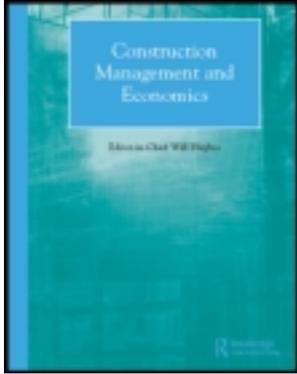


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A value chain statistical definition of construction and the performance of the sector

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A value chain statistical definition of construction and the performance of the sector

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Existing statistical analyses often fail to capture the true scope of the economic impact of the construction sector. They account for the construction of buildings, civil engineering, and construction specialized activities, as defined by Section F of the Statistical Classification of Economic Activities (or NACE) used in the European Community, but overlook related activities such as the manufacture of construction products and architectural and engineering services. This shortcoming is addressed and a wider definition of the construction sector is proposed that encompasses the whole value chain of the industry. Going beyond the 'core' construction sector section (Section F), activities from other NACE sectors that fully or principally depend upon or are functional to core construction activities are considered. These 'non-core' classes relate to 'pre-production' activities, such as the provision of intermediate goods and services; various 'support' activities and 'post-production' functions such as maintenance and management services. Equivalent broad definitions of the construction sector based on the North American Industry Classification System (NAICS) and the International Standard Industrial Classification (ISIC) are also developed to allow for optimum comparisons across countries and over time. Using detailed data from Finland and the Community Innovation Survey 4 (CIS4), core and non-core activities are characterized and quantified. Evidence suggests that indicators measuring the composition, structure, value added, skills, and R&D input and output of the construction sector change substantially when a broader definition of the sector is applied. Policies targeting the 'wide' construction sector, and exploiting the innovation, growth and productivity leverage potential of non-core activities are thus advocated.

Keywords: Construction sector, NACE classification, value chain, pre-production, post-production.

Introduction

Economic downturns, like the one that started in 2008, emphasize the need to address structural and sectoral problems, and to identify ways to increase productivity and competitiveness. They also underline the necessity to monitor the implementation and to assess the effectiveness of the policies put in place to meet these challenges. This in turn calls for a precise and systemic definition and measurement of the industries to be targeted in order to determine the most suitable policy tools to be chosen. Whether employment, innovation or sustainability related, to

maximize impact policies often need to be cross-cutting and to encompass the entire value chain of the industry in question. This is especially true for sectors like construction, with its multiplicity of heterogeneous actors, specialities and trades (Kokkala, 2010).

Despite the strategic importance of the construction sector for economies worldwide, attempts to capture its true scope have been relatively incomplete, and have changed across countries and over time (Francis, 1997). As Ruddock (2000, 2003, 2009) underlines, this has caused dissatisfaction about the state and quality of construction statistics among researchers

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and practitioners (e.g. Briscoe, 2006; Runeson and de Valence, 2009; Lewis, 2009), and has raised concerns about the incompleteness and narrowness of the statistical definition of the sector. Such a shortcoming is addressed by proposing a definition of the sector that builds on Pearce (2003) and encompasses the most important activities performed within the construction value chain. To achieve this, the codes defined within the Statistical Classification of Economic Activities used in the European Community (NACE¹) are analysed to identify those activities outside the official definition of the construction sector that are fundamentally linked to construction. The 'wide' definition of construction proposed is, to the best of our knowledge, the first to explicitly formalize in terms of NACE classes the extensive range of activities traditionally considered as part of the construction industry value chain. As it is NACE-based, the implementation of this approach does not require changes in the way statistical data are gathered or aggregated.

Equivalents of the definition are also developed for other established industrial classifications notably the North American Industry Classification System (NAICS, www.census.gov/eos/www/naics/) of business establishments as used primarily in the US, Canada and Mexico; and the International Standard Industrial Classification (ISIC) of all Economic Activities developed by the United Nations. Although the taxonomies considered may sometimes differ in the breadth and depth of their definitions, the NACE–SIC–NAICS correspondence table built should facilitate the use of the broad definition proposed, enable a better quantification of the construction sector's value chain, and allow for comparisons across countries and over time.

Using data from Finland and the Community Innovation Survey 4 (CIS4) the extent to which derived statistics and performance indicators of the construction sector can differ when accounting for the full value chain of the industry is discussed. The different roles played by core and non-core activities and the way they shape the performance of the broad construction sector are highlighted. This in turn warns about designing policies that target only the 'strict' NACE-defined construction industry (Section F), which covers the construction of buildings, civil engineering, and construction specialized activities, while overlooking components like the manufacturing of construction products and architectural and engineering activities. These activities and components are fundamental for the functioning and advancement of the construction sector and may cause interventions to fail, if left outside the scope of too narrowly defined vertical policies.

The present work aims to reach three main target readers, namely construction experts and practitioners; statisticians and economists; and policy makers and all those interested in sectoral dynamics. The way the article is articulated mirrors such an attempt. The first section characterizes the construction sector, underlines its relevance for economies worldwide, and discusses construction's main features *vis-à-vis* the performance of the sector. It highlights the importance and peculiarities of the construction industry, and explains the rationale behind the broad definition proposed. The second section constitutes the main contribution of the present article. It provides the motivation for the analysis and shows the way it relates to and builds on prior contributions, especially the seminal Pearce (2003) report. It further discusses the current NACE-based definition of the industry introduces an alternative value chain statistical definition of construction, and supplies NAICS- and ISIC-based equivalents of the taxonomy proposed. This section is mainly directed towards prospective users of an alternative definition of the construction sector, notably those involved in the statistical measurement and empirical analysis of construction, as well as policy makers. It seeks construction experts' and practitioners' assessment of the relevance and completeness of the definition proposed, and aims to open a forum for discussion. The third section offers some statistical evidence about how much of the sector is overlooked when only NACE Section F activities are considered and describes the performance of the wide construction sector in terms of firm size, turnover, and innovative input and output. Finally, as a conclusion, the possible implications for policy making of adopting the proposed broad definition are discussed.

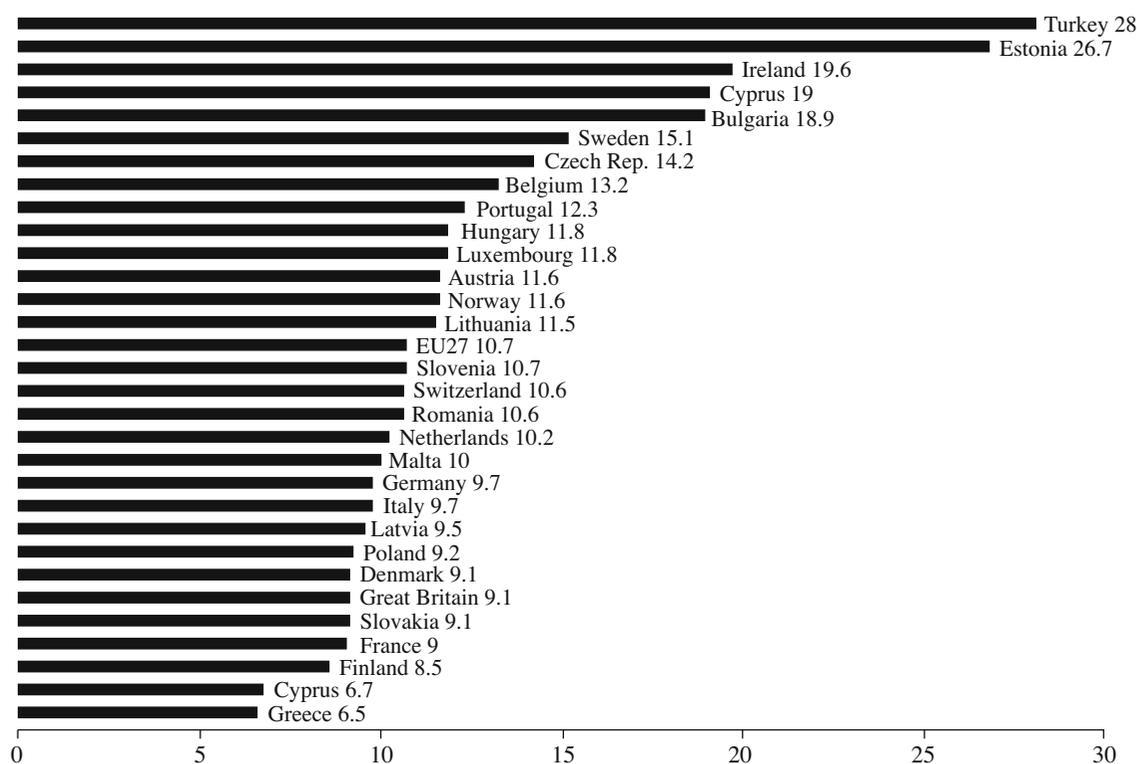
The industry and its relevance

Construction represents a fundamental part of economies. According to the European Construction Industry Federation (FIEC), in 2008 the construction sector consisted of about three million enterprises in the European Union (EU27), 95% of which have fewer than 20 workers. In 2008, the sector was responsible for 50% of gross fixed capital formation and was a major employer, accounting for almost 8% of total employment (EU27)—about 30% of 'industrial' employment (FIEC, 2009). Table 1 shows the total employment in construction (in thousands) during the period 1999–2007, for selected countries.

