summer Conference 2005 on DYNAMICS OF INDUSTRY AND INNOVATION: ORGANIZATIONS, NETWORKS AND SYSTEMS*, (July 2011), 43. https://doi.org/10.1080/13662710601130863

Mairesse, J., & Mohnen, P. (2005). The importance of R&D for innovation: A reassessment using french survey data. *The Journal of Technology Transfer*, 129–143. https://doi.org/10.1007/0-387-25022-0_10

Malerba, F. (1999). Sectoral systems of innovation and production. *Policy*, (May), 1–36.

Manseau, A., & Seaden, G. (2001). *Innovation in Construction: An international review of public policies*. New York: Taylor & Francis Books Ltd.

Marklund, G., Nilsson, R., Sandgren, P., Thorslund, J. G., & Ullström, J. (2003). *The Swedish national innovation system - a quantitative international benchmarking analysis*. Stockholm.

Maslesa, E., Thomsen, A., Thuesen, C., & Arnklit, S. R. (2014). *InnoBYG case-samling fra udviklingsprojektet Bæredygtige Forretningsmodeller*. Lyngby. Retrieved from http://orbit.dtu.dk/files/97871958/Casebrochure.pdf

McKinsley Global Institute. (2017). *Reinventing Construction: A Route To Higher Productivity*. Retrieved from http://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/reinventing-construction-through-a-productivity-revolution

Ministry of Economic Affairs. (2014). *Kennis maken, kennis delen*. Den Haag. Retrieved from https://www.rvo.nl/sites/default/files/2014/07/IPC-resultatenboekje Kennis maken, kennis delen.pdf

Ministry of Economic Affairs. (2016). *Tussentijdse evaluatie TKI-toeslagregeling*. Den Haag.

Ministry of Economic Affairs. (2017). *Eindrapport evaluatie van de MIT-regeling*. Den Haag. Retrieved from file:///C:/Users/User/Downloads/17034552kamerbriefMIT.pdf

Ministry of Enterprise Energy and Communications. (2012). *The Swedish Innovation Strategy*. Retrieved from http://www.government.se/content/1/c6/20/25/58/ace0cef0.pdf

Ministry of Finance. (2016). *Sweden's convergence programme 2012*. Stockholm. Retrieved from http://ec.europa.eu/europe2020/pdf/csr2016/cp2016_sweden_en.pdf

Ministry of Higher Education and Science. (2015). General organization and administration. Retrieved February 15, 2017, from http://ufm.dk/en/education-and-institutions/the-danish-education-system/general-organisation-and-administration

Ministry of Higher Education and Science. (2017). Funding programmes for research and innovation. Retrieved February 25, 2017, from http://ufm.dk/en/research-and-innovation/funding-programmes-for-research-and-innovation/find-danish-funding-programmes

Miozzo, M., & Dewick, P. (2004). *No TitleInnovation in Construction - A European Analysis* (1st ed.). Cheltenham: Edward Elgar Publishing Limited.

Murray, M., & Langford, D. (2003). *Construction Reports 1944-98*. Wiley-Blackwell.

NAO. (2016). *Local Enterprise Partnerships*. London. Retrieved from https://www.nao.org.uk/wp-content/uploads/2016/03/Local-Enterprise-Partnerships.pdf

Nazarko, J., & Chodakowska, E. (2015). Measuring Productivity of Construction Industry in Europe with Data Envelopment Analysis. *Procedia Engineering*, *122*(Orsdce), 204–212. https://doi.org/10.1016/j.proeng.2015.10.026

Nelson, R. R. (1992). National innovation systems: A retrospective on a study. *Industrial and Corporate Change*, *1*(2), 347–374. https://doi.org/10.1093/icc/1.2.347

New York Times. (2013). World University Rankings 2012-2013. Retrieved February 10, 2017, from https://www.timeshighereducation.com/world-university-rankings/2013/world-ranking#!/page/0/length/25/sort_by/rank/sort_order/asc

Nilsson, R., & Hellman, J. (2016). Sweden's Innovation System. Retrieved March 8, 2017, from http://www.vinnova.se/en/About-Vinnova/Vinnova-and-the-outside-world/Swedens-innovation-system/

Noordhuis, M., & Vrijhoef, R. (2011). *Ketensamenwerking in de bouw*.

NWO. (2017). Financieringsinstrumenten. Retrieved March 29, 2017, from http://www.stw.nl/nl/financieringsinstrumenten

OECD. (2005). *Oslo Manual* (Vol. 3rd editio). European Commission and OECD Publishing. https://doi.org/10.1787/9789264013100-en

OECD. (2014). *OECD Economic Surveys - Denmark 2014: An overview*. Retrieved from http://www.oecd.org/eco/survey/denmark

OECD. (2015). *OECD Reviews of Innovation Policy: Sweden 2015*. Retrieved from http://strategiprocessen.stratresearch.se/Global/utvärderingar/OECD 2015 assessment and recommendations TO SWEDEN.pdf

OECD. (2016a). International Survey on Science, innovation and education policies. Retrieved March 1, 2017, from http://qdd.oecd.org/DATA/STIO_2014_COUNTRY_ITEM_TOPIC_POLICY_SOURCE/DNK.A1..STIO_2014?Page=1

OECD. (2016b). *OECD Reviews of Innovation Policy: Sweden 2016*.

OECD. (2016c). *Public Procurement for Innovation. Good Practices and Strategies*. Retrieved from http://www.oecd.org/gov/ethics/procurement-innovation-practices-strategies.pdf

OECD. (2017). *R&D Tax Incentive Country Profiles 2016: Denmark*. Retrieved from http://oe.cd/rdtax

Oepen, R.-P. (2017). BWI-BAU. Retrieved March 14, 2017, from http://www.bwi-bau.de/bwi-bau/

Olsen, I. S., Bertelsen, N. H., Frandsen, A. K., & Haugbølle, K. (2010). *The Benchmark Centre for the Danish Construction Sector (BEC)*.

ONS. (2017). United Kingdom National Accounts. Retrieved February 3, 2017, from http://webarchive.nationalarchives.gov.uk/20160105160709/http://www.ons.gov.uk/ons/rel/naa1-rd/united-kingdom-national-accounts/index.html

Ozorhon, B., & Oral, K. (2017). Drivers of Innovation in Construction Projects, *143*(4), 1–9. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001234.

PACEC. (2011). *Ealuation of the Collaborative Research and Development Programmes: Final Report*. Cambridge.

Palmer, E. (2014). National Funding of Road Infrastructure: Germany. Retrieved March 16, 2017, from https://www.loc.gov/law/help/infrastructure-funding/germany.php

Passport to Trade 2.0. (2014). Swedish business culture. Retrieved March 8, 2017, from http://businessculture.org/northern-europe/sweden/

Passport to Trade 2.0. (2016). Bussiness culture - Northern Europe. Retrieved March 17, 2017, from http://businessculture.org/northern-europe/

Pedersen, E. H., & Isaksen, J. (2015). Recent Housing Market Trends, 51–62.

Pettersson, S. (2016). *WHY SWEDEN ! INFRASTRUCTURE AND CONSTRUCTION*. Den Haag. Retrieved from http://zweden.nlambassade.org/binaries/content/assets/postenweb/z/zweden/nederlandse-ambassade-in-stockholm/infrastructuurseminar-3-november-201/1.-soren_business-sweden_haag.pdf

Porter, M. E. (1985). Competitive Advantage - Creating and Sustaining Superior Performance. *New York: FreePress*. https://doi.org/10.1182/blood-2005-11-4354

Porter, M. E. (1990). *The competitive advantages of nations*. Simon & Schuster. https://doi.org/10.1002/cir.3880010112

PWC. (2017). *UK Economic Outlook*. London. Retrieved from http://www.pwc.co.uk/en_uk/uk/assets/pdf/ukeo-jul2015.pdf

Rasmussen, G. M. G., Jorgensen, K., Gottlieb, S. C., Hesdorf, P., & Bonke, S. (2013). *The institutionalization of benchmarking in the Danish construction industry*. Lyngby.

Rhodes, C. (2015). Construction Industry: Statistics and policy. *House of Commons Library*, (1432), 1–13.

RIBA. (2017). Who we are. Retrieved March 22, 2017, from https://www.architecture.com/RIBA/Aboutus/Whoweare/Whoweare.aspx

Rigillo, N. (2016). Denmark faces “out of control” housing market. *Bloomberg*. Retrieved from https://www.bloomberg.com/news/articles/2016-07-21/denmark-faces-out-of-control-housing-market-in-negative-spiral

Rijksdienst voor Ondernemend Nederland. (2017). *Technologische ontwikkeling loont! WBSO in 2017*. Den Haag.

Rijksvastgoedbedrijf. (2017). *RVB Marktvisie Samenwerken op basis van vertrouwen Marktvisie in de praktijk*. Denhaag.

Rolfstam, M. (2013). *Public Procurement and Innovation - the role of institutions*. Cheltenham: Edward Elgar Publishing Limited.

Rutten, M. E. J., Dorée, A. G., & Halman, J. I. M. (2009). Innovation and interorganizational cooperation: a synthesis of literature. *Construction Innovation: Information, Process, Management*, *9*(3), 285–297. https://doi.org/10.1108/14714170910973501

SABO. (2016). *Making it easier for foreign construction companies in Sweden*. Stockholm. Retrieved from http://www.sabo.se/om_sabo/english/Documents/Making it easier for foreign construction companies.pdf

Samardžija, V., & Butković, H. (2012). *From the Lisbon Strategy to Europe 2020*. (S. Tišma, Ed.), *Srpska pravna misao* (Vol. 18). Zagreb: Institute for International relationss. https://doi.org/10.7168/spm.12.1845.04C

Saxon, R. (2005). *Be Valuable: A guide to creating value in the built environment*. London.

SBR. (2016). Wat doet SBRCURnet? Retrieved January 21, 2017, from http://www.sbrcurnet.nl/over-sbrcurnet/wie-zijn-we-en-wat-doen-we

Seaden, G., & Manseau, A. (2001). Public policy and construction innovation. *Building Research & Information*, *29*(3), 182–196. https://doi.org/10.1080/09613210010027701

Sergeeva, N. (2013). Making Sense of Innovation in the Uk Construction Sector. *Proceedings of 29th ARCOM Conference*, (September), 1083–1092. Retrieved from http://www.arcom.ac.uk/-docs/proceedings/ar2013-1083-1092_Sergeeva.pdf

Singh, A. (2012). Engineering mixes with politics. *Construction Innovation*, *12*(2), 128–132. https://doi.org/10.1108/14714171211215976

Statista. (2016). *Dosier: European Union*. Retrieved from http://en.wikipedia.org/wiki/European_Union

Statistiska centralbyrån. (2015). Half the population lives in one- or two-dwelling buildings. Retrieved March 7, 2017, from http://www.scb.se/en_/Finding-statistics/Statistics-by-subject-area/Household-finances/Income-and-income-distribution/Hushallens-boende/Aktuell-pong/378518/Behallare-for-Press/389205/

Sveriges Byggindustrier. (2015). Fakta om byggandet, 47–51.

Sveriges Byggindustrier. (2016). *Sveriges Byggindustrier*. Stockholm. Retrieved from https://www.sverigesbyggindustrier.se/

Swedish Construction Federation, & Swedish Building Workers’ Union. (2010). *The Construction Agreement 2010* (1st ed.). Stockholm.

The Danish Government. (2010). *Denmark 2020 - Knowledge, Growth, Prosperity, Welfare*. Copenhagen: STM. Retrieved from www.stm.dk

The Danish Government. (2012). Denmark - a nation of solutions, (December), 28. Retrieved from http://fivu.dk/en/publications/2012/denmark-a-nation-of-solutions

The Danish Government. (2014). *Danish architectural policy - Putting people first*. Copenhagen.

The Danish Government. (2016). *Denmark’s National Reform Programme 2016*. Copenhagen: Ministry of Finance.

The Infrastructure and Projects Authority. (2016). *Government Construction Strategy 2016*. Retrieved from https://www.gov.uk/government/publications/government-construction-strategy-2016-2020%250Ahttps://www.gov.uk/government/uploads/system/uploads/attachment_data/file/510354/Government_Construction_Strategy_2016-20.pdf

Thuesen, C., & Koch, C. (2011). Driving sustainable innovation in construction companies. In *Management and Innovation for a Sustainable Built Environment*. Amsterdam.

TNO. (2017). Over TNO. Retrieved January 17, 2017, from https://www.tno.nl/nl/over-tno/

TRM. (2017). The Ministry. Retrieved February 27, 2017, from https://www.trm.dk/en/the-ministry

Udannelses- og Forskningsministeriet. (2015). *Evaluering af innovationsagentordningen i perioden 2010-2014*. Copenhagen.

UK Government. (2012). Education System in the UK. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/219167/v01-2012ukes.pdf

Vaerdibyg. (2017). Om os. Retrieved July 6, 2017, from http://www.bygherreforeningen.dk/projekter/vaerdiskabende-byggeproces/1181-om-vaerdibyg

Van de Ven, A., Polley, D., Garud, R., & Venkataraman, S. (2008). *The Innovation Journey*. Oxford: Oxford University Press Inc.

Velzing, E.-J. (2013). *Innovatiepolitiek* (1st ed.). Delft: Eburon.

Verhoeven, W. H. J., Van Stel, A. J., & Timmermans, N. G. L. (2012). *Evaluatie WBSO 2006-2010*. *EIM in opdracht van het ministerie van Economische Zaken, Landbouw en Innovatie*. Zoetermeer.

Vestergaard, H., & Scanlon, K. (2007). *Social Housing in Denmark*. *Social Housing in Europe*. RealDania. https://doi.org/10.1002/9781118412367.ch5

Vi Bygger Sverige. (2015). Fakta om Byggandet 2015. Retrieved March 6, 2017, from https://www.sverigesbyggindustrier.se/fakta-om-byggandet-2015__5924

Visser, N. (2016). *Monitor Bouwketen*. Amsterdam.

Vrolijk, M. H. (2010). *Strategie en crisis*. Amsterdam.

Waldén, G. (2006). *Action for Sustainability - Sweden builds for the future*. Malmö.

Whitehead, C., & Scanlon, K. (2007). *Social Housing in Europe*. London: LSE London. https://doi.org/10.1002/9781118412367

Willetts, D. (2014). Innovation, Research and Growth: Innovation Report 2014, (March), 1–62. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/293635/bis-14-p188-innovation-report-2014-revised.pdf

Winch, G. (1998). Zephyrs of creative destruction: understanding the management of innovation in construction. *Building Research & Information*, *26*(June 2013), 268–279. https://doi.org/10.1080/096132198369751

Winch, G. M. (1999). Innovation in the British Construction Industry: The Role of Public Policy Instruments. *University College London*.

World Bank Institute. (2009). *Measuring Knowledge in the World's Economies*. *Knowledge for Development Program*. Washington. Retrieved from http://siteresources.worldbank.org/INTUNIKAM/Resources/KAM_v4.pdf

Zentralverband Deutsches Baugewerbe. (2009). *Leitbild Bau*. Berlin.

Zuijdam, F., Ploeg, M., Schipper, J., Vermeer, J., Werff, S. van der, & Swetsloot, J. (2017). *Evaluatie MKB Innovatiestimuleringsregeling Topsectoren (MIT), 2013 - 2016*. Amsterdam. Retrieved from file:///C:/Users/User/Downloads/17034552kamerbriefMIT.pdf

Appendix I: Different research frameworks

The famous analysis of the Dutch CI as presented by Jacobs et al. (1992) explains the industry by means of Porter's Diamond. In Porter's Diamond, presented in Competitive Advantages of Nations (Porter, 1990), Michael Porter links the firm's or sector's factor conditions, strategy, demand conditions and substitutes or supporting industries. In this way, the production, market, networks and economy is related to one another, with its strengths, weaknesses and structure as a whole. Also the competitiveness is considered in this way between customer, suppliers, substitute and potential entrants on the basis of Porter's theories. Hence, the profit potential of a firm, market or sector is determined. The framework is shown in Figure 28. However, how it is used in Jacobs et al.'s 'De economische kracht van de bouw', the focus has been on mapping the industry as a whole rather than focusing on the innovation. Porter developed the Diamond so to say for microeconomic evaluation, as well as macro-economic analysis as Porter has discussed in 'Competitive Advantages of Nations' and 'Techniques for Analyzing Industries and Competitors'.

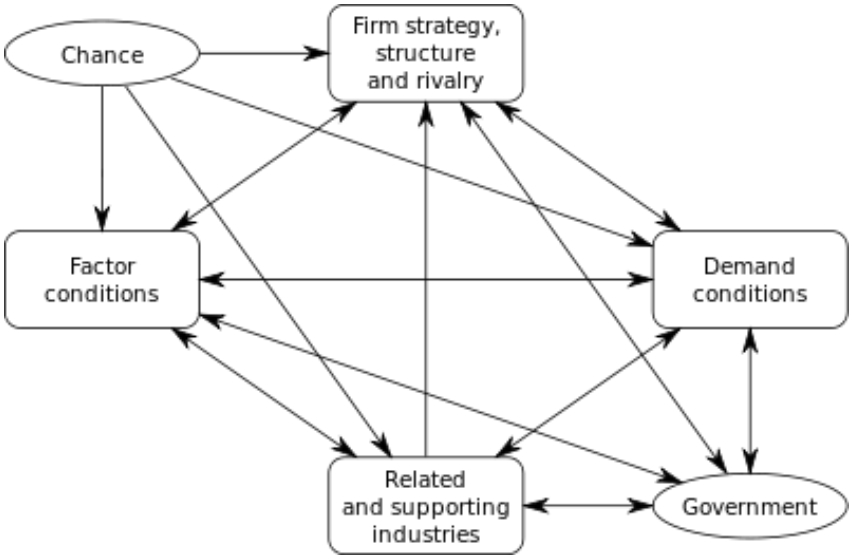


Figure 28 – Porter's Diamond (Source: Porter, 1990)

Another concept, entirely based on the innovation of countries, is called National Systems of Innovation (NSI). The term was first introduced by Freeman and Lundvall in 1988. The concept was elaborated further by Lundvall (From 1988 to 2005) and also Nelson (1992) contributed to development of this concept, both with a slightly different, though not hostile, view. From then on, lots of publications appeared on the subject, all with their own view on it (Edquist & Hommen, 2008). However, the basics of the framework were presented in a widely supported paper by Edquist and Hommen (2008). First of all, the NSI is to be defined per country by means of determinants. Secondly, within the SI's (Systems of Innovation) fall 'all important economic, social, political, organizational, institutional and other factors that influence the development, diffusion and use of innovations' (Edquist & Hommen, 2008). An adopted version of these NSI's, concentrated on the CI, can be constructed based on this theory. As the name itself says it, the NSI-approach is macroeconomic in nature.

