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Global Expert Mission
Japan Transforming Construction 2019

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Welcome

Innovate UK[1] global missions programme is one of its most important tools to support the UK's Industrial Strategy's ambition for the UK to be the international partner of choice for science and innovation. Global collaborations are crucial in meeting the Industrial Strategy's Grand Challenges and will be further supported by the launch of a new International Research and Innovation Strategy.

Innovate UK's Global Expert Missions, led by Innovate UK's Knowledge Transfer Network (KTN), play an important role in building strategic partnerships, providing deep insight into the opportunities for UK innovation and shaping future programmes.

The Transforming Construction Expert Mission travelled to Japan in the first week of April 2019. During the mission, a delegation of experts from industry, government and academia visited the cities of Tokyo and Osaka over five days to meet key stakeholders from the Japanese construction sector.

Two of the meetings were with government organisations:
1. The British Embassy[2]
2. The Ministry of Land, Infrastructure, Transport and Tourism[3] (MLIT)

Three meetings were with Japanese government funding, and trade and investment agencies:
3. The New Energy and Industrial Development Organisation[4] (NEDO)
4. Japan Bank for International Cooperation[5] (JBIC)
5. The Japan External Trade Organisation[6] (JETRO)

Eight meetings were with Japanese companies:
1. Obayashi Corporation[7]
2. Komatsu Ltd[8]
3. Sekisui House[9]
4. Daiwa House Industries[10]
5. Mitsui & Co Ltd[11]
6. Panasonic Homes[12]
7. Muscle Corporation[13]
8. Hankyu Hanshin Holdings Inc[14]

The group also visited a home materials, fittings and equipment showroom operated by LIXIL Group Corporation[15].

In this publication we share the information and insights gathered during the delegation's time in Japan.

[1] www.gov.uk/government/organisations/innovate-uk
[2] https://www.gov.uk/world/organisations/british-embassy-tokyo
[3] http://www.mlit.go.jp/en/index.html
[4] https://www.nedo.go.jp/english/
[5] https://www.jbic.go.jp/en/
[6] https://www.jetro.go.jp/en/
[7] https://www.obayashi.co.jp/en/
[8] https://home.komatsu/en/
[9] https://www.sekisuihouse-global.com/
[10] https://www.daiwahouse.com/English/
[11] https://www.mitsui.com/jp/en/index.html
[12] https://homes.panasonic.com/english/
[13] http://www.musclecorp.com/english/index.php
[14] https://www.hankyu-hanshin.co.jp/en/corporate/about_us/realestate.html
[15] https://www.lixil.com/

1. Introduction

1.1 Transforming Construction Programme

The UK Government identifies construction as one of the largest sectors in the UK economy – with an annual turnover in 2017 of £370 billion, contributing £138 billion in value-added to the UK economy, and employing 3.1 million people (nine per cent of the total UK workforce).[16]

However, the Farmer Review of the UK Construction Labour Model[17] diagnosed deep structural problems in the sector. These included low productivity, low predictability, fragmentation, labour and skills shortages, and a lack of research, development, and investment in innovation.

The Farmer Review made a number of recommendations, most of which were accepted by the UK Government[18], paving the way for the Construction Sector Deal.[19] By encouraging investment in innovation and skills, creating new and well-paid jobs, and maximising its export potential, the deal will substantially boost the sector's productivity. This will also reduce the environmental impact, improve the efficiency and reduce the whole life cost of new projects and buildings to help build the houses, schools, hospitals and major transport projects British society needs.

The Construction Sector Deal is being delivered through the Programme on Transforming Construction[20]. It aims to co-invest £170 million of public money to encourage the development and uptake of advanced manufacturing, energy and digital solutions in the construction sector.

Its success will be partly measured by the extent to which its activities open up new opportunities and markets internationally. As a developed nation facing similar socioeconomic challenges to the UK and with a strong reputation for industrial innovation and process efficiency, Japan has been identified as a potential strategic partner for collaboration in the construction sector.

