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A definition and valuation of the UK offsite construction sector

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The offsite construction sector is now established as a significant contributor to the delivery of UK construction industry output. The exact value of this contribution is questionable and has been subject to substantial debate in recent literature. Existing offsite construction sector valuation methodologies have been based upon market research questionnaires and estimates of turnover and manufacturing output. Considerable attention has been given to the definition of the terms used to describe the various constituent technologies and manufacturing processes. However there has been limited reference to its size, sector classification, employment statistics and value added to the UK gross domestic output. A method is presented for the determination of the UK offsite construction sector gross output and value added. Historical data for the period 1998 to 2008 with growth forecasts up to 2013 are offered. A breakdown of the sector, examining the common standard industrial activity classification codes (SIC), the gross output and value added for each sub-sector is provided. The results show that there has been significant underestimation of the gross output and value added when compared to previous studies. An understanding of the broad and diverse nature of the offsite construction sector is provided with data that demonstrate an overview of the sector's historical performance. The data will assist government and industry in benchmarking, market research and forecasting the further growth and diffusion of offsite construction techniques.

Keywords: Offsite construction, prefabrication, gross output, value added.

Introduction

The development of manufactured buildings has been well documented in historical literature. Herbert (1978) provided an extensive historical review of the international development of prefabrication from John Manning's portable colonial cottage in the 1830s to the splendid standardized cast iron castings catalogues of the Macfarlane's Saracen Foundry located in Glasgow in the 1890s. He provided detailed evidence of the historical architectural evolution from ad hoc building to planned multiple production. Powell (1980) and Stone (1983) both cite the economic significance of the offsite fabrication undertaken in the emergency housing periods following the Second World War. Powell stated that one of the lessons learned from prefabrication was that traditional methods were seldom susceptible to radical alteration, and more amenable to gradual evolution if anything.

Finnimore (1989) reviewed the historical link with mass social housing demand and the importance of a manufactured and systemized approach to construction. The early 1990s witnessed the rise of modular construction techniques for social housing, hotels and prison buildings (Neale *et al.*, 1993). Establishing the need for onsite automation to support offsite manufactured systems, Warszawski (1999) provided technical guidance on automated systems and demonstrated the financial benefits of construction automation and mechanization.

Importantly, Ross (2002) contributed to the understanding of the non-traditional offsite manufactured building systems that remained in use in the UK housing stock. Various successes and failures have been reported (Gibb, 2001) and the construction industry is all too aware of the challenges of offsite construction, standardization and pre-assembly. Gruneberg (1997) stated that since the Second World War there has been an increase

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in the use of prefabricated components as a proportion of total construction costs with materials and components becoming cheaper relative to land and labour.

Prefabrication and offsite construction have been identified in recent literature as a means of improving the often inefficient and wasteful practices of the construction industry (Ashworth and Hogg, 2000; Gibb and Isack, 2003; Corner *et al.*, 2005; Blismas *et al.*, 2006). Goodier and Gibb (2007) presented the results of a questionnaire study of the views and opinions of the various parties to construction and identified the importance of managing the confusion and misrepresentation of the true value and size of the market for offsite construction.

Improving resource efficiency in all stages of the construction process including design, manufacture and construction will contribute to the sustainability credentials of the construction sector. Myers (2008) identified that offsite construction methods would assist a firm to achieve resource efficiency, improve product quality and achieve greater profit levels. Ive and Gruneberg (2000) attributed the increased use of prefabrication techniques as a construction industry response to increases in the wages of site labour relative to site productivity.

The UK offsite construction sector now has an established campaigning organization, known as Buildoffsite, that promotes the greater uptake of offsite construction techniques. The development of the Buildoffsite Registration Scheme operated by Lloyds Register EMEA has provided the first internationally recognized scheme for providing confidence to client organizations, end users and insurers when employing offsite construction systems undertaken by a registered service provider (Mundy, 2007). Fox and Skitmore (2007) concluded that investor confidence was a contributing factor to the development of the construction industry. The Buildoffsite Registration Scheme will inevitably contribute to improving business confidence in the use of offsite construction techniques; however, further data must be captured to measure the uptake and the impact of this scheme upon the performance of the industry.

Guidance on matters relating to procurement and design coordination have been recently published and provide clients and design consultants with invaluable insight into the fundamental differences associated with offsite construction procurement when compared to traditional construction procurement procedures (Neale *et al.*, 1993; Ross *et al.*, 2006; Tam *et al.*, 2007; Buildoffsite, 2008). Manley (2008) reported on case studies examining the implementation of manufacturer's innovation and concluded that the relationship-building activities of the manufacturers had facilitated knowledge diffusion that engendered informed clients who were then willing to specifically design procurement systems which enabled them to use the manufacturers' unique products.