As well as being a major employer in all economies, construction accounts for a substantial GDP share: in 2007, construction accounted for about 11% of GDP in the EU27 (FIEC, 2008); see Figure 1. Among

Table 1 Total employment in construction 1999–2007 (thousands) (FIEC, 2008)

	1999	2000	2001	2002	2003	2004	2005	2006	2007
Austria	281	276	265	258	255	253	253	257	260
Germany	2859	2769	2598	2439	2322	2254	2165	2159	2199
Spain	1570	1749	1914	2006	2113	2233	2390	2520	2697
Finland	149	154	152	153	154	157	164	165	174
France	1527	1586	1630	1652	1661	1689	1736	1809	1890
Great Britain	1854	1900	1917	1948	1997	2069	2119	2165	2230
Italy	1559	1611	1711	1746	1794	1823	1890	1902	1911
Netherlands	461	472	484	478	460	450	453	466	482
Portugal	539	596	586	622	584	548	554	553	571
Romania	270	281	262	279	378	337	363	380	420
Sweden	225	225	232	235	238	242	254	270	285
Slovakia	136	127	125	128	131	134	143	156	166
EU	13 000	13 488	13 618	13 715	13 938	14 097	14 459	14 880	15 623

**Figure 1** Construction's share of GDP in 2007 (in percentage) (FIEC, 2008)

others, Pietroforte and Gregori (2003) noticed that the role of construction seemed to decline as the development level of countries increased. Bon (1992), and Ruddock and Lopes (2006) further noticed the existence of an inverted U-shaped relationship between the development level of a country and the importance of its construction sector. In particular, Bon (1992) carries out a macroeconomic analysis of the role of construction at various stages of economic development, and relates the development pattern of the industry to the development stage of countries. Ruddock and Lopes (2006) acknowledge the

complexity of the 'Bon' relationship and attempt to assess the validity of this proposition by means of examining its underlying data, in an effort to address the role of construction in highly developed economies.

Construction's share of GDP translates into a remarkable contribution of the sector to the generation of value added. This is true for all nations, whether industrialized nations as Europe and the US, or emerging countries like India—Figure 2.

According to Eurostat (2009), more than half (58%) of the total value added of the construction sector is generated by general building and civil

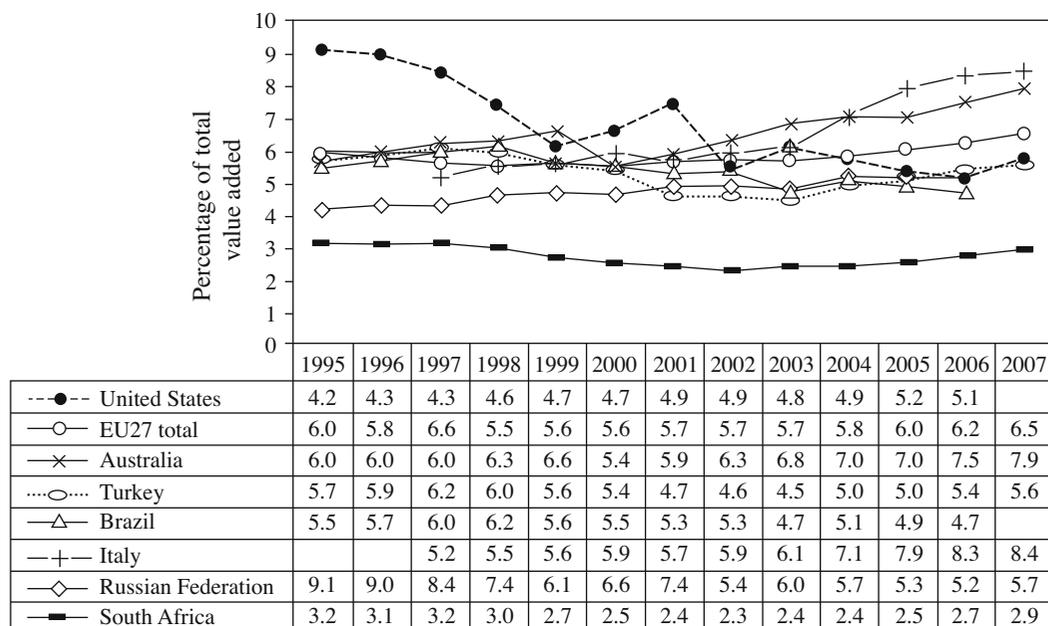


Figure 2 Construction's share of value added 1995–2007 (selected countries) (OECD, 2009)

Note: The 1993 revision of the System of National Accounts (SNA93) defines gross value added as output minus intermediate consumption. It equals the sum of employee compensation, gross operating surplus of government and corporations, gross mixed income of unincorporated enterprises and taxes less subsidies on production and imports, except for net taxes on products. Total value added is less than GDP because it excludes value added tax (VAT) and other product taxes.

Table 2 Construction's value added by activity (Eurostat, 2009)

Activity	% value out of total
Renting of construction or demolition equipments	0.7
Site preparation	3.5
Building completion	15.1
Building installation	22.4
General and building civil engineering	58.2

engineering activities while building installation and building completion account for 22% and 15% respectively; see Table 2.

Although construction is a major contributor to employment, GDP, value added and capital stock creation of all countries, the sector makes significant use of, and has a very strong impact on, natural resources. More than 50% of all the materials extracted from the earth are transformed into construction materials and products. Construction and the built environment are accountable for the largest share of greenhouse gas emissions in terms of energy use and produce one of the largest waste streams (European Commission, 2007). As Hooton (2008) underlines, the US Environmental Protection Agency estimates that three-quarters of demolition waste—the result of the total and fast disassembly or tearing down of a construction or other built structures (Shami,

2006)—could be reused or recycled. At present construction is unfortunately far from being a sustainable industry.

Construction's main features

Construction is commonly perceived as a low-productivity, low-technology sector, a scarcely dynamic industry that underperforms compared to other industries (Manley, 2008). Despite the existence of country-specific differences, construction is generally characterized by low expenditure in research and development (R&D) (Gann, 2001), very long economic cycles, and strong cyclical variations in both demand and profits. These accentuate the financial risks associated with R&D investment in the sector (Blackley and Shepard, 1996), and ultimately limit the innovative capacity of the industry. Construction

generally lacks the necessary financial resources for innovation. This is partly due to low profitability and the small average size of its firms. In addition, barriers to entry are low in the sector, and firms tend to compete in prices.

As Gann (1996) underlined when comparing the extent to which technological learning occurs in industrialized housing and in car manufacturing in Japan, construction activities are mainly project-based and lack the skills required for innovative activities. This makes construction firms suffer from a short-term perspective which may lead to behaviours that impinge upon those firms' ability to develop technically. Furthermore, Dubois and Gadde (2002) remarked that the construction industry was a loosely coupled system characterized by complexity, uncertainty, independence and inefficient operations. Construction couplings build on two interdependent layers, namely tight couplings in individual projects,

and loose couplings and collective adaptations in permanent networks, and these coupling patterns ultimately favour short-term productivity, and hamper innovation and learning.

Construction owes its dynamics and performance to the very characteristics of its output. Whether directed to the residential, non-residential or infrastructure markets, construction output differs in many ways from other manufactured goods. It is generally represented by large and immobile goods; it entails a high degree of complexity and interdependence in terms of the number and range of resources and components involved, and the degree of interactions needed; and it is meant to be more durable and is usually more expensive than other manufactured goods, with a life cycle of several decades or more. As Gann (1996) highlights, cars are on average assembled from around 20 000 items, whereas houses might require 200 000 components.

Table 3 United Kingdom total employment in construction by occupation (Construction Skills Network, 2009)

	2009	As % of SIC [^] 45	As % of SIC [^] 45 & 74.2
Senior, executive, and business process managers	98 010	4.4	3.9
Construction managers	219 080	9.8	8.6
Non-construction professional, technical, IT, and other office-based staff	282 340	12.6	11.1
Wood trades and interior fit-out	281 150	12.5	11.1
Bricklayers	88 160	3.9	3.5
Building envelope specialists	92 590	4.1	3.7
Painters and decorators	135 660	6.1	5.4
Plasterers and dry liners	48 300	2.2	1.9
Roofers	46 520	2.1	1.8
Floorers	38 050	1.7	1.5
Glaziers	41 740	1.9	1.7
Specialist building operatives n.e.c.*	56 170	2.5	2.2
Scaffolders	24 260	1.1	1.0
Plant operatives	46 750	2.1	1.8
Plant mechanics/fitters	27 060	1.2	1.1
Steel erectors/structural	28 330	1.3	1.1
Labourers n.e.c.*	116 590	5.2	4.6
Electrical trades and installation	177 880	7.9	7.0
Plumbing and HVAC trades	176 920	7.9	7.0
Logistics	32 280	1.4	1.3
Civil engineering operatives n.e.c.*	59 660	2.7	2.4
Non-construction operatives	123 930	5.5	4.9
Total (SIC 45)	2 241 430	100	88.4
Civil engineers	52 300		2.1
Other construction professionals and technical staff	143 930		5.7
Architects	40 550		1.6
Surveyors	57 280		2.3
Total (SIC 45 and 74.2)	2 535 490		100

Notes: The United Kingdom Standard Industrial Classification of economic activities (UK SIC) is used to classify business establishments and other standard units by the type of economic activity in which they are engaged (UK ONS, 2010). The UK SIC is equivalent to NACE to the four-digit level.

