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Technical and Organisational Change in UK Construction

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Abstract

This study examines the broad technological and organisational change trends in the UK construction sector. This uses the information from the input-output balances to track the key inputs to construction from the production and services sectors, along with self-input from construction.The inputs to the UK construction sector from 1997 through to 2020, based on the current supply and use tables, form the basis for the analysis. Changes in the inputs from the key commodity groups for materials and services are presented as a time series. Regression analysis is used to evaluate the relationship of the input coefficients against time to see if the slope is significantly different from zero. The changes in the material and service sector inputs are also discussed. The results demonstrate that most of the twelve material groups showed downward trends over the period studied, while most of the five service groups showed increases. This shows that materials provide a declining share of inputs to construction while most services sector inputs, along with self-input from construction, absorb higher shares. This is used to throw some light on changing trends in construction technology and organisational change in areas such as subcontracting, off-site prefabrication, and plant hire. The approach is limited because it can only identify changes between the various broad groups used in the supply and use tables. The analysis confirms certain of the well-documented technological changes in construction. These include the ongoing replacement of traditional brick-build structures with timber-framed technology. It does confirm the continued expansion of the use of subcontracting in construction. It also shows increased inputs from technology and information services and architectural and consultancy services. More surprisingly it does not indicate any rise in off-site prefabrication.

Keywords: Construction economics, input-output analysis, organisational change, technical change.

1. Introduction

The UK construction sector has long been known for conservatism and resistance to change. This was demonstrated in the nineteenth century when the UK lagged behind the USA in adopting steel-framed construction and was way behind Germany and France in adopting reinforced concrete technology (Bowley, 1966). These trends continued into the twentieth century, with the industry slow to pick on innovative materials (Lowe, 1996) unless forced to by governments. Mainly, innovations in building materials were the product of state policy, usually during after-wars or in situations of pressure on housing provision.

This included using new materials in council house building in the 1920s, prefabricated housing in the 1940s, and system building in the 1960s. It is possible to add the use of timber-framed technology in the 1980s. The latter was the exception to the rule in that it was introduced by private sector speculative builders rather than being promoted by central or local government. The fragmentation between design and construction has also been cited as a factor inhibiting innovation (Ive & Gruneberg, 2000).

The paper is intended to identify the extent of the spread of technical and organisational change in the UK construction sector over recent years. This focus is on broad technical changes (innovations in building materials and construction techniques) and organisational initiatives in areas such as provision of finance, design issues, real estate management, and use of plant hire. The objective is to track changes in key inputs to construction over time towards measuring the extent of technical and organisational change. This will focus on selected material and service sector inputs and construction self-inputs. This is compared with the total value added and the shares received by labour and capital.

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2. Literature review

Technological change stems from three distinct but complementary stages: invention, innovation, and diffusion. Freeman (1974) described invention as developing an idea, sketch or model for a device, product or process. Innovation can be seen as the commercial exploitation of that idea, sometimes coming several decades or longer after the invention. Diffusion will be the spread of that innovation to the broader economy.

Innovation can be seen as either process or product innovation (Coombs et al., 1987). The first involves the more efficient production of the existing products, while the latter will be concerned with developing completely new products or processes. Clark (1985) cites the sometimes very long delays along the process of invention and innovation through to diffusion. The spread or diffusion of such innovations throughout the economy will be key. They are likely to change or adapt as they spread through the economy (Rosenburg, 1976), and such developments may have a more significant impact than the initial innovation.

The issues with invention and innovation are that they are impossible or not easy to quantify. Invention can be measured by the number of patents applied for (Schmookler, 1966), but there will be no distinction between financially viable patents and those unlikely to ever be used commercially. Innovation can sometimes be a misleading indicator of technical change. Certain technical developments may initially appear to gain ground before being eclipsed by better-marketed or cheaper alternatives. It is not unknown for technically superior innovations to fail to survive against less advanced competitors. The case of the Betamax v VHS conflict in video recording systems (Wielage & Woodcock, 2003) gives this example. Only diffusion offers any realistic prospect of a quantifiable measure of technological change. See (Comin & Mestieri 2014) for a review of this area of measurement of technical innovation.

The development of input-output analysis (Leontief, 1936) provides an excellent approach to measuring the spread of innovations into the economy. The assumption behind Leontief's input-output approach was that the technical coefficients, representing inter-industry flows, would be relatively stable over time. Hence, input-output tables have been published infrequently, usually corresponding to a production census. When such coefficients change significantly, this will indicate technical changes in the economy (Gregori, 2009). Input-output analysis has the advantage that the data is readily available for most advanced economies worldwide.

3. Research method

The objective of the study is to identify and analyse technical and organisational change in the UK construction sector over a 24-year period from 1997 through 2020 using statistical analysis.

Simple linear regression analysis is used on the coefficients of the inputs of various production and service groupings and the primary inputs to construction against time. This used an ordinary least squares regression model with the input coefficients as the dependent variable and time as the independent variable. If the inputs from a given group to construction increase over time, this will show a positive slope coefficient in the regression model. Similarly, if the input coefficients decline over time, this will produce a negative slope coefficient. The slope coefficients are evaluated to see if they differ significantly from zero.

The paper examines the three main groups in the economy that supply construction. This involves production (mining and extraction, manufacturing, and utilities), construction (self-inputs), and services. In addition, value added (labour and capital) are considered. Twelve sub-groups of production and five sub-groups from services will also be analysed. Agriculture, forestry, and fishing are not included in the analysis as they supply few direct inputs to construction. Similarly, food and drinks and several service sector industries are omitted because they provide minimal or zero inputs to construction.

3.1 Intermediate input coefficients

The intermediate inputs from the selected product groups and sub-groups are divided by the total output to give coefficients. These coefficients represent the direct inputs needed to produce £1 of construction output. The analysis is focussed on the key sectors providing significant inputs to construction.

There are twelve commodity sub-groups from the production sector of the economy responsible for inputs to construction. The self-inputs to construction to itself constitute a second category. These, along with inputs from the five service sector sub-groups, are listed in Table 1. The selected sub-groups are those that supply the most inputs to construction. Between them, they account for over 97% of the total inputs to the industry.

3.2 Assumptions Underpinning input-output data

The implicit assumption of input-output analysis was always relative stability in the coefficients, at least in the short term. Hence, the UK IOT tables were produced at intervals of around five years, usually corresponding with the production census.

Where the coefficients change over time, this is assumed to be indicative of technical or organisational developments within the sector in question. Thus, the direction and magnitude of any changes to the coefficients can be used to estimate the impact of technical and organisational changes to inputs to construction from 1997 to 2020.