The offsite construction industry is now established as a significant contributor to the continuous improvement of construction processes and site procedures. In order to determine the magnitude of the contribution, it is essential that a robust method is developed to provide government ministers, directors of trade organizations, consultants, contractors and manufacturers with a true understanding of the constitution, gross output and value added from this sector. The key objective of the present study is to provide baseline data to allow the sector to examine past and present performance from which to develop future growth predictions. Furthermore, it is essential that the offsite sector is described and categorized in a similar manner to that employed by the traditional construction sector identifying the structure and the output contribution of sub-sectors. This research identifies the shortcomings and discrepancies in the existing methods and the previous attempts to describe and value the offsite construction sector.

Building upon the work of the Mtech Group (2006) and Goodier and Gibb (2007), the author seeks to provide greater depth to their results, which identified the need for a more robust methodology for the valuation of the UK offsite construction sector. A review of previous works is presented and demonstrates the greater need to rely on financial accounts based data to develop accurate and valid data.

A broad definition and method for the valuation of the UK offsite construction sector is presented. Historical data are presented for the period 1998 to 2008 to provide a review of the development of each sub-sector. Data are also presented to describe total employment and the size and structure of the sector in 2007, and growth forecasts are provided for the period up to 2013. These appear to show that the previous methods have significantly underestimated the value that the offsite construction sector contributes to UK construction activity output. The research objective is to rationalize, standardize and organize previously disparate data to provide a robust methodology to provide a benchmark market valuation for the UK offsite construction sector. The data are intended for use by the UK government, trade organizations, manufacturers, suppliers, contractors and subcontractors who require accurate knowledge of the historical development and growth of the offsite construction sector. Furthermore, the offsite construction sector is defined and categorized in relation to accountancy standards and established industry classification coding systems. The true extent of the offsite construction sector is broader than previously acknowledged and its gross output is considerably greater than previously calculated. The following sections provide a review of the terms and definitions adopted and a critical

review of the existing valuation methods identified in previous research.

Offsite construction: defining the industry

There are various terms and acronyms associated with offsite construction—offsite prefabrication (OSP), offsite manufacturing (OSM), offsite construction (OSC) and modern methods of construction (MMC) to name a few (Goodier and Gibb, 2007; Buildoffsite, 2008). The definition of offsite construction has received considerable attention in the existing literature. Historically, the terms used to define the process of manufacturing buildings and construction elements have been subject to change and evolution. Figure 1 provides a summary of the terms used in the existing literature from 1968 to 2009. The term 'prefabrication' has been common since the late 1960s. However, the term 'offsite construction' was coined in 1998 and its use became more common by 2003. The terms used to describe the offsite manufacture of building and construction elements has been subject to extensive debate and discussion in the existing literature.

Table 1 provides a summary of the terms and definitions used in existing literature to describe the various design approaches and define the construction processes. The present study aims to build upon these categories and to provide clarity, e.g. the expansion of timber frame to differentiate between open panel, closed panel and structural elements such as engineered joists and gang nailed roof trusses.

Table 2 provides a breakdown of the sub-sector categories and provides a brief description of each category adopted in the present study. A total of 245 UK registered companies were selected from the offsite directory (Goss, 2008) and categorized accordingly. Merchants are considered in relation to the delivery, supply and sorting in the provision of vendor maintained stores that contribute to supply chain efficiencies. The miscellaneous category includes companies that are producing components or systems that are not covered in other categories and would add unnecessary confusion to the sub-sector classification and, hence, do not justify their own category. Such companies may be providing a broad range of construction related services and do not specialize in one particular offsite sub-sector.

The system of standard industrial classification (SIC, 2003) codes used for government taxation, revenue and customs classification purposes has been considered for the present study. The United Kingdom Standard Industrial Classification of Economic Activities (SIC) is used to classify business establishments and other standard units by the type of economic activity in which they are engaged. It provides a framework for the collection, tabulation, presentation and analysis of data and its use promotes uniformity. In addition, it can be used for administrative purposes and by non-government bodies as a convenient way of classifying industrial activities into a common structure. Further information on the UK Standard Industrial Classification of Economic Activities and the more