* n.e.c. = not elsewhere classified.

[^] SIC = Standard Industrial Classification.

Technical interdependence and organizational independence

Construction is characterized by technical interdependence and organizational independence (Crichton, 1966), i.e. by the fact that many independent and heterogeneous actors are needed for construction (multi-inputs) goods to be obtained. The many specializations and tasks belonging to the sector can be seen in Table 3, showing data from the United Kingdom (Construction Skills Network, 2009).

The distribution and type of tasks accomplished by construction workers mirror the relatively low educational requirements of the sector's workforce. This often leads to firms having little absorptive capacity—meaning firms' ability to recognize the value of new information, assimilate it, and apply it to commercial ends (Cohen and Levinthal, 1989)—and to construction trades where learning is neither organized nor widespread. Such features are worsened by the high turnover of human resources within the sector, with 12%–13% of all construction workers in the EU27 reporting just one year or less of service (EFILWC, 2007).

Project-based organizations

Construction companies are normally structured as project-based rather than functionally organized enterprises, and supply clients with custom-designed products and services (Blindenbach-Driessen and van den Ende, 2006). Construction activities entail varying degrees of uniqueness and are mainly carried out on site. The impracticality of producing a test piece means that everything has to be done right the first time (MacLeod *et al.*, 1998; Koivu *et al.*, 2001).

Project-based production significantly undermines the learning processes essential for productivity improvements. Despite projects representing flexible systems of production that enable the coordination of loose networks of firms (DeFilippi, 2001), they rarely enable firms to integrate, develop and transform into organizational capabilities, any knowledge they acquire (Davies and Brady, 2000; Acha *et al.*, 2005).

In project-based production all activities are usually conducted in collaboration with clients, suppliers and project partners and despite their different backgrounds they all need to be engaged in the process for the activities to be successful (Bayer and Gann, 2007). Construction projects' phases are generally divided into well-defined and discrete work packages accomplished in a sequential and commonly known order by purposely contracted specialists. The complexity of the supply chain may vary greatly and

depends on the type of project carried out. Each contractor is ultimately responsible only for its own contribution, and this almost inevitably leads to workflows facing major interruptions, possible conflicts, time and cost overruns, and quality problems (see Barlow, 2000, for a detailed account).

Incremental and 'hidden' innovations

Engaging in R&D and innovation is relatively expensive for construction firms since the risks related to innovation, also 'hidden' innovation, are allocated to the producers and not to the users (Widén and Hansson, 2007). 'Hidden' innovations are those that remain undetected by conventional measures, for example project-level innovation activities, and organizational and design innovations (Barrett *et al.*, 2007). In construction, successful innovations are often based on hitching and matching existing technologies, and on implementing systemic innovation aimed at improving the whole production process (Koivu *et al.*, 2001).

Innovation in construction is typically incremental in nature, and leads to dramatic transformations only in the long term. Examples of radical transformations that have occurred since 1950 include: changes in materials; the introduction of standardization and prefabrication; the use of information technologies (IT) in design and construction; the introduction of automation and robotics; and changes in the supply chain management (Miozzo and Ivory, 2000).

Standards and regulations

Construction is a highly regulated sector, with a vast range of directives, regulations and legislation that directly and indirectly affect practically every aspect of the construction industry, whether safety, energy or environment related. Examples are the planning and environmental regulations governing finished products, and the labour market regulations governing the welfare of the workers taking part in construction work (Dewick and Miozzo, 2002).

Although standardization and regulations may enable the widespread deployment of novel technologies and processes, this can lead to relatively static systems which may ultimately hinder innovation (Acemoglu *et al.*, 2010). Certification practices, whether related to products or firms, may also discourage efforts and investments in small firms due to the additional costs and delays they might imply.

Standing on the shoulders of giants to redefine construction

Scholars and practitioners have for some time voiced the need for a definition of construction that is able to capture the full economic breadth and technical depth and diversification of the industry. As Ruddock and Ruddock (2009) remark, construction data and statistics often appear of poorer quality, consistency and usability than many other sectors' statistics. Such availability and reliability problems stem from construction being a sector that is often overlooked in many data collections, including those designed to measure innovation. For instance, until 2006, construction was excluded from the base sample of the Community Innovation Survey (CIS), which is the main European data collection exercise focusing on the innovative activity of firms.

Construction statistics also suffer from the incomplete coverage of small firms (Briscoe, 2006), and this hampers analyses of the dynamics of the sector in terms of entry and exit of enterprises—and the associated monitoring of job creation and destruction. In addition, different authorities and organizations collect different types of data in different countries. These (often private) data collections typically follow tailored approaches and definitions serving the specific needs of the commissioning party. This prominence of private data collections such as those compiled by federations, trade unions and interest groups reflects the inability of official statistics to cater for the users' needs, whether analysts or policy makers (Ruddock, 2003).

The availability, quality and consistency problems that flaw construction data have restricted research on the sector (see Lewis, 2009, for a discussion on the lack of economic research on construction). Moreover, the varying classification practices followed in different countries have stifled international comparisons (Ruddock and Ruddock, 2009). As Francis (1997) notes, some countries include in the statistical definition of the sector many more activities than those included in the NACE classification. This lack of a unified definition of the sector and the consequently varying range and type of activities included in it represents one of the main problems in construction statistics (Ruddock, 2003).

Since the 1960s many researchers have tried to quantify the scope and scale of the sector (e.g. Turin, 1969; Strassman, 1970). One of the best-known attempts was that by Pearce (2003) in an influential report commissioned by nCRISP (the new Construction Research and Innovation Strategy Panel, UK). Pearce raised the question of the definition of the sector, and of the coverage and scope of activities included within it. He formulated a broader definition

of the sector for the United Kingdom, and quantified construction under both 'broad' and 'narrow' definitions. The narrow definition confines its attention to onsite construction activities, whereas the broad definition draws in activities such as the quarrying of raw materials for construction, manufacturing of building materials, sale of construction products, and the associated professional services. Owing to the unavailability or non-reliability of certain data, Pearce excluded, among other things, land, property and facility management from the broad definition. Nevertheless, he concluded that the construction sector would double its size under his broad definition, in terms of both the number of firms and their contribution to GDP.

Building on Pearce's (2003) seminal contribution, the statistical formalization of the sector is taken a step further. Rather than follow Pearce and produce definitions of construction based on the UK Standard Industrial Classification of Economic Activities (UK SIC), definitions based on four-digit NACE codes are developed, and translated into the equivalent ISIC and NAICS codes. This ensures a broad and immediate applicability of the proposed wide taxonomy, as well as data homogeneity and comparability over time and across countries.

As for the activities included in the definition of construction, the 'strict' definition presented here basically coincides with Pearce's narrow one, since both mirror the way construction is defined in industry classifications and national statistics. However, the broad definition of construction proposed is wider than that developed by Pearce and is built following a different rationale. Pearce's broad definition draws attention to the economic activities that directly depend on the narrow definition of construction, whereas our 'wide' construction taxonomy follows a value chain approach. This implies looking at construction as a system made up of subsystems, each with inputs, transformation processes and outputs involving the acquisition and consumption of resources (Porter, 1985). To this end, class codes are identified that cover activities that fully or principally depend upon, or are functional to, core construction activities but that are officially included in other sectors. These are grouped into pre-production, post-production and support activities, and are described in more detail later.

A value chain based 'wide' definition of the sector

NACE classifications and the construction sector

Statistical offices in Europe collect and present data related to economic activities following NACE classi-

fications. NACE nomenclatures are divided into: (i) sections, denoted by a letter; (ii) divisions, denoted by two-digit codes; (iii) groups, denoted by three-digit codes; and (iv) classes, characterized by four-digit codes. Here, the term ‘code’ is used in a general sense, to refer to any level of the nomenclature.

Currently, two NACE classifications coexist: NACE Revision 1.1 (NACE Rev. 1.1), which has been in force since 2002 and was used for the collection of structural business statistics until 2008; and NACE Revision 2 (NACE Rev. 2, European Commission, 2008). The latter was introduced in 2008 and is expected to be fully adopted in the EU, for all industry-oriented statistics by 2012. Industrial classifications are periodically revised to better capture the prevailing structure of the economy—for example, taking account of recent technological changes. The latest revision of NACE pays more attention to services, particularly information, business and environmental services; to some expanding industries (such as pharmaceuticals); and to emerging production processes, and offers a more detailed classification of economic activities in general.

