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Analysing the rising price of new private housing in the UK: A national accounting approach

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ABSTRACT

Discussion of the price of private new-build housing is dominated by land price, but is this the most important element? Other factors are examined for increasing prices, using the rich and robust datasets produced by government departments and agencies. In organising these complex datasets a Sankey diagram is introduced to explain the relationship between type of trade and type of work to show the relative importance of prices. The land value component has been trending downwards, so is not a factor in the rising prices of new private dwellings. Prices of components, other than land value, are obtained from gross fixed capital formation data and construction output. When corrected for inflation, these have risen by factors of 1.7 and 2.0, respectively, over 1998–2018. By including the self-employed, the total labour per new-build private dwelling is derived which has risen 2.4 to 3.0 man-years over 2011–2020. Since 2000, construction companies' gross operating surplus per job has risen much faster than compensation of employees per job. This extra gross operating surplus, which can be associated with profit, totalled £11.6b in 2019 reaching £70k (at 2016 prices) per new private dwelling in 2019. Rising prices have created the opportunity for housebuilders to extract larger profits.

1. Introduction

Although creating a dwelling requires the input of capital, energy, land, labour, and materials, it is the price of land which dominates the debate. The argument about the relationship between land price and new-build house prices is long-standing and contentious (Ball et al., 2022; Barlow, 1993; Kaiser & Weiss, 1970), but is land price the most important element?

Housebuilders are private companies and will attempt to minimise the payment for inputs and maximise the price of the final output (homes), subject to market constraints. The structure of house-building markets and the regulatory frameworks vary across the world (Ball, 2003), and there is a wide variety of related problems that have been investigated. For example, affordability in Australia (Yates & Berry, 2011) and sub-Saharan Africa (Tipple, 2015); pricing models in Hong Kong (Fung & Lee, 2014), Japan (Suzuki & Asami, 2022), and Malaysia (Tan, 2008); land prices in the USA (Davis et al., 2017; Davis & Heathcote, 2007; Davis & Palumbo, 2008), market reforms in China (Clark et al., 2021) and Sweden (Blackwell, 2021); market failure in India (Ram & Needham, 2016) and Mexico (Rodríguez-Reyes et al., 2019); and housebuilding firm structures in Canada (Buzzelli, 2001; Buzzelli & Harris, 2003), Korea (Cho, 2003, 2007), and USA (Buzzelli, 2001). Despite these differences the role of property markets is important in all economies (Shuid, 2016) and is perhaps more important than country-specific characteristics (Schätz & Sebastian, 2009); indeed, investors are often highly internationalised (Aalbers, 2017).

According to Craig et al. (2021) UK house-building is a profitable venture with firms sustaining profits between 13 and 24%, with the widely accepted profit margin for housebuilders being assumed as approximately 20% of Gross Development Value (McAllister et al., 2018), although Farmer (2016) disputes these values stating that *"low profitability is a long standing problem for the industry"*. Karadimitriou (2013) suggests that housebuilder profits are reduced by paying higher prices for land, implying that such additional costs are not transferred to the home-buyer. In his supporting econometric analysis for Barker (2004), Meen (2005) noted the lack of sensitivity of the construction rate to price signals and showed that new-build profitability strengthened through the 1990s (a view supported by Karadimitriou (2013)). Recently Stewart (2022) notes that some researchers found that land price adds little to the house price increase, or may even offset increases in construction costs. Payne (2013) claims that profit margins are sensitive to interest rates and house prices, exemplified by the collapse in profits following the financial crash (Payne, 2015). The input costs of the

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Acronyms

@bp	at basic prices
@cp	at current prices
@cvm	at chain volume measure prices
@pp	at purchasers' prices
ABS	Annual Business Survey
aGVA	approximate Gross Value Added
AWE	average weekly earnings
BCIS	Building Cost Information Service
CSAT	Construction Statistics Annual Tables
COM	Construction Output Monthly
CoE	compensation of employees
CPA08	Classification of Products by Activity revision 2008
cvm	chain volume measure
EPC	Energy Performance Certificate
F	SIC92, SIC03 and SIC07 section 'Construction'
LFS	Labour Force Survey
GDP	gross domestic product
GFCF	gross fixed capital formation
GOS	gross operating surplus
GVA	gross value added
HPI	house price index
MI	mixed income
MV6M	COM New Housing, Private
ONS	Office for National Statistics
PHCPI	Private Housing Construction Price Index
R&I	major repairs & improvements to dwellings
R&M	repair & maintenance
RICS	Royal Institute of Chartered Surveyors
RMS	Regulated Mortgage Survey
SIC03	Standard Industrial Classification of economic activities revision 2003
SIC07	Standard Industrial Classification of economic activities revision 2007
SIC92	Standard Industrial Classification of economic activities revision 1992
SUT	Supply and Use Table

Nomenclature

$A(t)$	AWE construction index
$B_x(t)$	number of jobs in industry (SIC division) construction of buildings for data type of jobs x
c	trade or industry SIC classes and sub-classes (see Appendices B and C)
$C_x(t)$	number of jobs in industry (SIC division) civil engineering for data type of jobs x
$D(t)$	build output per dwelling at cvm
dwlg	number of dwellings
$EB_c(t)$	employment per new build dwelling in industry (trade) c
$EF_c(t)$	employment factor of jobs per unit output for industry (trade) c
$E(t)$	CoE for SIC07 group 41.2
$G(t)$	GOS for SIC07 group 41.2
$IJ_c(t)$	industry jobs in industry c
$IO_c(t)$	industry output in industry c
$IOB_c(t)$	industry output per new-build dwelling in industry c
$J(t)$	jobs for SIC07 group 41.2
$M(t)$	total output of MV6M (private new-build)
s	scalar from jobs of the old 45.21 series (2007 and earlier) to 41.2 series (2008 and on)
$S_x(t)$	number of jobs in industry (SIC division) specialists for data type of jobs x
$X(t)$	GOS-extra at current prices
$X_{dwlg}(t)$	GOS-extra per dwelling at cvm prices

site, construction, and financing with each carry risks (Ball, 2012; Callcutt, 2007), whilst Barlow and King (1992) contend that profit-making strategies are affected by a combination of regulation, uncertainty, and risk. But what is behind the rising price of new-build dwellings and the profitability of housebuilders?

Commentators frequently assert – without robust evidence – that land price is the dominant factor for new-build housing. For example, to an inquiry held by the UK House of Lords Select Committee on Economic Affairs (HoL, 2016), Martin Wolf (Financial Times chief economics correspondent) said that "*it must be the case*" that differential value between land for different uses is a "*fundamental factor in determining the price of housing*". However, the policy community support this stance with more strongly considered analysis (Davis & Palumbo, 2008; Knoll et al., 2017; Macfarlane, 2017; Morton, 2012; Murphy, 2018; Ryan-Collins et al., 2017). Theoretical econometric analyses for various nations (Davis et al., 2017; Davis & Palumbo, 2008; Knoll et al., 2017; Nneji et al., 2013; Stewart, 2022) also support the house-land price relationship, but have methodological limitations. The opposite – and potentially more compelling – view is taken by some industry professionals who consider that the achievable price of new homes drives the land price i.e. they are willing to make higher bids to landowners (Hudson, 2015; Smith, 2017; Ward et al., 2018). Furthermore, in an interview conducted by Karadimitriou (2013) an industry representative claimed that the land cost might be only 5–10% of the final sale price for high-density development on a brownfield site, even though the outlay may have cost tens of millions of pounds. However, the same interviewee stated that for a greenfield site the land cost might amount to 35–40% of the sale price. In an attempt to bridge policy approaches across multiple UK government departments, the report by Edwards (2015) describes discussion of the housing market as being *"bedevilled by rival simplifications"*.

The affordability of dwellings in the UK is a long-standing problem (Ball, 2016; Barker, 2004), but although prices of new-build dwellings continue to rise, build rates are not meeting the housing shortage (Davies et al., 2018). The literature describing the supply constraints is summarised by Coelho et al. (2017), but planning constraints are frequently identified as a key constraint and lead to increasing house (and land) prices (Bramley & Watkins, 2016; Cheshire & Sheppard, 2005; White & Allmendinger, 2003). Barker (2004) notes the planning constraint and concludes that housing industry profits are contingent of obtaining valuable land. Muellbauer (2018) observes that profit from land banks (whether built on or not) drives the capital valuation of large housebuilders. Understanding the value of each parcel of land is important for valuing specific projects as it forms the basis of negotiations for affordable housing (Crosby & Wyatt, 2019). However, McAllister et al. (2018) show how the value can be difficult to define and estimate, so it is easy to see how land value is assumed to be the key to profits made by housebuilders.

There is evidence that the regulation for inclusionary housing (IH) potentially reduces profit margins (Li & Guo, 2021) with some housebuilders opting to build projects with the number of units below the threshold triggering the IH requirement. The proportion of IH in UK projects halved through the 2010s, but return on capital quadrupled (Crosby et al., 2020). Similarly, when the Dutch Government abolished IH subsidies prices rose steadily with a shift from low-cost to higher-value housing (Altes, 2007). The campaigning group Shelter claim that housebuilders are negotiating down the contribution to affordable homes to enable them to pay higher prices for land and

maximise their profits (Banks, 2017). However, it is equally plausible to state that landowners are demanding higher prices, which adds to the confusion. Little is known publicly about the detail of how housebuilders operate (Payne, 2020), and coupled with a lack of good quality data (Albouy et al., 2018; Stewart, 2022) and the need to infer land price (Davis & Heathcote, 2007; Diewert & Shimizu, 2016) has led to speculation that land price is the key to new-build house prices. As (Payne, 2015) sets out clearly, the factors affecting volume housebuilders and their responses is complex, and the heterogeneity across cities reported by (Stewart, 2022) may indicate the importance of factors other than land price.

It is clear that the debate is not settled and a different approach is justified. The UK housebuilding model is different from that of many nations, in part because housing policy is not strongly interventionist (Payne, 2013). Our aim is to use robust national datasets for gross fixed capital formation (GFCF, the national accounts), construction industry data, business surveys, employment statistics, and energy efficiency data, in addition to house prices as a new way to probe this problem. A broader understanding of the factors has implications for policy for affordable (inclusionary) housing and potentially the state of the competitive market. Changing regulations manifests as increases in time (cost of labour) or additional specialists (workforce per dwelling). Furthermore, additional or higher specification materials will manifest as inflation. Does the price of new-build follow the overall housing market, responding to demand with a small premium over existing? Or are new buildings costing more to construct? We examine the following components over time: the value of land, inflation, size of dwellings, energy efficiency requirements, development density, workforce (employed and self-employed) required, and the extraction of larger profit.

The remainder of this paper focusses on the UK and is structured as follows. First, the data available for new-build of private dwellings covering historical time series is explored for: house price, inflation, rate of house-building, construction prices, index of construction price, construction industry output, industry costs for gross operating surplus, net capital and compensation of employees, jobs, dwellings floor area, dwellings energy use and development density. Next, methods are shown for analysing the data. For data from national accounts for GDP, a Sankey schematic is used to explain technical terms and show the relative importance these through thickness of the lines. All data sources are mapped onto a grid of national accounts terms and types of industry or trade. Procedures are introduced for jobs and calculating extra gross operating surplus. The results section explores changes over time which correlate with increasing prices since 1998. The value of underlying land and inflation-corrected prices (net of land) are distinguished to identify residual increases in cost. Unit cost is changed to jobs per dwelling to use other data sources. A method has been developed to map extra gross operating surplus to profits for housebuilding. Man-years are derived for the average private new-build for the whole workforce of employed and self-employed combined.