1.2 Scope of Enquiry

The delegation's scope of enquiry was related to all issues with the potential to improve the construction sector's processes and outputs, from design through to maintenance and demolition of buildings and infrastructure assets. While there was no limitation on the areas of innovation or technology included, in the mission there was a strong focus on offsite manufacturing processes and digitalisation.

It is worth noting that the goals of improved productivity, efficiency, sustainability and market viability go beyond the boundaries of the mission's formal sector-specific scope. When appropriate, the delegation extended its remit, asking about issues relating to, for example, Japan's wider economic and cultural context.

1.3 Disclaimer

This report is based on discussions held during a single week with a small number of construction industry representatives and government bodies in Japan's largest and third largest cities, Tokyo and Osaka. While its findings accurately reflect those discussions, it cannot hope to be an entirely accurate reflection of the state of play in the Japanese construction industry.

[16] https://www.gov.uk/government/publications/construction-sector-deal/construction-sector-deal#fn:3
[17] http://www.cast-consultancy.com/news-casts/farmer-review-uk-construction-labour-model-3/
[18] http://www.constructionleadershipcouncil.co.uk/wp-content/uploads/2017/07/Government-Response-to-the-Farmer-Review_19-July-2017.pdf
[19] https://www.gov.uk/government/publications/industrial-strategy-sector-deals/introduction-to-sector-deals#construction
[20] https://www.ukri.org/innovation/industrial-strategy-challenge-fund/transforming-construction/

2. Overview of Japan and its Business Environment

Understanding the differences between Japan and the UK's respective social and economic contexts helps in the assessment of the merits of collaboration between the countries.

Japan's international profile is currently very prominent. The old Emperor Akihito has abdicated, ushering in a new imperial era with a theme of "Rei-wa" - order and harmony. The country will host the G20 summit and Rugby World Cup in 2019. In addition, Tokyo will host the Olympics in 2020. Osaka, Japan's third city, will host the World Expo in 2025. As a consequence, Japan's construction sector is booming.

2.1 Understanding the Underlying Market Context

2.1.1 Geographical Factors

Similar to the UK, Japan is an island nation. However, the country's land area is over 1.5 times[21] bigger and its population is twice as large at 127 million people, compared to just 66 million in the UK[22].

Because the natural landscape is comparatively mountainous, conurbations in Japan are significantly more densely populated than the UK. Indeed, Tokyo is the most populous megacity in the world at more than 38 million people[23], four times more than London.

Japan is more exposed to natural disasters than the UK. In particular, it is very seismically active, meaning that it is at heightened risk of earthquakes and tsunamis. Also, it is in the path of severe weather in the form of typhoons. This threatens Japan's built environment, leading to important differences in the two countries' construction sectors.

2.1.2 Declining, Ageing Population, and Skills Shortages

Japan's average life expectancy is the highest in the world at just under 84; the UK's is 81[24]. Meanwhile, its population is now declining and ageing. There is a similar but less pronounced trend in the UK. An ageing population presents very real social and economic challenges to both countries. Related to that, they face severe labour and skills shortages in their respective construction industries. The Japanese and British governments' objectives are thus aligned and give rise to opportunities for mutually beneficial partnerships in resolving the challenges.

2.1.3 Response to Environmental Protection

The UK performs better than Japan on CO_2 emissions, although that is after having a far worse record for many years in the previous century. Whereas the UK's emissions are on a steady decline from a high of 11.823 metric tons per capita in 1970 to 6.497 metric tons per capita in 2014, Japan's has steadily risen (from a much lower base) and, while now levelling off, is still relatively high at 9.589 metric tons per capita in 2014. [25]

This suggests that the UK's national policy framework and technical strategies for reducing carbon emissions are more effective than Japan's. With tackling climate change a pressing global concern and because Japan is committed to stringent GHG-reduction targets (80 per cent by 2050[26]), there is a possible opportunity for the UK to export its products, services and expertise in this field.