In both NACE Revisions 1.1 and 2 construction activities are accounted for in ‘section F’. In NACE Rev. 1.1 section F coincides with division 45, whereas NACE Rev. 2 section F is subdivided into divisions 41, 42, and 43. Substantial differences also exist with respect to the number of groups and classes contained in the section. From NACE Rev. 1.1 to NACE Rev. 2 the sector’s number of groups and classes has increased from 5 to 9, and from 17 to 22, respectively. These changes highlight the attention now paid to the details of the production process, and to the different technologies used in the sector. Moreover, in NACE Rev.1.1 groups are generally divided according to the various stages of the construction process—from site preparation to renting and demolition

activities, whereas NACE Rev. 2 classifies the sector according to the outcomes obtained.

Table 4 shows the construction sector’s divisions and groups of both NACE Rev. 1.1 and Rev. 2 classifications. In NACE Rev. 2 (right hand side of Table 4) division 41 covers the complete construction of buildings; division 42 relates to the complete construction of civil engineering works, and division 43 deals with specialized construction activities, if carried out only as a part of the construction process.

The greater number, type and level of details characterizing NACE Rev. 2 compared to NACE Rev. 1.1 reflect the willingness to account more for the wide range of activities carried out by construction firms. Such an aim is expressly stated in the documentation published by Eurostat (2009), which highlights a number of activities that could have been included in section F, but were excluded to ensure the general consistency of the classification.²

From a ‘strict’ to a ‘wide’ definition of construction

While NACE Rev. 2 defines the construction sector in a broader manner than its predecessor, it still excludes many activities that could come under its umbrella. Building on NACE classification, a ‘wide’ definition is proposed that adds ‘non-core’ codes to the activities listed in section F. Non-core codes are activities that are not listed in section F but exclusively or predominantly belong to the construction value chain.

Figure 3 summarizes the main activities, phases and components of the construction value chain. The schematization centres around construction activities intended as building and civil engineering, including soil- and water-related constructions (i.e. ‘core’

Table 4 Statistical classification of activities in the construction sector (Eurostat, 2009)

NACE Rev. 1.1 (2002): Section F codes		NACE Rev. 2 (2008): Section F codes	
45	Construction	41	Construction of buildings
45.1	Site preparation	41.1	Development of building projects
		41.2	Construction of residential and non-residential buildings
45.2	Building of complete construction or parts thereof; civil engineering	42	Civil engineering
45.3	Building installation	42.1	Construction of roads and railways
		42.2	Construction of utility projects
45.4	Building completion	42.9	Construction of other civil engineering projects
		43	Specialized construction activities
45.5	Renting of construction or demolition equipment with operator	43.1	Demolition and site preparation
		43.2	Electrical, plumbing and other construction installation activities
		43.3	Building completion and finishing
		43.9	Other specialized construction activities

Note: NACE Rev. 1.1 and Rev. 2 divisions and groups are listed in numerical order. No correspondence is meant among the codes considered.

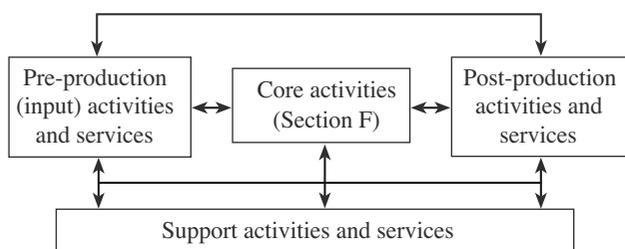


Figure 3 Construction value chain, based on NACE codes

activities in Figure 3). The chart attempts to capture the value chain of construction, as well as the time sequence in which core and non-core activities take place. Within ‘core’ activities no differentiation is made with respect to whether building and civil engineering works relate to newly built or renovated constructions, are carried out by private or public firms or by private individuals.

Pre-production activities are upstream activities—mainly manufacturing—whose output constitutes an input into construction’s core activities, as well as services preceding the construction core phases. Examples of input activities are the manufacture of construction materials like concrete, cement and plaster, bricks, tiles, etc. These manufacturing activities produce those components and systems (or kits of components) that are used in a permanent way in construction works (see also PRC BV, 2006). These input suppliers are normally classified as belonging to industries other than construction such as chemicals, forestry and concrete. Examples of pre-production services include architectural and engineering services, i.e. services preceding core construction activities like geodetic surveying, building design and drafting.

Post-production activities are downstream activities normally carried out after the ‘completion’ of building or civil engineering projects such as the maintenance of buildings, real estate selling and letting services, and facility management. Finally, support activities and services cover a broad range of production and service activities: from wholesale of construction materials, to renting machinery and equipment, to recycling waste and scrap. The present taxonomy also considers as support activities certain public services such as area and urban planning, steering, inspections, certification, market surveillance and research, as well as construction-related finance and insurance, facility management and services.

Table 5 illustrates the NACE section, divisions, groups and classes contemplated in the wide definition. The NACE Rev.1.1-based wide classification is shown on the left hand side of the table, whereas the corresponding NACE Rev. 2-based one is displayed

on the right. Section F ‘core’ construction codes are shown for both NACE revisions followed by those ‘non-core codes’ that supplement the core codes to obtain a more systemic—and, arguably, more policy relevant—definition of construction. Codes and activities are listed following the NACE Rev. 1.1 order (on the left hand side), with the corresponding NACE Rev. 2 group/class on the right. Owing to the official correspondences between NACE revisions, some NACE Rev.2 class codes are repeated.

The proposed wide definition of construction is in line with that contained in the European Commission communication COM(2007) 860-final about sustainable construction: ‘[sustainable construction] embraces a number of aspects such as design and management of buildings and constructed assets, choice of materials, building performance as well as interaction with urban and economic development and management’ (European Commission, 2007, p. 4). In both definitions, emphasis is on the systemic nature of the industry and the need to account for all its major stakeholders and actors.

The wide definition and the construction value chain

Given that the official names of the NACE sections, groups and classes may sometimes not be fully indicative of the activities comprised therein, non-core activities have been chosen after a careful inspection of the complete NACE nomenclature and of its exact content. Attention has been paid to: the type and content of each activity; the extent to which it relates or is functional to core activities; and, more generally, the way in which activities are articulated over the construction value chain. Examples are NACE Rev. 1.1 classes 51.53–54 (classes 46.73–74 in NACE Rev. 2), ‘Wholesale of construction materials’, since the demand for construction materials is affected by, reflects and contributes to shape the performance of the sector.

Figure 4 relies on the schematization proposed in Figure 3 to visualize the positioning of non-core activities within the construction value chain. Three- and four-digit codes are used for non-core activities, whereas core functions are denoted by two-digit codes.

No code explicitly reflects the extensive range of public construction activities that relate to the maintenance of public buildings, construction safety inspections, major infrastructure planning and tendering, urban planning and so on. Often, instead of being independently accounted for as (specific types of) construction, these activities are measured as part of—and therefore merely functional to—other public functions like education, transport and public administration. Such a feature of the NACE classification

Table 5 The construction sector: a 'wide' definition (Eurostat, 2009)

NACE Rev. 1.1 (2002)* Section F: Construction—core codes		NACE Rev. 2 (2008)^
45	Construction	41
45.1	Site preparation	41.1
45.2	Building of complete construction or parts thereof; civil engineering	41.2
45.3	Building installation	42
45.4	Building completion	42.1
45.5	Renting of construction or demolition equipment with operator	42.2
		42.9
		43
		43.1
		43.2
		43.3
		43.9
	Non-core codes	
14.11	Quarrying of ornamental and building stone	8.11
17.54	Manufacture of other textiles n.e.c.	9.90
20.20	Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board, fibre board and other panels and boards	13.96
20.3	Manufacture of builders' carpentry and joinery	16.21
24.30	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	16.22
25.23	Manufacture of builders' ware of plastic	16.23
26.14	Manufacture of glass fibres	41.20
26.26	Manufacture of refractory ceramic prod.	43.32
26.30	Manufacture of ceramic tiles and flags	22.23
26.4	Manufacture of bricks, tiles and construction products, in baked clay	23.14
		23.20
		23.31
		23.32
		23.51
		23.52
26.51	Manufacture of cement	23.6
26.52	Manufacture of lime	23.7
26.53	Manufacture of plaster	25.11
26.6	Manufacture of articles of concrete, plaster and cement	41.20
26.7	Cutting, shaping and finishing of ornamental and building stone	
28.11	Manufacture of metal structures and parts of structures	