Table 1: Industrial sub-groups used in the analysis (1997-2020)

No	Industry Group	SIC Categories	Share of inputs
1.	Mining, quarrying and oil production	B05 − B09	1.5%
2.	Textiles and textile products	C13 − C15	0.2%
3.	Wood and paper products	C16 − C18	2.2%
4.	Paint and chemical products	C19 − C21	1.5%
5.	Rubber and plastic products	C22	2.0%
6.	Cement, lime, plaster, and concrete	C23.5	3.8%
7.	Glass, bricks, and ceramics	C23.1-4, C23.6-7	2.2%
8.	Metals and metal products	C24 − C25	3.6%
9.	Computers and electrical products	C26 − C27	2.3%
10.	Mechanical products	C28 − C29	1.1%
11.	Furniture and other manufacture	C30 − C31	0.4%
12.	Gas, electricity, and water	D35 − E39	0.7%
13.	Construction (self-input)	F41 − F43	30.2%
14.	Communications and IT services	J61 − K63	0.9%
15.	Finance and management services	K64 − K66	1.7%
16.	Real estate services	L68	0.4%
17.	Architectural and engineering consultancy	M71	1.4%
18.	Hiring and leasing services	N77	1.7%
1-18.	Selected industrial groups		57.8%
VA	Value added for selected industrial groups		39.4%
All	**Total for selected industrial groups**		**97.2%**

3.3 Sources of data

From the above, an obvious source of data is input-output tables (IOTs). They have been produced in detail for the UK since 1963. These IOTs are currently presented 105 x 105 in a commodity-by-commodity format (Gregori, 2009). The problem is that they have been published infrequently in the UK (usually every four to five years) and typically up to four years in arrears. There was a ten-year gap between the tables published for 1995 and the next from 2005. While the IOTs have been published annually since 2013, this does not help for a medium to long-term analysis.If changes in the standard industrial classification (SIC) are added, it makes comparison quite difficult. The last thirty years have seen the use of four different SICs (1992, 1997, 2003 and 2007). Thus, making a medium to long-term analysis using IOTs is not easy.

An alternative approach is to use supply and use tables (SUTs) produced annually in the UK over the past thirty years in an industry-by-commodity format. The first SUTs for 1989 were published in Economic Trends (Central Statistical Office, 1992). Similar tables with more detail were published in 1990 and 1991 and in Economic Trends (Central Statistical Office, 1993, 1994). SUTs were later produced from 1992 to 2004 as a continuous series (Office for National Statistics, 2006). A change in the SIC (Office for National Statistics, 2007) led to a new series. The 2020 SUTs were backdated to give consistent results from 1997 (Office for National Statistics, 2022) using the current 2007 SIC.

The SUTs have two distinct advantages over IOTs: they have been produced annually since 1989 and are published with only a two-year delay compared to around four years for IOTs. While the SUTs are not symmetrical, this should not be a significant problem for the requirements of this analysis. This gives three partially overlapping but internally consistent data series covering the 32 years from 1989 to 2020. The first ran from 1989 (or 1990 for some commodities) to 1992. The second series covers 1993 through to 2004. The third series includes fully compatible data from 1997 to 2020.

The fundamental changes to the SIC (Office for National Statistics, 2007) and the incompatibility of the earlier data with the new series from 1997 to 2020 make it impossible to get a consistent data set throughout the whole period. Thus, a meaningful analysis across the 1992-2004 and the 1997-2020 SUTs is impossible, let alone including the SUTs from 1989 or 1990-91. Hence, the analysis is restricted to the period from the current SUTs and only covers data from 1997, with a single series across the whole period.

4. Analysis

4.1 Research framework

The analysis will involve comparing the three groups: production (sub-groups 1-12), construction (sub-group 13), and services (sub-groups 14-18), as well as examining all of the eighteen industrial sub-groups named. The first test is to look at the direction of any movements in the coefficients and then to examine the significance of any changes found. In addition, the changes in wages and profits within value added will be analysed. Each of the above four groups and the various sub-groups were considered separately in the analysis. The test intended to find the coefficient of determination (R^2) for each group and sub-group, along with the direction of the slope. The change of each sub-group within their group, weighted by share, is presented along with the magnitude and direction of change. These results and the statistical significance (95% confidence) were used as the basis for the above analysis. The results are illustrated in Table 1 and in Figures 1 to 4.

Table 2: Regression analysis of the groups and subgroups

No	Commodities	Trend	R^2	Change	Significant
1.	Mining and quarrying	Negative	84%	−13%	Yes
2.	Textile products	Negative	17%	− 0%	Yes
3.	Wood and paper products	Negative	7%	−2%	No
4.	Paint and chemical products	Negative	13%	− 2%	No
5.	Rubber and plastic products	Negative	94%	−18%	Yes
6.	Cement, lime, and plaster	Negative	48%	−18%	Yes
7.	Glass, clay, and bricks	Negative	96%	− 21%	Yes
8.	Metal products	Positive	2%	1%	No
9.	Computer and electricals	Negative	31%	− 7%	Yes
10.	Mechanical products	Positive	55%	6%	Yes
11.	Furniture and other manufacture	Positive	27%	1%	Yes
12.	Gas, electricity, and water	Negative	36%	− 3%	Yes
1-12.	**Production**	Negative	76%	− 76%	Yes
13.	**Construction**	Positive	89%	89%	Yes
14.	Telecoms and information	Positive	55%	17%	Yes
15.	Banking and financial services	Positive	33%	19%	Yes
16.	Real estate services	Positive	21%	3%	Yes
17.	Architecture and consultancy	Positive	82%	40%	Yes
18.	Rental and leasing services	Negative	7%	− 4%	No
14-18.	**Services**	Positive	75%	75%	Yes
19.	Wages	Negative	80%	− 51%	Yes
20.	Profit	Positive	8%	5%	No
19-20.	**Value added**	Negative	45%	− 45%	Yes

4.2 Production

The production group, overall, has an obvious negative slope with an R^2 value of 76%. That suggests that over three-quarters of the change in contributions from the production group to construction can be explained by time and the technical changes introduced over the period. Of the twelve production sub-groups, nine have a negative slope. The clearest is the production of glass, clay, bricks, and stone, with an R^2 value of 96%. This was closely followed by rubber and plastic products at 94% and mining and quarrying at 84%. The latter sub-group involves the production of aggregates and stone. The results for computers and electrical installations (R^2 = 31%) and utilities (gas, electricity, and water supply), with R^2 at 36%.