2. Background

By necessity, the datasets upon which this new methodology rests must form the background, since they are not used by other authors with the exception of (Holmans, 1994). The Office for National Statistics (ONS) collects and publishes a wide range data series in connection with the UK construction industry (Table 1). Additional sources are gathered by the Royal Institution of Chartered Surveyors (RICS). However, not all data is gathered at the same rate, nor for the same historical period, nor even for the whole of the UK.

The National Accounts for GDP are an integrated description of economic activity within the economic territory of the UK (ONS, 2021a). These include supply and use tables (SUT) which are a complete view of the whole UK economy used to produce statistics, such as Gross Domestic Product (GDP). SUT are systemically consistent and a permanent

Table 1
Characteristics of UK datasets relevant to the construction industry. Datasets are for the whole of the UK unless specified.

Type	Granularity	Source	Period Available	Frequency
Volume flows of value added and products	105 industries and products	Supply and Use Tables (SUT) (ONS, 2021a)	1992 to 2019	Annual
Intermediate consumption at basic prices	105 industries and products	Input-output analytical tables (IOAT) (ONS, 2021c)	1984 to 2017	5- to 10-yearly to 2013 then annual
Products needed for Gross Fixed Capital Formation (GFCF)	105 products	Supply and Use Tables (SUT) (ONS, 2021a)	1992 to 2018	Annual
Gross Fixed Capital Formation (GFCF)	13 asset types	National Accounts for GDP (ONS, 2021a)	1997 to 2018	Annual
Construction industry output, including MV6M (private new-build)	11 types of work	Construction Output Monthly (COM), GB only (ONS, 2022c)	1955 to 2020	Quarterly to 2009 then monthly
Implied price deflator of construction output	11 types of work	Construction Output Monthly (COM), GB only (ONS, 2022c)	1997 to 2020	Quarterly to 2009 then monthly
Construction industry output	27 trades and 11 types of work	Construction Statistics Annual Tables (CSAT), GB only, Table 2.8 (Table 1.4 for 2020) (ONS, 2021d)	2011 to 2020	Annual
Gross operating surplus (GOS)	SIC classes (4 levels)	Annual Business Survey (ABS) (ONS, 2021e)	1997 to 2018	Annual
Compensation of employees (CoE)	SIC classes (4 levels)	Annual Business Survey (ABS) (ONS, 2021e)	1997 to 2018	Annual
Employment	SIC classes (4 levels)	Annual Business Survey (ABS) (ONS, 2008; 2021e)	1998 to 2018	Annual
Workforce	SIC divisions (2 levels)	Labour Force Survey (ONS, 2022d)	1978 to 2020	Quarterly
Workforce, Northern Ireland	Employed and self-employed	NI Construction Output Statistics (NISRA, 2021)	2000 to 2020	Quarterly
Average Weekly Earnings (AWE) index	24 industries	Employment and labour market, GB only (ONS, 2022e)	2000 to 2020	Quarterly
Mixed income of self-employed	SIC sections (1 level)	Sectional Unit Labour Cost (SULC) (ONS, 2020a)	1997 to 2017	Annual
House-building	3 types of commissioning[a]	House-building data (ONS, 2022f)	1949 to 2020	Annual
Floor area	4 types of dwellings	Energy Performance of Buildings Registers, England and Wales only (DLUHC, 2022a)	2009 to 2020	Quarterly
				Quarterly

(continued on next page)

Table 1 (*continued*)

Type	Granularity	Source	Period Available	Frequency
Energy consumption density	4 types of dwellings	Energy Performance of Buildings Registers, England and Wales only (DLUHC, 2022a)	2009 to 2020	
Dwelling type	2 types of dwellings	Housebuilding: permanent dwellings completed, by house and flat, number of bedroom and tenure (DLUHC, 2022b)	1991 to 2021	Annual
House prices	80 thousand mortgages per month	Regulated Mortgage Survey (RMS) (ONS, 2021b)	1986 to 2020	Annual
House prices	100 thousand transactions per month	Land Registry HPI (Land Registry, 2022)	2005 to 2020	Monthly
House prices	12 thousand transactions per month	Nationwide HPI (Nationwide Building Society, 2022)	1973 to 2020	Quarterly
Private Housing Construction Price Index (PHCPI)	1 standard house	Royal Institution of Chartered Surveyors Building Cost Information Service (RICS, 2021)	1998 to 2021	Quarterly

[a] Private enterprise, housing associations, local authorities.

time-series comparison. However, the level of detail for each economic sector varies and for construction are only at the top level of Standard Industry Classification (SIC) and Classification of Products by Activity (CPA). In addition to SUT, the ONS construction output statistics (GB only) sample the construction industry to estimate the output defined as the amount chargeable to customers for building and civil engineering work done in the relevant period excluding VAT and payments to sub-contractors (ONS, 2022a). The construction output statistics are specific to new-build private dwellings, thus are an essential resource. The Annual Business Survey (ABS) is unique in going down to all four levels of SIC class but does not distinguish type of work (the products produced). Furthermore, as for the output estimate, ABS covers only businesses that employ labour (ONS, 2016).

2.1. House prices

Fig. 1(a) shows the three principal sources of house prices, along with the GDP deflator (measure of inflation). The ONS house price index (HPI) (ONS, 2022b) is based on data from the Regulated Mortgage Survey (RMS); the RMS-HPI is combined by arithmetic mean. The Land Registry HPI (Land Registry, 2022) is for all transactions (including cash sales) and uses a geometric mean to reduce the significance of a small number of very expensive transactions. The Nationwide Building Society (2022) HPI uses data only from its own mortgages to model the value of a typical UK property. Since 1998, house prices have risen much faster than inflation for all three indices. Inflation has increased by 1.6, while house prices have risen by 3.3-3.8 times. The price of new dwellings has mostly been above the price of existing stock, except for the RMS-HPI between 2007 and 2014. In recent years the RMS-HPI shows a new-build premium of about 10%. For the RMS-HPI, the premium of new-build over existing stock was about 20% before 2003, but about 10% since 2018. Other analyses show this as 25% (Close Brothers, 2021) or 29% (ONS, 2021b).

Fig. 1(b) shows that the fluctuation of output from Construction Output Monthly (COM) of private new-build dwellings closely matches the fluctuation of prices obtained by the existing stock, trailing by 6–12 months (ONS, 2020b). This suggests the industry may be controlling the release of new private dwellings to maximise benefit from high prices (Miles & Whitehouse, 2013), whereas the OFT (2008) state that the prices of new and existing constrain each other.

The Energy Performance Certificate (EPC) dataset gives the floor area of new-build dwellings (Figure A.1(a)). This shows that the total floor area for houses, flats, and bungalows has changed little since 2009, and for maisonettes since 2012. Maisonettes are a small part of the market. The energy consumption density of new-build dwellings is shown in Figure A.1(b) in the inverse for comparison to price of construction. After improvement in performance in the first 4 years, the performance has changed little since 2012. Dwelling type shown in Figure A.1(c) shows a varying ratio between houses and flats.

An alternative narrative considers the profit of housebuilders (Archer & Cole, 2016, 2021; The Economist, 2019). Fig. 1(c) shows the profits per dwelling of the nine largest UK housebuilders, which have been climbing since the financial crisis (Archer & Cole, 2021). This shows that the profits of housebuilders have risen sharply since 2010, overshooting the pre-2008 level.

2.2. Building rates and costs

The rate of new-build of private dwellings in the UK (Fig. 2(a)) has averaged 150,000 p.a. since 1998 (ONS, 2022f) which is less than 1% of the stock (currently 30 million dwellings) (Department of Finance Northern Ireland, 2022; DLUHC, 2022b; Scottish Government, 2022; Welsh Government, 2022). The stock is usually about 4% larger than the number of households (ONS, 2022g) due to vacant and second homes. Letwin (2018) noted the slow build-out rates of housebuilders concluding that determining factors were the homogeneity of the types of homes and tenures and the size of the local market.

For prices of new-build private dwellings, Fig. 2(b) shows two sources of data, namely GFCF volume at current prices (ONS, 2017; 2019a) and COM (ONS, 2019b) detailed in Section 3. The rates of build and volume peaked just before the financial crisis, briefly plummeting, but have been rising since. Construction Statistics Annual Tables (CSAT) (ONS, 2021f) is available by trades (Fig. 2(c)) aggregated into six categories (Table B.1).

Along with GFCF price per dwelling in the UK, Fig. 3(a) shows output from COM per dwelling in GB. It includes the RICS Private Housing Construction Price Index (PHCPI) is based on housebuilders' costs for constructing a defined (standard) house accounting for the underlying direct costs (RICS, 2021). The index has been graphed at the same level as the output per dwelling value in 1998. Over 1998–2018, the index grew by a factor of 2.1 while GFCF price and output from COM grew faster, by factors of 3.9 and 4.4, respectively. Note that the PHCPI index as a benchmark for pricing residential buildings is used across the insurance industry to ensure cover tracks rebuild cost. Given that a rebuilt dwelling is similar to a new-build dwelling, it is striking how the new-build prices (Fig. 3(a)) have been rising much faster than the PHCPI index.

It is important to correct the datasets for inflation. GFCF volume (ONS, 2019a) is available at inflation corrected prices (chain-volume measure, @cvm) and output from COM is corrected by an implied output price indicator (ONS, 2022a); both shown in Fig. 3(b). For COM, materials, plant and labour costs are estimated and a fixed profit mark-up is applied (ONS, 2018a).

Fig. 3(c) shows the GFCF price and output from COM at inflation-corrected prices per dwelling. Both measures rise between 1998 and 2018, with GFCF price by a factor of 1.7 and output from COM by 2.0, so prices are running ahead of inflation.