The framework of SIs as described in the NSI approach, is expressed in later published literature in different forms. Carlsson, Jacobsson, Holmén, and Rickne (2002) remark that several dimensions can be viewed, consisting of the national (NSI), regional (RIS), technological (TIS) and Sectoral Innovation System (SIS). This last system is strongly comparable to the TIS and aims at the flow of technological and economic capabilities in a specific sector (Gao & van Lente, 2008). Just as in Porter's analysis, the system definition here is based on 'industry' or 'sector'. It distinguishes industrial enterprises, universities and individuals. Actors are characterized by a specific learning process, competence, belief, organizational structure and behavior (Malerba, 1999). Sectoral systems may prove therefore

a useful tool in various respects. For a descriptive analysis of sectors, for a full understanding of their working, dynamics and patterns of change, for the identification of the factors affecting the performance and competitiveness of firms and countries and finally for the development of new public policy indications.

Appendix II: Construction industry

CIs have several characteristics which do not differ in the different countries. To avoid repetition and clutter, these universal characteristics are discussed in this chapter. When the general construction concepts are clear, CI related statistics are presented in order to provide an overall impression of the proportions between the selected countries

Construction characteristics

In the terminology part of the introduction (section 1.4), the CI was briefly explained and system boundaries were set, but substantive aspects were not discussed. As explained, we roughly distinguish building construction, civil and heavy construction, specialized construction activities and service activities. Below these subsectors are discussed on the aspects that might be subject to innovation policies.

Structure of the construction sector

Construction is a project-oriented industry with a site-based nature and a high level of uniqueness of each individual project. In order to understand the behavior of the different entities in the sector, and finally to understand the way innovation stimulation actions in the industry work, it is inevitable to describe the system as a whole. The past two decades, several researches have been done on the industry's internal behavior. Dubois and Gadde (2001) described, backed by other studies by several researchers, the industry as a loosely coupled system with tightly coupled project structures. The complexity of the project structure as described by Winch (1998) leads us to adapt the theory of Dubois and Gadde (2001) which is discussed briefly.

The pattern of tight and loose couplings, describing the nature of relations, can be interpreted as a means of handling the complexity in the CI. Tight couplings in individual projects with the loose couplings in the whole system makes it possible to deal with uncertainty on one hand and interdependency on the other. The pattern of loose couplings in the industry's behavior goes along with competitive tendering and market-based economics. As a consequence of this loosely coupled project structure, learning is not promoted and the decentralized company structure prevents knowledge from becoming transparent which is considered to be an important barrier to innovation. Also the loose coupling between firms leaves no space for long-time cooperation which is a third consequence regarding innovation discussed by Dubois and Gadde (2001). The fourth point described as a barrier is the community of practice which, although it enhances productivity and efficiency, hampers differentiation and mutual dependencies, which are both important factors for an innovative context. These are important points to consider when evaluating the role of innovation and the accompanying policies.

The construction industry is known for its conservatism (Byggherre, 2016; Edler et al., 2016; Egan, 1998; Thuesen & Koch, 2011). This is partly a cultural characteristic of the sector and partly caused by the system how projects are established and procured. Nevertheless, this one of the foremost barriers to innovation in the industry (Farmer, 2016). Several initiatives are taken to stimulate a progressive attitude and moreover the recent achievements in demand-driven innovation as described in chapter 6 contribute to improvement of this matter.

As mentioned before, the CI consists predominantly of unique, one-of-a-kind projects in unique environments with a continuously changing set of actors and stakeholders. Therefore, construction project are considered under the group of 'Complex products and systems' (CoPS), as described by Hobday (2000). This principle was first applied to high-tech systems in for example the aviation industry. However, it was acknowledged that a lot of parallels could be drawn to the CI, especially in relation to the project-based nature and high risks of failure. Essential features are large and unpredictable effects on several parts of the projects as a result of small design changes and as a result early and intensive user involvement (Hobday, 2000). This nature leads to complexity through the entire process in projects and has large implications on the way innovation is approached – especially in relation to regular industrial consumer goods. As a result, innovations are usually incremental rather than radical.

Although the abovementioned theory is applicable to nearly the entire CI, the industry is not generalizable as a whole. The range of the CI carries along that different sub-sectors have different characteristics. Therefore a clear classification has to be given; first because of referring consistently and giving more specific analyses and secondly simply because the different behavior of different sub-sectors. Generally, we distinguish the building construction industry, heavy and civil construction industry and specialty trade construction industry. Finally there is also the service sector that contributes to this CI.

Within the building CI, the residential and office buildings are aimed at, while in the heavy and civil CI, road and waterworks, dredging, and other infrastructural constructions such as bridges, tunnels and sewage systems can be distinguished. The specialty trade CI includes specific works like installation companies, finishing contractors and more specialized firms like bar benders and rammers. The service sector contributes to the CI in the form of for example architects, project developers and financers. This subdivision is visualized in Figure 29. This subdivision is as used in this report and is mainly based on the classifications as can be found in the Dutch statistical office CBS and the UK SIC 2007. However none of these exact classifications is copied and a middle path is sought.

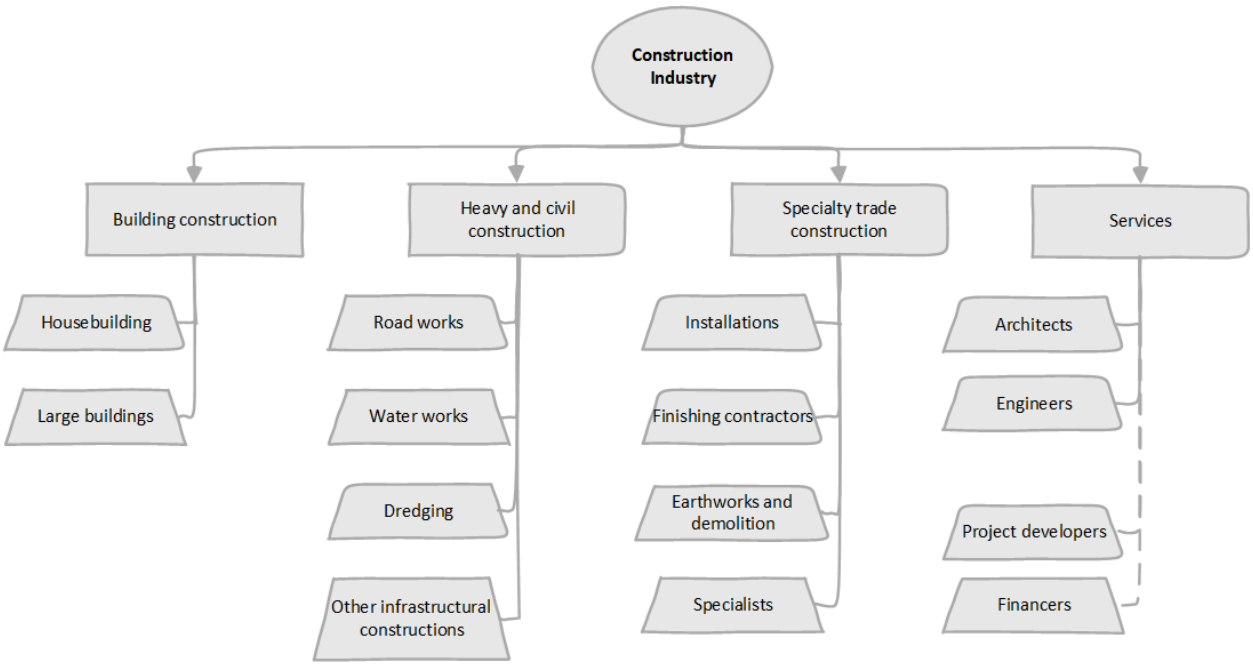


Figure 29 – subdivision construction industry

Building construction

In building construction, roughly dwellings, apartments and office buildings are built. These buildings are mostly commissioned by future users, exploiters or project developers. These are private organizations and these projects are funded with private money. However, there are some major exceptions to this. Some contractors are specialized in housebuilding, whereas others are into large buildings and flats, which require both a different set of skills and equipment. More split-up, the first one is government buildings, which means that government bodies will become users and therefore the buildings are funded with public money. Therefore, procurement law is applicable, which will be discussed in the next section. The second one is social housing which is mostly facilitated by private parties (although there are countries who manage this from government bodies) and funded with public money. The amount of social housing varies considerably per country, but is generally around 20% (Whitehead & Scanlon, 2007).

Generally the clients, which are described above, choose a main contractor who executes a project. Often also a separate company of architects or engineers is commissioned to design the building. In some cases, the main contractor also takes care of these activities. The main contractor takes care of the construction activities and for the specialized activities it hires subcontractors, such as plastering, plumbing and so on. For the materials and components it buys from suppliers lower in the supply chain. Innovation policies often aim at sustainability in building construction. All players in the supply chain are directly or indirectly responsible for implementation, from suppliers who use sustainable materials to architects who design energy-efficient dwellings. In addition, new cooperation forms have been introduced, in which the parties establish a new legal entity in order to cooperate more tightly, share the risks fairly and bypass legal difficulties between client and contractor (and sometimes architects, engineers and subcontractors).

Civil and Heavy construction

In civil and heavy construction, mainly infrastructure-related subjects are meant. Infrastructure, varying from dykes to roads to sewage systems is all public property. Therefore funding is done with public money. By the EU, there are thresholds set by which every public project, service or supply should be tendered. These are the minimum limits, but often individual countries have a stricter procurement policy themselves. The awarding of projects takes often, but decreasingly, place on the basis of the lowest bidder. However, the focus on price has its disadvantages; especially regarding neglecting of quality and cutting corners by contractors. In the past few decades, several new procurement methods have been introduced that focus more on quality, function-based design and collaboration – often containing integrated contracts. Also more and more emphasis has been put on reducing overruns in time and budget.

Another advantage of these new procurement methods is that innovation can be stimulated. The client can set requirements regarding sustainability or even the use of new techniques. In this part, the government can play the largest role as an innovation stimulator in the role of client. In the past decade, this is more and more common practice, but there is still a major reluctance toward new techniques as unproven techniques or methods bare next to increased profits a risk of failure. Reasonable risk sharing between client and contractor is hereby from utmost importance, but several more recent collaboration forms aid to this matter. As will become clear in later chapters, taken away those barriers to innovation in the tendering procedure is an important part of the innovation policies in construction.

Specialized construction activities

The specialized construction activities contain a broad spectrum of non-service activities that are relevant to buildings construction as well as civil and heavy construction. In the country-analyzing chapters, this group is therefore mentioned separately. As discussed before, roughly earth moving, installations, finishing works and specialized works are distinguished. Innovations from this group often come as a result of stricter requirements by (sub)contractors that force these companies to produce or deliver more sustainable, cheaper or different goods or services. Furthermore, some companies discern themselves by focusing on one for example a low climate footprint.

Construction services

Construction services is the subsector in which mostly architects and engineers are meant. Next to architect firms, also consultancy firms are included in this group. More and more project support is hired by for example contractors, but also clients, which leads to an increase of this subsector. Although project financing and development is considered in this service group, this is, however, not always completely representative, as those activities are in most cases far removed from construction activities. However, these financing activities are sometimes included in new ways of contracting, such as DBFM(O) (design, build, finance, maintain (and operate)). However, popularity of these types of contracts have decreased in most countries in the past few years (Ministerie van Financiën, 2017). In the statistical analyses in this study, mostly on the engineering, architect and consultancy activities are included.

Statistical comparison

In order to sketch a clear view of the different countries and their characteristics, a brief overview is given of the statistics. Most of these statistics are retrieved from Eurostat and the OECD. Only figures are given in this section and a qualitative elucidation and its relation to policies are presented in chapter 6.

Citizens and GDP

Of EU's all 508 million citizens, according to Statista (2016), the division of inhabitants per country is as presented in Figure 30. Also the prognosis for 2050 is included in the graph. It shows that that this study considers two large countries, one medium and two small countries, all with the own characteristics.

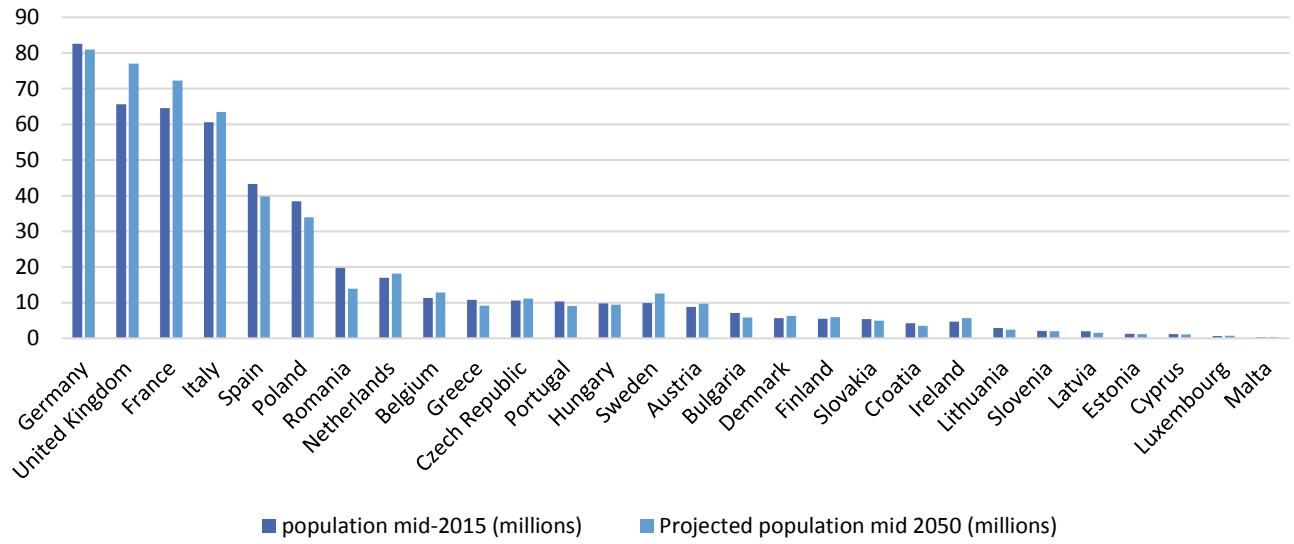


Figure 30 – Population per country in 2015 and prognosis for 2050 (Source: Statista, 2016)

Regarding the gross domestic product (GDP), Eurostat (2016) has provided useful information which is presented in Table 14. Also the amount per capital is presented in this table, showing that the Netherlands score best of these countries.

Table 14 – GDP per country total and per capita in 2015 (Source: Eurostat, 2016)

	GDP in billion PPS	per capita
Denmark	202	123,3
Germany	2.933	125,0
Netherlands	625	127,8
Sweden	347	122,9
United Kingdom	2.051	109,7

Regarding the construction industry, Nazarko & Chodakowska (2015) have calculated the labor productivity of the construction industry across OECD countries. The Data Envelopment Analysis method was used to calculate the productivity. Based on these calculations, also the Malmquist index was determined. This index compares the production in the different economies regarding the construction industry. In contrast to the DEA efficiency index, it also includes the improved possibilities of performance. The results were the following, based on figures of 2012 (Table 15).

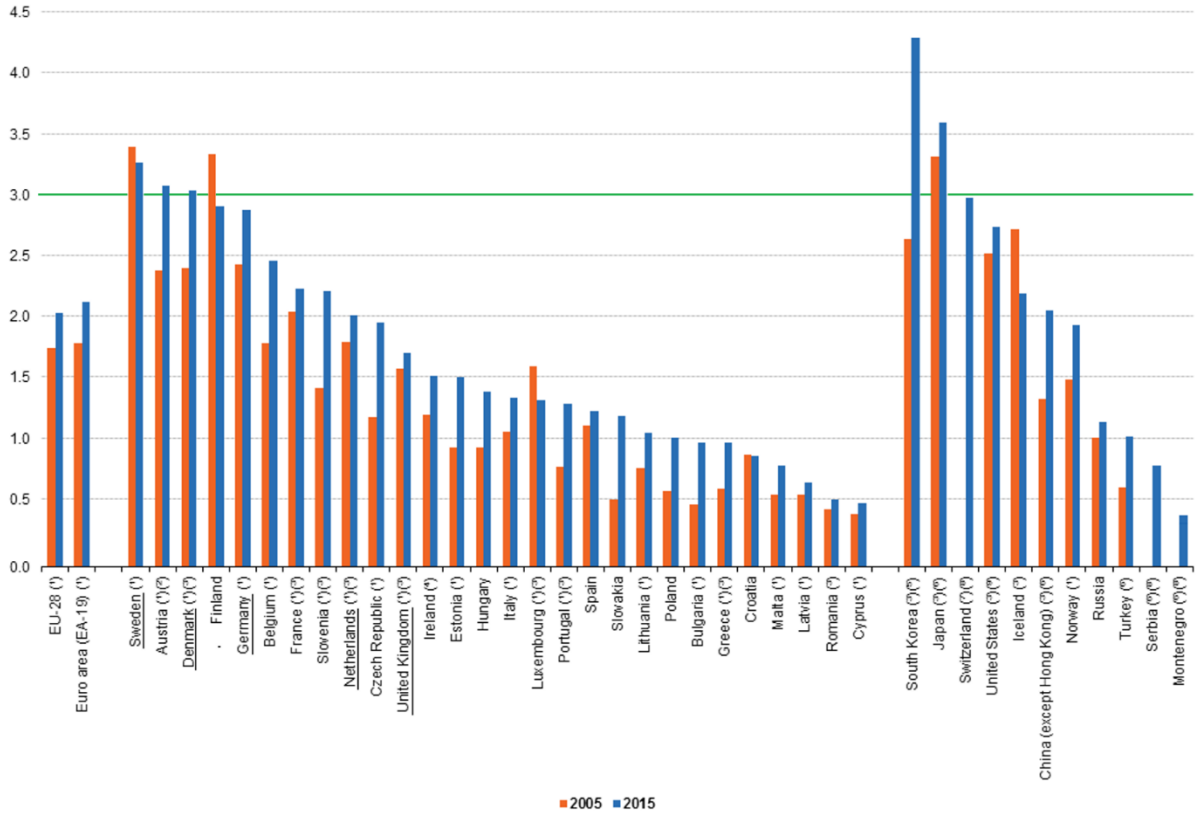
Table 15 – Labor productivity in construction (Source: Nazarko & Chodakowska, 2015)

	DEA efficiency 2012	Malmquist index
Denmark	0,639	1,272
Germany	0,798	1,143
Netherlands	0,838	1,029
Sweden	0,782	1,313
United Kingdom	1,000	0,909

National R&D expenditures

An important goal of the European strategy for growth is boost the percentage of R&D expenditures up to 3% of the GDP. This is in line with the most innovative and knowledge-oriented economies of

the world, such as North-Korea and Japan. In Europe, only a very few countries (nearly) reach this number at the moment and a majority of the countries barely reach 1,5%. Regarding the preselected countries, Sweden has the largest national R&D expenditure, followed closely by Denmark and Germany. The Netherlands and the UK score significantly worse and reach 2% and less.