The sub-groups with clear positive slopes are mechanical products (R^2 = 55%), furniture and other manufacturing (R^2 = 27%), and textile products (R^2 = 17%). Wood and paper products (R^2 = 7%), paint and chemical products (R^2 = 13%), and metal products (R^2 = 2%) straddle the divide between negative and positive slopes. All three have non-significant results with 95% confidence.

4.3 Construction

The self-input from construction consists of two components. The first involves repair and maintenance work on buildings owned by firms classified as construction. That would be restricted to the head, regional, and local offices and yards for contractors. This is comparatively small as most construction activities are carried out on-site.

The vast majority of this area comes from the subcontracting. This inevitably involves a degree of double counting as the work by subcontractors is included and output by main contractors, which will incorporate the subcontractors' inputs. Indeed, by convention, the early input-output tables had zeros along the leading diagonal and disregarded self-inputs. Later, the self-input was displayed in brackets but not in the row and column totals. Subsequently, the industrial self-inputs were fully incorporated into the tables despite the double-counting involved. Including industrial self-input has a far more significant impact on construction than on any other commodity.

The self-input from construction has been rising throughout the period studied. This has an R^2 value of 89% over the period studied and is undoubtedly statistically significant. The results for construction self-input are illustrated in Figure 7 by comparison with the inputs to construction from the production and services groups. This demonstrates the steady increase in subcontracting over the period studied. There was a fall after 2010, possibly reflecting the delayed impact of the world recession and a further small drop after 2015. Both

of these dips were soon reversed amid the steady increases.

4.4 Services

Overall, the contributions from the service group have risen over the period in question, with a statistically significant R^2 of 75%. That demonstrates an apparent increase in the importance of services to construction output. All but one of the sub-groups displayed rises in their contributions to construction. The most evident result is for architectural and professional services with a strong relationship, giving an R2 value of 82%.

Telecommunications and information services also have a positive relationship for inputs to construction (R2 of 55%). Banking and financial services (R2 of 33%) were remarkably erratic prior to 2010. Real estate services (R2 of 21%) also display a positive coefficient. The rental and leasing services sub-group covering plant hire is the exception and has a very shallow negative slope (R2 of 7%) but is statistically insignificant at 95% confidence. The service groups are shown in Figures 5 and 6. This illustrates that all sub-groups examined show significant positive results over time, besides rental and leasing services, which gives negative but inconclusive results.

4.5 Value Added

The value added for construction has a negative slope with an R^2 of 45% over the period studied. However, the share of the profits element continued to rise marginally (R^2 of 8%), while the proportion of wages fell sharply as a percentage of value added (R^2 of 80%).

Thus, the slight rise in profits over this period is not statistically significant at 95% confidence. However, the reduction in the share of value-added absorbed by wages is certainly significant at 95% confidence, as is the significant fall in value added. This is illustrated in Figure 7.

4.6 Summary of Results

The precise pattern of the results is that construction, in common with many other industries, the UK is becoming less dependent on inputs from the production industries. Mechanical products and furniture & other manufacturing are the only sectors to show statistically significant increases. The services sector inputs to construction also follow the rest of the economy and show increases in inputs apart from hiring and leasing of plant that gives inconclusive results for the period studied after substantial increases prior to 1997.

The most significant result is the rise in construction self-input from under a quarter to a third of total inputs to construction between 1997 and 2020. Given the double-counting implicit in the figure, this increase could distort shares of other material and services inputs to construction.

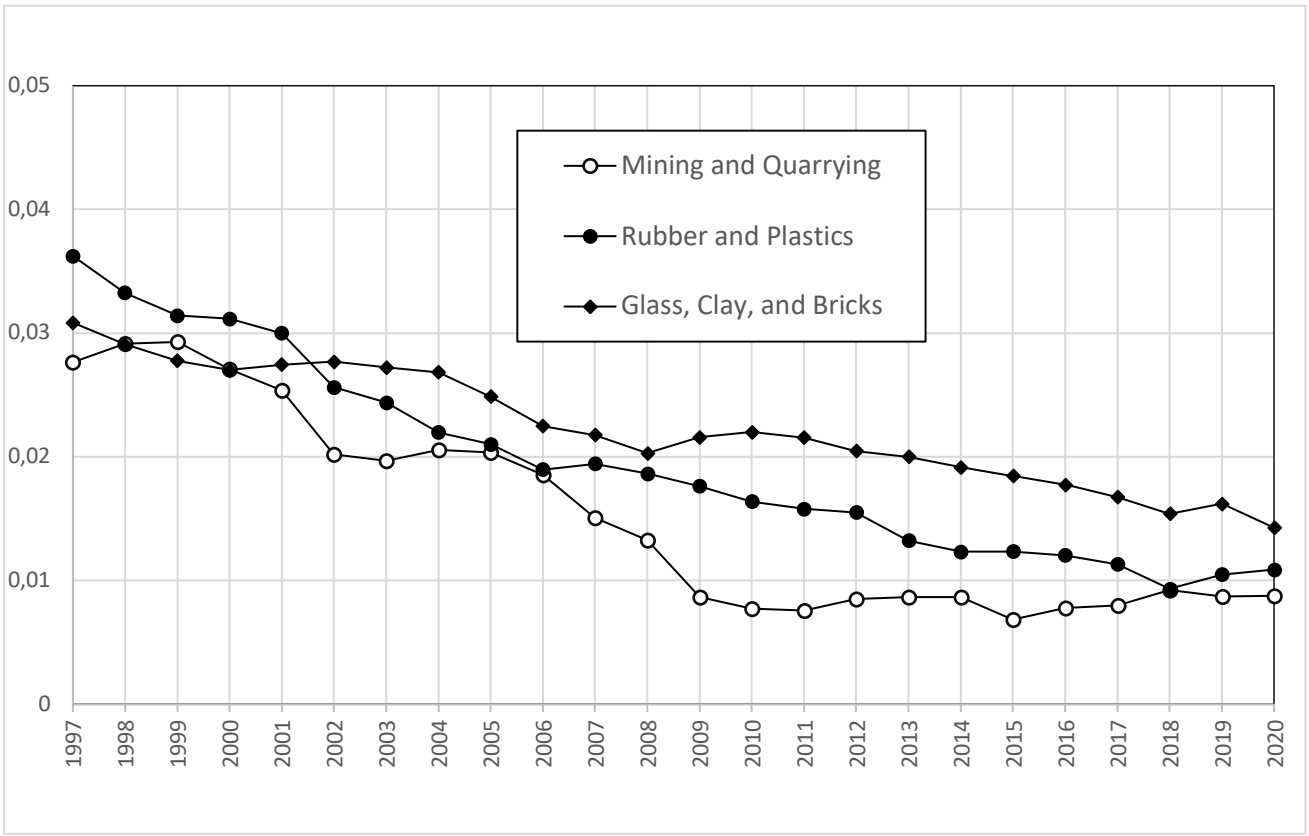

Figure 1: Inputs to Construction from Mining & Quarrying, Rubber & Plastics and Glass and Clay Products