Another source of cost is meeting the increasing regulatory standards

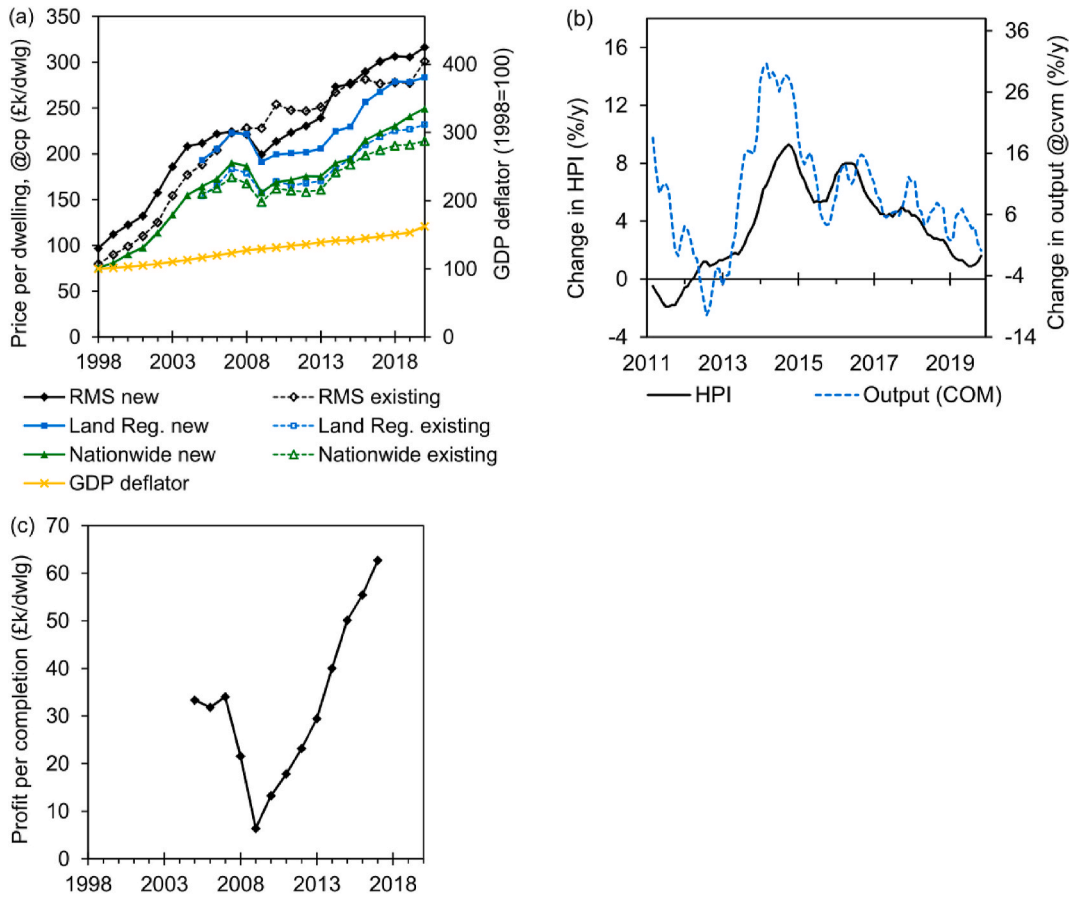

Fig. 1. (a) A comparison of house price indices at current prices and the GDP deflator. Data sources: (Land Registry, 2022; Nationwide Building Society, 2022; ONS, 2018a, 2021a, 2022f). (b) Private new housing. Annual changes in HPI and Construction Output cvm (*adjustment to vertical axes for clarity*). Data source: (ONS, 2020b). (c) Profit per completion for the nine largest UK housebuilders (Archer & Cole, 2021).

for energy efficiency of new homes. The UK Climate Change Committee described UK homes as *"unfit for the challenges of climate change"* (CCC, 2019). Although the legislation for zero-carbon homes was dropped in 2016, there are new requirements for low-carbon heating for new-build coming into force in 2025 (Potton & Hinson, 2020). Incremental technical improvements in house-building are considered to reduce costs (Cheshire et al., 2014; Glaeser et al., 2008) for which evidence is claimed in several European nations (Coelho et al., 2017). A useful international comparison of building codes has been conducted by Sun et al. (2016). However, Osmani and O'Reilly (2009) found that industry interviewees did not consider that there was a sales premium beyond the additional costs, suggesting that some firms will be willing to absorb the costs associated with low-carbon requirements.

2.3. Construction industry activity

The Construction Statistics Annual Tables (CSAT) by trades for the whole industry, not just new-build of private dwellings, is given in Fig. 4 (a) (aggregated according to Table B.1), excluding parts of civil engineering (Table C.1) with no involvement in the new-build of private dwellings. We use the term housebuilder explicitly for construction companies (SIC 41.2) building new private dwellings according to CSAT (Table C.1). The ABS can be used to approximate Gross Value Added (GVA), aGVA, which is distinguished between employees in the industrial category (SIC 41.2) of construction (Fig. 4(b)) and the industrial category (SIC 43) of specialists (Fig. 4(c)) (ONS, 2008, 2015; 2021g). Fig. 4(d) shows an index for the cost of labour in the construction industry from 2000 (ONS, 2022e).

2.4. Jobs

For the number of jobs *per dwelling built* there are industry estimates ranging between 3.1 (Litchfields, 2018) to 6.6 (Randstad, 2015). The formal number of employed jobs in the construction industry, there are three sources of data: COM, the ABS, and the ONS Labour Force Survey (LFS) (ONS, 2022d), compared in Fig. 5(a). Since COM is for GB only, it is shown with Northern Ireland construction for 2000 onwards (NISRA, 2021). The ABS appears to track COM with the variation due to different sampling methods. Fig. 5(b) shows jobs from CSAT detailed by trades for the whole industry, not just private new-build dwellings (aggregated according to Table B.1), excluding parts of civil engineering (Table C.1).

The construction industry has the highest proportion of self-employed compared to other industries, shown in Fig. 5(c) as the difference between the whole workforce (ONS, 2022h) and of employed-only. The self-employed are missed by COM and ABS which sample only what is on the inter-departmental business register (IDBR) comprising VAT and/or PAYE registered enterprises. In Fig. 5(c) the number on the IDBR register (ONS, 2021h) is compared with the number of enterprises sampled for ABS and CO. The latter are only slightly lower with the excess in the register being sole proprietors and partnerships. As this is much lower than the number of self-employed, virtually all are being missed from the sampling in COM and ABS.

Fig. 5(d) compares the proportions in the trades of construction of buildings, civil engineering, and specialists for self-employed from the LFS (ONS, 2021i) and employed from COM, and ABS. The proportions for COM and ABS are very similar for all trades. The self-employed is slightly higher for specialist, a lot higher for construction and a lot lower for civil engineering.

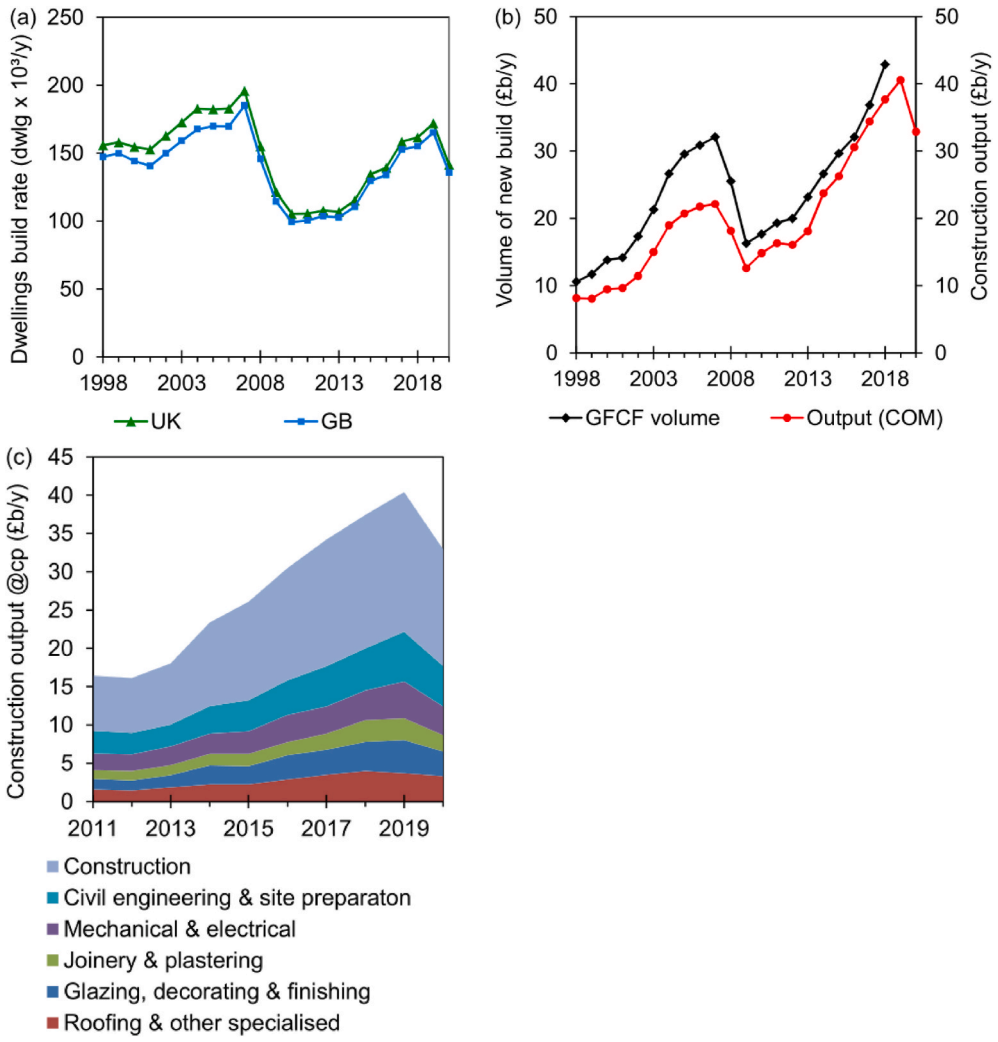

Fig. 2. Details for new-build private dwellings. (a) rate of house-building for the UK and GB. Data source: ONS (2022c). (b) total GFCF volume and output from COM at actual or current prices. Data sources: ONS (2019b, 2019a, 2017). (c) output from CSAT specific to trades (see Table B.1 for aggregation). Data source: ONS (2021b).

3. Method

Using the datasets described, a multi-unit integrated Sankey diagram (Roberts et al., 2015) can be developed for the UK house-building industry. The method processes these data in a transparent manner and provides a convenient way to visualise the relationships between the various flows (materials, jobs, money). In a Sankey diagram, the width of the lines is proportional to each variable. The national accounting methodology has been used previously to examine the impact of energy use across all sectors of the UK economy (Roberts et al., 2018), and has been applied to a single-industry (Roberts et al., 2021). A method is given to estimate the 'extra' gross operating surplus for the UK house-building industry.

3.1. Applying national accounts to UK house-building

National accounting methods were developed as a standard (adopted globally) with the express purpose of providing reliable datasets of economic activity (GDP) in a transparent manner (Lequiller & Blades, 2006; United Nations, 2008). GDP is derived from Supply and Use Tables (SUTS) which link different sectors of the economy together with imports, exports and final expenditure. Producing SUTs enables the ONS to examine the consistency and coherency of national accounts components within a single detailed framework. Concepts in national accounts for GDP are used to extract the specific details of the construction industry.

Within the UK SUTS, construction is treated as a single industry (Section F in SIC92, SIC03 and SIC07) and shown schematically in Fig. 6 as a Sankey diagram. The progression left to right in the diagram is by volume from industry output through products to buildings as assets. On the left, the construction industry is represented as being made up of two parts: establishments with employees and the self-employed (lines for the number of jobs in each). For the employed, national accounts provides costs of compensation of employees (CoE) and gross operating surplus (GOS). For the self-employed, their equivalent is the combined value of mixed income (MI). The sum of these three, along with tax on production, is the gross valued added (GVA) of the whole industry. The Sankey line of GVA goes from industrial activity as its contribution to the value of the construction product. Products are categorised according to CPA08 (see Table D.1), which at the upper levels (sections and divisions) have the same numbering as SIC07 for industry activities.