Note. When definitions differ, see http://ec.europa.eu/eurostat/cache/metadata/en/rd_esms.htm.
(1) 2015: estimate or provisional.
(2) 2005: estimate.
(3) Break in series.
(4) 2014 instead of 2015. 2014: estimate.
(5) 2005: definition differs. 2014 instead of 2015.
(6) 2014 instead of 2015.
(7) 2012 instead of 2015.
(8) 2005: not available.
(9) Definition differs. 2013 instead of 2015. 2013: estimate.
Source: Eurostat (online data code: rd_e_gerdtot)

(3) Break in series.
(4) 2014 instead of 2015. 2014: estimate.
(5) 2005: definition differs. 2014 instead of 2015.
(6) 2014 instead of 2015.
(7) 2012 instead of 2015.
(8) 2005: not available.
(9) Definition differs. 2013 instead of 2015. 2013: estimate.
Source: Eurostat (online data code: rd_e_gerdtot)

Figure 31 – R&D expenditure per EU country and several non-EU countries (Source: Eurostat, 2016)

Innovation Scoreboard

On a year basis, the EC publishes an Innovation Scoreboard in which an assessment of the EU and Member States' innovation performance, as well as that of key international competitors is given. A graphical representation of the innovative performance and linked aspects is given in Figure 32. It shows the performance regarding research, intellectual capacity, innovative capacity and its relation to economic effects.

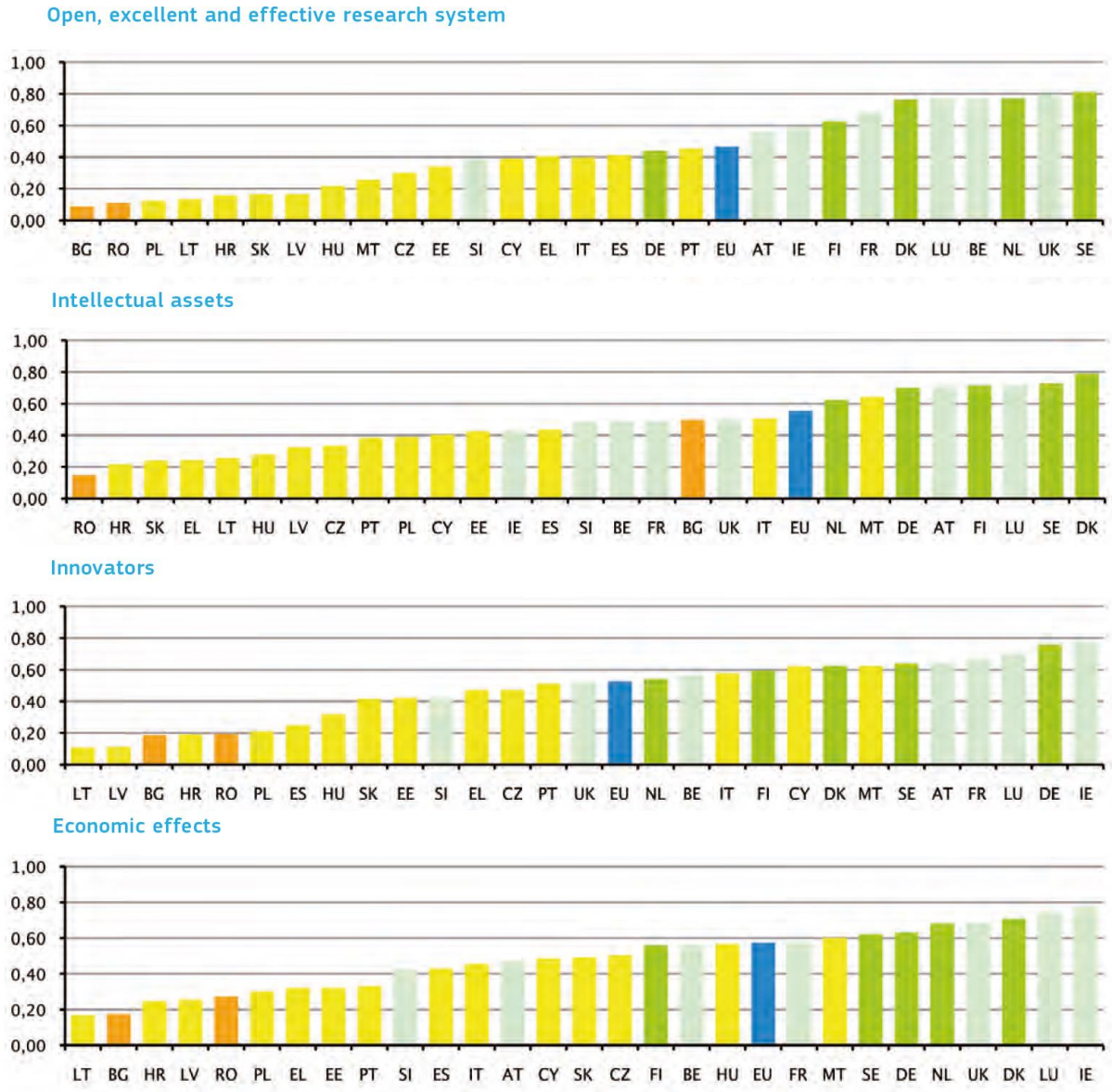


Figure 32 – Innovative capacity of the EU member states (Source: European Commission, 2016c)

Public Sector Innovation Scoreboard

The innovation scoreboard focusses merely on the public sector, and a large part of construction – especially civil and heavy construction – is publicly commissioned. The study was done in 2013 but might still give a valuable insight in innovativeness of countries. In the contrary to the private sector, the different types of innovation on which the scoring was based was service innovation, process innovation, organizational innovation and communicational innovation. Several frameworks of public sector innovation measurement were used, among which Innobarometer, NESTA survey and Australian framework. Thereafter, several indicators regarding innovation enablers, activities and outputs were defined. The scorecard for the preselected countries is shown in Table 16, classified from good (green) through average (yellow) to bad (red). It is clear that Sweden performs extremely well, followed roughly by Denmark, the Netherlands and the UK. From this table it is obvious that Germany performs well below average as public innovators.

Table 16 – Public EPSIS Innovation scorecard (Source: European Union, 2013)

Human Resources	**DK**	**DE**	**NL**	**SE**	**UK**
Creative Occupations					
University Education					
Quality Public Services					
Government Effectiveness					
Regulatory Quality					
Increased Efficiency					
Availability Services					
E-Government					
Capacities					
Service in-house					
Process in-house					
Drivers and barriers					
Internal barriers					
External barriers					
Active Management					
External Knowledge					
Groups					
Innovators					
Innovators					
New Services					
Productivity					
Effects business performance					
Improved services					
Innovative services					
Government Procurement					
Procurement Driver					
Advanced Technology					
Innovation Procurement					

Good	Average	Poor

Turnover

The turnover of the CIs is presented in Table 17. In the left column, the sector turnover is presented in million euros. In the middle one is the share of the total country's GDP given and in the right column the sector growth from 2010 to 2014.

Table 17 – Turnover comparison in different countries in 2014 (Source: Eurostat, 2016)

	Construction turnover in m euros	**Share of construction of GDP (%)**	**Turnover index of 2014 (2010 = 100)**
Denmark	€ 28.316	10,68	107,80
Germany	€ 241.201	8,25	106,40
Netherlands	€ 79.287	11,96	106,00
Sweden	€ 63.272	14,62	112,30
United Kingdom	€ 268.299	11,86	111,40

Employees

For all preselected countries, the employment statistics of the CIs are presented in Table 18. The different between the left and the right column is that the former includes self-employment, while the second contains only people who are employed by enterprises. A low percentage in the third column therefore represents a large amount of freelancers in the sector.

Table 18 – Employees and persons employed in the CI in 2014 (Source: Eurostat, 2016)

	Number of persons employed	Number of employees	Share of employees in persons employed	Growth rate of employ-ment (%)	People employed per enterprise
Denmark	169.288	158.884	93,9%	2,7	5,4
Germany	2.202.152	1.906.974	86,6%	11,7	6,5
Netherlands	429.255	306.070	71,3%	-4,6	2,8
Sweden	363.586	298.113	82,0%	2,8	3,8
UK	1.337.324	1.243.281	93,0%	2,8	4,9

Although those statistics presented above will not be used in the individual policy analysis, this information may place the policies more in context. An increase in unemployment may for example explain certain job creation-oriented policies, while economies with a high growth and low unemployment are more likely to invest in research and innovation.

Appendix III: Elaboration on industry structures

The preselected countries, except for the Netherlands, are very briefly described in chapter 5. This appendix elaborates on these industries which are discussed in the same order, being the UK, Denmark, Sweden and Germany.

The United Kingdom

The structure of this industry is not exactly the same as the Dutch one, as is summarized in chapter 5. Tis summary, however, was based on an extensive industry analysis as presented in the section. We went through the same steps according to the previously discussed framework for the UK CI. However, several subjects are discussed way more concise, as appendix II includes definitions and general elaborations on the CI.

Actors

The actors are subdivided into knowledge institutes, educational organizations, industry, market actors and government bodies and support organizations. Below, these groups are briefly discussed.

Knowledge institutes

Different from the Dutch CI, in the UK, the knowledge institutes are managed from the central Research Councils UK (RCUK). This is a non-departmental government body which's aim it is to allocate research funds. It consists of seven councils from which the Economic and Social Research Council (ESRC) and the Engineering and Physical Sciences Research Council (EPSRC) are most relevant to the construction industry. Those seven councils are each an umbrella of sub-councils and research institutes with each their own research institutes. The public funds are obtained via the Department for Business, Energy and Industrial Strategy (formerly Department for Business, Innovation and Skills). Tens of thousands of researchers and PhDs are annually granted from these funds. The decision making processes on funds are made by researchers independently from government, known as the Haldane principle (Bird & Ladyman, 2013). The funding system for university research goes through a so-called Dual Support System (Hughes, Kitson, Bullock, & Milner, 2013). In this way, the funding councils are in one way through Research Assessment Exercises and the second as described above.

The different organizations are mostly incorporated under a Royal Charter, such as the National Standards Body (NSB) that develops industrial standards; also for the CI. The more specific researches are commissioned by the government, but commonly executed by temporary research organizations, published by the British Crown, such as the Latham Report and Egan Report. Also private organizations are commissioned, as for example in the case of the more recent Farmer Review. The UK has also an office for National Statistics (ONS). This organization, the executional body of the UK Statistics Authority is non-ministerial and reports directly to the UK Parliament. Its function is similar to the previously discussed Dutch CBS. It produces leading statistics which are presented annually in The Blue Book (ONS, 2017).

Further legislative research organizations do not exist in the UK as they do in the Netherlands. Research reports are directly commissioned and also published by ministries or by for example the House of Commons. Therefore research and knowledge organizations such as the Dutch EIB does not exist. However, the department of Business, Innovation and Skills (BIS) keeps track of construction statistics and commissions regularly researches that are relevant to the CI.

Educational organizations

The UK top universities are considered to be among the world's best, containing above all of the University of Cambridge, University of Oxford, University College London and Imperial College London. According to the NYT, the global top 200 consists of 30 UK universities (New York Times, 2013). Also in the field of the CI, several universities offer very good prospects. Especially University College London, Loughborough and Reading are outstanding in their kind. More focused at the civil and heavy engineering side, Cambridge has a formidable reputation.

Next to these top universities, there are dozens of other Universities and furthermore, there are institutes which fall under the heading of Further Education, which have more practical rather than academic purposes (UK Government, 2012). However, with regard to innovational activities in the CI, the Universities and their alumni play a major role. This also counts for the research capabilities as shown by the fact shown by Ibid that based on the amount of scientific citations the UK hold the 3rd place globally (Willetts, 2014).

The English education system was traditionally characterized by high degree of self-governance and academic autonomy, and it is only since the '70s that attempts for more centralized steering emerged. However, the country has been characterized by a strong tendency towards increased use of market mechanisms, also in recent years. Currently, the governance structure is being reformed, further towards employing market mechanisms and restructuring the existing intermediary bodies in the governance system. Funding councils are going to be abolished, and whole UK higher education will be governed by two bodies: a single market regulator for education and a single research and innovation body (Elken et al., 2016).

The UK has in the past decade a decrease in the amount of graduates. The higher education (HE) sector has a significant role to play in responding to the predicted skills shortage for the CI (Carter, 2007). Not only in providing the graduates, but in motivating them to a career in construction. For a large number of school leavers, university is often the first step towards a career in the CI. There is an opportunity for the HE sector to take a more joined-up approach for developing these skills within academic programs for enable graduates to start their careers from a stronger position. Not enough professionals are entering the industry and not enough are currently being retained (Carter, 2007). Interesting to mention is that in the light of education capital, according to James (2011), it could have been produced 30% cheaper.

Industry

The industry as a whole does not change a lot in structure from the Dutch CI. However, statistics show us, that in the contrary to the Dutch infrastructure, a majority is privately funded. Figure 33 shows clearly that the private sector is in terms of worth of orders dominant. In the housing sector is this visible most clearly. The public housing sector is quite stable on account of the continuous need of social housing (Rhodes, 2015). During the economic crisis, the social housing output even increased as the public demand increased. BIS (2013) showed us that in the industry the contracting, concerning construction of buildings, civil engineering and specialized activities, accounted for 2.030.000 jobs within 244.000 businesses, the services industry, concerning mostly of architecture and wholesale, accounted for 580.000 jobs within 30.000 businesses and the products industry accounted in 2013 for 310,000 jobs within 18.000 businesses. Drever and Doyle (2012) studied the different occupations within the CI and found that 48,7% of the workers in the CI were manual workers, whilst the rest worked in non-manual activities.

Figure 33 – Housing output (left) and Infrastructure output (right) in £ billion (Source: ONS, 2015)

The UK CI as a whole covered 6,5% of the economic output in 2015, equal to 6,2% of the jobs (Rhodes, 2015). Since 2011, when the recovery of the crisis started, the tendency has been a growing one, and still continues to do so. The services sector counts for 6,5% of the sector, equal to the share of suppliers (BIS, 2013). The self-employment rate is very high in the UK in the CI, also in comparison to other countries (Infrastructure UK, 2012). As a consequence, the fragmentation of the sector is relatively big. Another feature is that the degree of sub-contracting is relatively large due to the high self-employment rate. The structure as a whole and therefore the supply chain, however, is very comparable to the Dutch CI.

Market actors

The market actors are subdivided into the ones active in building construction, heavy and civil construction and the remaining group, predominantly consisting of architects, engineering firms and other consultancies.

Building construction

In 2011, 67% of the residential buildings were owner-occupied, 19% rented from public parties and housing associations and 14% privately rented (Keohane & Broughton, 2013). Almost 90.000 dwellings were in 2012 completed by private enterprises, while only a little more than 25.000 were built by local authorities and housing associations. In the building construction, therefore the major group of contractors work from private project developers and individuals, just as being the case in the Dutch CI, while a minority works (in)directly for government clients.

In building construction, the tenure of properties counts in total almost 28 million dwellings. In 2012, by far the largest share was owner occupied, and from the rented homes, roughly half was privately rented and half publicly rented. An overview with the distribution in 2012 is presented in Table 19.

Table 19 – Division of type of occupation per dwelling (source: ARUP, 2016)

	Owner occupied	Rented privately of with a job or business	Rented form housing associations	Rented from local authorities	Other public sector dwellings	All dwellings
Amount in thousands	17.835	4.920	2.747	2.189	75	27.767
Percentage	64,2	17,7	9,9	7,9	0,3	100

Heavy and civil construction

The heavy construction engineering is led by private parties, such as project developers and investors. More than in the Netherlands, the UK economy is privatized, which started as early as in the 1970s

(Bortolotti & Milella, 2006). In infrastructure projects like roads, bridges and so on, the (local) government(s) are client, but when infrastructure assets are viewed in a broader perspective, including for example rail and airfields, it is largely owned by private parties, be it domestic as well as foreign (Infrastructure UK, 2014).

The contractors working on heavy and civil construction are largely SMEs as Figure 34 shows us. This is confirmed by BIS (2013), who state that 99,9% of the firms in contracting are SMEs in terms of amount of companies. When the employees are considered, the share of big companies are logically way higher.