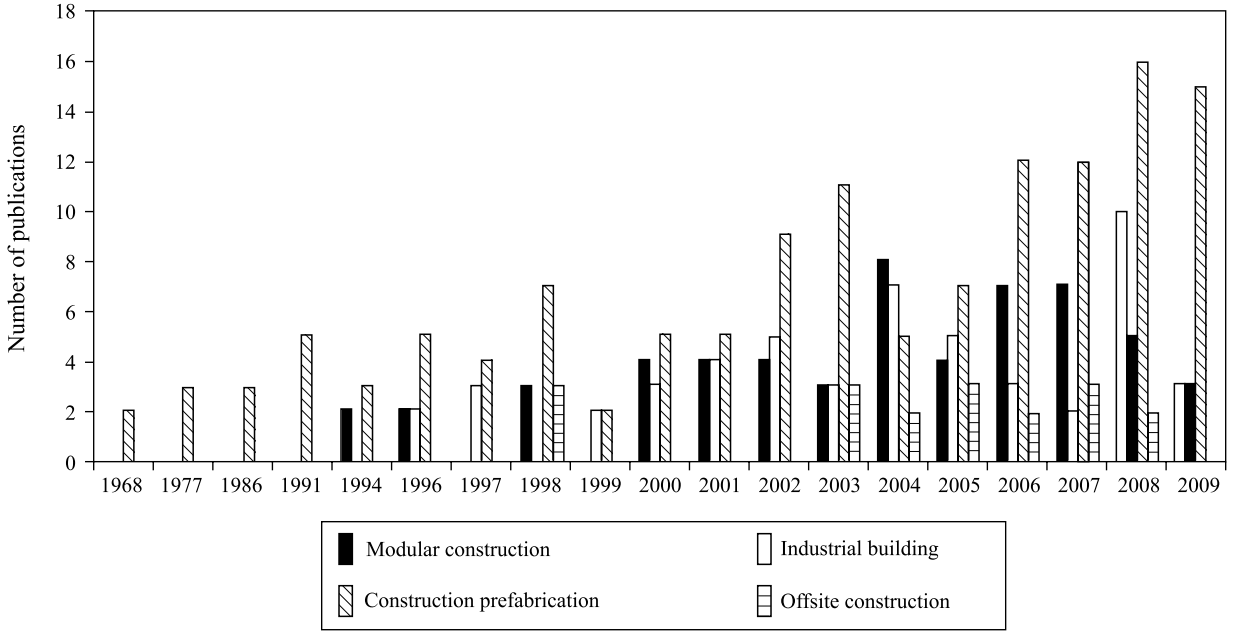

Figure 1 Offsite construction publications between 1968 and 2009 (ISI Web of Knowledge, 2009)

Table 1 Offsite construction industry definitions

Year	Reference	Definition
1993	Neale *et al.*, 1993	The complete manufacture of substantial constructional elements in factories.
1999	Warzsawski, 1999	Industrialization process defined as an investment in equipment, facilities, and technology with the purpose of increasing output, saving manual labour and improving quality.
1999	Gibb, 1999	A process which incorporates prefabrication and pre-assembly. The process involves the design and manufacture of units or modules, usually remote from the work site, and their installation to form the permanent works at the work site. A project strategy that will change the orientation of the project process from construction to manufacture and installation.
2001	Gibb, 2001	OSC Categories include: (1) component manufacture and sub-assembly, e.g. door furniture and light fittings; (2) non volumetric pre-assembly, e.g. wall panels, structural sections and pipe work assemblies; (3) volumetric pre-assembly, e.g. toilet pods, plant room units, service risers and modular lift shafts; (4) modular buildings, e.g. units themselves form usable buildings and enclose usable space and clad externally such as McDonalds drive-thru or prison cell modules.
2003	Gibb and Isack, 2003	Pre-assembly subdivided into four categories: (1) component manufacture and subassembly, e.g. factory manufactured components such as bricks, tiles door furniture and windows; (2) non-volumetric pre-assembly, e.g. structural frames, cladding, wall panels, bridge deck units, M&E services, units do not create usable space; (3) volumetric pre-assembly, e.g. plant rooms, toilet pods, units create usable space; and (4) modular building, e.g. pre-assembled units which form the structure of the building and create usable space.
2004	Venables *et al.*, 2004	In early 2003 the term 'modern methods of construction' started to be used … of which offsite manufacture (OSM) is a subset. OSM defined as panellised and volumetric systems, and major prefabricated components.
2006	Ross *et al.*, 2006	Housing Corporation construction classification system for dwellings: (1) offsite manufactured – volumetric; (2) offsite manufactured – panellised; (3) offsite manufactured – hybrid; (4) offsite manufactured – sub-assemblies and components; (5) non offsite manufactured modern methods of construction.
2006	Blismas *et al.*, 2006	The completion of substantial parts of 'construction' works prior to their installation on site.
2008	Jaillon and Poon, 2008	Prefabrication is a manufacturing process, generally conducted at a specialised facility, in which various materials are joined to form a component part of the final installation. The term offsite fabrication is used when both prefabrication and pre-assembly are integrated.

Table 2 Offsite construction sub-sector categories and descriptions (adapted from Goss, 2008)

Offsite Category	General Description	No.
Bathroom/kitchen pods	Volumetric modules	8
Cladding & façade	Modular, pre-engineered façade systems	21
Components	Ducting, fittings, insulation and windows	13
Light steel frame	Cold formed steel sections	17
Merchants	Construction materials and components	5
Pre-cast concrete	Considered to be providing offsite systems	15
Pre-engineered M&E systems	Pre-assembled, modular M&E systems	35
SIPS	Structural insulated panels (walls and roofs)	10
Timber frame (closed panel)	Sheathing material, insulation and M&E pre-installed	6
Timber frame (general)	Green oak and similar constructions	3
Timber frame (open panel)	Traditional open panels (no insulation or sheathing)	33
Timber frame (structural elements)	Beams, trusses and prefabricated elements	20
Volumetric (permanent)	Non-relocatable modular building systems	14
Volumetric (temporary)	Such as site accommodation buildings	22
Miscellaneous	Ground engineering, design services, special trades	23
Total		245

recent edition (SIC, 2007) can be obtained from the Great Britain Office for National Statistics (2009). The use of such classifications assists in defining the industrial sectors that contribute to the broad definition of offsite construction.