Other products are also required to produce construction – the intermediate consumption (IC) of products between industries – with the Use Table of SUTS listing which products are used by others. IC is shown at basic prices from input-output analytical tables (IOAT) (ONS, 2021c), to distinguish imports. The final construction product requires: materials, equipment, architects, engineers, and various other services (e.g. insurance, rental, security). Uses other than IC covered by a Use

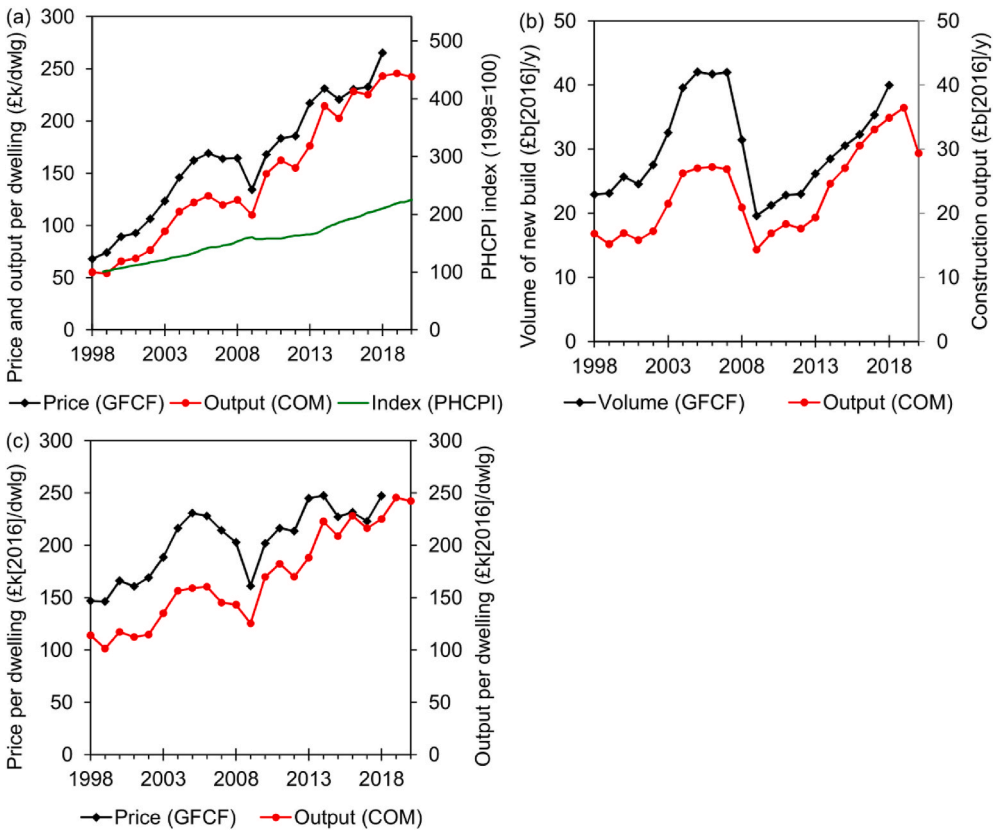

Fig. 3. (a) At current prices, GFCF price per new dwelling in the UK and output from COM per new dwelling in GB with comparison to the PHCPI (private housing construction price index). Data source: RICS (2021). (b) total GFCF at cvm prices and output from COM with implied output price indicator applied. Data sources: ONS (2019b, 2022a). (c) At cvm prices (indexed to 2016), GFCF price per new dwelling in the UK and output from COM per new dwelling in GB.

Table are expenditure (at purchasers' prices), as shown on the right in our Sankey diagram. In the full IC table for all products, there are complex loops of products used by each other. IC as a whole is managed through a matrix approach to avoid double-counting. The construction products F are a special case which makes them amenable to our Sankey format.

The destination for most construction products is buildings, which are treated as expenditure outside of IC. Use of construction products in IC is just for repair and maintenance. These users are utilities and other goods, architecture and engineering, and other services. The overlap of uses and the users remaining is a small number of products (see Table D.1), and the Sankey lines for these are very narrow. Therefore, this Sankey diagram representation is valid since there is minimal double-counting.

After IC, tax on products is applied for products are at purchasers' prices (@pp). Such products are for final expenditure of which the only type that applies to construction is the GFCF of buildings (assets). There is no standardised labelling system comparable to CPA08 for assets. GFCF covers fixed assets that are used repeatedly or continuously in production for more than one year. Data is available for GFCF of new dwellings, of interest, and GFCF excludes the value of *land underlying buildings* (ONS, 2018b). The assets split of buildings is referred to as type of work for COM and CSAT data. GFCF is specific in covering the type of work of new dwellings, and unique by including all costs corresponding to all the columns. However, it only applies for SIC07 section F construction (the top level) without any resolution at the second level, divisions 41–43.

ABS and GFCF data are represented in Fig. 6. A tabular view of their coverage and granularity, along with COM and CSAT data, are summarised in Figure E.1 with specific reference to new-build private dwellings of row 4. This shows that ABS data is granular (in separate columns) but does not distinguish type of building or work (bottom rows). In contrast, COM, CSAT and GFCF data are specific to new-build private dwellings but combine stages of production (across several columns).

3.2. Jobs

Jobs (employed and self-employed) in private new-build are derived using industry data, but data from COM and ABS for jobs is only for employed. For each trade c (SIC07 class or subclass, see Table B.1), an employment factor $EF_c(t)$ is derived from industry jobs $IJ_c(t)$ (Fig. 5(b)) and industry output $IO_c(t)$ (Fig. 4(a)),

$$EF_c(t) = IJ_c(t) \,/\, IO_c(t) \tag{1}$$

For each trade, c, employment per new-build $EB_c(t)$ is obtained from industry output per new-build $IOB_c(t)$ and $EF_c(t)$,

$$EB_c(t) = IOB_c(t) \cdot EF_c(t) \tag{2}$$

The ratio of self-employed to employed for each trade across industry F construction is assumed to apply to the type of work of new-build private dwelling. For different data types of jobs x, $B_x(t)$, $C_x(t)$ and $S_x(t)$ are set as number of jobs for each SIC division: construction of buildings, civil engineering, and specialists. The jobs per private dwelling of self-employed, $B_2(t)$, $C_2(t)$ and $S_2(t)$, are set by simple ratios,

$$B_2(t) = B_1(t) \cdot B_4(t) / B_3(t) \tag{3}$$

$$C_2(t) = C_1(t) \cdot C_4(t) / C_3(t) \tag{4}$$

$$S_2(t) = S_1(t) \cdot S_4(t) / S_3(t) \tag{5}$$

where data type x is set as 1 for jobs per private dwelling of employed, 2

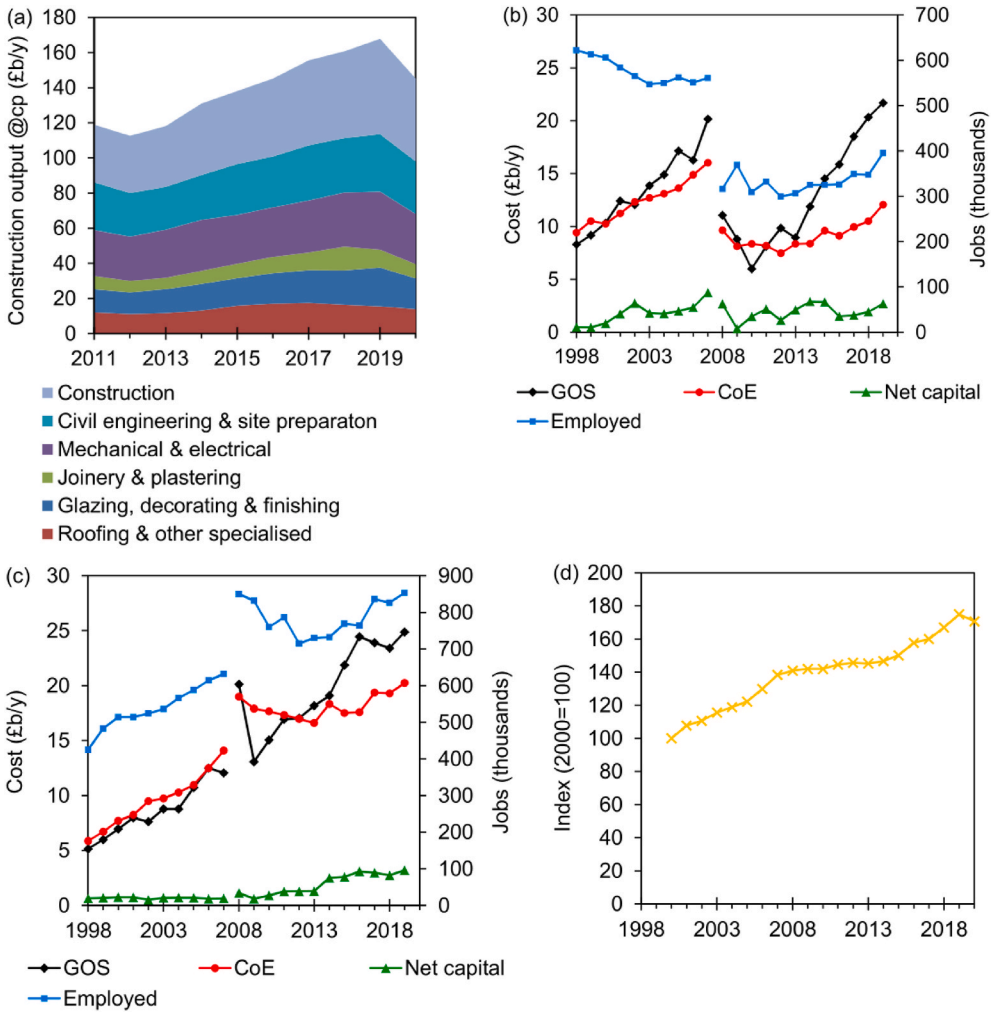

Fig. 4. Activity of the construction industry. (a) output from CSAT aggregated by trades (see Table B.1 for aggregation). (b) ABS costs and jobs for construction 45.21 up to 2007 and 41.2 from 2008 onwards. The break in the time-series between 2007-08 is due to switching from SIC92 and SIC03 class 45.21 to SIC07 group 41.2. Group 41.2 is 'Construction of residential and non-residential buildings', the nearest to building of dwellings. Class 45.21 is 'General construction of buildings and civil engineering works' which covers slightly more activities. Data sources: (ONS, 2008; 2021e). c) ABS costs and jobs for specialists 45.3 to 45.4 up to 2007 and 43 from 2008 onwards. The break between 2007-08 is due to switching from SIC92 and SIC03 groups 45.3 and 45.4 to SIC07 division 43. Division 43 is 'Specialised construction activities'. Group 45.3 is 'Building installation' and 45.4 is 'Building completion' which covers slightly less activities. Data sources: (ONS, 2008; 2021e). (d) AWE (average weekly earnings) index for construction. Data source: ONS (2022e).

for jobs per private dwelling of self-employed, 3 for all employed per SIC division from the LFS and 4 for all self-employed per SIC division from the LFS.

3.3. Estimating GOS-extra for new-build private dwellings

Using average weekly earnings (AWE) as an indicator of the CoE, ABS data can be used to derive GOS-extra. If all of this GOS-extra is assumed for new-build private dwellings, a method is developed of examining the size of GOS-extra for each new-build.