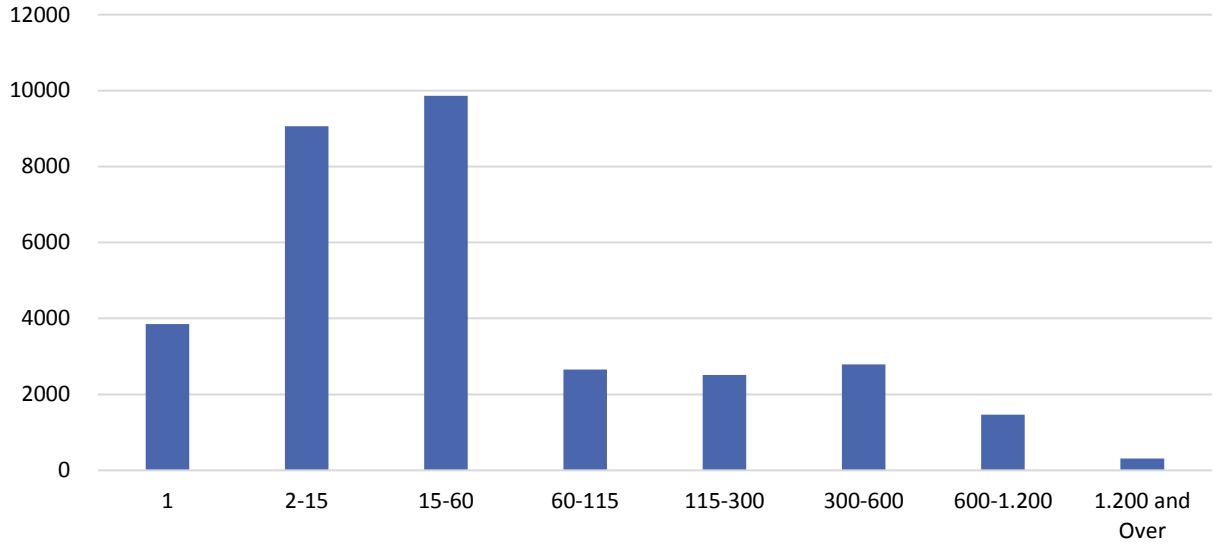


Figure 34 – Firms in the heavy and civil sector (Source: ONS, April 2015)

Architects and engineering firms

The consultancy branch of the CI represents between 10% and 15% of the value in the industry (Brookhouse, 2014). This is also a large part of the UK CI export activities, as UK architects are internationally praised because of their designing skills, complemented by the fact that three UK universities can be found in architecture educational programs in the global top-10. The architects are united in the Royal Institute of British Architects (RIBA), which provides standards, training, support and recognition for their members. Together with government, it works to improve the design quality of public buildings, new homes and new communities (RIBA, 2017).

Government bodies and supportive organizations

The departments as well as their roles are in UK government organizations very different from the Dutch ones. Most prominent is the department for Business Innovation and Skills (BIS), which comprises the BIM Task Group, Construction Sector Unit and Green Construction Board which is a consultative forum for Government and the UK design, construction and property industry in order to ensure a sustained high level conversation and to develop and implement a long term strategic framework for the promotion of innovation and sustainable growth (Designing Buildings, 2016). It furthermore involves the non-departmental Technology Strategy Board (TSB) and took the lead in the Construction 2025 project which emerged jointly with the industry. The second group is HM Treasury which includes the Cabinet Office and Infrastructure and Projects Authority (heretofore placed under the abovementioned Infrastructure UK). The former consists of the Efficiency and Reform Group

(ERG), Major Projects Authority (MPA) and the Government Construction Strategy and Government Construction Board, responsible for several important strategy publications. The latter includes the National Infrastructure Plan and Government Construction Pipeline, both initiatives in order to improve the practices in the CI on policy level.

Thirdly, the Department for Work and Pensions (DWP) has a hand in the CI by first of all developing construction regulations (CDM) and also in the non-departmental safety regulations Health and Safety Executive (HSE). Fourth, the Department for Communities and Local Government (CLG) makes the building regulations, planning permission, planning policy and houses the non-departmental public body Homes and Communities Agency and the Fire and Rescue Service. Furthermore is it responsible for the national architecture. The Home Office issues also special licenses in construction. The Departments for Environment, Food & Rural Affairs (DEFRA), Culture, Media and Sport (DCMS) and Business, Energy & Industrial Strategy (BEIS) have common ground with the CI, mostly in relation to environmental issues (Designing Buildings, 2016). Finally, local authorities are responsible for a large share of planning permissions, the approval of building regulations, licensing and environmental health.

The industry itself also has an industry association that on one serves the interests of industry players and on the other hand formulates sectorial visions and strategies. In the UK, the major industry association in construction is Build UK. It has also close cooperation with government organizations such as the Cabinet Office. More on content is the Engineering Construction Industry Association (ECIA), which is the principal trade and employer Association for the UK engineering construction industry. In cooperation with other employers' associations, it operates the National Agreement for Engineering Construction Industry through the Industry National Joint Council (NJC). Another notable association is the Construction Industry Council, which is the representative forum for the professional bodies, research organizations and specialist business associations in the CI. Rather than representing employers, its vision is to represent the industry as a whole and improve the UK construction industry by collectively representing and supporting the built environment professions. It furthermore promotes collaboration and knowledge sharing amongst its members.

Institutions and political and social structures

The British are known for their tight bond with institutions and civics. The government is quite centralized, although for example Scotland and Wales have autonomy on several areas. However, construction has been championed from a fairly centered position as is the research and innovation funding. Socially, the system is market-driven and is therefore for example comparable with the USA and Canadian system and is therefore rather exceptional from an European perspective (Seaden & Manseau, 2001). As a consequence, regulation has been kept to a minimum although more and more standardization initiatives can be noted. This goes hand in hand with the fact that since several decades the political liberalism has taken a central place which is noticeable through the entire institutional structure. Although one of the two big parties, Labour Party, is a political party with socialist ideals, the system is according to European standards liberal and the degree of privatization is considerable (Arksey & Morée, 2008). Considering behavior, the British are famous for their politeness and respect for rules and laws. However, their stubbornness and geographical separation from European main land has caused it to develop own standards and norms, for example expressing in differing from SI dimension. Harder rules and legislations are formulated in the 'Building Regulations'. Each chapter is accompanied by a more elaborate Approved Document.

Denmark

In this section, a more detailed analysis of the actual structure of the Danish CI is given. This will be done in accordance with the chapter about the UK CI and according to the structure presented by Hekkert et al. (2011), as discussed in the research methodology chapter.

Actors

In the same way as the section on the UK construction industry the Danish actor analysis is structured, containing of knowledge institutes, educational organizations, industry, market actors and governmental organizations.

Knowledge institutes and Educational organizations

The World Bank Institute created an index to rank economies on their extent to be Knowledge Economies, based on the Knowledge Assessment Methodology (KAM). The Knowledge Economy Index (KEI) takes into account whether the environment is conducive for knowledge to be used effectively for economic development. It is an aggregate index that represents the overall level of development of a country or region towards the Knowledge Economy. Regarding the aspects of education and knowledge, Denmark tops the list in the last publication of 2008 and regarding innovation, only Switzerland scores higher (World Bank Institute, 2009).

In Denmark there are more than 200 knowledge institutes and brokers (Haugbølle, 2012a). As their will be no merit in discussing them all, the most significant ones are elaborated. Broader than the CI, the Danish Technological Institute (DTI) is the main Danish research institute, which focusses most on technological research topics. Although it is an independent, non-profit organization, it is the official technological research service of the Ministry of Business and Industry (Danish Technological Institute, 2017). Technically speaking, however, the DTI is a private institution (Hampson et al., 2014). Regarding construction, the Danish Building Research Institute (SBI) is the most productive organization concerning research in the Danish CI. It is located at the Aalborg University and develops research-based knowledge to improve buildings and the built environment and employs an over 120 people workforce. It researches as broad as the CI can be regarded, including economics, construction techniques, automation (BIM and the like) and social aspects. Market parties can also obtain specific knowledge for a fee. Statistical knowledge is developed by Statistics Denmark under the Ministry of Economic and Interior Affairs in which the publicly available database is presented in StatBank. The institute operates independent from government control and produces practically all statistics in-house (DST, 2017).

In 2007, a large change in setup of universities and research institutes has taken place, resulting in centralization and fusions. In this trajectory, the national building research institute merged with the Aalborg University and became a separate faculty of the university. The former 12 universities became only eight and the 15 public research institutes merged into just a few (Hampson et al., 2014). Annually, approximately 40 m euro of public money is spent on construction research in research institutes as well as universities (Haugbølle, 2012a).

A large share of the Danish construction knowledge is developed by universities. Especially the department of building technology at the Aalborg University and the department of Civil Engineering at the Technical University of Denmark (DTU-byg) play major roles. Next to public funding, over 35% of the turnover is externally and privately funded. A clearer view on the ways of funding and the

determination of the agenda will be given in the sections regarding education, government bodies and policy. A network published by OECD (2014) regarding the research structure in Denmark is presented in Figure 35. It shows the entire chain of research organization and visualizes the relation between policy and actual research. Note that since 2014 the a new cabinet has been formed after which several ministry's names have been changed, but the structure as a whole, however, remains untouched.

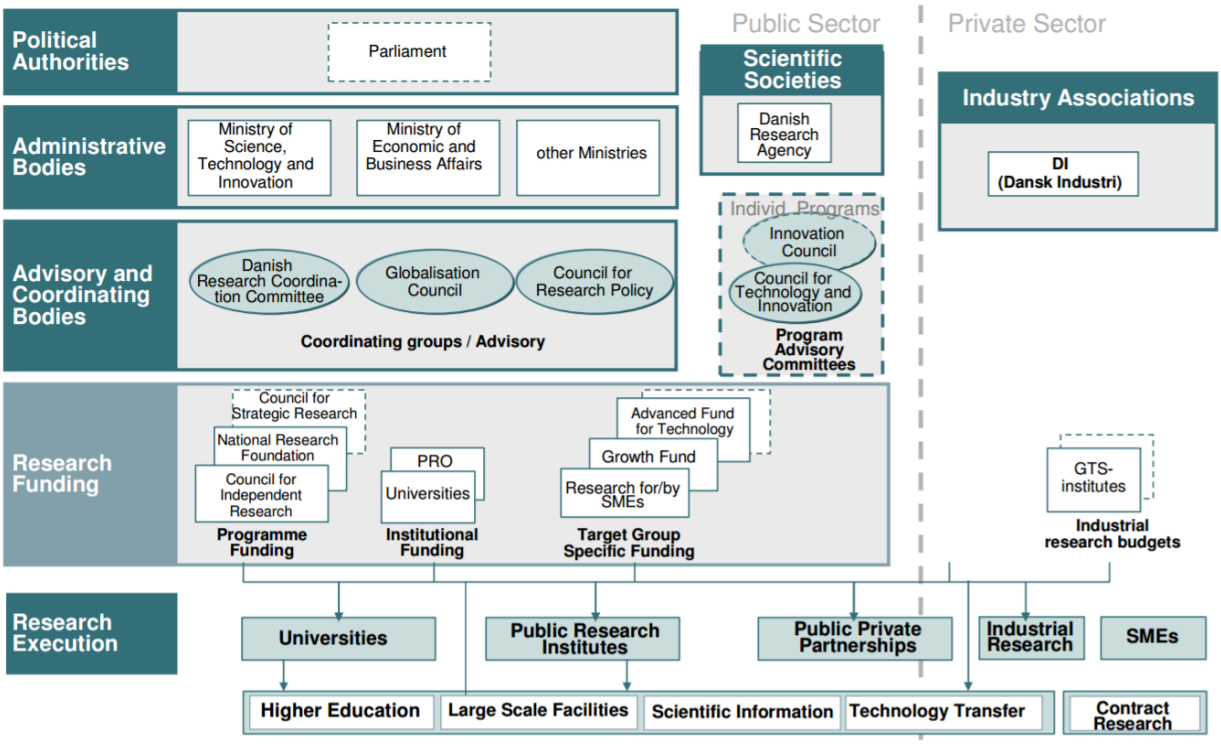


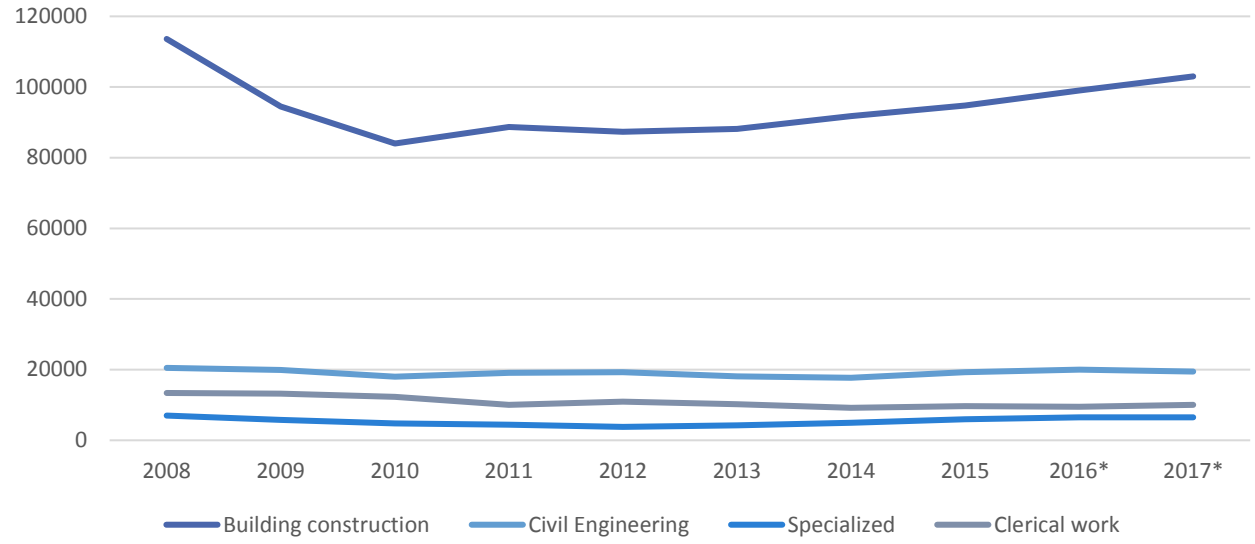
Figure 35 – Research system Denmark (Source: OECD, 2014)

Denmark presents itself as a highly educated nation and the global rankings support this claim. The NYT University rankings, strange enough, place only one university in the global top 100 and merely three in the top 200. Important, however, is that Denmark highly stimulates high education for everyone on a life-long basis. After primary and lower secondary education, specialized upper secondary education can be attended, which is succeeded by higher education. For almost this entire trajectory, no tuition fee is demanded when the student's performance is rated as sufficient (Ministry of Higher Education and Science, 2015). Up to the Universities, every capable and willing Dane is able to receive free education. The top-level education regarding construction policy and innovation almost entirely takes place at the DTU and the Aalborg University.

Industry

Regarding the countries addressed in this study, Denmark is the smallest in terms of population and, together with the Netherlands, in surface area. Of course this is visible in the statistics regarding workforce, turnover and companies. However, on a relative basis, this does not necessarily affect the sector structure. The financial crisis has also had an impact on the Danish economy as the working force statistics show us in Figure 36 (Dansk Byggeri, 2016). Similar to the previously studied countries, the largest impact of the crisis has been on the building construction, the sub-sector which is strongly dependent on private housing demand. The turnover statistics presented in 'Forecast for the Construction Sector', strongly support this claim (Dansk Byggeri, 2016). These figures are visualized in

Figure 38, in which a recovery of the industry is visible from 2013, albeit weaker than in cases of the Dutch and UK CIs. For the figures in the table, the currency is calculated by 1 DKK = 0,1345 Euro (Wisselkoers.nl, 2017).



*Forecast numbers

Figure 36 – Workforce per sub-sector (Source: Statistics Denmark, 2016)

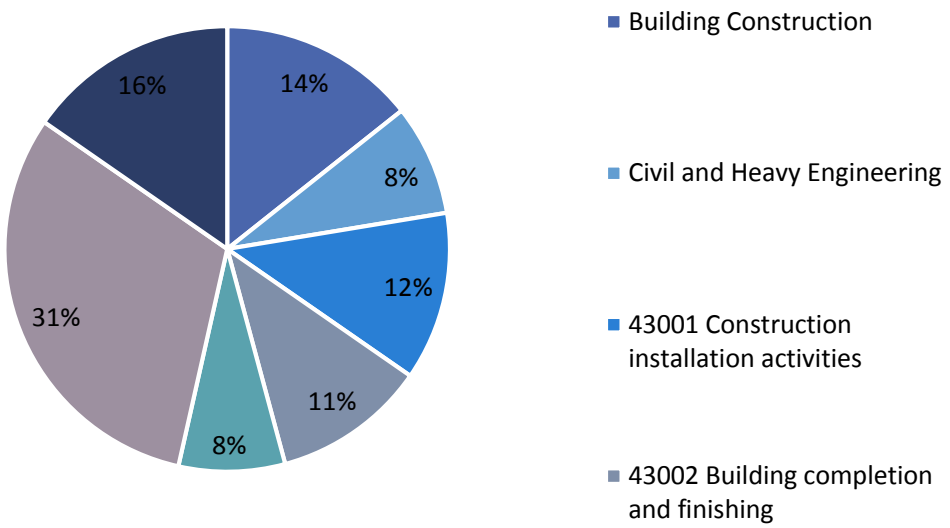


Figure 37 – Division of subsectors based on turnover in 2014 (Source: StatBank, 2015)

In the industry, a mere 12% of the turnover is related to heavy and civil construction engineering (Figure 37). The other construction works, including for example earthmoving, but also installations, are related to building construction as well as civil and heavy construction. Therefore, the figure may give an ostensibly wrong impression. Notwithstanding, it remains true that the building construction is way larger than the civil part. Just as in the other researched countries, the large share of the companies are SMEs, in which the freelancers account for almost half of the businesses. The crisis has had large impact on the industry but the figures as presented in Table 20 show that in recent years a significant recovery is visible. More recent statistics show a continuation of this tendency. This

increase is also visible in terms of turnover, as presented in Figure 38. It is important to note that the large amount of freelancers is largely coming from the companies lower in the value chain, such as plastering works and electricians.