2.2 General Business Environment

Japan punches well above its weight on the world economic stage, with a GDP in 2017 of USD 4.872 trillion[27], the third-largest in the world behind the USA and China. (The UK's was USD 2.622 trillion in 2017.) Japan has free trade agreements with large parts of the world[28]. Almost a third of Japan's GDP comes from the industrial sector, which employs 26 per cent of the workforce. By contrast, the service sector in Japan accounts for almost 70 per cent of GDP, employing 70 per cent of the workforce. [29]

[21] According to the Geospatial Information Authority of Japan, Japan's land area is 377,974 km², whereas according to Trading Economics, the UK's is 241,930 km²
[22] https://data.worldbank.org/?locations=JP-GB
[23] https://www.un.org/en/events/citiesday/assets/pdf/the_worlds_cities_in_2018_data_booklet.pdf
[24] https://data.worldbank.org/?locations=JP-GB
[25] https://data.worldbank.org/?locations=JP-GB
[26] Figure quoted in meeting with NEDO
[27] https://data.worldbank.org/country/japan
[28] Evidence from meeting with JETRO
[29] Innovate UK & Future Cities Catapult (2018) Japan: Country Overview and Innovation Ecosystems

Unemployment in Japan was 2.5 per cent[30] at the start of 2019, compared to 4 per cent[31] in the UK. Japan has a large, affluent consumer market, but consumer confidence, while high compared to ten years ago, is falling.[32]

For a country famed for its process efficiency, productivity in Japan is low (see Figure 1), with large numbers of people employed in relatively low-skilled jobs. This is a reflection of culturally ingrained employment practices, backed up by employment laws that prefer to keep people in both the private and public sectors employed even in economically challenging circumstances – a process described as "economic adjustment". The delegation found this to be at odds with both the Japanese government's stated ambition to improve productivity and for a nation that has deployed high levels of automation and robotics.

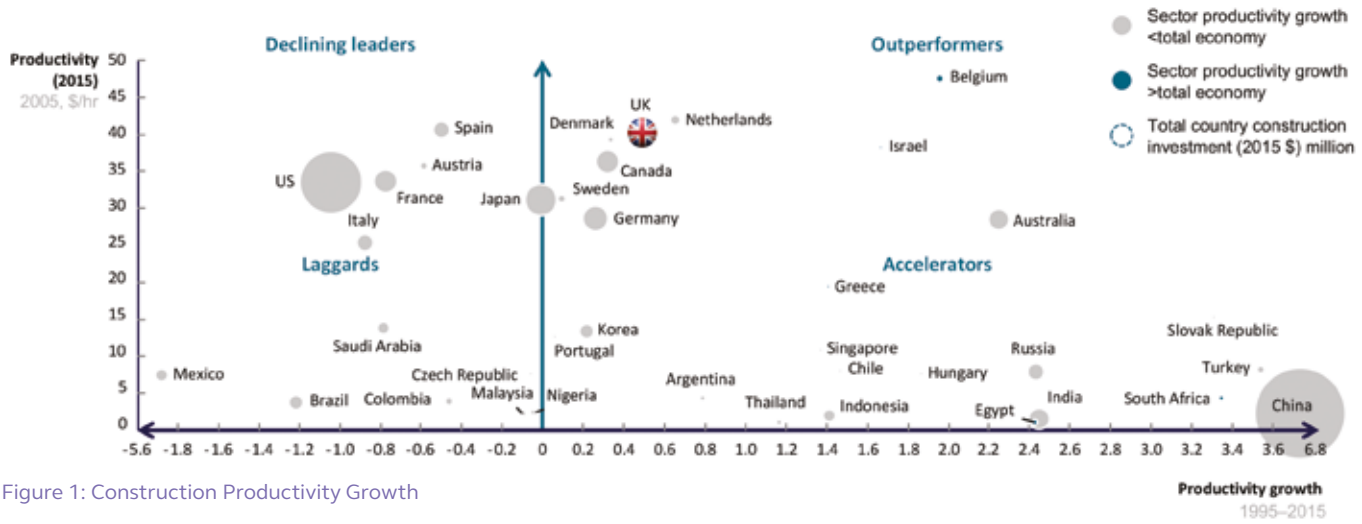

Figure 1: Construction Productivity Growth

2.3 Trading History

Japan and the UK have strong trade links. Well over a thousand Japanese companies have offices in the UK,[33] attracted not just because of its world-leading expertise in many fields or because it has a business-friendly political and regulatory environment, but also because it provides a strategic base from which to access the EU market.