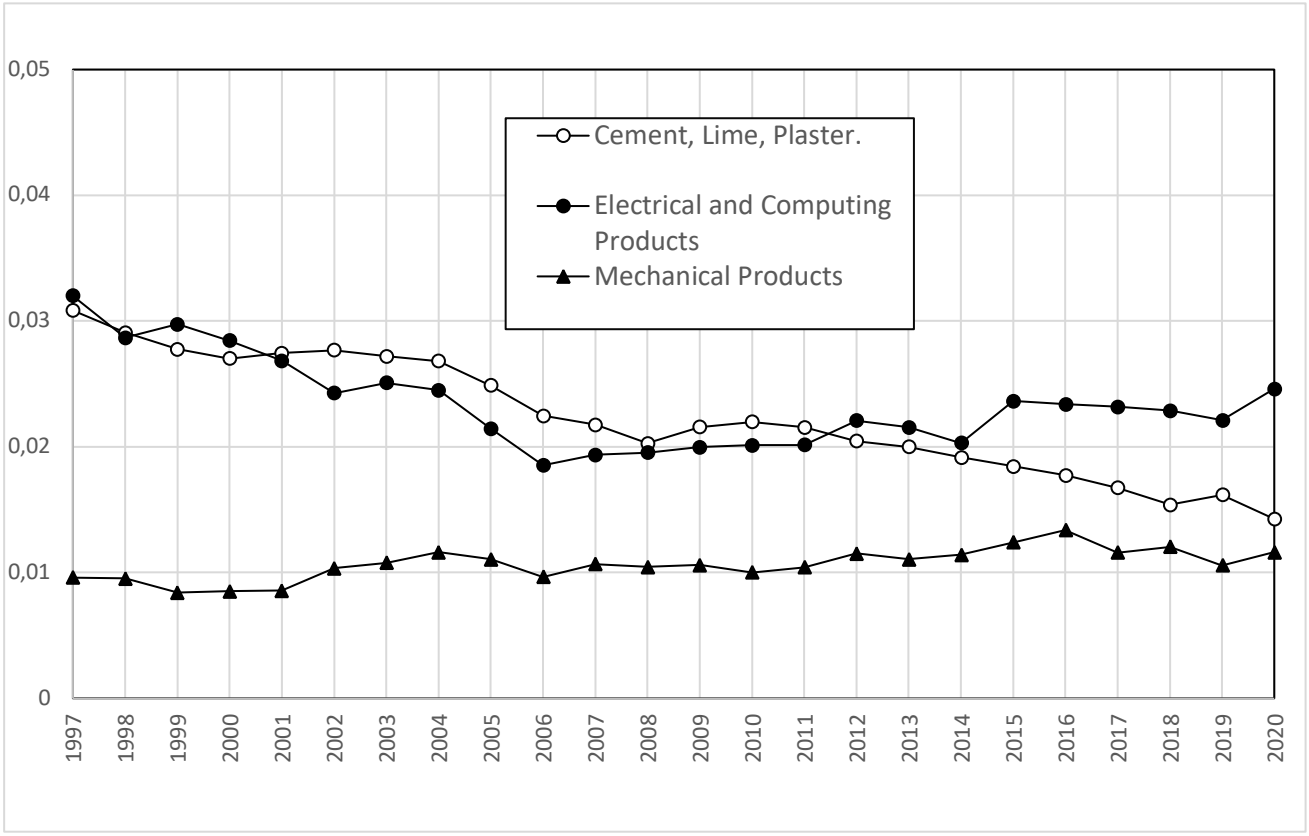

Figure 2: Inputs to Construction from Cement, Lime & Plaster, plus Electrical and Mechanical Products

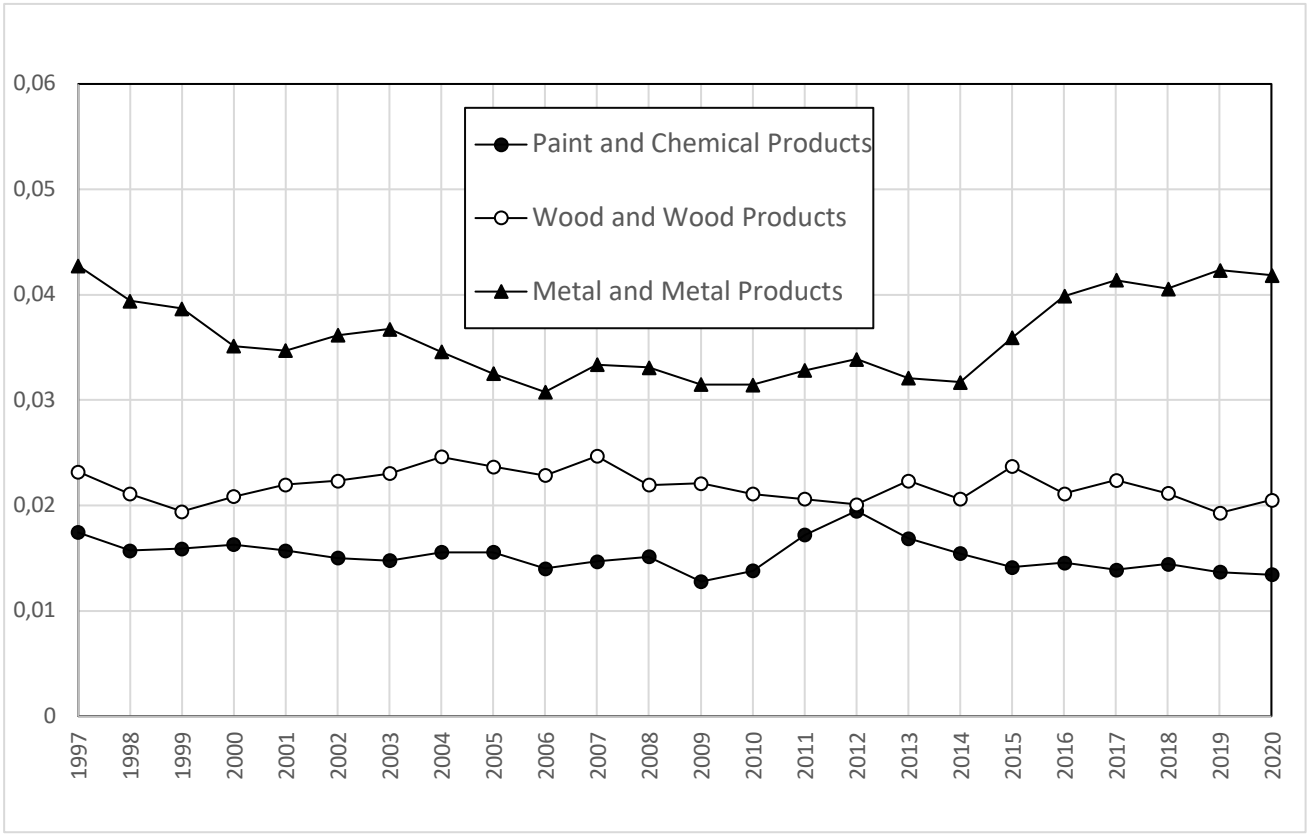

Figure 3: Inputs to Construction from Paint & Chemicals, Wood Products, and Metal Products