Table 20 – Number of construction enterprises Denmark (Source: StatBank, 2015)

	2010	2011	2012	2013	2014
Total, all enterprises	31.588	31.575	31.300	30.707	31.282
Freelancers	15.295	15.393	15.036	13.728	15.126
1-9 employees	13.809	13.639	13.764	14.484	13.559
10-19 employees	1.535	1.559	1.494	1.482	1.540
20-49 employees	737	755	761	778	798
50-99 employees	129	148	161	145	161
100 employees and more	83	81	84	90	98

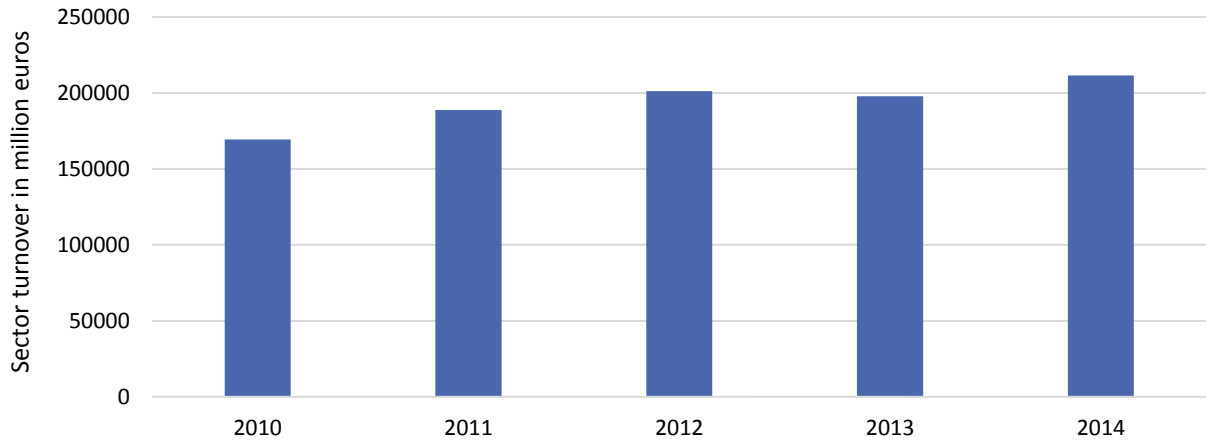


Figure 38 – Annual turnover construction industry in million euros (Source: StatBank, 2016)

Market actors

Just as in other countries, the market structure depends on the sub-sector. In this section the three distinguished sub-sectors, being building construction, heavy and civil construction and services (architects and engineering) are discussed.

Building construction

In Denmark, the size of the dwelling per person was in 2007 with 51 m^2 by far the largest in Europe, implying a high welfare in the country (Vestergaard & Scanlon, 2007). However, important to note when discussing the Danish building construction market is the fact that in few countries the negative financial rates have ever been longer than in Denmark, with the Brexit being a danger for extending this period of financial drawback, because of the large dependency on trade between these countries (Rigillo, 2016). This all has been the result of the well-known Danish property bubble that occurred, between 2001 and 2006, with years in which property prices rose with more than 25%; higher than in any other European country (Pedersen & Isaksen, 2015). In building construction, the clients of building construction are public as well is private, just like in the other studied countries. Denmark is

a known welfare state with a large social structure, which is also visible in the way (social) housing is managed.

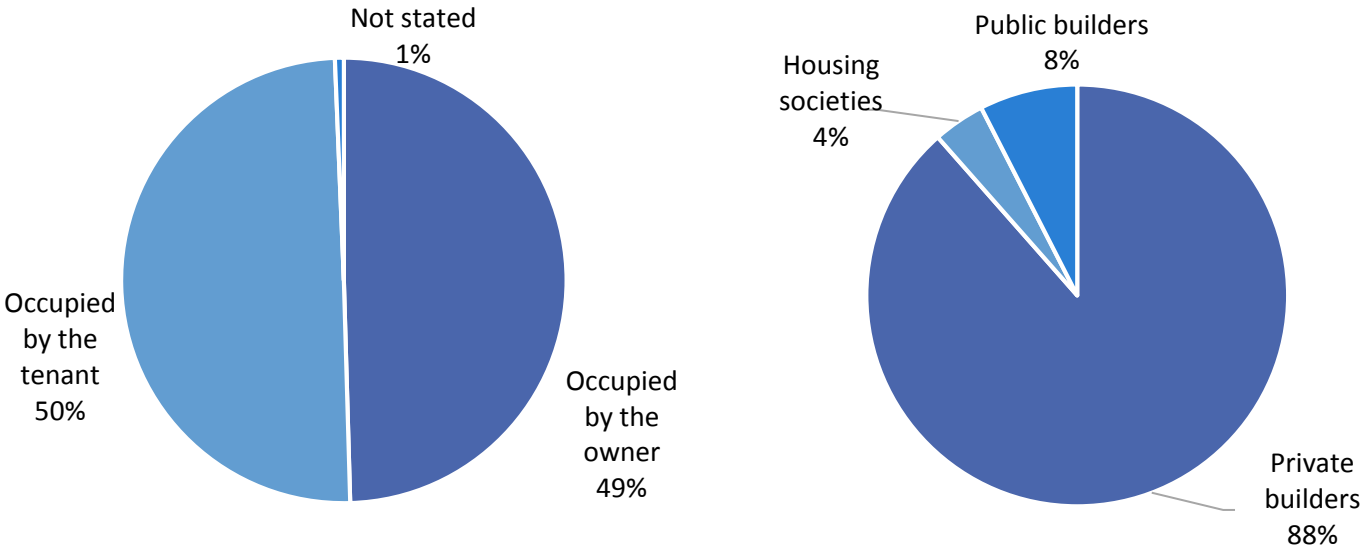


Figure 39 – Division of type of dwelling occupation (left) and Completed buildings in 2016 by client (right; source: StatBank, 2017)

In recent years, the percentage of dwellings occupied by owner and by tenant are quite close (Figure 39, left), leaving only a small group of not stated residues. Regarding the clients of finished buildings, including residential, production and administration and other buildings, it is clear that by far the most is built by private parties, calculated on the basis of built floor area (Figure 39, right).

Heavy and civil construction

Regarding infrastructure, the government is by far the biggest client. The performance of this sector is therefore largely dependent on government policies. In 2015, the subsector has been through a period of major growth, noticeable since 2010 after the crisis years, which smoothened during 2016. A decline is expected for 2017 (Dansk Byggeri, 2016). This normalization is largely caused by sharp falls in investment by the Road Directorate since 2015. Those falls in investment are also visible in the closely related energy and environmental sectors. Employment in the sector, however, has not been jeopardized by this decrease (Dansk Byggeri, 2016). Large public building projects, however, are still in the lift, equally to the tendency described in the previous section.

Architects and engineering firms

With a turnover of 768 million euro in 2015, the construction engineering advisories have shown a little, but almost negligible increase since 2013 (StatBank, 2016). This same trend can be noted regarding architectural firms, with a turnover of 830 million euro in 2015. The architects, however, have a strong position, united in Danish Architects, with philanthropic investor Realdania as important source of funding. Realdania is a private association which supports philanthropic planning and architecture projects in Denmark, which is led by a small network of rich investors. A large emphasis is on future-proof city planning.

Government bodies and supportive organizations

Government bodies play a grand role in Danish construction. Regarding research, the most prominent public body is the Ministry of Higher Education and Science (UFM). This ministry especially promotes research and innovation and has a very extensive and centrally organized funding program, aimed at universities as well as public research institutes, industrial research and PPPs (Ministry of Higher

Education and Science, 2017). The ministry is advised by the Danish Council for Technology and Innovation. Also the Danish Council for Independent Research (DFF) funds specific research activities within all scientific areas that are based on the researchers' own initiatives and the ones to improve the quality and internationalization of Danish research. Regarding innovation, the largest funding program is Innovationsfonden, aimed at new knowledge and technology for stimulating growth and employment. It launched several programs and initiatives to stimulate innovation as is discussed in chapter 6.

Public projects, however, are commissioned by the Ministry of Transport, Building and Housing (TRM). It covers from housing projects, to public transport to road construction (TRM, 2017). The ministry is an umbrella to different public agencies, such as the Danish Road Directorate, Rail Net Denmark and Danish Building & Property Agency and several more. All agencies and institutions together employ around 40.000 people, which shows that the privatization of public services is way lower than in the Netherlands, but even more in comparison to the UK.

The industry in Denmark is famous of its low level of formality and its nature to collaborate. For example the amount of industry associations is relatively big and moreover they are all active. Moreover, the tendency of associations to collaborate with government parties, clients and users is very high. This is also the case of the CI, in which the Dansk Byggeri (Danish Construction Association) is the most important one, representing the industry. This association is, among other industry associations, as well as public and research organizations, united in InnoBYG, which is a public-private innovation network which is co-funded by the Agency of Science, aimed at the stimulation of innovation and collaboration. Another initiative, is Det Digitale Byggeri, launched in 2010, aimed at improvement of ICT in the Danish CI. This is a government initiative and is largely aimed at streamlining of information. Byggeri, Informationsteknologi, Productivitet, Samarbejde (bips), the organization behind this initiative, has developed a ICT specification system which should standardize coding and measurements nationwide and is implementable in combination with BIM. This initiative, incorporated in Cuneco, is financed by the European Regional Development fund, Danish Government, Realdania and market players. Cuneco was in 2016 integrated in bips.

Furthermore, there are numerous sector associations. The major association is Dansk Industry which comprises the whole manufacturing industry, among which a lot of suppliers, but also several contractors. Next to the aforementioned Dansk Byggeri and Danish Architects, IDA for engineers and several more specialized associations act in the interest of particular groups of construction actors. Furthermore, very noteworthy is the Danish Client Association (Bygherre Foreningen), which is the professional construction client association, in which public as well as private professional clients are involved. It has very tight bonds with the government and acts moreover as a consultant to public bodies about construction issues. An associated partnership is Værdibyg which is aimed at value-creating construction and process improvement in which clients are highly represented. It publishes regularly publicly available brief reports on new ways of construction processes, regulation and methods.

Institutions and political and social structures

In a political and socio-economic sense, the Scandinavian countries, including Denmark, govern in a social-democratic system (Seaden & Manseau, 2001). It has a lot of similarities with the government-led system, but has a large emphasis on the tripartite approach (industry – government – labor). The

government is centralized and policy is made largely on a national level with short ties to the industry associations.

Just as in the other studied countries, the Danes are a low-context people, meaning that information is direct, straight and unambiguous, in contrast to for example Italians or Japanese people for which unwritten rules influence largely the meaning of information (Djurssa, 1994). The research shows that the Danish find social contact when doing business extremely important. Several decades ago, Geert Hofstede already found out that the power distance within Danish companies is very low, with a very collective approach (Hofstede, 1980). Although these characteristics are indicative for northern European countries, Denmark amply tops the list.

The main Danish Building Regulations prescribes the guidelines, norms and regulations regarding construction in Denmark, which was published by the Danish Ministry Economic and Business Affairs, currently known as the Ministry of Business and Growth (EM), which was lastly updated in 2015. Regarding further policies and regulations in the CI, chapter 6 elaborates further.

Sweden

Chapter 5 briefly discusses the Swedish construction sector and way it is organized. An elaboration is found in this sector, containing of an actor analysis and review of social institutions.

Actors

The actor analysis of the Swedish CI is done in a same way as in the sections regarding the UK and Denmark, with the theory of Hekkert et al. (2011) in mind, considering, knowledge organizations, educational institutes, industry, market and the network in which the operate. Also the government and industry organizations are analyzed.

Knowledge institutes

For a long time, Sweden was a country with a large, centralized government. The building market was highly regulated and social housing was largely publicly organized and financed (Bygballe & Ingemansson, 2011). In the beginning of the 1990s, a major political reform took place with a large emphasis on market liberalization, resulting in Sweden having according to Bygballe and Ingemansson (2011) “one of the most market liberally controlled housing markets of the western world”. After this change, the Swedish Construction Research Council was merged into Formas, the much broader oriented research agency. Although several research institutes conducted construction-related research, a major focus on the CI was lacking. Although repeatedly heaving called by several research institutions upon launching a construction-specific research platform, construction research still plays a mere role in the research landscape.

Knowledge institutes such as TNO in the Netherlands do not exist, which stems from recommendations in 1942 to incorporate all research capabilities into universities (OECD, 2016b). However there are several research institutes that receive public funding. The largest Swedish knowledge institute is RISE, which is formally a network of 18 research organizations and was only recently merged into one research body. It is largely owned by the Swedish state, which also provides the largest part of the funds. RISE is meant to be the largest partner in strategic expertise in various fields. More specifically regarding a sustainable future, SP Technical Research Institute provides with around 1.300 employees the largest bulk of sustainability knowledge. Moreover, there are several ICT-related research institutes, being SICS and Interactive Institute Swedish ICT, EIT ICT Labs and Swedish

ICT. Furthermore, Sweden is active in the European KIC as part of the EIT. Finally, STRI provides technology consultancy. Furthermore, there are lots of smaller institutes which focus on specific areas. The funding of technology has increased rapidly in the last 20 years (Figure 40). Especially the base funding for university research and the research councils has increased significantly (OECD, 2016b).

More general knowledge, norms and guidelines are also in Sweden developed and maintained by separate government-controlled institutions. The Swedish Standards Institute (SIS) is responsible for standardization conform the international ISO and European CEN. Regarding innovation, Sweden has set up the agency Vinnova, which steers, promotes and strengthens innovation in Sweden. It develops knowledge on innovation and innovative technologies by launching programs in several fields. Considering statistics, Sweden has its own Statistics Sweden (SCB) that develops national statistics in-house. Regarding the CI, RISE provides good knowledge as a big research institute.

More specific, however, CBI has a large expertise in concrete, infrastructure and building constructions. This one is the most relevant regarding the CI, especially in relation to materials. Furthermore, there are several privately funded research firms, also working in construction such as Skanska, Assa Abloy, Cardo and Lindab International. The entire network of the Swedish research system is presented in Figure 41. However, it is important to stress out that universities are by far the most important base of publicly funded research. More about the universities and their role can be found in the following section.

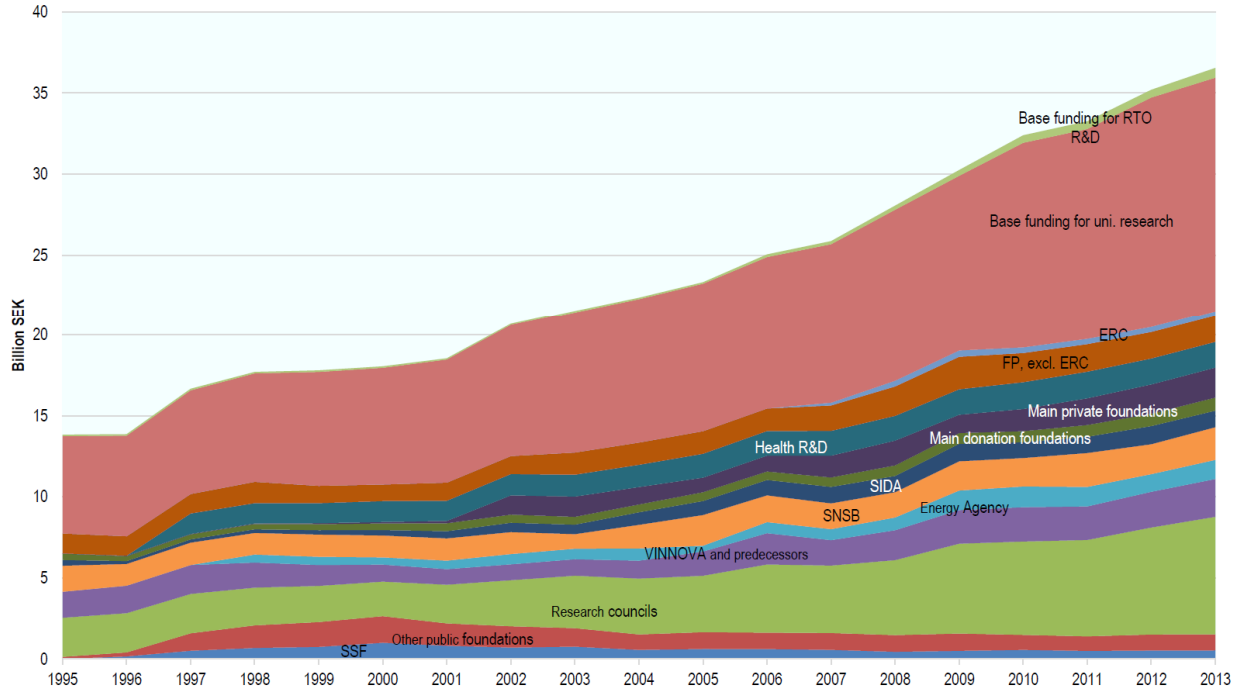


Figure 40 – Main sources of R&D funding in Sweden in the last two decades (Source: OECD, 2016)