First, GOS-extra at current prices from ABS is calculated over the longest time period from available data. Fig. 4(b) shows a major change in GOS from 2007 to 2008 with the change from SIC02 class 45.21 'General construction of buildings and civil engineering works' to SIC07 group 41.2 'Construction of residential and non-residential buildings', which have slightly different coverage. GOS, G(t), CoE, E(t), and jobs, J(t), are set for SIC07 group 41.2 over 2008–2018 and extend them back to 1998. Note that jobs are reasonably constant on either side of the change, over 2002–2016, so can be used for scaling section 45.21 to 41.2. From jobs according to the 41.2 series J(t) and according to the 45.21 series $J_{old}(t)$, the scalar s of the old 45.21 series to 41.2 series is

$$s = J(2008)/J_{old}(2007) \quad (6)$$

$$= 0.56$$

Over $t = 1997$ to 2007 scalar s is used to convert GOS for 45.21, $G_{old}(t)$, and CoE for 45.21, $E_{old}(t)$, to the continuous time series, GOS G(t) and CoE E(t),

$$G(t) = s \cdot G_{old}(t) \quad (7)$$

$$E(t) = s \cdot E_{old}(t) \quad (8)$$

Instead of using E(t) directly, E(t) is indexed according to AWE construction index, A(t), as $E_{index}(t)$ from the year 2000,

$$E_{index}(t) = E(2000) \cdot A(t)/100 \quad (9)$$

GOS-extra, X(t), is calculated as the difference between GOS and the AWE index version of CoE,

$$X(t) = G(t) - E_{index}(t) \quad (10)$$

M(t) is set as the total output from COM for private new-build at current prices (MV6M) of which X(t) of GOS-extra, at current prices, is a part. From the output per dwelling at cvm, D(t), GOS-extra per dwelling at cvm is

$$X_{dwlg}(t) = D(t) \cdot X(t)/M(t) \quad (11)$$

The output per dwelling less GOS-extra at cvm is

$$D_{net}(t) = D(t) - X_{dwlg}(t) \quad (12)$$

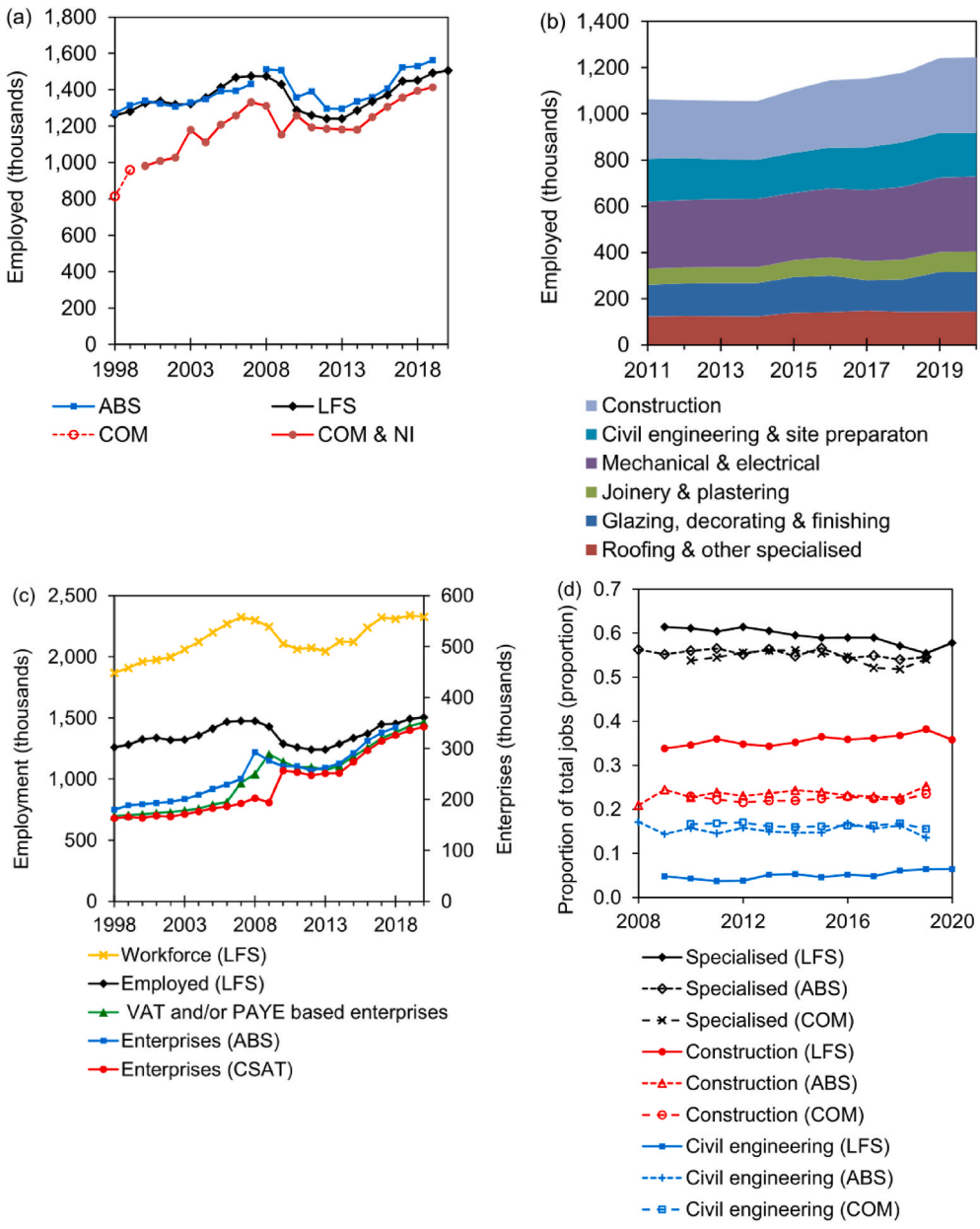

Fig. 5. (a) jobs sources for employed in construction (SIC section F). Data sources: NISRA (2021), ONS (2022f). (b) jobs from CSAT aggregated trades (see Table B.1 for aggregation). (c) jobs and registered enterprises over 1990–2020. Data sources: (ONS, 2008; 2021d; 2021e; 2021h; 2022d) (ONS, 2021h). (d) proportions by job type for self-employed from LFS and employed from ABS and COM 2008–2020. Data sources: (ONS, 2008; 2021d; 2021e; 2022d).

4. Results

The following possible factors of the increasing prices over time are examined:

- the value of land,
- inflation
- the changing size, energy efficiency, and density of dwellings,
- the employed labour required,
- the total workforce (employed and self-employed) required, and
- profit of housebuilders.

4.1. Value of underlying land and build cost

Fig. 7(a) shows GFCF price per new private dwelling (at current prices) net of land value and compares this to 'price of new' or final price according to HPI RMS; as expected, the net price stays below final price. Since GFCF excludes the cost of land, the difference between final price and net price is likely to be land value. The absolute level averages at £48k (Fig. 7(a)) and as a proportion of price (Fig. 7(b)) starts at 33% in 1997 falling to 13% by 2018. Over two decades (1998–2018), inferred land value per dwelling stays substantially constant (at current prices) while the net price of new build rises. This analysis suggests that the inferred price of land is decoupled from the rising price of new house-building. However, the data of actual price paid for land is not open-source so, we cannot be certain about the exact value of the commonly considered land price to build price ratio.

Fig. 3(c) shows the GFCF price and output from COM at inflation-corrected prices per dwelling. Output from COM is slightly less than GFCF price. The two key differences are shown in Figure E.1. First, output from COM excludes SIC07 group 41.1 developers in its summary figures. Second, as shown in Fig. 6, 'GFCF all buildings' has inputs in addition to construction products. These additional inputs are a small

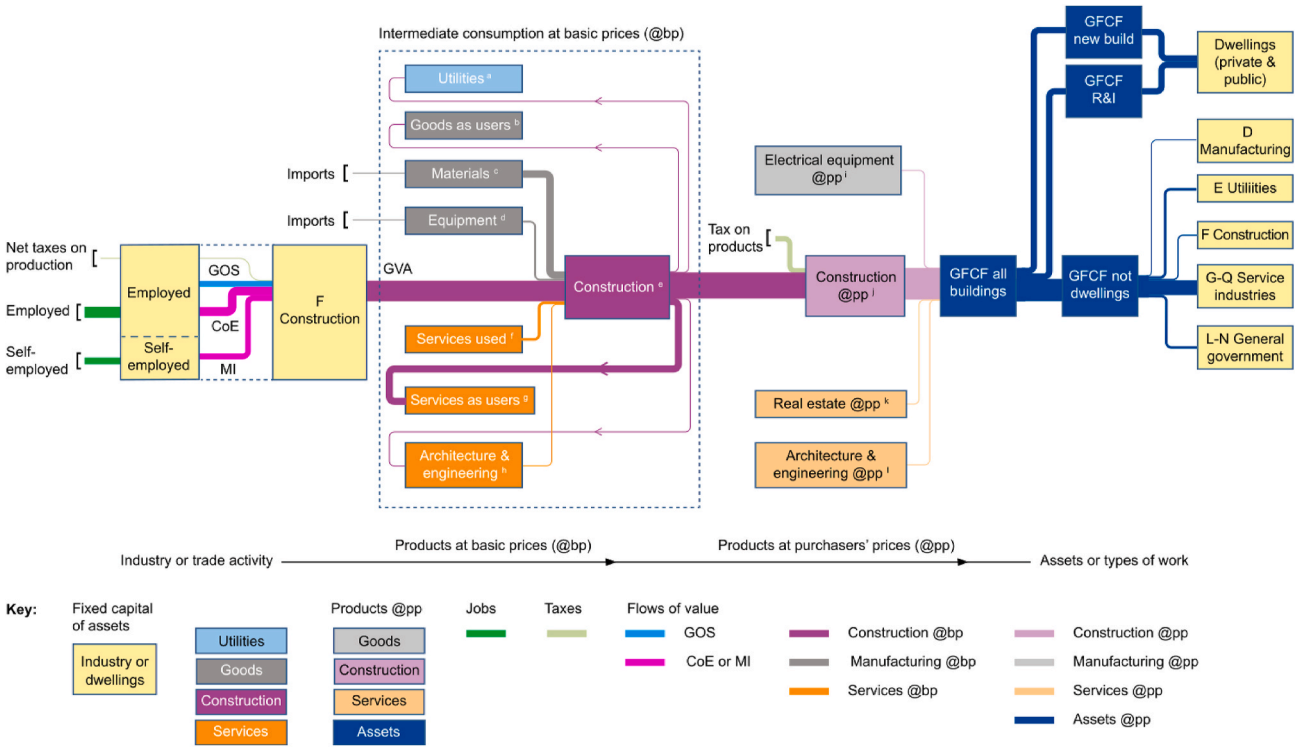

Fig. 6. Flow of value from construction industry GVA to GFCF assets using data for 2017. See Table D.1 for key to footnote letters and full details of the product aggregations.

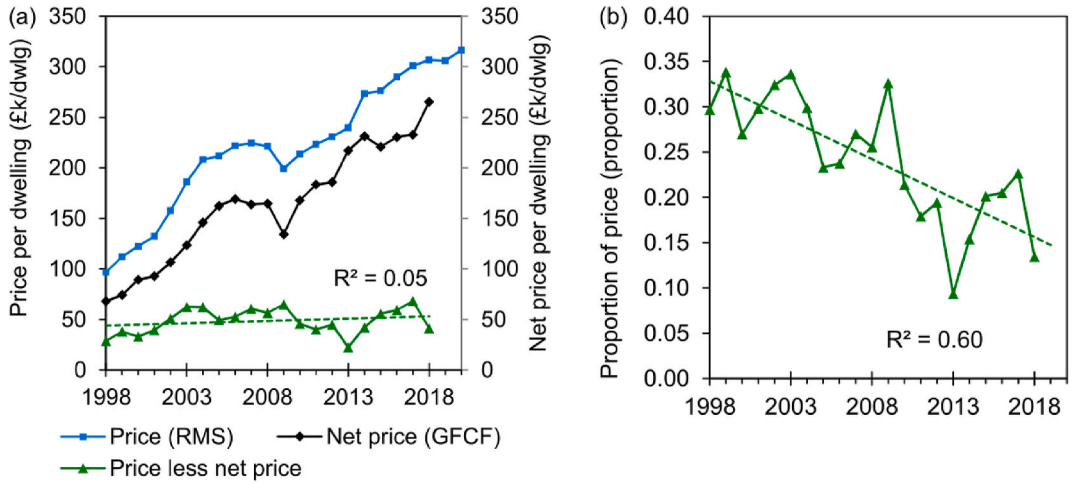

Fig. 7. Details for new-build private dwellings. (a) Final price and GFCF price net of inferred land value per dwelling. (b) Difference between final price and GFCF price as a proportion of final price.

proportion, starting at 14% falling to 10% (Figure A.2). Thus, it is valid to switch from GFCF price to output from COM to investigate the rising inflation-corrected prices. Although there are differences between the two series, the ONS notes they have similar underlying trends and output from COM is the primary data source for estimating GFCF private sector dwellings (ONS, 2019a). Using COM data means that the influence of developers is excluded from the remainder of this analysis.