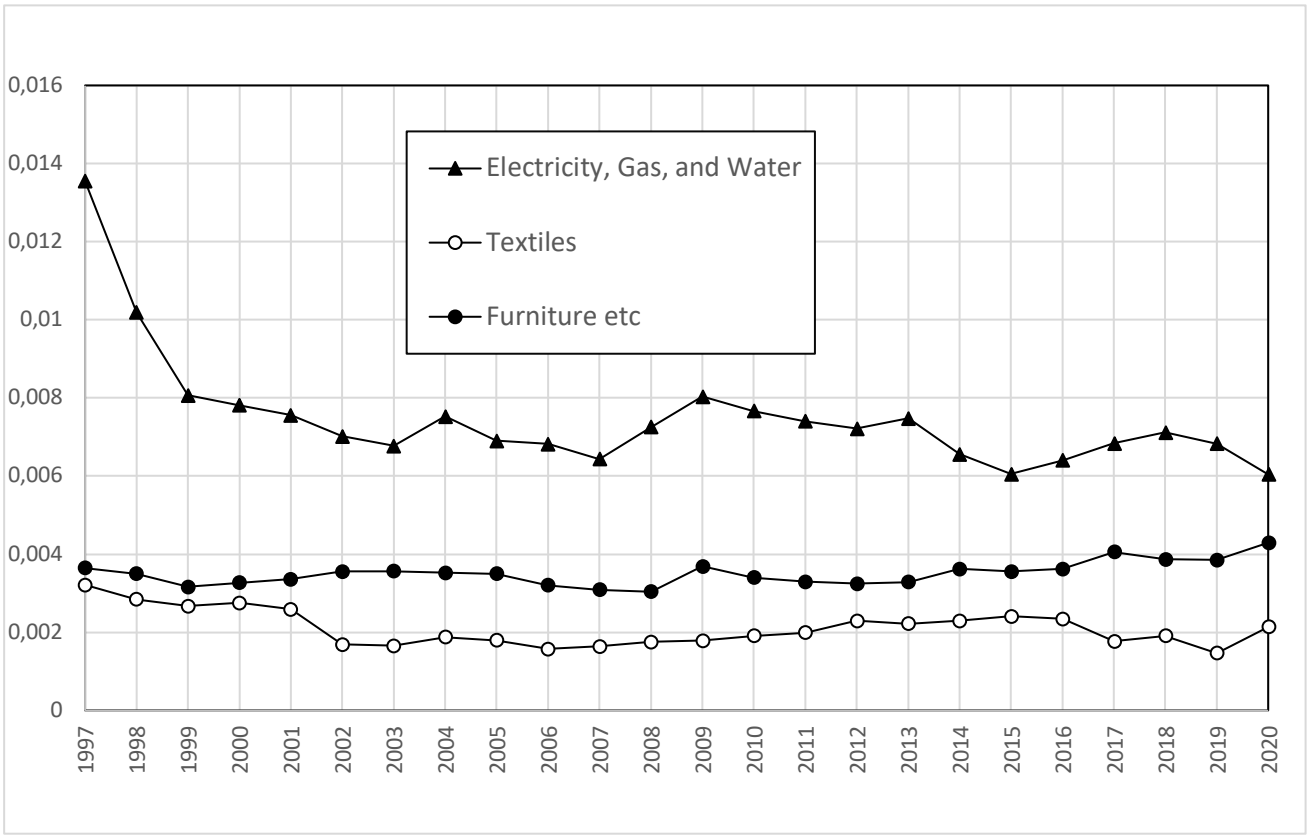

Figure 4: Inputs to Construction from Electricity, Gas, Water, Textiles and Furniture