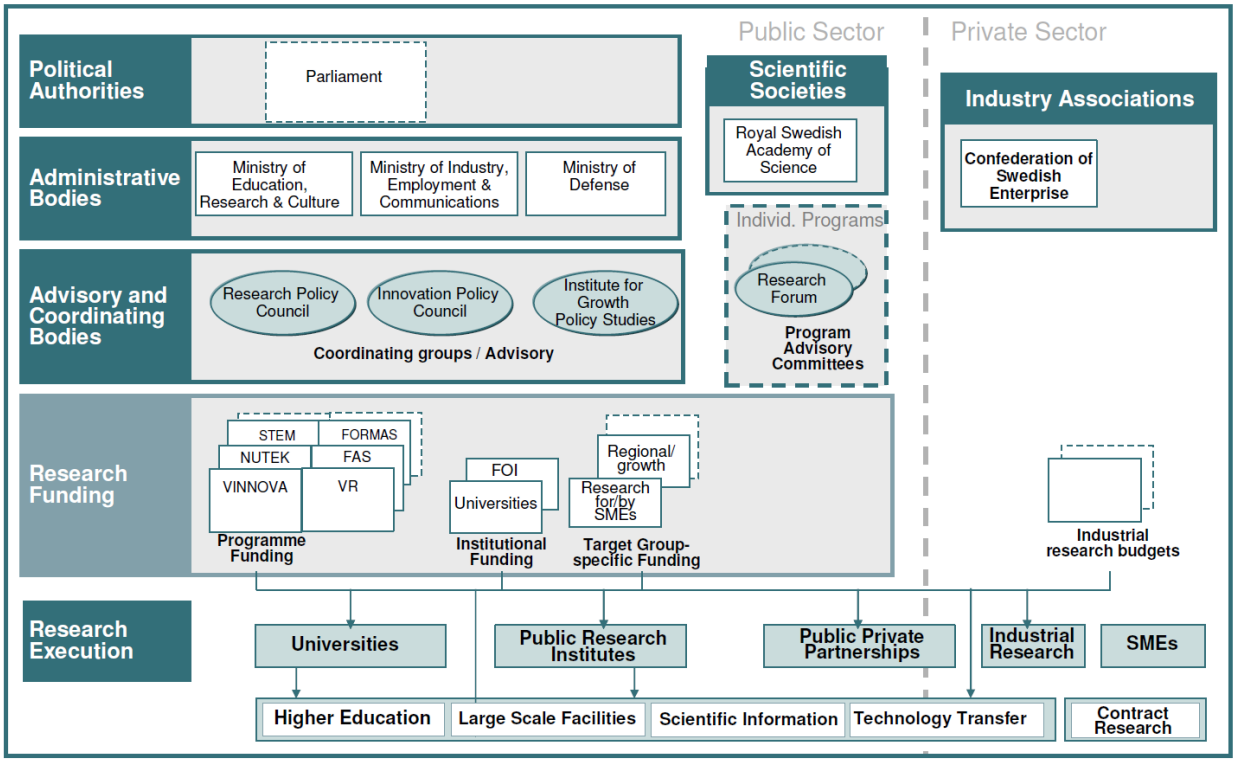


Figure 41 – Research system Sweden (Source: OECD, 2014)

Educational organizations

The Swedish educational system is different from the other studied, as it has two institutional categories where the main change is related to the option to provide PhD education. Currently, there are 14 public and 2 private universities as well as 14 public university colleges. Universities are autonomous institutions governed and funded by the ministry (Elken et al., 2016). There has been an option for university colleges to become universities and an increase in research capacity at university colleges. The Swedish system does not operate with formalized performance contracts as for example in the Dutch case. Institutions and the state agree upon a "public service agreement" (regleringsbrev) on an annual basis. In these agreements, the obligations and aims of the higher education institutions are clarified. A performance component for research was first introduced with 5%, which was later increased to 10% (Elken et al., 2016).

Three of the Swedish universities fall within the global top 100 of the NYT university ranking 2016. This indicates a high level of education, especially for a country with only 10 million inhabitants. The Chalmers University of Technology, appearing on the list, offers a program aimed at Infrastructure and Environment, next to a structural Engineering Master. This last Master is also offered by the Linnaeus University. A comparable study, but aimed at construction safety is offered at the Luleå University of Technology. This university offers also masters regarding building design and building materials. Aimed at the IT side, including BIM, the Jönköping University offers a specialized master. Furthermore there are several education institutes which offer construction and civil engineering related bachelors and further education. As mentioned before, the universities play a large role in public research and compensate largely for the lack of a centrally organized research institution.

Industry

The Swedish CI accounts for 10% of the Swedish GDP and 12% of total employment (Sveriges Byggindustrier, 2015). This is a considerably larger percentage than the Netherlands (9%), the UK (8%), Denmark (9%) and Germany (10%) in 2014. This report shows that in 2014, almost 100.000 people were working in the CI, from which a majority freelancers. 30% was working in small companies with only 1-4 employees and merely less than 15% was employed in larger companies. Only 2% of the companies has employed more than 50 people. The amount of companies increased heavily in comparison to two years earlier in 2012. The profit margins are, according to this report, especially in the civil subsector extremely small.

Regarding the amount of companies, it is clear that, just as in the other countries, the specialized construction activities comprise by number the largest amount. This includes for a great deal freelancers. For civil engineering activities, the companies are rather big, which results in a small amount of companies. For all subsectors, a slight increase of amount is visible. For architectural and engineering activities, however, merely 2013 was made available by Statistiska Centralbyrån, which explains the straight line.

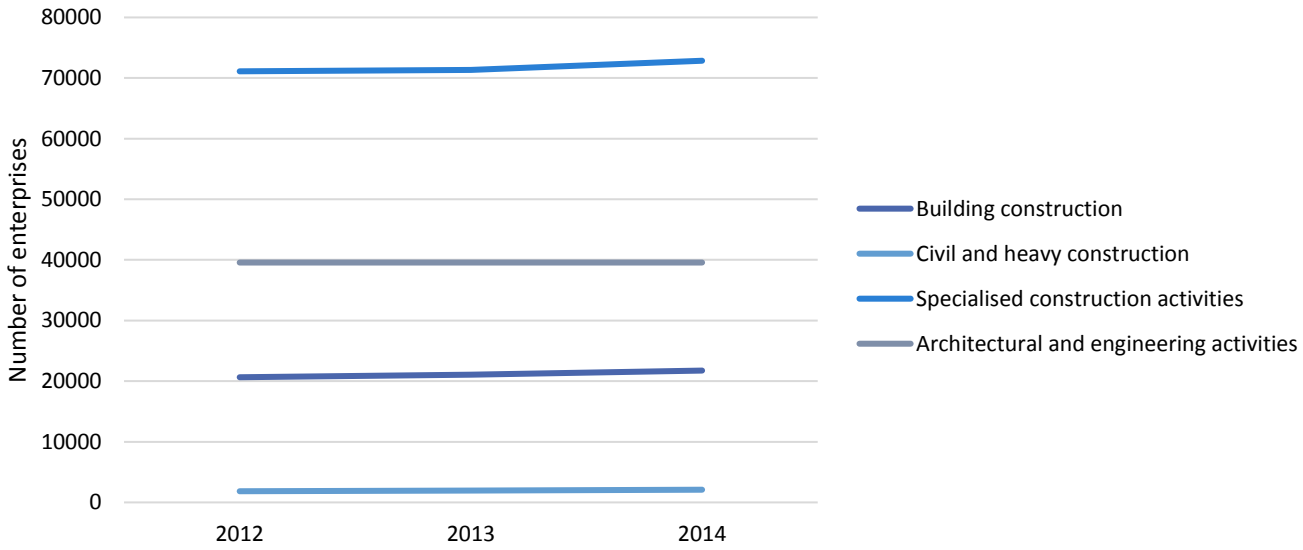


Figure 42 – Number of enterprises per subsector (Source: Statistik Databasen SCB)

Market actors

In this industry, several classes of market actors are active. Per subsector, those actors, focusing at market players as well as clients are described below. These consist of building construction, civil and heavy construction and the service subsector.

Building construction

Sweden will need 710,000 new homes within ten years according to the latest forecast presented by the National Board of Housing, Building and Planning. This housing shortage is not only a urban problem, but an issue in around 85% of Sweden's municipalities (SABO, 2016). Public housing associations throughout Sweden have to meet this demand. The overall objective for the public housing sector in the coming five years is to build 75,000 new homes between 2015 and 2020.

In building construction, Sweden has formed the association Swedish Construction Clients (SCC). It is an association for construction clients who develop properties and build for long term ownership and

property management. There consist currently of about 130 members, including publicly owned and privately owned companies (Byggherre, 2016). The SCC's aim is to develop the role of construction client by lobbying efforts and monitoring of the course of events in the industry. It also offers support on for example legal issues to their members. This tight unification of clients makes Sweden unique. The tight network of clients encourages partnering and collaboration and also regarding knowledge distribution, the network is of great use.

The turnover in building construction is roughly four times bigger than civil and heavy construction turnover, with an annual turnover in 2014 of 217.770 million SEK, equal to 23 billion euro (Statistiska centralbyrån, 2016). Half of Sweden's population lived in 2014 in a tenant-owned one or two dwelling building, which is the most common type of housing in Sweden. Rented dwellings in multi-dwelling buildings comprise the next most common type of housing. 25 percent of the population lives in these buildings, while 16 percent live in tenant-owned apartments in multi-dwelling buildings (Statistiska centralbyrån, 2015). It is predicted that in the coming 13 years, around 700.000 new residential and office building are needed, for an amount of almost 160 billion euros (Pettersson, 2016). The main reason is a strong urbanization of regions such as Gothenburg, after which the leading minority government has made it one of its main election promises. Industry officials and analysts are, however, skeptical about the plan's feasibility. Their main objection is a shortage of contractors and construction workers for such a huge amount of dwellings.

Heavy and civil construction

Just as in the rest of Europe, civil constructions are mainly commissioned by public parties, such as the Swedish Transport Agency (STA) and fall within procurement law. For heavy construction, it stands that a small percentage is commissioned by private project developers, but this is insignificant compared to the public funds. On a national and regional level taken together, the current expenditures on civil projects, including maintenance are close to 130 billion euro for the coming decade (Pettersson, 2016). Roughly half of this budget is part of the National Road Plan. Although, the last few years, the market has gradually been improving, the civil sector has only very slowly been recovering from the crisis. In 2012, the volume reached merely 60% of the volume compared to 2008, which was in 2010 already 25% lower than in 2008, while the building construction market was more or less stable (European Commission, 2016b). Although some toll bridges and tunnels exist, all road infrastructure are publicly funded and owned (Hofverberg, 2014).

In the heavy and civil construction, less companies are active than in the building construction. However, a large part of the companies who are active in installation techniques are also working on civil projects. This also is this case for specialized companies, such as soil movers and bar benders.

Architects and engineering firms

The share in construction for architects and engineering firms is considerably large, unified in Sveriges Arkitekter. Although, Swedish statistics databases lack in recent figures on this subsector, in 2013, the net turnover was bigger than the one of the civil construction and 80% of the building construction sector. The sector is very labor intensive, which makes the employment in the subsector even higher than the civil and building construction subsectors combined (Statistiska centralbyrån, 2014). An important note, however, is that installation companies are not included in this count, while they make a significant contribution to the civil and building construction, but not to this subsector.

Government bodies and supportive organizations

The main central government body responsible for the CI is the Ministry for Housing and Construction. Its main goal is to maintain an effective long-time housing market policy. Moreover, it strives for long-term sustainable structures, effective policy on resource and energy usage in constructions and to facilitate healthy competition in the construction and property sector. Furthermore, Sweden has a separate Ministry for Infrastructure and Transport. The ministry is about ensuring economically efficient, sustainable transport services for the general public and businesses throughout Sweden. This area includes railways, roads, shipping and aviation, as well as transport and infrastructure research (Government of Sweden, 2017). In Sweden, there are a relative large amount of government agencies, on which the ministers' influence is limited, which enables those agencies to develop long-term strategies.

As usual for Scandinavian countries, the level of formality is low and the propensity to collaborate high. Before, the architect association was mentioned, but in Sweden the number of sector associations is substantial. The biggest and most prominent one is Sveriges Byggindustrier in which the main contractors are united, but also SMEs are represented (Sveriges Byggindustrier, 2016). This federation has also several subsidiaries that represent more specific groups of firms. The other big association is the Swedish Building Workers' Union (Byggnads), which aims at the employees rather than the firms. Together those two parties wrote together the Construction Agreement 2010 and its supplement in 2015, in which rights and obligations are formulated for employers and employees in the sector (Swedish Construction Federation & Swedish Building Workers' Union, 2010). Furthermore, every subsector has its own federation in which related companies are united.

Institutions and political and social structures

Sweden has an extensive social system and politically speaking it has a big, centralized government. Just as Denmark, the system is typical for Nord-European countries and it has a separate ministry for construction and housing. The social system is rather social-democratic and mixes a large government-steered approach with a strong tendency to cooperate with industry and labor. This goes along with high taxes, but for example cheap, free education and healthcare and a solid infrastructure system. As a result, the average level of education is high as discussed in education section.

The Swedes are polite and punctual, but also highly regard honesty (Passport to Trade 2.0, 2014). Slightly outdated, but very accurate, Bröchner, Josephson, and Kadefors (2002) discuss the construction culture in Sweden, stating that "social and cultural traits reflected in a national management style based on low power distance, loose control and low uncertainty avoidance can be traced in the development of specific quality and collaboration practices in Swedish construction. Egalitarian distrust of both elitism and strong professions, expressed as a tendency for two parties to settle disputes without referring to neutral third parties, has also been identified." More legislative and policy related institutions are discussed in chapter 6.

Germany

In order to establish a proper view on the German system of innovation in the CI, a structural analysis is conducted, including actor analysis, policy analysis and visualization of the industry's network structure. The same structure as in the structural analyses of the other countries is applied. This is an extensive version of the summarized reflection as presented in chapter 5.

Actors

In a same fashion as the previous four actor analyses, the actor classification as suggested by Hekkert et al. (2011) was applied in order to give a consistent actor analysis, distinguishing knowledge and educational institutes, industry players, clients, government and supportive organizations.

Knowledge institutes

The German public sector provides almost one third of the total expenditures on research, innovation and development in Germany, of which the private sector provides the rest. The country is based on the principle of federalism and on constructive cooperation between the federal government and the 16 individual states (Länder). The German industry makes the second largest contribution to German research and development funding. Business enterprises provide 57 billion euros of Germany's R&D expenditure. The industry runs furthermore its own research and knowledge institutes in specific fields and cooperates with public institutions. The third largest contribution to research funding is done by foundations. Those foundations are unified in the 'Stifterverband'.

The main research projects are organized through the Deutsche Forschungsgemeinschaft (DFG), which organizes funding and supports research. Hereby it counsels private as well as public organizations. It is financed by individual states and the central government (DFG, 2017). A large majority of the universities are organized under the DFG. The government, which currently is embodied in the Ministry of Science and Education (BMBF), is advised by the Wissenschaftsrat (WR) on the development of scientific institutions and the higher education system (European Commission, 2006). Figure 43 shows that the WR is not the only advisory body. All advisories together decide on the funding which is received by universities and public research institutes. Among those research institutes are the national Max Planck Society, Helmholtz Associations, Fraunhofer Society and G.W. Leibniz Scientific Association, all umbrella organizations who are non-university, but aid public interests in their research activities (European Commission, 2006).

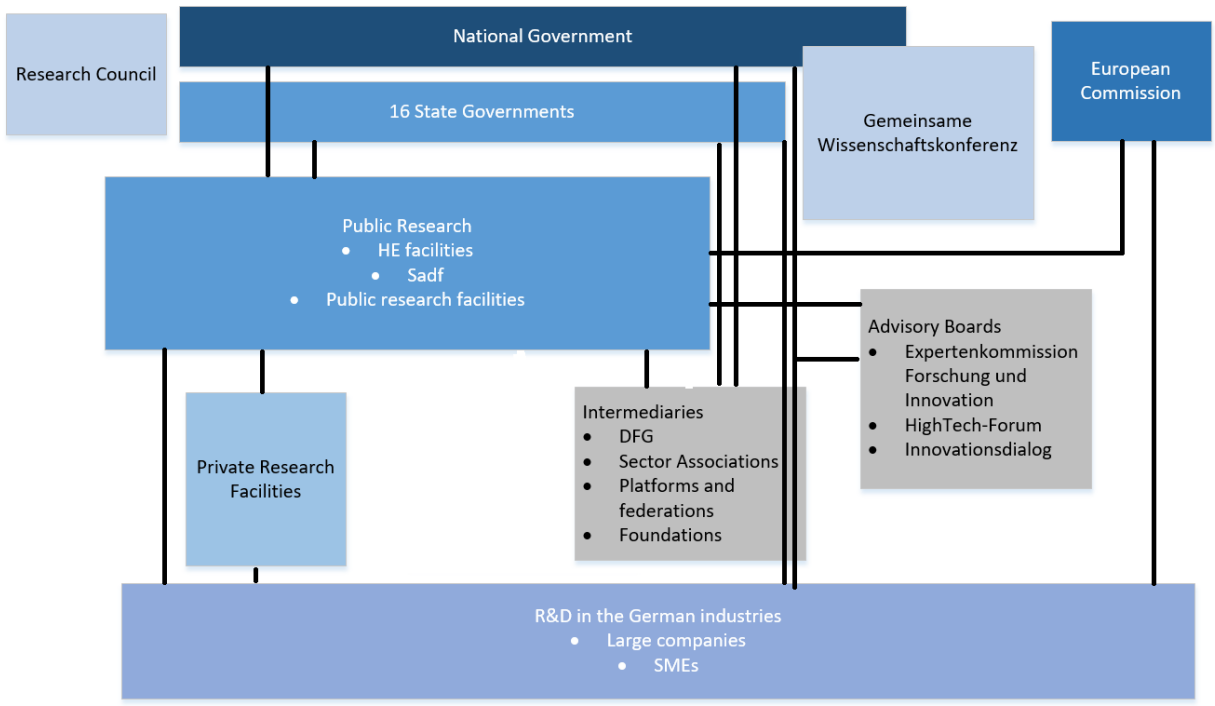


Figure 43 – German research and innovation system (adopted from BMBF, 2016)

Regarding the CI, the Institut der Bauwirtschaft (BWI Bau) is a large research institute. Its focus is on the economic side of the sector and also policy analysis. A large part of the work is related to supply chain management in construction (Oepen, 2017). Also government-initiated Forschungsinitiative Zukunft Bau is an initiative to develop knowledge through applied research, contract research and Effizienzhaus Plus pilot projects. This program is coupled to the EU Horizon 2020 program and individual research institutes can apply for grants (BMUB, 2017). The institutes mentioned in the previous section furthermore contribute also to construction research. Especially the Fraunhofer Society gives priority to construction research.