Once the recipient of high levels of FDI, Japan has slipped down the ranks in the last decade or so, especially in the wake of the earthquake and tsunami in 2011. Since then, however, FDI is increasing again, actively helped by its strong respect for intellectual property[34] and Japanese Prime Minister Shinzo Abe's FDI-friendly policies, which include tax breaks and subsidies for foreign companies to establish businesses in Japan and structural reforms of corporate governance rules.[35] Nonetheless, its ease of doing business index – 39 – is significantly worse than the UK's – 9.[36]

2.4 Doing Business in Japan

The British Embassy[37] is on hand to help British companies interested in doing business in Japan, able to put them in touch with local contacts, stage events, and provide research and expertise. It advises that Japanese companies' approach to partnerships is cautious and slow. They like to be sure of the fit and will sign memoranda of understanding sooner than enter into firm contracts. They will accept partners in the role of a critical friend.[38]

2.5 Attitude to Innovation

In 2016, Japanese Prime Minister Shinzo Abe announced a new industrial strategy for Japan known as Society 5.0.[39] It sets out a vision of a human-centred, highly-connected, "super-smart" society that fully incorporates the technological innovations of the fourth industrial revolution[40]. Aligned to the UN's Sustainable Development Goals, it bets on advanced manufacturing, ICT,

[30] https://www.reuters.com/article/us-japan-economy-unemployment/japan-jobless-rate-25-percent-in-january-government-idUSKCN1QH33U
[31] https://www.bbc.co.uk/news/business-47290331
[32] https://tradingeconomics.com/japan/consumer-confidence
[33] https://www.uk.emb-japan.go.jp/files/000201478.pdf
[34] Evidence from meeting with JETRO
[35] https://uk.practicallaw.thomsonreuters.com/7-596-7228?transitionType=Default&contextData=(sc.Default)&firstPage=true&comp=pluk&bhcp=1
[36] https://tradingeconomics.com/japan/ease-of-doing-business
[37] https://www.gov.uk/world/organisations/british-embassy-tokyo
[38] Evidence heard in meeting with the British Embassy
[39] https://www.japanindustrynews.com/2017/08/japans-society-5-0-going-beyond-industry-4-0/ and https://www8.cao.go.jp/cstp/english/society5_0/index.html
[40] https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/

What is Society 5.0?

Society 5.0 is Japan's super-smart human-centred vision for how it would like its future to unfold. The concept trusts in the exploitation of digital technologies for social good. It is comparable to the UK's Industrial Strategy.

By focusing on innovation in the fields of AI, big data analysis, robotics, advanced manufacturing, sensor technology and IoT, the Japanese government can fulfil two pressing goals.

First, it can boost Japan's economic performance sustainably in the face of global and domestic threats and fierce competition from other countries. The UK equivalent is the "Sector Deals". [45]

Second, it can solve the challenges of climate change, resource depletion, social and economic inequality, food insecurity, an ageing population, and so on. These concerns correlate with the UK's "Grand Challenges". [46]

This innovation will see a convergence of physical space with virtual space. It will unlock big data (currently tied up in data silos or simply not collected) automatically to create new value-adding information, help those in need equitably, and free humans from many kinds of heavy, dangerous or stressful work.

This will be expressed in all facets of life. For example, healthcare will be preventative and given by robots, improving quality of life and reducing the healthcare burden. Energy generation will be diversified to renewable sources and produced locally, stabilising supply and reducing greenhouse gas emissions. Industrial and agricultural supply chains will be optimised, and processes automated for mass customisation, promoting sustainable industrialisation, overcoming labour shortages, and minimising waste.