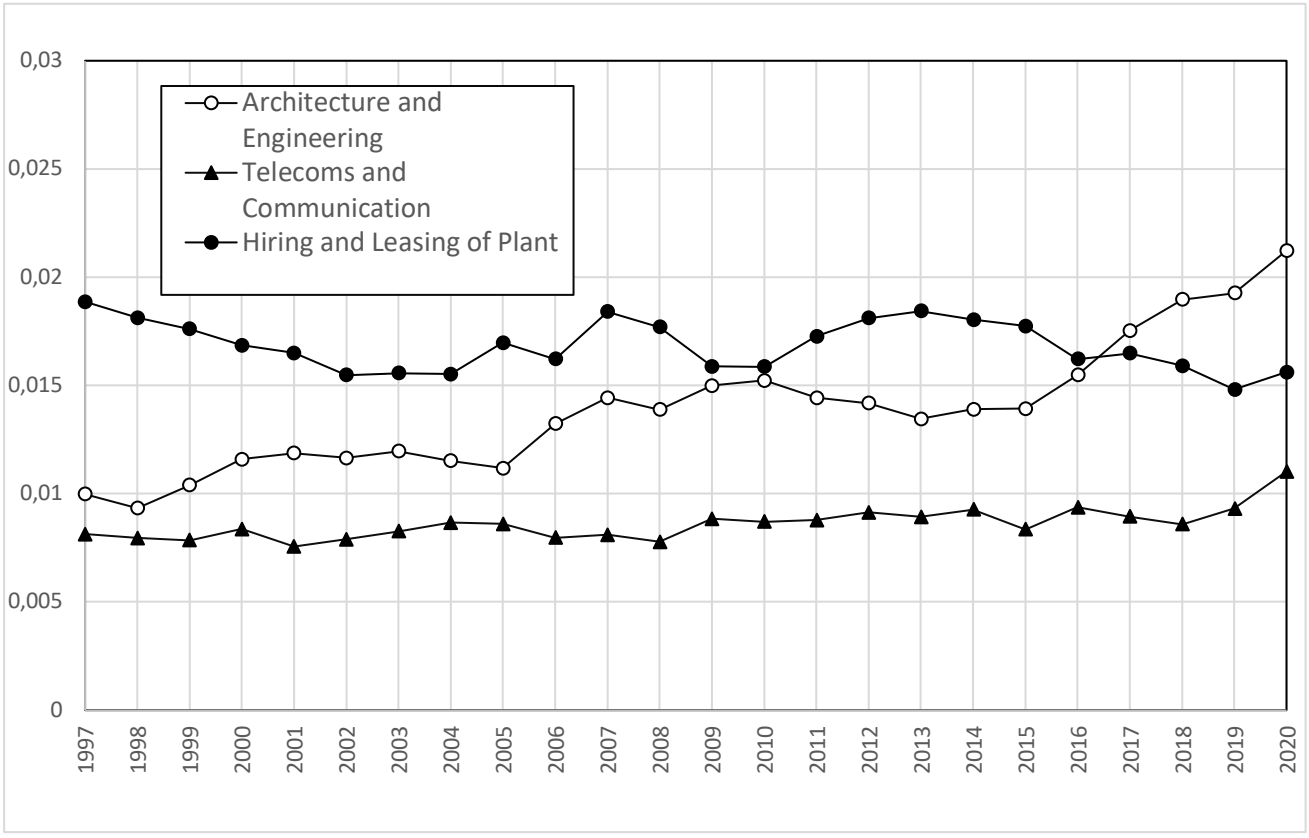

Figure 5: Inputs to Construction from Architecture, Telecoms, and Hiring and Leasing of Plant

Figure 6: Inputs to Construction from Banking and Financial Services and Real Estate Services