Educational organizations

The German education system is just as with the other studied countries among the world's best and several top-notch universities are contributing to this claim. Those universities are mostly governed by the individual states rather than the federation, such as the Technische Universität München, Ludwig-Maximilians-Universität and Ruprechts-Karls-Universität Heidelberg. Next to these universities, also Fachhochschule and Berufsakademien, respectively applied science and vocational education, consist in the tertiary education in Germany. For the CI, a dozen of universities offer suited master programs. Notable are the RWTH Aachen University, Technical University of Munich and KIT in Karlsruhe. Not only on educational field, but also regarding research the universities are important assets for knowledge production and distribution in the CI.

Industry

The German CI is one the largest CI in Europe with a turnover of 241,2 billion euro in 2014 and 2,2 million people employed (Destatis, 2015). The total share of the German GDP was in 2013 16,3% (European Commission, 2016a). Bräuninger et al. (2016) note that since 2010 an increase in the construction sector turnover is visible which is likely to continue. The turnover in for example completion of apartments has grown with more than 10% annually in the past three years. It also argues that the euro is not likely to depreciate which may attract foreign investments in the German CI and especially the housing market is expected to expand which goes hand in hand with an increase in housing prices. The European Commission (2016a) state about this growth that "despite a relatively stable initial phase between 2008 and 2010, production levels first peaked in 2011 across all sub-sectors (+10.8% for civil engineering, +7.2% for construction of buildings). Production then fell in 2012, but subsequently picked up in 2013 for civil engineering and in 2014 for construction of buildings. Overall, since 2010, production in civil engineering and construction of buildings increased by 18% and 7.5%, respectively." This confirms the earlier made statement that the German economy remains strong, including the CI.

Market actors

In the CI, different actors are active in different subsectors. For each of these different subsectors, different statistics, networks and types of clients are applicable, as indicated in the previous section. The subsectors buildings construction, civil and heavy construction and services in construction are considered to be relatively homogenous and therefore more generalizable than the CI as a whole, especially when clients and ways of contracting are considered. The whole sector together is represented in Figure 44, which shows that by far the most registered enterprises are very small, but when the workforce is considered, more than 20% works in companies with over 100 employees. However, for the subsectors would the table look slightly different, which is discussed in the following sections.

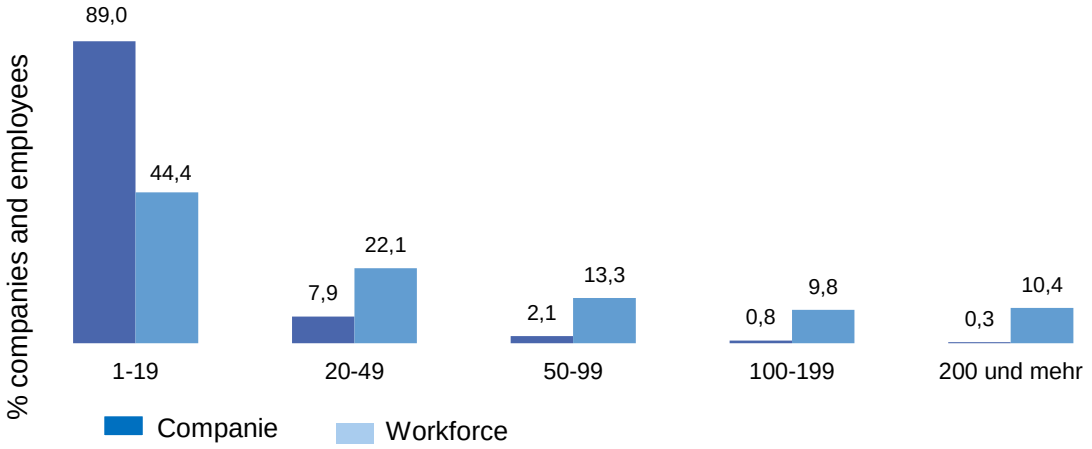


Figure 44 – Workforce and companies in construction in relation to company size (Source: Destatis, 2017)

Building construction

The building construction in Germany has been relatively stable, even during the crisis. A slight increase has been noted since 2008, but in 2014, in relation to 2008, the volume index increased only with 7 index points and a stable increase after 2014 was expected (European Commission, 2016a). Germany's statistics office Destatis has calculated that the number of completed dwellings has strongly increased from 2011 to 2014 and in 2015 the amount was almost equal to 2014. The ownership is as good as completely private, as the social housing market is privatized.

From the housing stock of 39,6 million dwellings, 25,7 million are owned by professional or small private landlords. Only 15,9 million are owner-occupied, which is relatively small. The homeownership rate is increasing in these numbers (Kofner, 2011). However, this rate remains lower than in the other studied countries. Herein, the social housing stock has been decreased from 30% of all housing in 1970 to merely 6% in 2014 (Knorr-Siedow, 2015). This decrease has strong correlation with the privatization of Germany's social housing market (Amann, 2015). In the building construction, the number of companies and employees from more than 100 employees is significantly lower than presented in Figure 44, in the contrary to civil engineering activities (Destatis, 2017).

Heavy and civil construction

In 2014, 10,3 billion euro was invested in traffic-related infrastructure. The investments in the coming 4 years show a slight increase until 2018 and up to 2020 a minor decrease (BMVI, 2016). The whole infrastructure investment is done publicly, by the individual states as well as the federal government and municipalities. The infrastructure is also owned by public bodies and for passenger cars, toll does not apply. However, there are plans to introduce toll for foreign cars. In the civil and heavy construction, the growth has been bigger since the crisis than in the building construction (European Commission, 2016a). After a minor fall in 2012, the growth has been significant in 2013 and 2014. Needless to say, this whole sector turnover is strongly dependent on government policy, be it on state as well as federal level.

Architects and engineering firms

For consultancy firms related to the CI, the value added was roughly 15% of the entire sector in 2012 (European Commission, 2016a). The same report shows that the fluctuation of turnover are strongly correlated between the construction firms and consultancy firms. These firms are unified in the

Deutsche Architektenverband (VDA) in order to achieve an improvement in the economic and legal framework conditions for architects in Germany. Also in the Verein Deutsche Ingenieure (VDI) German engineers are united, be it in a wide range of disciplines.

Government bodies and supportive organizations

The main public construction body is undoubtedly the Ministry for Environment, Nature Conservation, Building and Nuclear Safety (BMUB). It takes among other things care of the construction policies and city planning. This also includes social housing policies, building regulations and other construction-related policies. However, the infrastructural assets are governed by a different ministry, being the Ministry of Transport and Digital Infrastructure (BMVI). It captures rail, waterways, roads, digital infrastructure and spatial planning. The infrastructure is partial owned and maintained federal, by states and by municipalities. Funding for the national road infrastructure is not granted though a dedicated fund for building and maintaining highways (Palmer, 2014). The annual federal budget, however, has a highway construction plan that describes ongoing and planned construction projects. It lists the revenues achieved by the federation that are tied to highway construction and maintenance. The most important one of these revenues is the toll imposed on truck traffic on federal highways. Additionally, there is some miscellaneous income, such as fees and concessions (Palmer, 2014). The remainder of the needed funds for federal highway construction and maintenance comes from general revenue.

Regarding innovation in construction, the government, including the two mentioned above, but not least the ministry of science and education (BMBF), have a role in policy making and prioritization, which expresses itself for instance in the BMUB publication 'Reform Bundesbau' (2016). However, the most concrete reform initiatives and innovation drivers come from private parties and most notably from the industry association 'Die Deutsche Bauindustrie'. Also 'Das Deutsche Baugewerbe' is an influencial industry player in the field. Together, they published for example 'Positionspapier zu Construction 2020' in which a unified vision is presented. Other notable sector organizations are 'Zentralverband Deutsches Baugewerbe', 'Hauptverband der Deutschen Bauindustrie' and 'Verband Beratender Ingenieure'.

Institutions and political and social structures

Germany is amongst the other selected countries unique because of its federal type of constitution. This decentralized government structure affects the entire way of policy-making and funding (Seaden & Manseau, 2001). For example, the universities are largely funded and governed from a state-perspective, while the federal government merely is interested with the main strategy. Various agencies deal with these issues rather than separate ministries. Despite the federal system, politically speaking the system is government-led in contrast to a large majority of countries with a federal constitution such as the USA. Regulation is next to state-level strongly set in the national system. Germany is moreover leading in several government-initiated country-wide innovation initiatives such as Industry 4.0.

Germans are in general a very punctual and long-term thinking people. Usually politeness and honesty are considered of great importance and therefore, corruption is limited. However, the level is formality is way higher than in for example the Scandinavian countries. Work and private life are strictly separated in Germany and loose conversations and chit-chat are not common practice (Passport to Trade 2.0, 2016). Furthermore, its fairly recent war history and morally questionable

practices less than a century ago led to a certain debt awareness that currently observable in very open migrant policies and stance toward minorities. This is, as will be shown later, reflected in the country's policy field.

Legislative institutions regarding construction are formulated in the Baugesetzbuch. This BauGB is the main legal basis for urban development law. More specific building regulation are enacted by the different states individually (BMUB, 2014).

Appendix IV: Summary policy measures

This appendix contains summaries of the different construction innovation measures for the Netherlands, the UK, Denmark, Sweden and Germany. In Table 21 to Table 25, the different measures are characterized and in Table 26, the impact estimation is shown.

Table 21 – Innovation policies and strategies relevant to Dutch construction

Title or name	Short description	Public budget (euro)	Category	Sub-category	Start Year	End Year	Ongoing?	CI-specific?	Innovation specific?	Winch taxonomy
Umbrella strategies										
High-Tech Strategy 2020	A nation-wide strategy for Germany to become the worldwide innovation leader in 2020				2006, with a substanti		Yes	No	Yes	
IT Consolidation Programme/ Digital Strategy 2015	Federal attempts to modernize the government and expand digital infrastructure				2015		Yes	No	No	
Die Digitale Agenda	A government document on network policy issues regarding digitalization				2014	2017	Yes	No	No	
Die Energiewende	A transition strategy towards a low-carbon and sustainable energy supply				2010	-	Yes	No	No	
Industry 4.0 und Digitale Wirtschaft	A strategy on measures to digitalize the German public sector and improve the digital infrastructure				2015	-	Yes	No	No	
Reform Bundesbau - Bessere Kosten-, Termin- und Qualität	BMUB strategy paper on faster, cheaper and better constr	-			2016	-	Yes	Yes	No	
General innovation policies										
Inno-Regio	Cluster programme for cross-sectoral innovation clusters	255 mln	Connections and com	Cluster policies	1999	-	No	No	Yes	
ZIM Program	Central SME Innovation Programme is a funding programme for ambitious R&D pro		Input for innovation a	Direct support	2015	2019	Yes	No	Yes	
Standardization in High-Tech Strategy	An important part of the High-Tech Strategy contains of standardization in the high-		Standardization and r	Standards	2014	-	Yes	No	No	
German Standardization Roadmap	As part of the Industry 4.0 strategy, standards play an essential role as they provide		Standardization and r	Standards	updated 20	-	Yes	No	No	
Excellence Strategy	R&D strategy on making the German sector excellent	533 mln anually	Connections and com	Network program	2016	-	Yes	No	No	
Vorfahrt für den Mittelstand	An part of the HighTech Strategy to make SMEs more innovative		Input for innovation a	Direct support	2016	-	Yes	No	Yes	
Construction policies directly aimed at innovation										
BIM step plan and Pilot BIM projects	Pilot projects for the use of BIM and standarization of BIM in 2020		Standardization and r	Standards	2015	2020	Yes	Yes	Yes	
Effizienzhaus Plus	Pilot projects to innovatively reduce energy consumption and environmental impac		Input for innovation a	Direct support			Yes	Yes	Yes	
Construction policies that indirectly influence innovation										
Energy-Optimized Construction (Energieoptimalisierte Bau	In German construction, innovative buildings with a high d	23,7 mln in 2014	Improving access to e	Technology advis	2007	2015	No	Yes	No	
Zukunft Bauen	A long term plan to strengthen the German CI, including re	115 mln betwn 2006 and	Foresight	Structural or syste	2006	-	Yes	Yes	No	
Leitbild Bau	Industry vision paper on construction where goals are published		Foresight	Structural or syste	2009	-	No	Yes	No	
Right of suspension of payment	Client pays 5% of the construction bill five years after con	-	Standardization and r	Command-and-co	-	-	Yes	Yes	No	
Deutschland baut!	An association by the German government in order to stim	-	Improving access to e	Technology advis	2013	-	Yes	Yes	No	
KfW Programmes	One of Europe's largest and best known support schemes	1,8 bln in 2014	Connections and com	Network program	2006	2020	Yes	Yes	No	

Table 22 – Innovation policies and strategies relevant to UK construction

Title or name	Short description	Public budget (euro)	Category	Sub-category	Start Year	End Year	Ongoing?	Construction	Innovation specific?	Winch taxonomy
Umbrella strategies										
Enterprise Policy - Top Sector Approach	General business strategy, in which particular attention is paid to nine top-sectors.	High emphasis on science, education and			2011	-	Yes	No	Partly	
Top-consortia for Knowledge and Innovation (TKIs)	Within the top sectors, TKIs are launched aimed at promoting PPPs.				2012	-	Yes	No	No	
Quality in Deversity - Strategic Agenda	A strategic agenda for HE, research and science for the long term				2011	2025	Yes	No	No	
Wetenschapsvisie 2025: Keuzes voor de toekomst	A joint vision for science with goals for 2025				2014	2025	Yes	No	No	
De waarde(n) van weten - strategische agenda hoger onde	Strategic plan for HE and research for 2025				2015	2025	Yes	No	No	
Actie Agenda Bouw/Routekaart Innovatieakkoord	Shared vision on increasing innovation in construction				2014	-	Yes	Yes	Yes	
De Bouwagenda	A joint vision on construction up to 2021 with a large emphasis on collaboration and	R&D			2017	2021	Yes	Yes	No	
Platform energy transition built environment (PeGO/energi	A joint platform on energy lowering construction				2006	2016	No	Yes	Yes	
General innovation policies										
Creation of National Commission of Valorization (LCV)	Commission aimed at knowledge management and distribution		Improving access to e	Technology adviso	2011	2013	No	No	No	
RDA (R&D tax deduction scheme)	A tax deduction scheme for R&D activities		Input for innovation a	Fiscal incentives	2012	2015	No	No	No	
WBSO	A tax deduction on the employee's wages for R&D activiti	1205 mln in 2017	Input for innovation a	Fiscal incentives	1994	-	Yes	No	No	
Innovatiebox	A tax deduction on corporation tax for innovative projects	625 mln in 2017	Input for innovation a	Fiscal incentives	2010	-	Yes	No	Yes	
SME innovation promotion TKIs (MIT)	Interregional stimulation of innovation of SMEs	14,35 mln in 2017	Improving access to e	Technology adviso	2013	2018	Yes	No	Yes	
SME innovation promotion TKIs (MIT)	Interregional stimulation of innovation of SMEs	14,35 mln in 2017	Input for innovation a	Direct support	2013	2018	Yes	No	Yes	
SME innovation promotion TKIs (MIT)	Interregional stimulation of innovation of SMEs	14,35 mln in 2017	Connections and com	Collaboration pro	2013	2018	Yes	No	Yes	
PIANOo	A governmental center of expertise in order to consult the market on procurement-		Improving access to e	Technology adviso	2005	-	Yes	Partly	No	
Innovatiekrediet	A government loan for innovative projects	60 mln in 2017	Input for innovation a	Finance and ventu	2012	-	Yes	No	Yes	
Small Business Innovation Research (SBIR)	SBIR is a competition where a firms with the best tenders get the opportunity for a		Demand for innovatio	Support private de	2006	-	Yes	No	Yes	
IPC regeling	Subsidies for two-year innovation projects in collaboratio	2,8 mln in 2016	Input for innovation a	Direct support	2013	-	Yes	No	Yes	
Tightened IPS	Ministry of EZ has tightened the IPS as incentive for innova	-	Improving access to e	IP support measu	2015	-	No	No	No	
Strong SMEs support	Strongly supporting with for example funds, financing and	-	Input for innovation a	Finance and venture capital			Yes	No	No	
2,5% 'Innovatiegericht Inkopen'	2,5% of the govrernent-procured goods and services should	-	Demand for innovatio	Support public pro	2011	-	Yes	Partly	Yes	
Public research investments	Universities will receive 15% more and research facilities	28% between 2010 and 20	Input for innovation a	Direct support	2010	2021	Yes	No	No	
Ondernemersplein	Advisory network for innovations in SMEs		Improving access to e	Entrepreneurship	2014	-	Yes	No	Yes	
Construction policies directly aimed at innovation										
Inkoop Innovatie Urgent	Selection of innovative contractors is stimulated	A joint program to advice	Demand for innovatio	Support public pro	2012	-	Yes	Partly	Yes	
Brede Stroomversnelling	Innovatively upgrade dwellings towards energy-neutral bu	-	Connections and com	Collaboration pro	2013	-	Yes	Yes	Partly	
Pilot projects	Examplary subsidized projects in order to create best prac	-	Improving access to e	Technology adviso	-	-	Yes	Yes	Yes	
Construction policies that indirectly influence innovation										
Top Sector Water	The Top Sector approach includes the water sector, which is largely included in the	construction industry.	Knowledge develo		2011	-	Yes	Yes	No	
Bouwagenda (Strategic agenda for the CI)	Government, industry and associations, as part of the Bouwcampus, agreed togethe		Connections and com	Collaboration pro	2017	2050	Yes	Yes	No	