Firms traditionally considered as officially comprising the construction sector tend to embrace a range of onsite activities including those relating to infrastructure, new construction, repair, maintenance and eventually demolition (Myers, 2008). Table 3 shows the SIC codes that are attributed to the companies that have been considered for the present study as extracted from Goss (2008). These SIC codes show that the UK offsite construction sector covers a broad range of services and industrial sectors relating more to manufacturing and mechanical engineering services. However, codes relating to traditional onsite construction activities are evident. It is apparent that there are no great single contributors to the offsite construction sector, more a combination of existing industrial sectors adapting their service provision to meet the demands of the construction sector becoming more in step with the capabilities of the manufacturing sectors.

When referring to an industry's structure, economists usually refer to the distribution of firms by size measured by output or turnover (Morton, 2002). This measure relates mainly to the degree of concentration or the proportion of industry's output attributable to each company. Table 4 provides a summary of the employment figures obtained for the companies selected for the present study. The value of their contribution, in terms of turnover (gross output), is provided.

Existing valuations

A review of the existing surveys, data and valuation methodologies is presented in Table 5. The most

Table 3 Dominant standard industrial classification codes for offsite sector (FAME, 2009)

Standard Industrial Classification (SIC 2003) Primary Code	No.
20.10 – Sawmilling and planing of wood, impregnation of wood	5
20.20 – Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board, fibre board and other panels and boards	2
20.30 – Manufacture of builder's carpentry and joinery	14
20.51 – Manufacture of other products of wood	15
26.40 – Manufacture of bricks, tiles and construction products, in baked clay	4
26.61 – Manufacture of concrete products for construction purposes	10
27.32 – Cold rolling of narrow strip	2
28.11 – Manufacture of metal structures and parts of structures	7
28.52 – General mechanical engineering	6
28.75 – Manufacture of other fabricated metal products not elsewhere classified	6
36.63 – Other manufacturing not elsewhere classified	19
45.20 – Building of complete constructions or parts therof; civil engineering	2
45.21 – General construction of buildings and civil engineering works	34
45.22 – Erection of roof covering and frames	7
45.25 – Other contruction work involving special trades	25
45.31 – Installation of electrical wiring and fittings	5
45.32 – Insulation work activities	4
45.34 – Other building installation	3
45.43 – Floor or wall covering	3
45.45 – Other building completion	6
51.13 – Agents involved in the sale of timber and building materials	8
51.53 – Wholesale of wood, construction materials and sanitary equipment	4
51.90 – Other wholesale	5
70.11 – Development and selling of real estate	2
74.00 – Other business activities	2
74.87 – Other business activities not elsewhere classified	11
93.05 – Other service activities not elsewhere classified	5
Sub-total SIC codes with only one count (*i.e.* one company in SIC classification)	29
Total	245

Table 4 Size of firm, total employees and value added for 2008

Size by no. employees	No. of companies	Total employment	Value added (2008)
1	1	1	£ 174 393
2 to 3	0	0	£ –
4 to 7	1	7	£ 210 822
8 to 13	6	60	£ 400 147
14 to 24	14	381	£ 18 608 150
25 to 34	8	233	£ 12 302 799
35 to 59	16	747	£ 15 606 688
60 to 79	7	488	£ 8 638 143
80 to 114	20	1905	£ 56 090 802
115 to 299	42	8007	£ 215 375 847
300 to 599	17	7043	£ 208 809 295
600 to 1199	7	6326	£ 200 275 000
1200 and over	9	20 370	£ 674 982 000
Not available	97	–	£ 126 080 908
Total	245	45 568	£ 1 537 133 350

recent surveys and valuation attempt have defined the value of the offsite construction sector based upon a so-called 'top-down' methodology (Mtech Group, 2006; Goodier and Gibb, 2007). Considerable debate was given to what constitutes an offsite manufactured product or system, the diffusion of inventions and subsequent innovations, the definition of financial value and the requirement for extensive industry questionnaires to collate financial performance data for the companies in question.

Historically, data have been presented for the value, size and proportional contribution of the UK offsite construction sector to the UK construction industry output based upon the turnover of manufacturers and surveys of manufacturing output (Venables *et al.*, 2004; Goodier and Gibb, 2005; Mtech Group, 2006; Goodier and Gibb, 2007; Buildoffsite, 2008). Goodier and Gibb (2005) provided their valuation of the offsite sector based upon an amalgamation of existing market research reports and historical questionnaire surveys. However, this valuation made limited reference to accounting and audited financial data sources, i.e. company annual accounts. It was stated that simply adding together company turnovers would be misleading as most companies manufacture and provide a variety of offsite and site-based construction products and services. However, if consideration is given to the calculations to derive gross output and value added, this issue may be negated. However, it is inevitable that there may be slight overlap between offsite and traditional construction operations. This reflects the broad definition of construction and those manufacturing and subcontractors who contribute to construction and civil engineering operations.