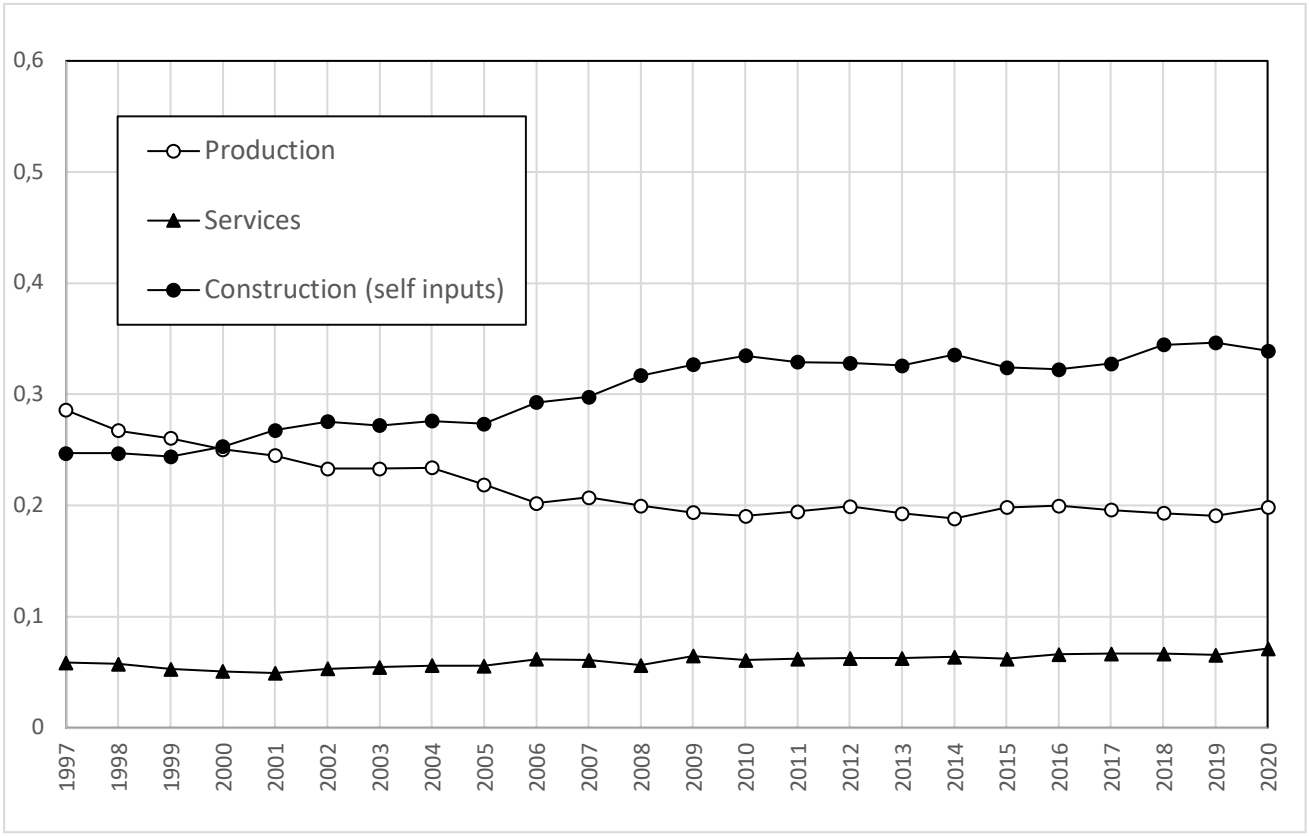

Figure 7: Inputs to Construction from Production, Self-inputs, and Services

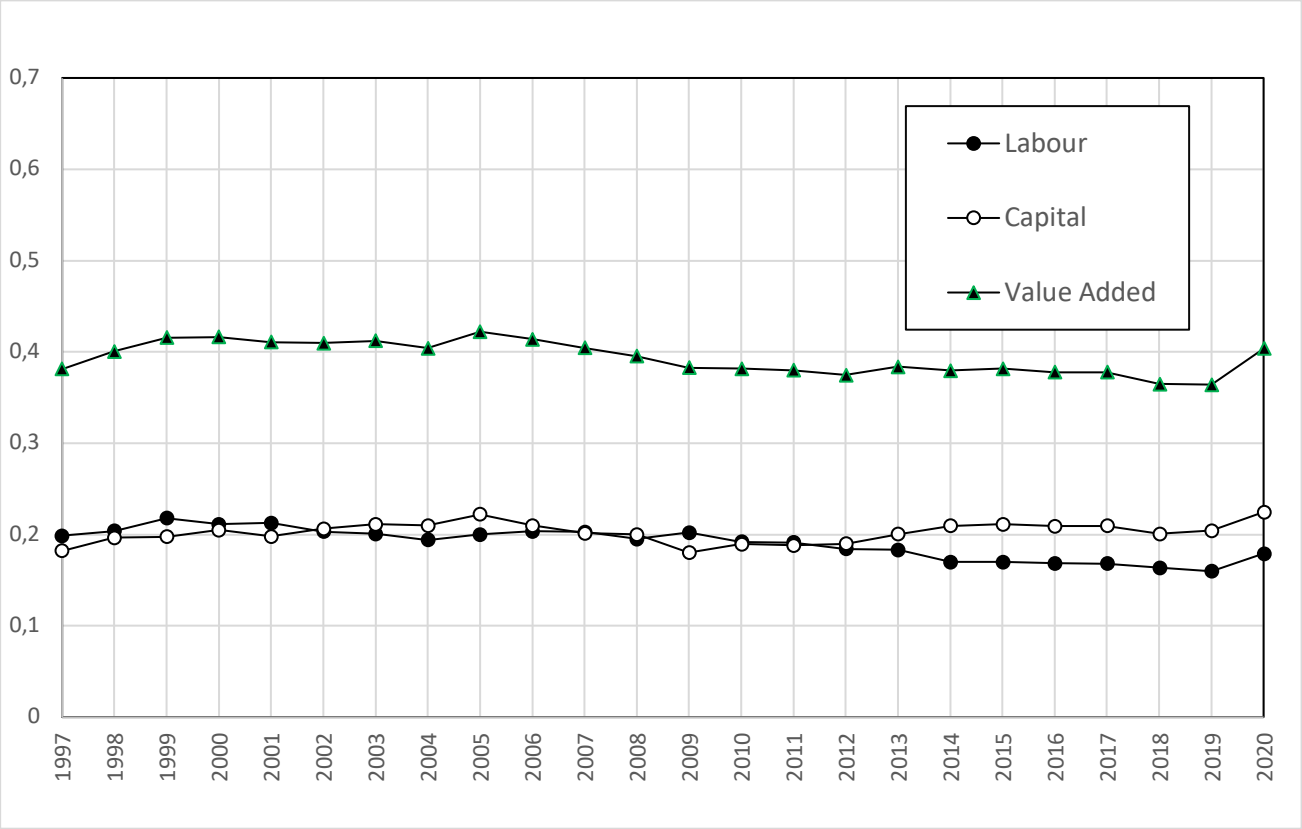

Figure 8: Inputs to Construction from Labour, Capital, and Value Added

5. Technical Change

5.1 Approach

This area is focussed on the changes within the production and construction groups. The areas of technical change include the extent of switching between different material inputs, any changes in the extent of off-site prefabrication, and changes in site mechanisation. The analysis is rather 'broad brushed' as it can only detect shifts between the various commodity sub-groups named and will not show changes within sub-groups. For example, a change from using internal block walls to stud partitions will be indicated. However, the statistics will not show a switch from brick partitions to lightweight blocks.

5.2 Material Switching

Most of the 12 selected production sub-groups are showing apparent absolute declines. This is indicative of a fall in spending on building materials. However, certain materials, mainly wood and wood products, experienced slower declines. Other sectors, including mechanical products, furniture and other manufacturing, showed increased shares. This points to a limited amount of switching of material inputs, in relative terms, as timber products replaced traditional building materials such as bricks, blocks and concrete. So, while the spending was declining in absolute terms, it was increasing in relative terms. It should be added that the timber-framed revolution in house building was well underway many years before the start of the period of study (Cullen, 1981).

The analysis will be unable to detect specific material changes, for example, the shifts from insitu plaster to plasterboard, as they form part of the same sub-group. There was also an earlier move from the use of fletton bricks to concrete or breeze blocks for the inner skin of cavity walls that certainly fell outside the scope of the time limit of this analysis

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5.3 Offsite Prefacation

An increase in the use of off-site prefabrication has been much vamped over recent years. If this were happening to any great extent, it would suggest that there would be an increase in intermediate inputs, particularly for wood, concrete and metal products. Most of the above indicators are on a downward path in absolute terms.

Value added for construction also appears to be on the decline, but this fall is not statistically significant. The increasing use of off-site prefabrication would have been expected to result in a decline in value-added as it would involve replacing on-site labour with off-site labour. The latter approach would result in more labour being employed off-site and classified to the manufacturing sector rather than construction.

There are relative increases in wood and wood products and, to a greater extent, for metal products. However, on balance, it would appear that the data shows no evidence of any discernible change in the extent of use of off-site prefabrication. There were earlier attempts at large-scale off-site prefabrication over the years. Most of

these initiatives were sponsored by the UK government, including innovative material after World War One and the use of prefabricated housing after World War Two (Bowley, 1966).

System building was in full swing by the late 1960s through to the early 1970s (Ive, 1980), once more as a governmental issue. However, these trends had certainly run their course prior to this period of the analysis. Timber-framed housing, which took off in the UK in the 1980s, is more significant. It could certainly be seen as equivalent to prefabrication. It involves substituting on-site labour for off-site labour (Hill, 1980). Unlike many other technical changes, timber-framed building was a private sector initiative.

5.4 Mechanisation

There is also some evidence of increased mechanisation from a superficial examination. The relative decline in wages as a proportion of output while increasing profits indicates increased mechanisation. It seems likely that construction firms' fixed capital is declining rather than rising with the increases in plant hire. However, there is no evidence of any corresponding increase in inputs to construction from plant hire. If anything, this is flat-lining or declining from the data. That is something of a conundrum that requires further investigation.

6. Organisational Change

6.1 Approach

The changes to the service sector of the economy above may tell us a lot more about changes in the management of construction than they do about technical issues. This covers issues such as increased use of plant hire and subcontracting. There will also be some procurement issues, such as the employment of work-package type procurement, including management contracting and construction management. In addition, innovative approaches such as contractor finance and contractor design are relevant here. These issues are characterised by design, build, and public-private partnership projects (PPPs).

6.2 Leasing and Hire of Plant

Plant hire had been increasing for many years partially due to the perceived higher utilisation of hired plants (Hillebrandt, 1988). The 1992-2004 series of SUTs (Office for National Statistics, 2006) showed steady rises in hiring and leasing of plants. However, these trends appear to have been partially reversed over the studied period following changes in the method used to produce SUT data.

The current SUT (Office for National Statistics, 2022) data shows some quite dramatic backdated modifications from the 2017 SUTs onwards. This initially reduced the inputs from hiring and leasing the plant to construction throughout the series to around 70% of the earlier results and ended up at approximately 50% of the previous values from 2002 onwards. There was no explanation in the SUTs other than a scheduled update/revision.