Table 23 – Innovation policies and strategies relevant to Danish construction

Title or name	Short description	Public budget (euro)	Category	Sub-category	Start Year	End Year	Ongoing?	Construction	Innovation specific?	Winch taxonomy
Umbrella strategiesand reports										
Growth Plan 2013					2013			No	No	
Danmark - Løsningenes Land (Denmark - A nation of soluti	Denmark's national innovation strategy				2013			No	No	
DK2050 - Green growth in Denmark towards 2050	Scenario study led by Danish Artchitecture Centre on the environmental transition				2016			No	No	
Cluster Strategy 2.0 - Strategy for Denmark's Cluster and N	Strategic paper by UFM about clusters in Denmark				2016	2018		No	No	
Denmark 2020 - knowledge > growth > prosperity > welfar	Strategic paper on government goals up to 2020				2010	2020	Yes	No	No	
Denmark's National Reform Programme 2016										
General innovation policies										
Skattekreditordningen (R&D tax incentive)	Danish tax incentive for loss making R&D firms, especially suitable for start-ups		Input for innovation a	Fiscal incentives	2012	-	Yes	No	No	
Innovationsfonden (IFD, Innovation Fund Denmark)	Direct support of projects within several sectors such as tr	164 mln euro in 2016	Input for innovation a	Direct support	2014	-	Yes	Partly	No	
InnoBooster	Direct support for innovative start-ups and SMEs within In	-	Input for innovation a	Direct support	2014	-	Yes	No	Yes	
MUDP (Danish Eco-Innovation Program)	Support of Danish companies in development and demons	80 mln DKK	Input for innovation a	Direct support	2015	2020	Yes	Partly	Yes	
Danish Growth Fund (Vaekstfonden)	A state investment fund for the creation of new companie	-	Input for innovation a	Finance and ventu	1992	-	Yes	No	No	
Innovation Network Denmark (Cluster programme)	Supporting the establishment of network and cluster organizations and facilitate an		Connections and com	Cluster policies	2002	-	Yes	Partly	No	
Employer selection and points system for skilled migrants	Employer selection and points system for skilled migrants where academic credenti		Increasing supply of s	Migration policies	-	-	Yes	No	No	
User-driven Innovation Program	The idea of companies that are constantly striving to delivera product that provides		Demand for innovatio	Support private de	2002	-	Yes	No	Yes	
Central Innovation Manual on Excellent Econometric Evalu	A paper on econometric outcomes and impact assessment	-	Standardization and r	Standards	2011	-	Yes	No	Partly	
Construction policies directly aimed at innovation										
Sustainable Building Innovation Challenge	More specific architectural policy - 10 innovations with th	-	Demand for innovatio	Innovation inducement prizes			Yes	Yes	Yes	
Construction policies that indirectly influence innovation										
Legislation on past performance	Public clients only allow tenderers with positive past proje	-	Standardization and r	Command-and-co	-	-	Yes	Partly	No	
InnoBYG	Construction cluster aimed at knowledge sharing	15 mln between 2014 an	Connections and com	Cluster policies	2010	2018	Yes	Yes	No	
Coordination and Innovation Group for Knowledge in Cons	Development of a action plan to stimulate construction R	-	Connections and com	Network program	2009	-	No	Yes	No	
Digital Construction	A development programme of digital technology (BIM) in c	-	Improving access to e	Technology advis	2000	2014	No	Yes	No	
Vejen til et styrket byggeri i Danmark	Danish construction strategy	-	Foresight	Structural or syste	2014	-	Yes	Yes	No	
Easing building permit procedures	Under the Growth and Development programme building	-	Standardization and r	Command-and-co	2013	-	Yes	Yes	No	
New procurement law	easing procurement in Denmark	-	Standardization and r	Command-and-co	2016	-	Yes	Yes	No	

Table 24 – Innovation policies and strategies relevant to Swedish construction

Title or name	Short description	Public budget (euro)	Category	Sub-category	Start Year	End Year	Ongoing?	Construction	Innovation specific?	Winch taxonomy
Umbrella strategies										
Swedish Innovation Strategy	Strategy paper in which goals as well as concrete policies are described. Supported by the government and industry				2012			No	Yes	
Sweden's national reform programme 2016	Strategic reform program in line with Europe 2020				2016	2020	Yes	No	No	
Sweden's Environemental Objectives	A strategic paper from Swedish Environmental Protection	-			2012	2020	Yes	No	No	
Bygginnovationen 2011-2016 (construction innovation)	Vinnova and a consortium of companies developed a strat	9,7 mln between 2011 and 2015			2011	2016	No	Yes	Yes	
General innovation policies										
Challenge-driven innovation program	A three-stage funding program for innovative programs for projects that are aimed		Demand for innovatio	Innovation induce	2011	-	Yes	Partly	Yes	
VINNVÄXT programme	A program that takes the form of a competition for regions		Connections and com	Cluster policies	2001	-	Yes	No	Yes	
Employer selected and points system for skilled migrants	Measure to attract skilled and talented non-EU migrants to Sweden		Increasing supply of sl	Migration policies	-	-	Yes	No	No	
Swedish Centre for Enterpreneurship	For support for assisting innovators in their absolute earlie	-	Improving access to e	Entrepreneurship	-	-	Yes	No	No	
Foresight programmes	Sweden had foresight programmes with advisory and instr	-	Foresight	Content-related is	1998	2005	No	No	No	
Sweden's Environemental Objectives	A strategic paper from Swedish Environmental Protection	-			2012	2020	Yes	No	No	
90-day guarantee	Individuals between 20 and 24 are guarantee to have a job	-	Increasing supply of sl	Levy schemes and	2016	-	Yes	No	No	
Government Bill on Adult Education	Offers tailored education to foreign and local adults	-	Increasing supply of sl	Levy schemes and	2017	-	Yes	No	No	
Swedish Technology Foresight Study	Joint study aimed at strengthening a future-oriented appro	-	Foresight	Content-related is	1997	-	Yes	No	No	
Forskningsavdrag	Tax reduction scheme for R&D on payroll taxes		Input for innovation a	Fiscal incentives	2014	-	Yes	No	No	
Construction policies directly aimed at innovation										
Swedish Construction Sector Innovation Centre (BIC)										
Innovation Vouchers	SME's access to advice and knowledge	5300 euro max per proje	Improving access to e	Technology adviso	2011	2017	No	Yes	Yes	
Planning grants	Mapping of regulation, legislation, IPR and cost/benefit an	max. 21.200 per project	Demand for innovatio	Support private de	2011	-	Yes	Yes	Yes	
Development grants	Stimulating commercialization of close-to-market-produc	max. 212.000 per compa	Improving access to e	Entrepreneurship	2011	2014	No	Yes	Yes	
Construction policies that indirectly influence innovation										
Stimulans för ökat byggande (Stimulus for increased constr	Government action plan to develop 15000 new flats per year		Demand for innovatio	Support private de	2016	-	Yes	Yes	No	
Housing Planning Committee for stimulate private investm	investigate and propose amendments as to how the regulatory framework is used a		Standardization and r	Command-and-co	2016	-	Yes	Yes	No	
Building Regulations (BBR)	New building regulations for simplifying construction processes		Standardization and r	Command-and-co	2016	-	Yes	Yes	No	
Transport Network under National Transport Plan	Infrastructure Plan in which funds are allocated to public p	56 billion between 2014 -	Demand for innovatio	Support private de	2014	2025	Yes	Partly	No	
Swedish Construction Industry Training Board (BYN)	National body for construction vocational training	-	Increasing supply of sl	Levy schemes and	-	-	Yes	Yes	No	
Act on energy measurement in buildings and act of certain	two acts on decreasing environmental impact of the CI	-	Standardization and r	Command-and-co	2014	-	Yes	Yes	No	
Strategy for public procurement	This strategy points to the innovative and creative potenti	-	Demand for innovatio	Support public pro	2016	2019	Yes	Partly	No	

Table 25 – Innovation policies and strategies relevant to German construction

Title or name	Short description	Public budget (euro)	Category	Sub-category	Start Year	End Year	Ongoing?	CI-specific?	Innovation specific?	Winch taxonomy
Umbrella strategies										
High-Tech Strategy 2020	A nation-wide strategy for Germany to become the worldwide innovation leader in 2020				2006, with a substanti		Yes	No	Yes	
IT Consolidation Programme/ Digital Strategy 2015	Federal attempts to modernize the government and expand digital infrastructure				2015		Yes	No	No	
Die Digitale Agenda	A government document on network policy issues regarding digitalization				2014	2017	Yes	No	No	
Die Energiewende	A transition strategy towards a low-carbon and sustainable energy supply				2010	-	Yes	No	No	
Industry 4.0 und Digitale Wirtschaft	A strategy on measures to digitalize the German public sector and improve the digital infrastructure				2015	-	Yes	No	No	
Reform Bundesbau - Bessere Kosten-, Termin- und Qualitä	BMUB strategy paper on faster, cheaper and better constr	-			2016	-	Yes	Yes	No	
General innovation policies										
Inno-Regio	Cluster programme for cross-sectoral innovation clusters	255 mln	Connections and com	Cluster policies	1999	-	No	No	Yes	
ZIM Program	Central SME Innovation Programme is a funding programme for ambitious R&D pro		Input for innovation a	Direct support	2015	2019	Yes	No	Yes	
Standardization in High-Tech Strategy	An important part of the High-Tech Strategy contains of standardization in the high-		Standardization and r	Standards	2014	-	Yes	No	No	
German Standardization Roadmap	As part of the Industry 4.0 strategy, standards play an essential role as they provide		Standardization and r	Standards	updated 20	-	Yes	No	No	
Excellence Strategy	R&D strategy on making the German sector excellent	533 mln anually	Connections and com	Network program	2016	-	Yes	No	No	
Vorfahrt für den Mittelstand	An part of the HighTech Strategy to make SMEs more innovative		Input for innovation a	Direct support	2016	-	Yes	No	Yes	
Construction policies directly aimed at innovation										
BIM step plan and Pilot BIM projects	Pilot projects for the use of BIM and standarization of BIM in 2020		Standardization and r	Standards	2015	2020	Yes	Yes	Yes	
Effizienzhaus Plus	Pilot projects to innovatively reduce energy consumption and environmental impac		Input for innovation a	Direct support			Yes	Yes	Yes	
Construction policies that indirectly influence innovation										
Energy-Optimized Construction (Energieoptimalisierte Bau	In German construction, innovative buildings with a high d	23,7 mln in 2014	Improving access to e	Technology adviso	2007	2015	No	Yes	No	
Zukunft Bauen	A long term plan to strengthen the German CI, including re	115 mln betwn 2006 and	Foresight	Structural or syste	2006	-	Yes	Yes	No	
Leitbild Bau	Industry vision paper on construction where goals are published		Foresight	Structural or syste	2009	-	No	Yes	No	
Right of suspension of payment	Client pays 5% of the construction bill five years after con	-	Standardization and r	Command-and-co	-	-	Yes	Yes	No	
Deutschland baut!	An association by the German government in order to stim	-	Improving access to e	Technology adviso	2013	-	Yes	Yes	No	
KfW Programmes	One of Europe's largest and best known support schemes	1,8 bln in 2014	Connections and com	Network program	2006	2020	Yes	Yes	No	

Table 26 – Estimated policy impacts and interaction

NL	Individual impact on innovativeness	Interaction with other measures
RDA (R&D tax deduction scheme)	Stimulated innovation effectively, but had unwanted side-effects	Interfered with WBSO and was integrated consequently
WBSO	Highly effective in stimulating R&D, with large additionalities and spill-over effects	Good interaction with Innovatiebox. No particular negative effects on other policies
Innovatiebox	Highly effective stimulating R&D and efficient procedures	Proper addition to WBSO
SME innovation promotion TKIs (MIT)	Unknown, but most likely positive	Unknown, but part of a bigger strategy, which is positive
PIANOo	Relation to innovation is unknown	Good complementary to innovative procurement measures
Innovatiekrediet	Highly effective in stimulating R&D	Partly overlapping with WBSO and Innovatiebox. No negative interaction.
Small Business Innovation Research (SBIR)	Effective for particular cases. Amount of cases is low, which tempers impact on innovation	Proper addition to innovative procurement initiatives and PIANOo
IPC regeling	Highly effective on stimulating innovation as well as collaboration in general	Very suitable in combination with direct measures
Tightened IPS	Unknown, but most likely positive	Barriers to innovation are removed. Not a lot of further interaction known.
Strong SMEs support	SMEs being most reserved towards risk, a positive effect on innovation	Reviewed as being particular successful in combination with for example tax reduction schemes
2,5% 'Innovatiegericht Inkopen'	Positive impact on innovation from the demand side	Useful in combination with SBIR and IIU and services as PIANOo
Ondernemersplein	Unknown, but most likely positive	Proper addition to several supporting schemes
Inkoop Innovatie Urgent	Unknown, but most likely positive	Proper addition to innovatiegericht inkopen and SBIR. Partly overlapping with SBIR, but also as an addition
Brede Stroomversnelling	Very positive on collaboration and indirectly on innovation	Does not interfere majorly with other projects

UK	Individual impact on innovativeness	Interaction with other measures
R&D Tax Relief (RDEC)	Highly effective in stimulating R&D, with large additionalities and spill-over effects	Good interaction with Innovatiebox. No particular negative effects on other policies
R&D Capital Allowances (RDA)	Highly effective in stimulating R&D.	Proper addition to RDEC
Patent Box	Unknown, but most likely positive	Addition to RDEC and RDA in later stages of projects
Catapult Centres	Effective regarding several fields, such as collaboration and innovation. Moreover, second order effects on other schemes	Improves usage of other facilities such as RDA
Collaborative R&D (CR&D programmes)	Successful in several fields among which R&D behavior and innovativeness	Participants made good use of other facilities as a result.
Small Business Research Initiative (SBRI)	Unknown, but based on reviews of similar mechanisms very positive with large spillover effects	Proper early-stage addition and initiation to other measures
Forward Commitment Procurement (FCP)	Unknown, but effects are probably positive, similar to SBRI.	Proper early-stage addition and initiation to other measures

Centre for Challenge Prizes	Impact on construction is minor, but positive. Impact on spillover, rather than companies	Minor interaction, but probably no negative effect on other measures
Construction Industry Training Board (CITB) and ECITB	Positive in improving supply of skills. Unknown impact on innovation, but most likely positive	Improving skills is important for commercializing innovations. Proper addition in innovation policy
BREEAM	This environmental impact-oriented quality guarantee fosters indirect innovation	Incentive to make use of financial research support
BIM Task Group and BIM regulation	Indirect positive influence on innovation by standardization	Offers framework for other initiatives to innovate. May also negatively influence innovation through extra regulation
Smart Cities Standards Strategy	Unknown, but standardization offers framework that stimulates innovation	Unknown
New Models of Construction Procurement (NMCP)	More room is offered to innovative and quality oriented solutions, so positive	Offers framework for other initiatives to innovate. No direct interferences

DK	**Individual impact on innovativeness**	**Interaction with other measures**
Skattekreditordningen	Highly effective and well-implemented	Proper complementaries to networking and collaboration programs
Innovationsfonden and InnoBooster	Unknown, but most likely effective	Additional to Skattekreditordninen
MUDP	Unknown, but most likely effective	Tight interaction with sustainability policy field and partly overlapping with InnoBooster
Vaekstfonden	Highly effective, although influence on construction limited	Works complementary to Skattekreditordningen and Innovationsfonden
Innovation Network Denmark	Positive impact on innovation	Stimulates use of financial measures and works complementary to the networking programs
User-driven Innovation Program	Positive, although impact on innovation diffusion is limited	Stimulates collaboration for diffusion
Central Innovation Manual	Effective in networking for collaborative innovation in construction	Stimulates knowledge and expertise exchange measures and works complementary to direct stimulating measures
Sustainable Building Innovation Challenge	Effective network on construction innovation	Complementary to direct initiatives
InnoBYG	Unknown, but probably slightly positive	May stimulate companies to search for direct support measures
KIG	Highly effective and well-implemented	Proper complementaries to networking and collaboration programs
Vejen til et styrket byggeri i Danmark	Unknown, but most likely effective	Additional to Skattekreditordninen

SE	**Individual impact on innovativeness**	**Interaction with other measures**
Challenge-driven innovation program	Highly stimulates demand for innovation	Highly suitable for complementing supply-driven approaches
VINNVÄXT program	Stimulating direct through increasing demand and indirect through networking and access to expertise	Woven into other measures with complementaries effects
Swedish Centre for Enterpreneurship	Not evaluated, but expected to be indirectly positive	Complementary and additional

90-day guarantee	Minor	Minor
Government Bill on Adult Education	Improves pool of skilled people, so indirectly positive	Minor
Forskningsavdrag	Large incentive for performing R&D	Suitable addition to networking and demand-driven programs
Innovation Vouchers	Large incentive for performing R&D	Suitable addition to networking and demand-driven programs
Planning grants	Effective in early project stages	Proper complementary to financial support measures
Development grants	Effective in late stages for commercialization of innovations	Proper complementary to financial support measures
Swedish Construction Industry Training Board (BYN)	Indirectly positive for stimulating innovation	New innovations require new skills, so complementary
Strategy for public procurement	More room for innovation-oriented procurement	Gives space to other measures

DE	**Individual impact on innovativeness**	**Interaction with other measures**
ZIM Program	Positive effect with high levels of success for participants	Extensive program with lots of complementarities
Standardization in HTS and standardization roadmap	Indirect positive effect on innovation	Offers framework for innovation and complementary to direct supporting measures
Excellence Strategy	Large impact on R&D, but indirect on innovation by collaboration and supply of skill	Complementary to measures that increase need for skilled labor
Vorfahrt für den Mittelstand (from HTS)	Effective for making SMEs more innovative	SMEs are a suitable target group in combination to general measures
BIM step plan and Pilot BIM projects	Offers new innovation possibilities in construction	Useful with network activities
Effizienzhaus Plus	Minor but positive impact on innovative construction	Effective in combination with financial measures to trigger a wider audience
Energy-Optimized Construction (Energieoptimalisierte Bau, EnOB)	Through sustainability targets led innovation stimulation	Offers knowledge which is effective with direct support measures
Zukunft Bauen	Call for R&D stimulates innovation	Unifying strategy which is effective in combination with direct support measures
Right of suspension of payment	Goes two ways: orientation on performance may stimulate innovation, but risk may be avoided which stagnates innovation	Minor