The Mtech Group (2006) adopted a process of survey questionnaires with data being validated against accounts submitted to Companies House. The offsite directory was collated and utilized as the target sample frame (Goss, 2008). The methodology adopted relied upon the collation of responses from board level directors, senior management and accounts data from 104 companies. The final data validation process included the verification of data with previous research that had adopted a similar methodology.

Annual turnover and financial performance indicators can be collated without the need to undertake individual company questionnaires. Such a methodology would significantly reduce the errors associated with individual companies wishing to over inflate their performance and production capacity to ensure that

Table 5 Review of existing offsite industry valuation methods and data

Year	Topic	Reference	Comments
2003	M&E pre-fabrication market value	Samuelsson Brown *et al.*, 2003	Building services pre-fabrication market value estimation of £800.9 m (2002)
2004	UK capacity in offsite housing manufacturing	Venables *et al.*, 2004	Manufacturing capacity data drawn from 61 No. (51%) questionnaire responses. 21 No. organizations interviewed. Focus upon unit production forecast capacity figures and unit costs
2005	The value of the UK market for offsite	Goodier and Gibb, 2005	2005 market value of £2.2 bn. Top-down approach using existing market research data. Offsite classification system considered
2006	Offsite sector market survey and valuation	Mtech Group, 2006	365 companies, 107 responses (30.9%), accounts collated for 104 companies (30.1%), £1.53 bn 2005, £6 bn estimated value. Breakdown of accounts data not provided
2007	Market value and growth forecasts	Goodier and Gibb, 2007	Growth forecast presented (approx £4 bn by 2009). No derivation of forecast data calculations provided. Buildoffsite aspirational targets presented (£6 bn by 2009)

more positive results are reported for their company and sub-sector. The financial sector obtains due diligence data from a range of data sources. The data used in the methodology presented in the following section provides a valuation using only company accounts with the results being compared against previously published valuations for the offsite construction sector.

Research method

The research was based upon three main sources of data:

- Academic journals and specialist industry publications.
- Published offsite construction supplier and manufacturer databases.
- Financial accounts for UK registered companies.

The method is based upon data generated from a study of financial accounts for UK registered companies classified as offsite service providers in the UK offsite directory (Goss, 2008). Data for the study were obtained wholly from the FAME database. Compiled and hosted by Bureau van Dijk, FAME contains financial accounts for companies in the UK mainland and Northern Ireland. The provision of financial performance figures (a true and fair view of their status) comes under the control of the Financial Reporting Council and the Accounting Standards Board (Vaitilingam, 1996). The data incorporated in the valuation are consequently not open to misrepresentation and exaggerations provided by companies wishing to improve their corporate image and demonstrate superior production capacity.

Figure 2 depicts the process developed for the derivation of the valuation. Data were obtained in MS Excel format for each company. The company accounts contained a range of information that could be considered useful, but not relevant to the present study. Therefore, a Visual Basic macro code was assembled to extract and summarize the data of relevance to the present study.

As identified by Pearce (2003), two measures of industry output were adopted:

(1) Gross output—records the sum of all values of sales by all firms in an industry and corresponds to notions of 'turnover' or 'sales'.
(2) Value added—records the value added by the firm to the value of inputs received from suppliers.

Pearce (2003) indicated that while the gross output measure is useful for measuring the general level of economic activity in a sector, value added is the more relevant measure since it indicates the contribution that the sector makes to gross domestic product (GDP). This is because GDP is the sum of all value added across all sectors of the economy.

Value added has been calculated as defined by the UK Department for Business Innovation and Skills as:

- Value added = sales – cost of bought-in materials, components and services; or
- Value added = operating profit + employee costs + depreciation + amortization and impairment.

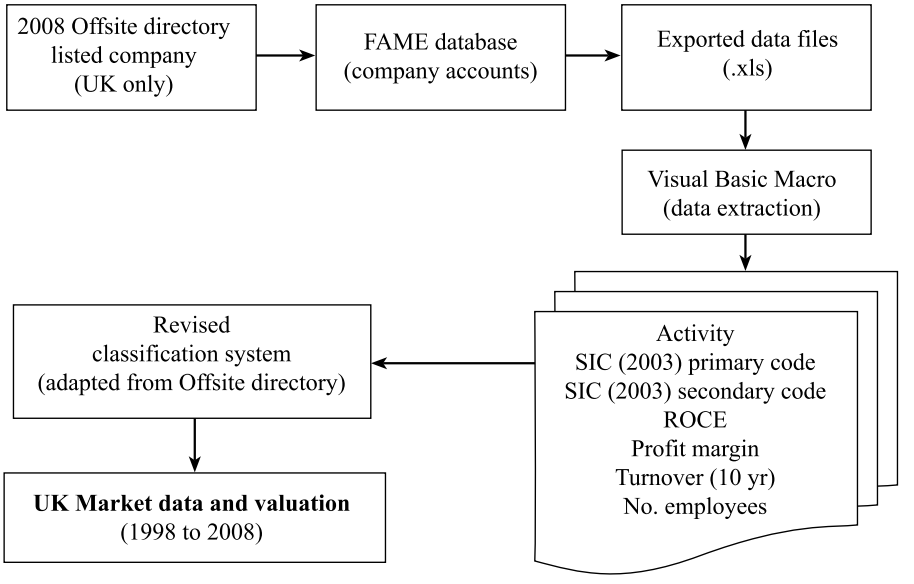

Figure 2 Valuation method

The following definitions are utilized:

- Operating profit—profit (or loss) before tax plus net interest paid (or minus net interest received) less gains (or plus losses) arising from the sale/disposal of businesses or assets.
- Employee costs—total remuneration costs (wages, salaries, social security and pension costs).
- Depreciation—depreciation and impairment charges on owned assets and assets held under finance leases.
- Amortization and impairment—depreciation of capitalized development, impairment of goodwill and amortization and impairment of other intangibles.

Table 5 provided a summary of the previous research methods considering the market valuation of the UK offsite construction sector. The significant assumptions and output of each study were summarized. Venables *et al.* (2004) provided an estimation of the production capacity of the UK offsite construction sector from a questionnaire survey response rate of 51% and a total of 61 responses. In 2006, the Mtech Group collated 107 responses from surveyed companies and validated the data provided by undertaking 104 comparisons with company accounts. The present study considers company financial accounts for a total of 245 companies. This represents a significant improvement over the previous studies undertaken to provide manufacturer capacity analysis and market valuations.

Purposive sampling was used to determine those companies that were to be considered in the sector valuation. The three selection criteria considered were:

- Company identified in the UK 2008 offsite directory.
- UK registered company.
- Company financial accounts and records available from FAME.

By selecting companies that are identified in the UK offsite directory (Goss, 2008), the methodology does not incorporate contractors and suppliers that are only providing traditional site-based construction services. UK registered companies are only considered, as the objective of this study is to provide a valuation of the UK offsite construction sector only. This excludes imported products and systems, but does incorporate those produced and exported from the UK.

It is not possible to draw statistical inferences from this method of sampling since, with a purposive non-random sample, the number of companies selected is less important that the criteria used to select them. The purposive sampling method has been considered as the research is concerned with particular members of the population and not the entire population. However, this sampling method does not include construction and civil engineering contractors who may develop offsite prefabricated bespoke solutions for a particular project as part of their buildability input to the project delivery strategy.

Results

Financial accounts were obtained for 245 companies operating within the UK offsite construction sector. The sub-sector market values were accumulated and the total sector value was calculated based upon the companies' turnover to identify sales volume. This provided a measure of gross output as an indication of the economic activity related to offsite construction. The total value added per annum is also provided as an indication of the total contribution to the UK GDP. The values derived from the research data are presented in Table 6 and Table 7.

Table 8 clearly indicates the growth of the offsite construction sector over the past 10 years and the significant impact that the recent global recession has had upon the performance of the sector.

Discussion of results

As identified in Table 3, the offsite construction sector comprises a broad range of industrial sectors. The SIC codes have identified the broad manufacturing base that constitutes the offsite construction sector. The derivation of the offsite construction sector as a combination of material processing, manufacturing, mechanical engineering, installation services, construction and civil engineering activities presents a more broad description of the sector. From the present study, it is clear that there are no great single contributors to the offsite construction sector. More a combination of existing industrial sectors adapting their service provision to meet the increasing demands of the construction sector as manufactured component assemblers.

In comparison with the previously published data, it appears that there has been a significant undervaluation of the contribution of offsite construction to total construction output. Figure 3 shows a comparison of the authors' valuation results (1998 to 2008) with previously published sector gross output valuations. Concerning fiscal year 2006, Goodier and Gibb (2005) estimated a market valuation of £3.2 bn with the Mtech Group (2006) providing a valuation of £1.5 bn. The Mtech Group valuation did provide an

Table 6 Offsite construction sector gross output from 1998 to 2008 (£ millions)

Offsite Categories	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Agents	1	3	1	2	4	4	5	5	6	6	1
Bathroom/kitchen pods	8	8	9	17	22	20	41	30	85	81	28
Cladding & façade	295	322	311	320	328	349	371	383	407	391	283
Components	127	136	208	220	216	243	264	244	414	520	378
Light steel frame	175	169	183	265	272	290	261	243	241	232	294
Merchants	0	50	56	61	68	75	83	85	87	114	32
Other	56	152	161	163	171	189	212	203	200	238	245
Pre-cast concrete	269	291	287	294	310	359	376	541	586	718	578
Pre-engineered M&E systems	892	1573	1663	1872	1929	1879	1827	2049	2344	2448	2207
SIPS	0	2	1	0	0	0	56	44	44	50	3
Timber frame (closed panel)	0	0	15	17	31	41	59	91	74	84	20
Timber frame (open panel)	31	165	230	264	270	316	385	425	519	650	528
Timber frame (structural elements)	199	302	328	339	398	435	475	507	532	575	515
Volumetric (permanent)	88	70	102	163	149	166	230	290	273	323	329
Volumetric (temporary)	112	198	245	295	344	386	396	290	443	499	325
TOTAL Gross Output (turnover)	2253	3441	3801	4292	4510	4752	5041	5429	6255	6930	5766