28.1.2	Manufacture of builders' carpentry and joinery of metal	25.12	Manufacture of doors and windows of metal
28.2.2	Manufacture of central heating radiators and boilers	43.32	Joinery installation
29.5.2	Manufacture of machinery for mining, quarrying and construction	25.21	Manufacture of central heating radiators and boilers
29.7.2	Manufacture of non-electric domestic appliances	28.92	Manufacture of machinery for mining, quarrying and construction
36.63	Other manufacturing n.e.c.	28.99	Manufacture of other special-purpose machinery n.e.c.
37.20	Recycling of non-metal waste and scrap	27.52	Manufacture of non-electric domestic appliances
45.31	Installation of electrical wiring and fittings	28.21	Manufacture of ovens, furnaces and furnace burners
51.53	Wholesale of wood, construction materials and sanitary equipment	22.23	Manufacture of builders' ware of plastic
51.54	Wholesale of hardware, plumbing and heating equipment and supplies	38.32	Recovery of sorted materials
52.46	Retail sale of hardware, paints and glass	80.20	Security systems service activities
70.11	Development and selling of real estate	46.73	Wholesale of wood, construction materials and sanitary equipment
70.2	Letting of own property	46.74	Wholesale of hardware, plumbing and heating equipment and supplies
70.3	Real estate activities on a fee or contract basis	47.52	Retail sale of hardware, paints and glass in specialized stores
71.32	Renting of construction and civil engineering machinery and equipment	41.10	Development of building projects
74.2	Architectural and engineering activities and related technical consultancy	42	Civil engineering
		68.2	Renting and operating of own or leased real estate
		68.31	Real estate agencies
		77.32	Renting and leasing of construction and civil engineering machinery and equipment
		77.39	Renting and leasing of other machinery, equipment and tangible goods n.e.c.
		71	Architectural and engineering activities; technical testing and analysis

Notes: NACE Rev. 1.1 codes on the left hand side of the table; NACE Rev. 2 codes on the right. 'Section F' contains the codes included in the official definition of construction, whereas the 'Non-core codes' section lists the additional groups and classes included in the 'wide' definition. Divisions and classes are listed following NACE Rev. 1.1 order, each time indicating the corresponding NACE Rev. 2 group or class. Code repetitions are possible due to correspondences NACE Rev. 1.1—NACE Rev. 2.

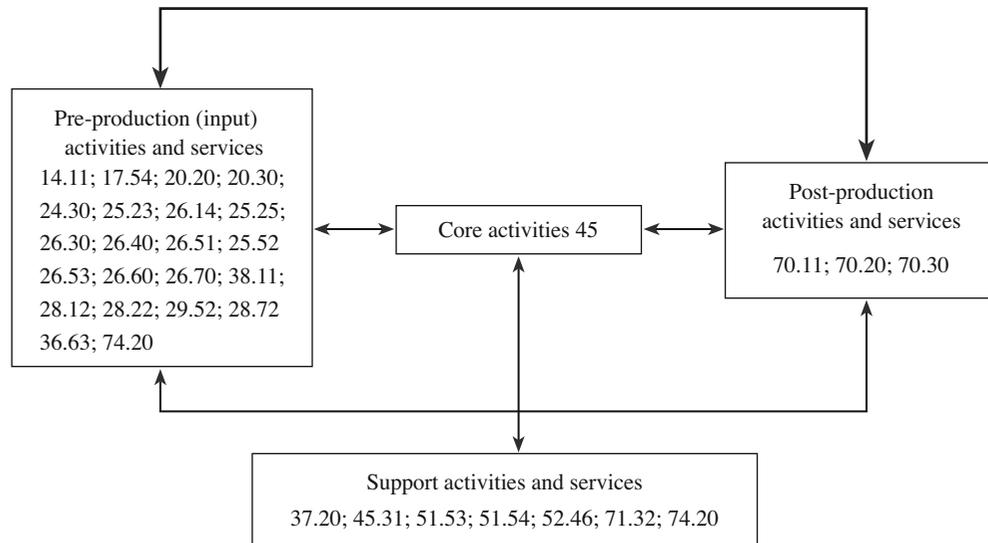


Figure 4 Construction value chain, NACE Rev. 1.1 codes

further confirms construction activities to be underestimated in official statistics.

NAICS and ISIC equivalents of the NACE-based wide definition of construction

Table 6 shows the NAICS 2002 and ISIC 3.1 equivalents of the NACE-based definition proposed. Correspondences are not perfect, since differences exist in the depth and breadth of the way classes are defined in the various classifications. This makes it necessary to overlook some NAICS and ISIC subclasses officially corresponding to the NACE classes included in the wide definition, but that are not related to construction.

Moreover, because of geographical variations in the building materials commonly used, related production processes and regulatory frameworks, when applied in practice, the wide definition may exhibit some country-specific features. For instance, the manufacturing of wood parts for construction is likely to play a more significant role in the Finnish construction industry than, say, in the Italian one. Hence, differences in the size of the various activities comprising the wide construction industry are likely to occur, given the specific characteristics of the country considered.

‘Core’ and ‘non-core’ activities: characterizing ‘wide’ construction

To illustrate some key features of the construction sector, and highlight how different the industry looks when a wide definition is considered, data from the Finnish Business Register are used to uncover possible differences in the composition of the sector, and

in the productivity and growth of core and non-core activities. Innovation input- and output-related data are drawn from the Community Innovation Survey (CIS) 4. The CIS is a harmonized survey carried out periodically by national statistical offices throughout the European Union, Norway and Iceland. The questionnaire is designed to give information about firms’ innovation-related activities, processes and output—the data gathered covering a three-year period. CIS4 covers the period 2002–04.

Figure 5 depicts the number of firms in the construction sector in Finland during the period 2000–06. The dotted area highlights the core NACE codes, and points out how much of the sector gets overlooked when only NACE section F is considered.

Table 7 also uses Finnish data and subdivides non-core construction codes into manufacturing and service activities to highlight the different roles that different sub-industries may play in the construction value chain. Bon and Pietroforte (1993) and Pietroforte and Gregori (2003) observe that, generally, the lower the development of the economy, the higher the input coming from manufacturing as compared to services. As the built environment matures, emphasis in construction shifts from onsite activities and raw material extraction to maintenance and repair activities (Ruddock and Ruddock, 2009).

Table 7 shows the average values and growth rates (in parentheses) over the years 2000–07 of four indicators:

- (1) average salary per employee, calculated as the total industry salaries over the total number of employees;

Table 6 Wide construction definition: NACE Rev. 1.1, NAICS 2002 and ISIC 3.1 equivalents

NACE Rev. 1.1 Codes	Titles	NAICS 2002 codes and titles	ISIC 3.1 codes and titles
14.11	Quarrying of ornamental and building stone	212311 Dimension Stone Mining and Quarrying; 212319 Other Crushed and Broken Stone Mining and Quarrying	1410 Quarrying of stone, sand and clay; 1429 Other mining and quarrying n.e.c.
17.54	Manufacture of other textiles n.e.c.	315999 Other Apparel Accessories and Other Apparel Manufacturing; 322222 Coated and Laminated Paper Manufacturing	2519 Manufacture of other rubber products; 1729 Manufacture of other textiles n.e.c.; 2109 Manufacture of other articles of paper and paperboard; 2029 Manufacture of other products of wood; manufacture of articles of cork, straw and plaiting materials
20.2	Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board, fibre board and other panels and boards	321211 Hardwood Veneer and Plywood Manufacturing; 321212 Softwood Veneer and Plywood Manufacturing; 321219 Reconstituted Wood Product Manufacturing	2021 Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board and other panels and boards
20.3	Manufacture of builders' carpentry and joinery	321213 Engineered Wood Member (except Truss) Manufacturing; 321911 Wood Window and Door Manufacturing; 321912 Cut Stock, Resawing Lumber, and Planing; 321918 Other Millwork (including Flooring); 321991 Manufactured Home (Mobile Home) Manufacturing; 321992 Prefabricated Wood Building Manufacturing	2010 Sawmilling and planing of wood; 2022 Manufacture of builders' carpentry and joinery; 2811 Manufacture of structural metal products
24.3	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	325510 Paint and Coating Manufacturing	2422 Manufacture of paints, varnishes and similar coatings, printing ink and mastics
25.23	Manufacture of builders' ware of plastics	326191 Plastics Plumbing Fixture Manufacturing; 326192 Resilient Floor Covering Manufacturing; 326199 All Other Plastics Product Manufacturing; 332913 Plumbing Fixture Fitting and Trim Manufacturing	2520 Manufacture of plastics products; 2519 Manufacture of other rubber products
26.14	Manufacture of glass fibres	327212 Other Pressed and Blown Glass and Glassware Manufacturing; 327993 Mineral Wool Manufacturing	2610 Manufacture of glass and glass products
26.26	Manufacture of refractory ceramic products	327124 Clay Refractory Manufacturing; 327125 Nonclay Refractory Manufacturing	2692 Manufacture of refractory ceramic products
26.3	Manufacture of ceramic tiles and flags	327122 Ceramic Wall and Floor Tile Manufacturing	2693 Manufacture of structural non-refractory clay and ceramic products
26.4	Manufacture of bricks, tiles and construction products, in baked clay	327121 Brick and Structural Clay Tile Manufacturing; 327122 Ceramic Wall and Floor Tile Manufacturing; 327123 Other Structural Clay Product Manufacturing	2693 Manufacture of structural non-refractory clay and ceramic products; 2695 Manufacture of articles of concrete, cement and plaster
26.51	Manufacture of cement	327310 Cement Manufacturing	2694 Manufacture of cement, lime and plaster
26.52	Manufacture of lime	327410 Lime Manufacturing	2694 Manufacture of cement, lime and plaster
26.53	Manufacture of plaster	327420 Gypsum Product Manufacturing	2695 Manufacture of articles of concrete, cement and plaster