6.3 Subcontracing

The construction sector in the UK has relied heavily on subcontracting for many years (Hillebrandt, 2000). A steady increase in construction self-input over most of the period studied suggests that subcontracting continues to rise. This could also reflect letting of work using work-package type arrangements as with management contracting and construction management. However, the trends from 2010, following the onset of the recession, appeared to be a temporary slight downward turn. In the early days of an economic downturn, a reduction in subcontracting will be expected. Contractors facing a loss of workload would likely keep more of that work in-house. As time goes on, an increase in subcontracting might be expected to follow because the main contractors would react to a continuing depressed state by downsizing their operations. Alternatively, the economy would recover and cause subcontracting to expand.

Another factor could be the partial retreat from work-package-type contracts towards traditional procurement. This is also likely to be expected during and immediately after a major recession. It will be interesting to see what happens in later years when the construction sector's recent economic recovery is fully reflected. As things stand, it will be best described as a possible rather than a probable increase over time.

6.4 Labour-only subcontracting

One factor that could impact changes in the use of labour-only subcontracting (Ball, 1988) comes in the same category as subcontracting and work packages. This first arose in the 1960s to avoid the selective employment tax in operation at the time. It continued to grow in the 1970s and 1980s. While the use of labour-only subcontracting appears to have declined by the end of the period studied, it was very significant for most of the period in question. The impact of labour-only subcontracting would undoubtedly confuse the issues. The fact that there is a steady reduction in the apparent labour inputs to construction over the period studied suggests that this could be a factor.

6.5 ContractorFinancing of Projects

This was always a factor for the speculative sector of the construction industry but gained momentum in the early 1990s via the private finance initiative (PFI), later rebadged as PPPs. The changes in inputs from banking and financial services over time are used to analyse this area.

The figures from 1997 onwards from the 2020 SUTs demonstrate a clear increase in contractor design. In the early years, PFI projects took time to get going and, in any event, were only pioneered in 1992. This approach gained ground after the change of Government in 1997. As PPP-type procurement expanded during the long boom, it took something of a hit after the 2008 downturn. This was

partially because contractor consortiums were less willing to undertake the risks involved with PPP and also because of the government's reversion to traditional contracts.

The expected growth of contractor-financed projects is undoubtedly consistent with the growth in inputs from the financial sector to construction, illustrated in Figure 4. The data relates not only to financial services but also to insurance. This would also be expected to grow along with increased contractor financing because of the need for complex documentation to satisfy the financiers. The recent figures are sufficient to indicate an overall trend of increased contractor financing over the study period.

6.6 Contractor design

There is a long history of contractor design in the UK construction sector. Initially, this was confined to speculative work, specific standardised design, and building 'package deal' projects. Design and build procurement eventually dominated the UK private sector commercial and industrial construction work by the 1980s. Later the advent of design, build, maintain and operate did much the same for the public sector by the end of the 1990s. A good deal of contractor design in such areas was traditionally in standardised or modular buildings and utilised in-house designers employed by the builders and contractors. This would not show up in an inter-industry analysis.

As contractors start to employ professional design and cost consultants rather than in-house staff, this will be reflected in increased inputs from the architectural and engineering services sector, including design consultancy. Inputs from consultants were needed for the more sophisticated levels of design needed as design and build procurement expanded from its initial limited niche market; with traditional procurement, construction clients, rather than contractors, would employ consultants. Hence, it would not appear in construction output.

The use of consultants was key in the design, build, maintain and operate contracts used for PFI/PPP projects. In addition to design and costing, consultants may be used for areas such as project and facilities management. The apparent increase in inputs to construction from professional consultancy to construction over the 1992 to 2020 period is perfectly consistent with the above points. Thus, this would confirm that contractor design of projects is increasing for the period under consideration. This could have implications for innovation if it is accepted that a unification of the design and construction processes would be more likely to encourage the spread of technical change.

6.7 Globalisation

Globalisation started to impact the UK construction sector significantly over the period studied. This could involve overseas-based contractors operating in the UK by purchasing existing UK builders. For example, traditional UK builders such as Gilbert Ash and Higgs and Hill were acquired by the Dutch contractor HGB, who later became BAM. They had taken over the civil engineering contractor, Edmund Nuttall, to form the current BAM Nuttall.

It is not obvious where this will be shown directly on the SUT figures. However, because of the technological change implicit with globalisation, the inputs from communications and information technology will be expected to increase. This would affect the design and construction processes and also the clients' briefs (Gruneberg, 2010). This impact of international ownership increased steadily over the period studied and will have impacts.

6.8 Comparison with other Countries

It is unlikely that other countries would avoid the issues listed above. The UK has a main contractual system similar to that employed in the USA, the Commonwealth, and much of the Far East. Most continental Europe, Latin America, and francophone Africa use a different trade-based contractual system. These differences will have a negligible impact on the technology used. Indeed, over the last 40 years, procurement systems such as management contracting and construction management in the UK are close to those employed in Europe.

Evidence from the USA seems to suggest that they are experiencing similar developments as those in the UK. See, for example, the input-output analysis of the US construction industry by Pietroforte et al. (2009) and the study of construction markets in the world economy (Gruneberg, 2009). The introduction of design supply and fix approaches to procurement, as highlighted, has certainly applied as numerous variants of the PPP approach were throughout many countries across the globe.

7. Conclusions

7.1 Main developments

This study sought to examine the broad technological and organisational change trends in the UK construction sector. The results from the materials sector were not very conclusive, with, at best, minimal switching of materials and limited increases in mechanisation but no evidence of significant changes in the use of off-site prefabrication. This can be seen as a continuation of the trends that have been clear throughout the post-war era (Lowe, 1996). The most conclusive result was the levelling off of the earlier increase in the use of plant hire. Positive but less conclusive results suggested the increased use of contractor finance and contractor design. Finally, the growth in subcontracting is illustrated by the increase in the extent of self-input from construction. This, along with the substantial increase in subcontracting, can also be seen as a continuation of post-war trends.

These results are consistent with contractors looking to reduce the level of risk in an era characterised by the growth of construction insolvency. This involved using subcontracting and plant hire more while displaying a degree of caution about mass moves to off-site prefabrication.

7.2 Suggestions for further Investigation

Areas from the research that have clear potential for further change that are worthy of investigation include the potential for further use of off-site prefabrication and industrial buildings. The issue of contractor funding is employed in speculative house building and in design, build, maintain, and operate projects. This is another aspect which might prove interesting.

There is the point highlighted earlier regarding the decline in the spending by contractors on plant and equipment while inputs from plant hire appear to remain static. This may be a short-term issue, but still requires investigation.

There is also the issue of the long-term impact of the COVID-19 pandemic. It had limited effects on the study apart from the lockdown in March 2020, the final year of the study period. There were undoubtedly strong effects of the resulting recession on construction output in 2020, but the long-term impacts, such as increases in home working and potential changes in retail distribution, remain unclear even at this stage.

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