Table 7 Offsite construction sector value added from 1998 to 2008 (£ millions)

Offsite Categories	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Agents	1	1	0	1	1	1	1	1	2	2	0
Bathroom/kitchen pods	2	2	3	5	5	4	6	5	15	18	5
Cladding & façade	136	135	141	145	151	162	170	163	163	175	93
Components	43	42	41	57	43	63	78	76	116	151	160
Light steel frame	32	38	38	58	57	51	52	71	79	86	105
Merchants	0	7	10	12	13	14	15	12	13	17	2
Other	21	44	44	47	52	56	58	60	57	72	60
Pre-cast concrete	138	136	139	139	147	117	165	206	206	257	147
Pre-engineered M&E systems	261	489	534	561	567	577	573	615	663	708	537
SIPS	0	1	0	0	0	0	6	4	5	6	0
Timber frame (closed panel)	0	0	1	0	−1	2	4	11	14	11	2
Timber frame (open panel)	8	39	52	62	67	82	98	109	144	166	129
Timber frame (structural elements)	28	59	62	70	76	78	90	97	101	107	96
Volumetric (permanent)	22	14	19	36	28	37	52	67	66	67	63
Volumetric (temporary)	39	90	114	135	158	178	171	150	209	239	138
TOTAL Value Added	731	1098	1198	1328	1365	1423	1541	1648	1851	2080	1537

additional estimate of the gross output value (incorporating an estimated value for non-response to the market questionnaire) quoting a value of £6 bn. However, this value was a subjective estimate and was not constructed from annual accounts data. The valuation proposed in the present study calculated a market value of approximately £6.5 bn, which is aligned with the 2006 Mtech Group gross output estimate. There has been considerable debate in the existing literature over what should be incorporated and excluded from the market valuation of the offsite construction sector. However, the present study builds upon the extensive market research and categorization of the sector by organizations such as Buildoffsite and specialist consultancy practices such as the Mtech Group.

Figure 3 also provides a growth forecast for 2009 to 2013. This forecast is based upon a comparative decline in output when compared to the construction industry (CPA, 2009) and post-recession recovery based upon five-year moving average using the historical 1998 to 2008 data. A summary of historical growth and the forecast growth projections to 2013 are presented in Table 8. If offsite sector growth following the 2009 recession is as per the CPA (2009) forecasts and the sector continues to hold between 6% and 7%

Table 8 Offsite sector historical and forecast gross output growth (Ormerod, 2008; CPA, 2009 and research dataset)

Year (*forecast)	All work & CPA growth forecast	Offsite sector value added	Offsite sector gross output	Gross output % growth year on year	% value of contractor's output (all work)
		£ bn			
1998	£ 68.409	£ 0.731	£ 2.253	–	3.29%
1999	£ 68.296	£ 1.098	£ 3.441	52.78%	5.04%
2000	£ 69.614	£ 1.198	£ 3.801	10.45%	5.46%
2001	£ 71.085	£ 1.328	£ 4.292	12.92%	6.04%
2002	£ 74.088	£ 1.365	£ 4.510	5.08%	6.09%
2003	£ 77.853	£ 1.423	£ 4.752	5.36%	6.10%
2004	£ 80.247	£ 1.541	£ 5.041	6.08%	6.28%
2005	£ 79.600	£ 1.648	£ 5.429	7.70%	6.82%
2006	£ 74.628	£ 1.851	£ 6.255	15.23%	8.38%
2007	£ 82.424	£ 2.080	£ 6.930	10.78%	8.41%
2008	£ 82.129	£ 1.537	£ 5.766	–16.79%	7.02%
2009*	£ 69.009	£ 1.291	£ 4.844	–16.00%	7.02%
2010*	£ 65.584	£ 1.227	£ 4.601	–5.00%	7.02%
2011*	£ 65.935	£ 1.233	£ 4.624	0.50%	7.01%
2012*	£ 67.191	£ 1.256	£ 4.712	1.90%	7.01%
2013*	£ 69.280	£ 1.295	£ 4.858	3.10%	7.01%