(Continued)

Table 6 (Continued)

NACE Rev. 1. 1 Codes	Titles	NAICS 2002 codes and titles	ISIC 3.1 codes and titles
26.6	Manufacture of articles of concrete, plaster and cement	327331 Concrete Block and Brick Manufacturing; 327332 Concrete Pipe Manufacturing; 327390 Other Concrete Product Manufacturing; 327320 Ready-Mix Concrete Manufacturing; 327999 All Other Miscellaneous Nonmetallic Mineral Product Manufacturing	2695 Manufacture of articles of concrete, cement and plaster; 2699 Manufacture of other non-metallic mineral products n.e.c.
26.7	Cutting, shaping and finishing of ornamental and building stone	327991 Cut Stone and Cut Stone Product Manufacturing	2696 Cutting, shaping and finishing of stone
28.11	Manufacture of metal structures and parts of structures	332311 Prefabricated Metal Building and Component Manufacturing; 332312 Fabricated Structural Metal Manufacturing; 332313 Plate Work Manufacturing; 332322 Sheet Metal Work Manufacturing; 332323 Ornamental and Architectural Metal Work Manufacturing	2811 Manufacture of structural metal products; 2812 Manufacture of tanks, reservoirs and containers of metal
28.12	Manufacture of builders' carpentry and joinery of metal	332321 Metal Window and Door Manufacturing	2811 Manufacture of structural metal products
28.22	Manufacture of central heating radiators and boilers	333319 Other Commercial and Service Industry Machinery Manufacturing	3699 Other manufacturing n.e.c.
29.52	Manufacture of machinery for mining, quarrying and construction	333120 Construction Machinery Manufacturing	2924 Manufacture of machinery for mining, quarrying and construction
29.72	Manufacture of non-electric domestic appliances	333414 Heating Equipment (except Warm Air Furnaces) Manufacturing; 333415 Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing; 335228 Other Major Household Appliance Manufacturing	2930 Manufacture of domestic appliances n.e.c.
36.63	Other manufacturing n.e.c.	321999 All Other Miscellaneous Wood Product Manufacturing; 322299 All Other Converted Paper Product Manufacturing; 325998 All Other Miscellaneous Chemical Product and Preparation Manufacturing; 326140 Polystyrene Foam Product Manufacturing; 326299 All Other Rubber Product Manufacturing; 332439 Other Metal Container Manufacturing; 332618 Other Fabricated Wire Product Manufacturing; 332999 All Other Miscellaneous Fabricated Metal Product Manufacturing; 339999 All Other Miscellaneous Manufacturing	2699 Manufacture of other non-metallic mineral products n.e.c.; 2520 Manufacture of plastics products; 2899 Manufacture of other fabricated metal products n.e.c.; 3699 Other manufacturing n.e.c.
37.2	Recycling of non-metal waste and scrap	423930 Recyclable Material Merchant;	3720 Recycling of non-metal waste and scrap
45.12	Test drilling and boring	Wholesalers; 562920 Materials Recovery Facilities 213115 Support Activities for Nonmetallic Minerals (except Fuels) Mining	4510 Site preparation

45.21	General construction of buildings and civil engineering works	236115 New Single-Family Housing (except Operative Builders); 236116 New Multifamily Housing Construction (except Operative Builders); 236118 Residential Remodelers; 236200 Nonresidential Building Construction; 237120 Oil and Gas Pipeline and Related Structures Construction; 237130 Power and Communication Line and Related Structures Construction; 238990 All Other Specialty Trade Contractors 238130 Framing Contractors; 238160 Roofing Contractors 237990 Other Heavy and Civil Engineering Construction 236210 Industrial Building Construction; 237110 Water and Sewer Line and Related Structures Construction; 238110 Poured Concrete Foundation and Structure Contractors; 238120 Structural Steel and Precast Concrete Contractors; 238140 Masonry Contractors; 238170 Siding Contractors; 238220 Plumbing, Heating, and Air-Conditioning Contractors; 238910 Site Preparation Contractors; 562910 Remediation Services	4520 Building of complete constructions or parts thereof; civil engineering; 4530 Building installation; 4550 Renting of construction or demolition equipment with operator
45.22	Erection of roof covering and frames		4520 Building of complete constructions or parts thereof; civil engineering 4510 Site preparation
45.24	Construction of water projects		
45.25	Other construction work involving special trades		4520 Building of complete constructions or parts thereof; civil engineering; 4530 Building installation; 9000 Sewage and refuse disposal, sanitation and similar activities
45.34	Other building installation	236220 Commercial and Institutional Building Construction; 237310 Highway, Street, and Bridge Construction; 238210 Electrical Contractors; 238390 Other Building Finishing Contractors	4520 Building of complete constructions or parts thereof; civil engineering; 4530 Building installation; 3420 Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers 4530 Building installation 4540 Building completion
45.41	Plastering	238310 Drywall and Insulation Contractors	
45.42	Joinery installation	238290 Other Building Equipment Contractors; 238350 Finish Carpentry Contractors	
45.43	Floor and wall covering	238330 Flooring Contractors; 238340 Tile and Terrazzo Contractors	
45.44	Painting and glazing	238150 Glass and Glazing Contractors; 238320 Painting and Wall Covering Contractors	4540 Building completion
45.45	Other building completion	238190 Other Foundation, Structure, and Building Exterior Contractors; 561790 Other Services to Buildings and Dwellings	4520 Building of complete constructions or parts thereof; civil engineering; 9000 Sewage and refuse disposal, sanitation and similar activities

(Continued)

Table 6 (Continued)

NACE Rev. 1. 1 Codes	Titles	NAICS 2002 codes and titles	ISIC 3.1 codes and titles
51.53	Wholesale of wood, construction materials and sanitary equipment	423310 Lumber, Plywood, Millwork, and Wood Panel Merchant Wholesalers; 423320 Brick, Stone, and Related Construction Material Merchant Wholesalers; 423330 Roofing, Siding, and Insulation Material Merchant Wholesalers; 423390 Other Construction Material Merchant Wholesalers; 423720 Plumbing and Heating Equipment and Supplies (Hydronics) Merchant Wholesalers; 423990 Other Miscellaneous Durable Goods Merchant Wholesalers; 424950 Paint, Varnish, and Supplies Merchant Wholesalers	5139 Wholesale of other household goods; 5143 Wholesale of construction materials, hardware, plumbing and heating equipment and supplies; 5159 Wholesale of other machinery, equipment and supplies; 5149 Wholesale of other intermediate products, waste and scrap
51.54	Wholesale of hardware, plumbing and heating equipment and supplies	423730 Warm Air Heating and Air-Conditioning Equipment and Supplies Merchant Wholesalers; 423830 Industrial Machinery and Equipment Merchant Wholesalers	5143 Wholesale of construction materials, hardware, plumbing and heating equipment and supplies
52.46	Retail sale of hardware, paints and glass	444110 Home Centers; 444120 Paint and Wallpaper Stores; 444130 Hardware Stores; 444190 Other Building Material Dealers; 444210 Outdoor Power Equipment Stores	5234 Retail sale of hardware, paints and glass; 5233 Retail sale of household appliances, articles and equipment; 5260 Repair of personal and household goods
70.11	Development and selling of real estate	236117 New Housing Operative Builders; 237210 Land Subdivision	4520 Building of complete constructions or parts thereof; civil engineering; 7010 Real estate activities with own or leased property
70.2	Letting of own property	531110 Lessors of Residential Buildings and Dwellings; 531120 Lessors of Nonresidential Buildings (except Miniwarehouses); 531190 Lessors of Other Real Estate Property	7010 Real estate activities with own or leased property
70.3	Real estate activities on a fee or contract basis	531210 Offices of Real Estate Agents and Brokers; 531320 Offices of Real Estate Appraisers; 531390 Other Activities Related to Real Estate; 531311 Residential Property Managers; 531312 Nonresidential Property Managers; 561210 Facilities Support Services; 532310 General Rental Centers; 532412 Construction, Mining, and Forestry Machinery and Equipment Rental and Leasing	7020 Real estate activities on a fee or contract basis; 7514 Supporting service activities for the government as a whole; 7122 Renting of construction and civil engineering machinery and equipment; 7129 Renting of other machinery and equipment n.e.c.; 7111 Renting of land transport equipment
74.2	Architectural and engineering activities and related technical consultancy	541310 Architectural Services; 541320 Landscape Architectural Services; 541330 Engineering Services; 541340 Drafting Services; 541350 Building Inspection Services; 541360 Geophysical Surveying and Mapping Services; 541370 Surveying and Mapping (except Geophysical Services; 541690 Other Scientific and Technical Consulting Services	4510 Site preparation; 7421 Architectural and engineering activities and related technical consultancy