4.2. Dwelling size, energy efficiency and development density

Can the increase in output from COM by a factor of 2.0 be attributed larger dwellings? Figure A.1(a) shows the floor area of four types of new-build dwellings since 2009. These data clearly show that houses, bungalows and flats have remained the same size with only maisonettes increasing in area, though these constitute less than 2% of new-build. Figure A.1(b) shows inverse energy consumption density of four types of new-build dwellings since 2009. After improvement in initial years, the performance has changed little since 2012. For development density, Figure A.1(c) suggests that the average density is varying (in aggregate). However, the proportion of flats does not correlate with price of construction (COM per new dwelling, $R^2 = 0.02$), nor with our inferred land value ($R^2 = 0.25$). Therefore, there must be other factors for the increasing prices than increase in size, improvements in energy efficiency or density of development.

4.3. Jobs per unit of new-build

Output from CSAT has resolution of employment, both by trade and by type of work. These data enable derivation of man-years per private new dwelling (Fig. 8(a)). In contrast to the rising output per private new dwelling, the labour input rises less (by only 23%) over 2011–2019 (Figure A.3) and by 42% to 2020, which includes the first year of Covid impact. Fig. 8(b) includes self-employed and shows that the man-years per private new dwelling rose by 29% over 2011–2020. Thus, the manpower to complete a dwelling cannot account for the rise in prices.

4.4. GOS-extra

Jobs can be used as the denominator (instead of number of dwellings built) to switch from products (dwellings) to industry (construction), and to access other data types. Changing to costs per job for ABS data in Fig. 9 shows there is continuity across the change of categorisation.

What is striking for construction of buildings (Fig. 9(a)) is that GOS per job starts comparable with CoE per job in 1997, but has a rising trend to 2018, only interrupted immediately after the financial crisis. Net capital is a component of GOS, but its trend is more similar to the overall slow rise of CoE. Fig. 9(a)) also has the AWE index for construction which starts from 2000 (set equal to CoE). Though CoE rose faster than the index initially, it resumed tracking the index after the financial crisis. For comparison, Fig. 9(b) shows the same set of data of specialists. Note that CoE tracks the index over the whole period and GOS is comparable to CoE, only going a little higher between 2014 and 2018. Therefore, the increasing GOS for construction of buildings is the exception.

It can be suggested that the rapid increase in GOS is only for private dwelling new-build where the final price is set by comparison to the market for existing housing i.e. it is 'extra' profit. As the data in Fig. 9(a) are available only from 1998, a conservative assessment is that the level of GOS to CoE in this initial year includes a normal profit level of a healthy industry.

For most types of work for construction of buildings, prices are competitive and often through a tender process. These can be referenced against tender price indices (BIS and BCIS, n.d.) *"based on the rates for measured work contained in Bills of Quantities or quantified schedules for accepted tenders"*. However, private new-build dwelling is unique amongst the types of work by construction of buildings since the majority of housebuilders are selling directly into the housing market. Therefore, competition is not by tender, but the market alongside extant housing.

Suppose that all of the GOS-extra over AWE (Fig. 9(a)) results from private new-build dwellings, then GOS-extra can be subtracted from the price per dwelling at cvm prices to see how much it accounts for the rising values. The total extra, X(t), is shown in Fig. 10(a), with the impact – $D_{net}(t)$ – in Fig. 10(b). The price corrected for GOS-extra has a slight reduction before the financial crisis and a levelling effect after. The extra itself shows an overall steady rise apart from a dip over five years after the financial crisis. This result shows that GOS-extra is of the right order of magnitude to account for much of apparent rising price. Fig. 10(b) shows the profit before tax of the nine largest UK housebuilders from Fig. 1(c) (adjusted to 2016 prices) using the GDP deflator. From 2015 the GOS-extra value approaches the profits of the largest companies suggesting that such high profits are becoming common across the industry for housebuilders of all sizes.

5. Conclusions

The long-standing problem of what factor(s) influence the rising price of new-build housing in the UK is amenable to analysis using the rich and robust time-series datasets produced by various government departments and agencies, including the national accounts. The prices of new private dwellings appear to track prices of extant dwellings; the RMS-HPI, new-build have premiums of 10–20%. We have shown that internationally agreed national accounting standards coupled with country-specific (but often common) datasets can be exploited to devise a method for investigating the individual factors affecting new-build house prices. Thus, we consider our method to be widely applicable.

The price of building a new house can be derived from GFCF and output from Construction Output Monthly (COM) and Construction Statistics Annual Tables (CSAT), all of which exclude land value. The inferred land value component of new private dwellings has been trending downwards from 23% of the selling price since 2010, with an average value at current prices over 1998–2018 being £48k.

GFCF price at current prices per dwelling and output from COM per dwelling are both rising faster than the price index, PHCPI. Inflation-

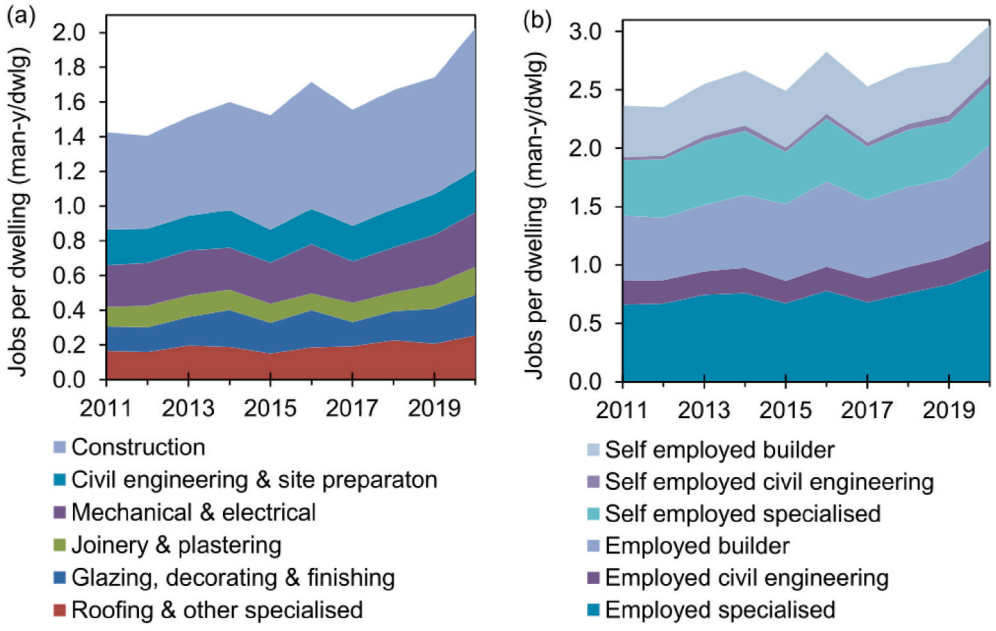

Fig. 8. Man-years of employed and self-employed per new private dwelling from CSAT over 2011–2019. (a) employed, detailed by trade. (b) self-employed and employed by broad categories. Data source: ONS (2021b).

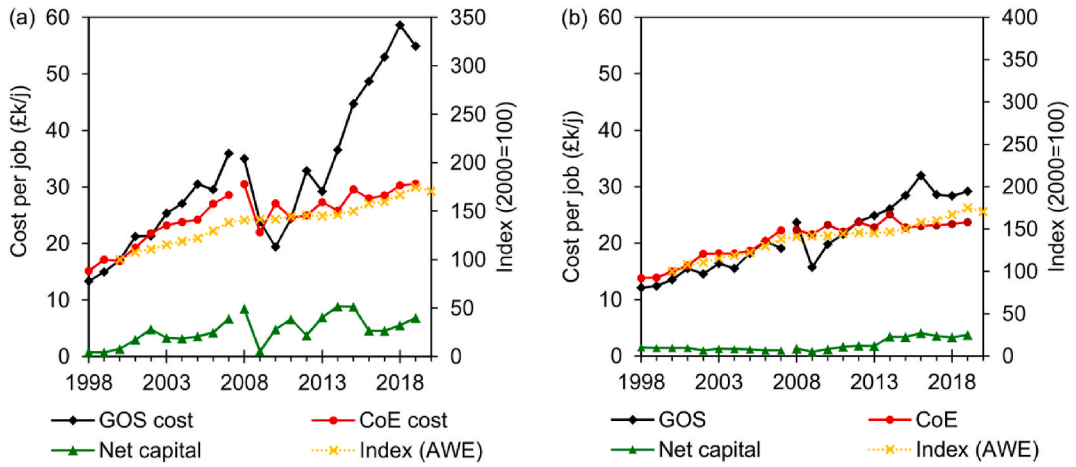

Fig. 9. ABS construction and specialist costs per job over 1998–2018 and the AWE construction index over 2000–2020. (a) costs per job for construction from 45.21 to 2007 and 41.2 from 2008. (b) costs per job for specialist from 45.4 to 2007 and 43 from 2008.

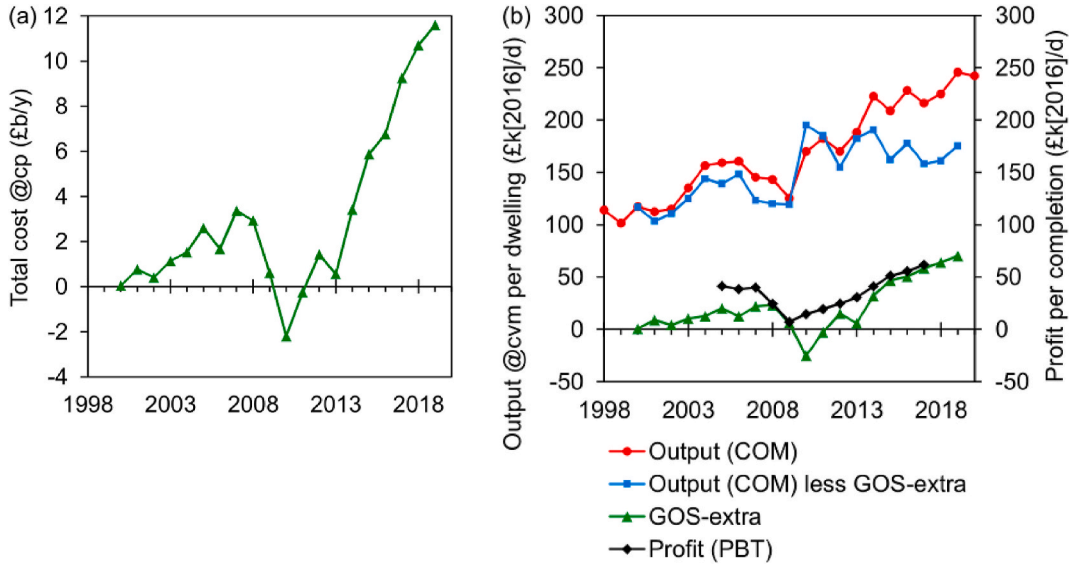

Fig. 10. Private new housing. (a) GOS-extra derived from ABS, at current prices. (b) output from COM per private dwelling at cvm less GOS-extra, also showing PBT (profit before tax) per completion from Fig. 1(c) at 2016 prices.

corrected prices (cvm) from GFCF and output from COM per dwelling have risen by factors of 1.7 and 2.0, respectively, over 1998–2018. Since 2009, the floor area of houses, bungalows and flats and their energy efficiency and mix of dwelling types have changed little and cannot account for the rising price of new-build. Density of development has varied but does not correlate with increasing price of new build. Including the self-employed, the total labour per new private dwelling is derived as 2.4 man-years in 2011 rising to 3.0 man-years in 2020. This change is insufficient to account for the increase in prices.