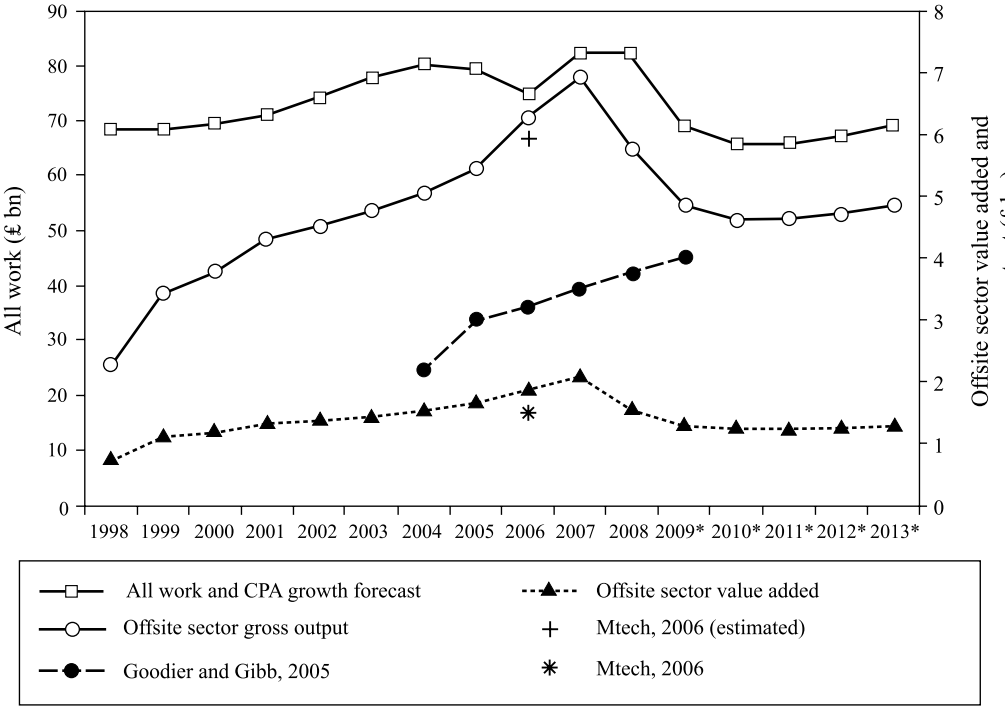

Figure 3 Offsite sector market valuation comparison (Goodier and Gibb, 2005; Mtech Group, 2006; CPA, 2009 and research dataset)

of the total construction output, then the forecast sector value for 2013 will stand at £4.848 bn. However, with greater emphasis on sustainable construction, increased demands for efficiency in construction and clients expecting improved quality standards, the development and growth of the offsite construction sector may outstrip that of the traditional construction sector.

Directions for future research

Having established a robust methodology for the financial valuation of the UK offsite construction sector, it is essential that further work is undertaken to define, quantify and value the European offsite construction market. European data may be obtained from comprehensive pan-European accounts database sets such as AMADEUS and OSIRIS (Bureau van Dijk). Categorization of the sub-sectors must then follow European activity classification systems such as NACE (Nomenclature générale des Activités économiques dans les Communautés Européennes). However, it is critical that a European directory of manufacturers and specialist contractors is developed to form the basis of a sufficiently encompassing EU definition of offsite construction. Importantly, there may be new categories of technology that should be considered which may result in the expansion of the technology classification categories utilized in the present study.

Imports to the UK and trade throughout Europe in offsite manufactured products and systems are critical to the development of the industry. Importantly, learning, understanding and trade in innovative construction materials and processes are essential in the global stance against climate change. It is possible that HM Revenue and Customs data could be analysed and the ICN (Intrastat Classification Nomenclature) coding system used to develop an understanding of the value of offsite or prefabricated building elements imported into the UK from mainland Europe.

Conclusions

Offsite construction is paramount to the efficiency and sustainability of the UK construction and civil engineering industry. Understanding the contribution of prefabrication, pre-assembly and offsite manufacturing to construction activity is critical for measuring, benchmarking and determining the growth and diffusion of innovative construction techniques. The results presented in this paper contribute to the greater understanding of the value of construction industry output that is designed and constructed using offsite construction techniques. Importantly, the results identify significant discrepancies and limitations in the existing literature and provide a replicable method for the financial assessment of the contribution of offsite construction to the traditional construction sector. This paper has contributed to the definition and quantification of the offsite construction sector through examining its economic breadth and diverse constituent industries.

It is critical that the construction industry, trade organizations and specialist consultants in the debates and discussions that include the offsite construction sector use accurate, reliable and valid data. The relevance of the research findings is the derivation of a robust and accurate methodology for the valuation of the offsite construction sector utilizing company accounts and incorporating appropriate industry classifications. This will contribute to corporate decision making, improved monitoring and reporting of the uptake and development of the offsite construction sector. It is essential that predictions and forecasts are founded upon robust and valid measures of gross output and value added by manufacturers and suppliers of offsite construction products and systems.

As a source of information for manufacturers, contractors, specialist subcontractors, trade organizations and consultants, the presented dataset could be used to provide a foundation for future market research and industry analysis. The key challenge facing the construction sector is the greater diffusion of offsite education, training, new products (systems) and the unambiguous demonstration of its ability to contribute to greater site safety, cost efficiency, cost control, quality control, design and construction efficiency. By understanding the structure of the offsite sector and the value added, researchers may now be able use the presented method to measure the year-on-year growth and development of offsite construction techniques in the United Kingdom construction sector.

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