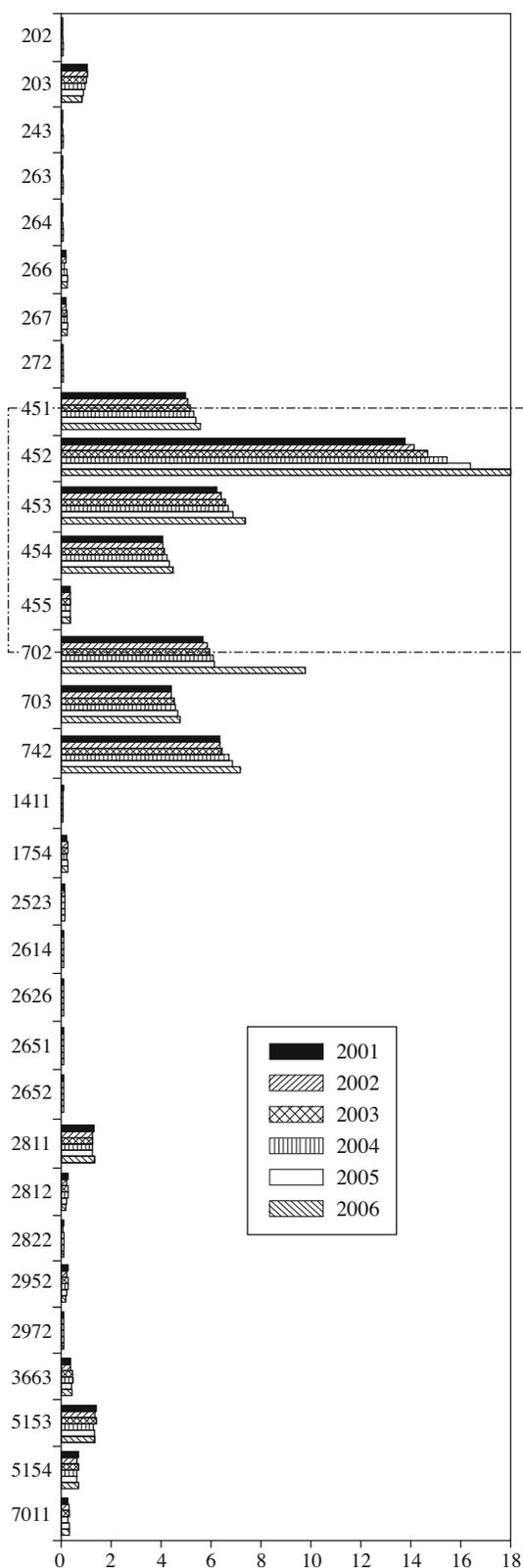


Figure 5 Number of firms in the construction sector, over time (2001–06) (Statistics Finland 2009)

Note: The dotted area points out the NACE Rev. 1.1 codes contained in Section F–Construction.

- (2) average turnover per firm, i.e. the total industry turnover divided by the total number of firms;
- (3) average number of employees per firm, corresponding to the total number of employees over the total number of firms in the industry;
- (4) average turnover per employee, i.e. the total industry turnover divided by the total number of employees.

The values of average salary per employee suggest that non-core construction firms employ more skilled workers, since higher average salaries are generally associated with higher skills (see e.g. Acemoglu, 2003, about skill premia). This is indirectly confirmed by the small difference in the growth of the average salary per employee, which might reflect the importance of collective bargaining for wage determination in Finland. If differences in the average salary per employee were due to changes in the composition and skill of the workforce, changes in growth rates would also be evident. The average turnover per firm highlights that core and service construction firms are on average smaller than manufacturing ones. This might be expected given the fragmented structure of the construction industry, its project-based nature and its many trades and specialisms (Dick and Payne, 2005). The average turnover per employee of non-core manufacturing also proves to have grown comparatively more over the period considered. A similar pattern emerges when looking at the average number of employees per firm. Non-core manufacturing firms are on average the largest but, in terms of growth, it is non-core services that lead the way—growing by a remarkable 18% during the period considered. Finally, the average turnover per employee, which can be considered as a rough measure of productivity, suggests non-core construction-related manufacturing performs almost 30% better than core construction activities with non-core construction-related services generating more than double turnover per employee than the core construction. A similarly stark pattern emerges when looking at growth rates. Taken altogether, the data suggest that (non-core) activities dependent on construction may be a hidden engine of growth in the economy, and that using a broad definition of construction, greater productivity and employment are apparent than when using ‘traditional’ measures (based solely on NACE section F).

To verify whether this is true also with respect to innovative activities, CIS4 data are analysed. The innovative input- and output-related figures are summarized in Table 8. The top and bottom half of the table first shows (row 1) the data related to core construction activities, followed by the non-core construction one (row 2). The third row presents the

Table 7 Finnish construction firms: 'core' and 'non-core' activities' figures (Statistics Finland, 2009)

	Av. salary per employee (growth rate %)	Av. turnover per firm (growth rate %)	Av. turnover per employee (growth rate %)	Av. numb. employees per firm (growth rate %)
Construction	28.9 (3.26)	572.3 (1.72)	145.1 (-1.86)	3.9 (3.63)
Non-core manufacturing	30.4 (3.52)	8408 (8.5)	188.6 (3.57)	37.3 (6.11)
Non-core service	33.3 (3.32)	1795 (6.37)	367 (18.0)	14.2 (6.1)

Notes: Averages for the period 2001–07. Turnover and salary figures in thousands of Euros.

values related to our wide definition of construction, whereas row 4 indicates the values for all the sectors but wide construction. Finally row 5 shows the average values of all industries, including construction.

Evidence about the higher importance of both innovation input and output for non-core construction firms is compelling with two main features emerging. First, core construction companies invest much less in R&D, innovate less, and profit less from innovative output than non-core construction firms. Secondly, with respect to R&D and innovation, non-core construction firms' performance is very similar to the average performance of all sectors considered. Consistent with a sector characterized by project-based activities, few core construction firms invest in R&D, and do so more on an occasional than a continuous basis. Whether related to internal R&D, external R&D, investment in ICT machinery or to the acquisition of external knowledge, the propensity of firms to invest in R&D is much lower in construction than in all other sectors. The same underperforming pattern of core construction firms is observed when considering the share of product and process innovators, and to the share of turnover generated by new-to-the-market and new-to-the-firm goods. Finally, further investigating construction firms' ability to appropriate the results of their innovative activities, Table 9 shows the percentage of firms relying on intellectual property rights (IPR)—namely patents, trademarks and designs.

Table 9 follows the same structure of Table 8 and a relatively poor performance of core construction firms is again observed. Meanwhile non-core firms score higher than the average for all sectors, in all indicators considered. Of particular note are the 11.8% and 4.9% of firms relying respectively on trademarks and designs.

The evidence presented strongly supports the necessity of considering construction in its entirety, i.e. according to a wide definition, rather than confining it to its core activities. In doing so it would be possible to more precisely identify the factors driving the employment, growth and competitiveness of the sector, and to design and implement more effective policies.

Conclusions

This paper addresses the often voiced concern about the need to define and quantify the construction sector in such a way as to capture the full economic breadth and technical depth and diversification of the industry. A better definition of the sector could help the construction industry attract more attention from researchers and decision makers and regain its place on the central policy stage that it deserves. The importance of construction in economies worldwide is often under-appreciated by many, and this is possibly due to several concurrent factors. First, construction is mistakenly perceived as a barely dynamic low-tech low-growth sector. This leads many scholars to be drawn towards 'hotter' sectors and to overlook construction. Secondly, the sector features peculiar characteristics that make it unique as well as complex and difficult to understand, depict and manage in its systemic dimension. Among these there are: the technical interdependence and organizational independence of the diverse and wide range of actors and specialties involved in construction; the mainly project-based organization of construction works; regulations and standardization playing a very important role in construction; and the fact that innovation in construction typically happens in an incremental and 'hidden' fashion, and leads to dramatic transformations only in the long run. Thirdly, the scarce quality, availability, reliability and comparability of construction-related data make it difficult to quantify the sector and to construct indicators—whether related to productivity, skills or firm dynamics. Such a difficulty in precisely assessing the performance of the sector also stems from the absence of a widespread systemic statistical definition of construction, able to picture the sector in its entirety while highlighting its main components.