Though output from COM and CSAT are less comprehensive than GFCF prices, they track well the GFCF prices per dwelling, and their finer resolution, in terms of type of trade, enable deeper investigate of the rising prices. Output from COM and CSAT can be interpreted as price of build and supplemented with ABS data for construction, though this is not specific to the type of work of new-build private housing.

From ABS data, cost per job of both compensation of employees (CoE) and gross operating surplus (GOS) were used to create continuous time series over 1998–2019 through the change of classification from SIC02 to SIC08 in 2008. For construction companies, GOS has been rising much faster than CoE while for specialist companies GOS has tracked CoE. CoE of both construction and specialist companies has tracked the index of Average Wage Earnings (AWE) and was used as a baseline to derive the increasing additional cost of GOS of construction companies, here termed GOS-extra. GOS-extra peaks at £3.4b in 2007, dips to -£2.2b in 2010 after the financial crisis, then rises steadily to £11.6b in 2019. GOS-extra is associated with increased profit above profit in 2000, the earliest year for our analysis.

GOS-extra derived from ABS is for all buildings (not infrastructure) including repairs and maintenance, but excluding developers. All of GOS-extra can be assigned to private new housing, since this type of work is speculative with variable profit levels, while all the other types of work covered by ABS are by competitive tendering which constrains profit levels. When GOS-extra is subtracted from the cvm output per dwelling from COM, it reduces much of the increase. In particular, *output less GOS-extra* is unchanging between 2010 and 2019, suggesting that GOS-extra, and thus additional profit, accounts for most of the increase in price. In 2019 this was £70k per dwelling at 2016 prices. GOS-extra has an impact on increasing GDP, by £11.6b in 2019, through no change in the inherent value of products, giving a false impression of economic growth in national accounts. Archer and Cole (2021) obtained profit before tax from published accounts of the 9 largest house-building companies, and the values of GOS-extra cvm (2016) per dwelling

aligning closely. This suggests that their analysis is applicable across the whole industry.

The intricacy of this method is a function of changes in statistical methods, inconsistency of dataset composition, and incompatibility of datasets. The Consultative Committee on Construction Industry Statistics (BEIS, 2022) discusses issues relating to dissemination of UK construction statistics. One recommendation is that they include publication of inflation-corrected output and GFCF of private dwellings, both per new-build dwelling, to highlight these increasing prices. Other bodies or organisations could investigate housebuilders to establish the true composition of their prices. Furthermore, transparency will be improved by the Land Registry's commitment to achieve comprehensive land registration by 2030, covering all property ownerships, transactions, and options to purchase (DCLG, 2017; Edwards, 2015). The reason for the extra profit has not been determined here; that is a task for future research. However, several possibilities are noted: the pricing-in of risk (Ball, 2012) particularly following the 2008 financial crash, foreign direct investment (Poon, 2017), market manipulation through holding back land (HoL, 2016), Help-to-Buy schemes (Carozzi et al., 2020), financialisation of housing production (Archer & Cole, 2016, 2021; Edwards, 2015), and planning constraints (Bramley & Watkins, 2016; DCLG, 2017).

Establishing the on-going value of the GOS-extra has important implications for the net-zero agenda, the alleviation of fuel poverty, energy demand reduction, thermal comfort, the roll-out of future technologies, improvement in the housing stock, and the health impacts of poor-quality housing. Housebuilders could be using the premium prices they are earning from their houses to maximise thermal efficiency and other sustainability features of their products.

Author statement

Simon Roberts: Conceptualization, Methodology, Software, Data curation, Investigation, Validation, Visualization, Writing - original draft. Colin Axon: Conceptualization, Investigation, Methodology, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Additional data

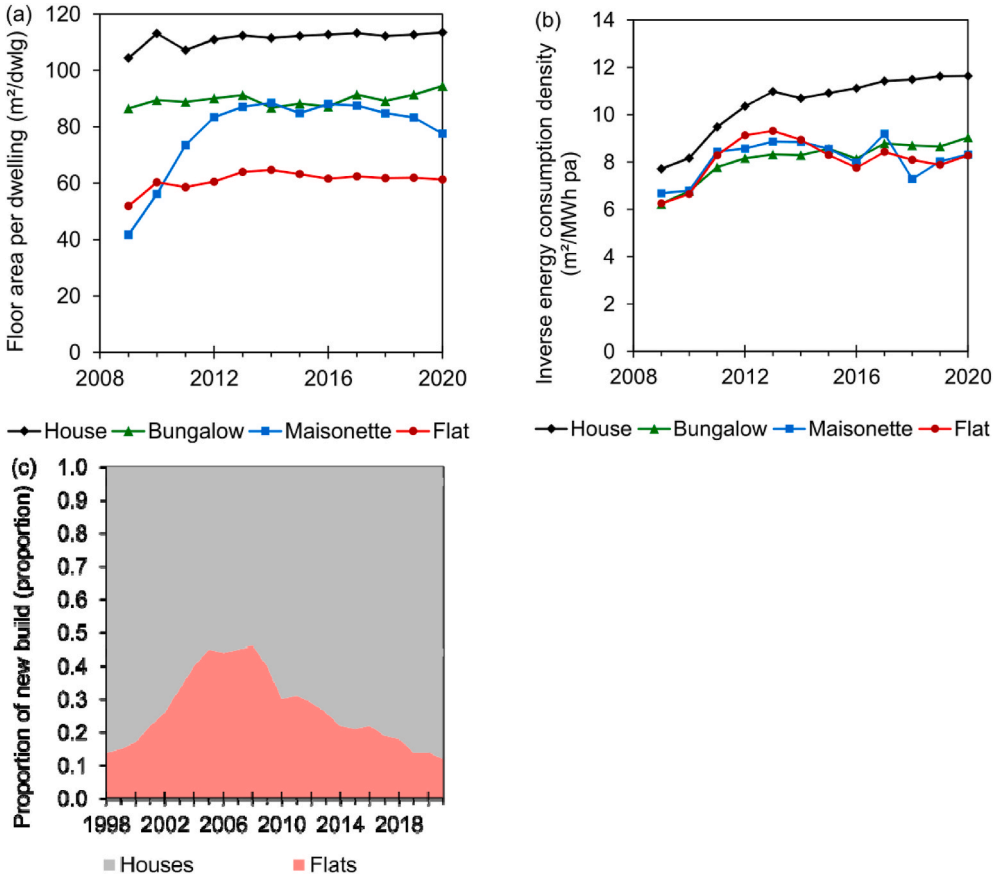

Fig. A.1. (a) Floor area of new-build dwellings according to EPCs. Data source: (DLUHC, 2022a). (b) Inverse energy consumption density according to EPCs. Data source: (DLUHC, 2022a). (c) Dwelling type of new-build dwellings. Data source: (DLUHC, 2022b).

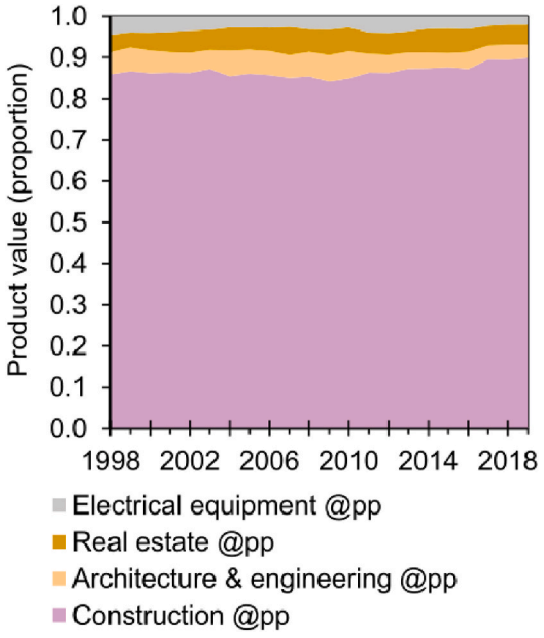

Fig. A.2. Proportions of products forming price of all buildings.

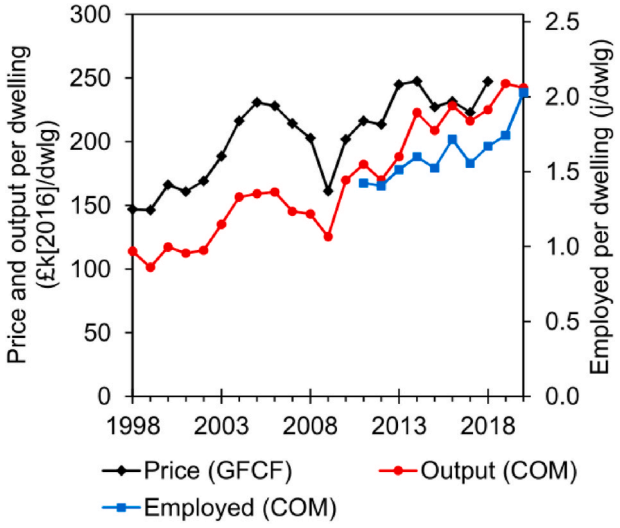

Fig. A.3. At cvm prices (indexed to 2016), price per new dwelling in the UK and output from COM per new dwelling in GB with comparison to employed jobs from COM per dwelling.

Appendix B. CSAT aggregation of trades

Table B.1
List of all trades under Construction Statistics Annual Tables (CSAT) and ABS by SIC07 with the aggregation used. Key: n.e.c, not elsewhere classified.

Aggregation	SIC07	Trade of firm
Note 1	41100	Development of building projects
Construction	41201	Construction of commercial buildings
Construction	41202	Construction of domestic buildings
Civil engineering & site preparation	42110	Construction of roads and motorways
Note 2	42120	Construction of railways and underground railways
Note 2	42130	Construction of bridges and tunnels
Note 2	42210	Construction of utility projects for fluids
Note 2	42220	Construction of utility projects for electricity and telecommunications
Note 2	42910	Construction of water projects
Civil engineering & site preparation	42990	Construction of other civil engineering projects n.e.c.
Civil engineering & site preparation	43110	Demolition
Civil engineering & site preparation	43120	Site preparation
Civil engineering & site preparation	43130	Test drilling and boring
Mechanical & electrical	43210	Electrical installation
Mechanical & electrical	43220	Plumbing, heat and air-conditioning installation
Glazing, decorating & finishing	43290	Other construction installation
Joinery & plastering	43310	Plastering
Joinery & plastering	43320	Joinery installation
Glazing, decorating & finishing	43330	Floor and wall covering
Glazing, decorating & finishing	43341	Painting
Glazing, decorating & finishing	43342	Glazing
Glazing, decorating & finishing	43390	Other building completion and finishing
Roofing & other specialised	43910	Roofing activities
Roofing & other specialised	43991	Scaffold erection
Roofing & other specialised	43999	Specialised construction activities (other than scaffold erection n.e.c.)