The wide definition of construction proposed has aimed to make up for this apparent shortcoming. We build on Pearce's (2003) seminal contribution and put forward a comprehensive definition of construction. In contrast to Pearce though, a value chain approach is followed which pictures construction as a system made

Table 8 Innovation input and output indicators for core and non core activities (Eurostat, 2009; Community Innovation Survey (CIS4))

Sector	Num. obs.	Investment in R&D (%)					
		Internal R&D	External R&D	Investment in machines	Acquisition of external knowledge	Continuous R&D	Occasional R&D
(1) Core	10 904	8.5	3.5	16.6	4	40.8	59.2
(2) Non-core	8510	21	11.8	29.3	8.4	54.8	45.2
(3) Wide construction	19 414	15.5	8.2	23.7	6.5	51.4	48.6
(4) All <i>but</i> wide construction	47 873	27.2	14.5	32.3	10.5	64.2	35.8
(5) All industries	67 287	23.8	12.7	29.8	9.4	61.8	38.2

Sector	Num. obs.	Innovative activities (%)			
		Product innovators	Process innovators	Share turnover Innovations new to market	Share turnover Innovations new to firm
(1) Core	11 846	4.8	5.9	0.7	1.9
(2) Non-core	9036	17.4	9.0	2.2	3.7
(3) Wide construction	20 882	11.9	7.7	1.6	2.9
(4) All <i>but</i> wide construction	52 828	20.3	13.4	3.3	5.1
(5) All industries	73 710	17.9	11.8	2.8	4.5

Note: Data related to 11 countries, i.e.: BE, CZ, ES, HU, IT, LT, LV, NO, PT, SI, SK. These are the countries included in Eurostat CIS4 survey also in the core construction sector. NACE codes considered: F or equivalently 45 for the core construction sector; 26, 28, 51, 70, DI and 742 for the non-core part. Not all non-core activities codes could be considered, due to the aggregation level of Eurostat data.

All variables considered correspond to survey questions allowing for a yes or no answer, and are coded as follows: yes = 1; no = 0.

Table 9 Innovation input and output indicators for core and non core activities (Eurostat, 2009; Community Innovation Survey (CIS4))

Sector	Num. obs.	Use of IPR (%)		
		Patents	Trademarks	Designs
(1) Core	10 789	1.2	2.4	0.7
(2) Non-core	8633	6.7	11.8	4.9
(3) Wide construction	19 422	4.2	7.6	3.0
(4) All BUT wide construction	47 501	7.1	12.2	4.6
(5) All industries	66 923	6.3	10.9	4.2

Note: Data related to 11 countries, i.e.: BE, CZ, ES, HU, IT, LT, LV, NO, PT, SI, SK. These are the countries included in Eurostat CIS4 survey also in the core construction sector.

NACE codes considered: F or equivalently 45 for the core construction sector; 26, 28, 51, 70, DI and 742 for the non-core part. Not all non-core activities codes could be considered, due to the aggregation level of Eurostat data.

All variables considered correspond to survey questions allowing for a yes or no answer, and are coded as follows: yes = 1; no = 0.

up of subsystems. The definition includes the core NACE section F codes and supplements this with selected four-digit NACE classes that relate to manufacturing and services activities in the pre-production, support and post-production construction segments. Being NACE based, our classification has the advantage of not requiring statistical data to be gathered or aggregated in a different way. Moreover, to facilitate its worldwide applicability and to allow for comparisons across countries and over time, ISIC and NAICS equivalents of the wide construction definition are proposed. The descriptive statistics presented help to characterize core and non-core construction activities, and highlight the differences that exist between them—especially in terms of productivity, employment and innovative behaviour. Non-core construction firms are shown to be systematically more productive, to invest more in R&D, and to be more innovative than their core construction counterparts.

The proposed wide definition of construction is not intended to replace the way in which statistical offices implement their national accounts. It is clear that undertaking a similar exercise for other industries would lead to duplications and overlaps, thus ultimately impinging upon the integrity of national accounts. The wide definition is instead intended as a complement to the way in which sectors are statistically defined—a classification reflecting the breadth and width of the whole construction sector value chain generated in order to formulate the most appropriate policy interventions. As the statistical evidence suggests, there is a need for more broadly defined sectoral policies in order to exploit the innovation, growth and productivity potential of non-core activities. Excluding, or otherwise overlooking, non-core construction activities when attempting to foster the innovativeness and productivity of the construction environment could seriously limit the effectiveness of such policies. Moreover, in periods of crisis, identifying and quantifying the different components of the construction value chain

may help policy interventions aimed at alleviating potentially harmful social and economic impacts and costly domino effects.

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Notes

1. The acronym NACE stands for ‘Nomenclature générale des Activités économiques dans les Communautés Européennes’, i.e. statistical classification of economic activities in the European Communities. See the Statistics section of Eurostat: epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home.
2. See the metadata provided by Eurostat at ec.europa.eu/eurostat (accessed 10 February 2009).

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Appendix

Table A1 Wide definition of the construction sector—NACE Rev. 1.1 and NACE Rev. 2 codes in numerical order (based on Eurostat data, Eurostat, 2009)

NACE Rev. 1.1 (2002)*	NACE Rev. 2 (2008)^
14.11 Quarrying of ornamental and building stone	8.11 Quarrying of ornamental and building stone, limestone, gypsum, chalk and slate
17.54 Manufacture of other textiles n.e.c.	9.9 Support activities for other mining and quarrying
20.2 Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board, fibre board and other panels and boards	13.96 Manufacture of other technical and industrial textiles
20.3 Manufacture of builders' carpentry and joinery	16.21 Manufacture of veneer sheets and wood-based panels
24.3 Manufacture of paints, varnishes and similar coatings, printing ink and mastics	16.22 Manufacture of assembled parquet floor
25.23 Manufacture of builders' ware of plastic	16.23 Manufacture of other builders' carpentry and joinery
26.14 Manufacture of glass fibres	20.3 Manufacture of paints, varnishes and similar coatings, printing ink and mastics
26.26 Manufacture of refractory ceramic products	22.23 Manufacture of builders' ware of plastic
26.3 Manufacture of ceramic tiles and flags	23.14 Manufacture of glass fibres
26.4 Manufacture of bricks, tiles and construction products, in baked clay	23.2 Manufacture of refractory products
26.51 Manufacture of cement	23.31 Manufacture of ceramic tiles and flags
26.52 Manufacture of lime	23.32 Manufacture of bricks, tiles and construction products, in baked clay
26.53 Manufacture of plaster	23.51 Manufacture of cement
26.6 Manufacture of articles of concrete, plaster and cement	23.52 Manufacture of lime and plaster
26.7 Cutting, shaping and finishing of ornamental and building stone	23.6 Manufacture of articles of concrete, cement and plaster
28.11 Manufacture of metal structures and parts of structures	23.7 Cutting, shaping and finishing of stone
28.12 Manufacture of builders' carpentry and joinery of metal	25.11 Manufacture of metal structures and parts of structures
28.22 Manufacture of central heating radiators and boilers	25.12 Manufacture of doors and windows of metal
29.52 Manufacture of machinery for mining, quarrying and construction	25.21 Manufacture of central heating radiators and boilers

(Continued)

Table A1 (Continued)

NACE Rev. 1.1 (2002)*		NACE Rev. 2 (2008)^	
29.72	Manufacture of non-electric domestic appliances	27.52	Manufacture of non-electric domestic appliances
36.63	Other manufacturing n.e.c.	28.21	Manufacture of ovens, furnaces and furnace burners
37.2	Recycling of non-metal waste and scrap	28.92	Manufacture of machinery for mining, quarrying and construction
45.1	Site preparation	28.99	Manufacture of other special-purpose machinery n.e.c.
45.2	Building of complete construction or parts thereof; civil engineering	38.32	Recovery of sorted materials
45.3	Building installation	41.1	Development of building projects
45.4	Building completion	41.2	Construction of residential and non-residential buildings
45.5	Renting of construction or demolition equipment with operator	42.1	Construction of roads and railways
51.53	Wholesale of wood, construction materials and sanitary equipment	42.2	Construction of utility projects
51.54	Wholesale of hardware, plumbing and heating equipment and supplies	42.9	Construction of other civil engineering projects
52.46	Retail sale of hardware, paints and glass	43.1	Demolition and site preparation
70.11	Development and selling of real estate	43.2	Electrical, plumbing and other construction installation activities
70.2	Letting of own property	43.3	Building completion and finishing
70.3	Real estate activities on a fee or contract basis	43.32	Joinery installation
74.2	Architectural and engineering activities and related technical consultancy	43.9	Other specialized construction activities
		46.73	Wholesale of wood, construction materials and sanitary equipment
		46.74	Wholesale of hardware, plumbing and heating equipment and supplies
		47.52	Retail sale of hardware, paints and glass in specialized stores
		68.2	Renting and operating of own or leased real estate
		68.31	Real estate agencies
		71	Architectural and engineering activities; technical testing and analysis
		77.32	Renting and leasing of construction and civil engineering machinery and equipment
		77.39	Renting and leasing of other machinery, equipment and tangible goods n.e.c.
		80.2	Security systems service activities
		81.1	Combined facilities support activities