Note 1. Not part of construction.
Note 2. No involvement with new housing.

Appendix C. CSAT example

Table C.1, from Construction Statistics Annual Tables (CSAT), illustrates that the trade of firm and its type of work is not an exact mapping. While the SIC07 subclass 41202 'Construction of domestic buildings' is the most active for private new housing, one third of this value is also provided by SIC07 subclass 41201 'Construction of commercial buildings' (ONS, 2021f).

Table C.1
Example of Construction Output Table 2.8 for 2019. All prices are £m at current prices. Key: n.e.c, not elsewhere classified. Data source: (ONS, 2021f).

Trade of firm	SIC07	New Housing		Other New Work		Repair & Maintenance				All Work
		Public	Private	Infra-structure	Excluding infrastructure	Housing		Infra-structure	Other Work	

(*continued on next page*)

Table C.1 (*continued*)

Trade of firm	SIC07	New Housing		Other New Work				Repair & Maintenance					All Work
		Public	Private	Infra-structure	Excluding infrastructure			Housing		Infra-structure	Other Work		
					Public	Private Industrial	Private Commercial	Public	Private		Public	Private	
					Public	Private Industrial	Private Commercial	Public	Private		Public	Private	
Construction of commercial buildings	41201	899	4,499 †	3,022	1,845	865	5,034	299	923	528	445	952	19,311
Construction of domestic buildings	41202	3,071	13,706 †	1,464	2,767	409	4,195	2,674	4,185	87	771	1,567	34,896
Construction of roads and motorways	42110	93	1,441	1,643	76	74	603	13	254	1,600	324	112	6,233
Construction of railways and underground railways	42120	2	12	1,594	2	5	15	2	3	332	4	2	1,973
Construction of bridges and tunnels	42130	0	0	13	0	0	0	0	0	40	0	0	53
Construction of utility projects for fluids	42210	3	62	1,122	180	2	156	3	11	89	5	7	1,640
Construction of utility projects for electricity and telecommunications	42220	0	48	3,852	8	4	6	0	7	492	5	1	4,423
Construction of water projects	42910	2	29	170	8	3	38	4	66	118	6	24	468
Construction of other civil engineering projects n.e.c.	42990	572	4,369	6,790	1,831	766	2,913	331	1,211	3,427	395	927	23,532
Demolition	43110	22	160	133	53	289	354	6	28	3	10	39	1,097
Site preparation	43120	31	506	153	83	92	491	10	52	118	15	82	1,633
Test drilling and boring	43130	1	38	129	8	101	49	1	5	2	7	7	348
Electrical installation	43210	270	1,962	1,611	1,067	1,271	5,807	742	1,813	902	828	3,296	19,569
Plumbing, heat and air-conditioning installation	43220	335	2,859	72	740	584	2,419	1,185	2,875	176	603	1,621	13,469
Other construction installation	43290	111	803	107	318	200	962	297	999	116	166	732	4,811
Plastering	43310	165	941	95	119	11	262	106	195	5	11	40	1,950
Joinery installation	43320	167	1,887	38	313	164	2,335	316	2,271	14	199	485	8,189
Floor and wall covering	43330	171	489	6	216	103	975	129	490	5	142	438	3,164
Painting	43341	114	467	4	62	68	334	466	851	125	242	674	3,407
Glazing	43342	8	189	0	24	19	154	40	392	7	48	74	955
Other building completion and finishing	43390	329	2,401	346	239	96	1,061	434	3,279	58	464	1,015	9,722
Roofing activities	43910	239	835	47	250	141	853	251	538	22	277	651	4,104
Scaffold erection	43991	171	675	95	161	92	510	123	387	254	101	251	2,820
Specialised construction activities (other than scaffold erection n.e.c.)	43999	254	2,178	747	335	592	1,956	159	825	770	177	623	8,616
All trades		7,030	40,556	23,253	10,705	5,951	31,482	7,591	21,660	9,290	5,245	13,620	176,383

† Provision of private housing is split between one third by the SIC07 subclass 41201 'Construction of commercial buildings' and two thirds by the SIC07 subclass 41202 'Construction of domestic buildings' which is the most active for private new housing.

Appendix D. Product aggregation

Fig. 6 shows in the form of a Sankey diagram product groups related to the progression from activity of the construction industry through to completed assets of buildings. Table D.1 details how these product groups disaggregate according to the CPA.

Table D.1
Product aggregation for Fig. 6. Key: n.e.c, not elsewhere classified.

Sankey label	CPA Group	CPA description
Utilities [a]	35.1	Electric power generation, transmission and distribution
	35.2–3	Manufacture of gas; distribution of gaseous fuels through mains; steam and aircon supply
Goods as users [b]	19	Manufacture Of Coke And Refined Petroleum Products

(*continued on next page*)

Table D.1 (*continued*)

Sankey label	CPA Group	CPA description
	25OTHER	Manufacture of fabricated metal products, excluding weapons & ammunition - 25.1-3/5-9
	33OTHER	Rest of repair; Installation - 33.11-14/17/19/20
Materials [c]	08	Other mining and quarrying products
	16	Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials
	19	Coke and refined petroleum products
	20.3	Paints, varnishes and similar coatings, printing ink and mastics
	22	Rubber and plastic products
	22.5–6	Manufacture of cement, lime, plaster and articles of concrete, cement and plaster
	23OTHER	Glass, refractory, clay, other porcelain and ceramic, stone and abrasive products - 23.1-4/7-9
	24.1–3	Basic iron and steel
	24.4–5	Other basic metals and casting
	25OTHER	Fabricated metal products, excl. machinery and equipment and weapons & ammunition - 25.1-3/25.5–9
Equipment [d]	26	Computer, electronic and optical products
	27	Electrical equipment
	28	Machinery and equipment n.e.c.
Construction [e]	41–43	Construction
Services used [f]	62	Computer programming, consultancy and related services
	64 *	Financial services, except insurance and pension funding
	65.1–2 & 65.3 *	Insurance, reinsurance and pension funding services, except compulsory social security
	69.1	Legal services
	77	Rental and leasing services
	78	Employment services
	80	Security and investigation services
	84 *	Public administration and defence services; compulsory social security services
Services as users [g]	46	Wholesale Trade, Except Of Motor Vehicles And Motorcycles
	47	Retail Trade, Except Of Motor Vehicles And Motorcycles
	52	Warehousing And Support Activities For Transportation
	64 *	Financial Service Activities, Except Insurance And Pension Funding
	65.1–2 & 65.3 *	Insurance, reinsurance and pension funding services, except compulsory social security
	68.3	Real estate activities on a fee or contract basis
	68BXL683	Buying and selling, renting and operating of own or leased real estate, excluding imputed rent
	68A	Owner-Occupiers' Housing
	70	Activities Of Head Offices; Management Consultancy Activities
	71	Architectural And Engineering Activities; Technical Testing And Analysis
	81	Services To Buildings And Landscape Activities
	84 *	Public Administration And Defence; Compulsory Social Security
	85	Education
	86	Human Health Activities
Architectural and engineering [h]	71	Architectural and engineering services; technical testing and analysis services
Electrical equipment [i]	27	Electrical equipment
Construction [j]	41–43	Construction
Real estate [k]	68.3	Real estate activities on a fee or contract basis
Architectural and engineering [l]	71	Architectural and engineering services; technical testing and analysis services

* Products appearing in both Services used and Services as users of Fig. 6.

Appendix E. Mapping of datasets

The coverage and granularity of data types ABS, COM, CSAT and GFCF is summarised in Figure E.1 with specific reference to new-build private dwellings of row 4. The columns 'Gross operating surplus' to 'Other inputs to assets' correspond to positions along the Sankey schematic (Fig. 6). Also included are 'LESS Construction products used by others' and 'Tax on products' for completeness but note both are zero for new-build dwellings. The rows correspond to SIC07 divisions and groups along with asset or types of work. Since COM is specific to actual construction activities, it excludes SIC07 class 41.1 (developers). COM in rows 2–4 refers to MV6M which is specific to covering the type of work of new housing, but does not distinguish between SIC07 class 41.2 and sections 42-43. The CSAT publication disaggregates to class 41.2 as well as to the types of work such as new housing in their Table 2.8 to 2018 (see Appendix B) and Table 1.4 in 2019. ABS is specific to the trades/industry of SIC07 41.2, but has no resolution of the type of work. This means it does not distinguish between private housing or other non-infrastructure buildings, or between new-build and repair and maintenance. However, it reports aGVA and within the resolution of CoE, GOS and net taxes on production.

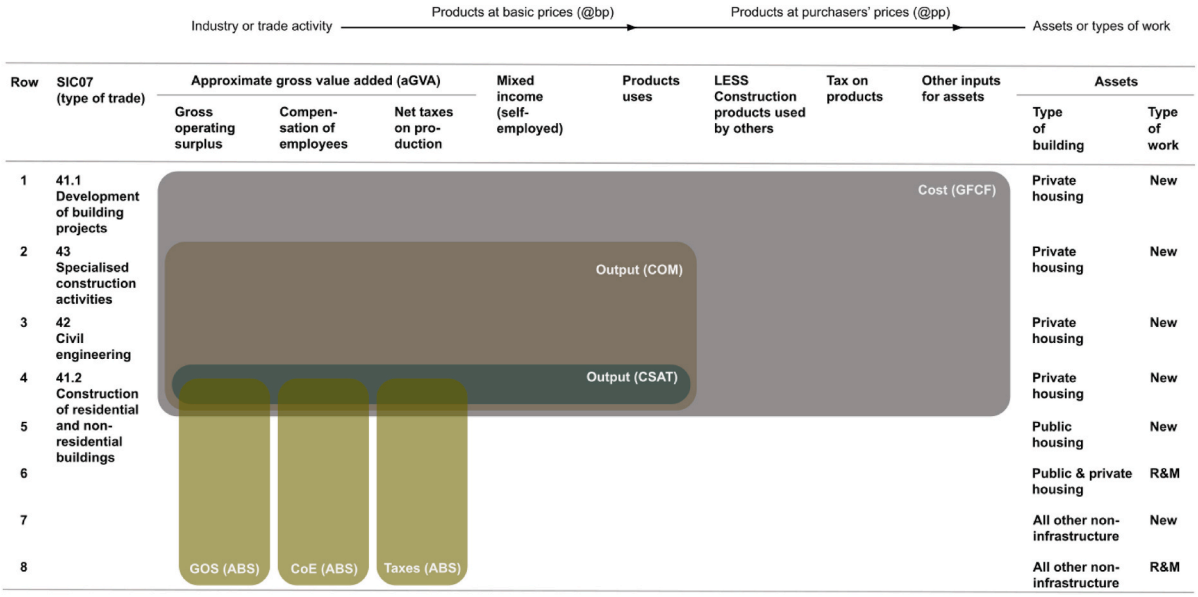

Fig. E.1. A mapping of datasets to the construction industry (SIC07 41.2) building new private housing (row 4). The map extends from type of industry (SIC07) or trade to type of asset or work with progressive accumulation of cost from left to right, in accordance with the Sankey diagram (Fig. 6). The dataset of output from CSAT is specific to row 4 but covers 5 columns. Datasets of output from COM and GFCF price include other industries covering rows 2 to 3 and 1 to 3, respectively. The ABS datasets have individual column resolution, but include activity in other types of work covering rows 5 to 8.

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