The name "Society 5.0" takes its cue from "Industry 4.0", a term coined by the German government to refer to the current trend for automation and data exchange in cyber-physical systems.

the Internet of Things (IoT) and artificial intelligence (AI) to tackle the challenges of, for example, Japan's declining birth rate, ageing population, infrastructure, healthcare, education, greenhouse gas emissions, and resource depletion. It is backed up by an "Integrated Innovation Strategy"[41], published by the Japanese Government's Cabinet Office.

The Japanese government aims to spend 4 per cent of GDP on R&D annually, equating to approximately USD246 billion by 2020, compared to the UK's 2.4 per cent by 2027 and the £725 million ISCF investment by 2021. In 2017, Japan's actual research spending amounted to 3.48 per cent of GDP;[42] by contrast, the UK's was just 1.69 per cent of GDP.[43] Since 20 per cent of the world's top R&D spenders in the private sector are based in Japan, it is no wonder that it ranks very highly in global innovation indexes.[44] It dominates the global market in automobiles, robotics, biotech, nanotech, and ICT. Japan is one of the countries leading the race to introduce 5G mobile networks, which it aims to have in place in Tokyo in time for the Olympics in 2020.

2.6 How Japanese Companies Innovate

Japan's innovation tends to happen within large, established businesses through organic growth and internal investment and less through merger and acquisition (M&A) or start-up activity. It is suggested that the culture of preserving employment at all costs disincentivises entrepreneurship. Certainly, the concept of entrepreneurship is not well-backed by venture capital since the amount available (0.03 per cent of GDP) lags far behind that available in the US (0.4 per cent of GDP), for example. [47]

The Japanese private sector is supported in their expansion, R&D and innovation efforts by three government-funded agencies: Japan Bank for International Collaboration (JBIC), New Energy and Industrial Development Organisation (NEDO) and Japan External Trade Organisation (JETRO) (see section 2.7). All three are sources of investment in innovation that British companies, research centres and universities can benefit from, albeit that their primary focus is to boost Japanese interests. The delegation met representatives from all three in separate meetings.

[41] https://www8.cao.go.jp/cstp/english/index.html
[42] https://www.nippon.com/en/japan-data/h00388/japan%E2%80%99s-science-and-technology-research-spending-at-new-high.html
[43] https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/ukgrossdomesticexpenditureonresearchanddevelopment/2017
[44] https://knoema.com/nyyasp/global-entrepreneurship-index-2018
[45] https://www.gov.uk/government/publications/industrial-strategy-sector-deals
[46] https://www.gov.uk/government/publications/industrial-strategy-the-grand-challenges/industrial-strategy-the-grand-challenges
[47] Innovate UK & Future Cities Catapult (2018), Japan: Country Overview and Innovation Ecosystems

2.7 Funding and Investment Agencies

2.7.1 NEDO - New Energy and Industrial Development Organisation

NEDO is Japan's national publicly-funded R&D management and funding organisation, the equivalent of Innovate UK. It reports directly to the Ministry of Economy, Trade and Industry (METI) but also liaises with the Ministry of Education, Culture, Science & Technology (MEXT). Ultimately, it sits under the Japanese Cabinet Office's Council for Science, Technology and Innovation.

Areas of Interest

Its two fundamental missions are to address global energy and environmental problems, and to enhance industrial technology. While it does not focus on specific sectors, the generic technologies it supports have many potential applications in the construction sector of interest to the delegation.

In the energy and environmental fields, it is developing the following technologies:

- renewable energy
- clean coal
- energy conservation
- global warming mitigation
- rechargeable batteries and energy systems
- environment and resource conservation
- support for international expansion.

In the industrial fields, it is developing the following technologies:

- electronics, information and telecommunications
- advanced manufacturing
- materials and nanotechnology
- robotics
- crossover peripheral fields.

Funding Activities

NEDO helps to fund innovation in a variety of ways. Although this funding is concentrated in Japan, it will fund partnerships that include foreign parties or overseas collaboration projects where there is Japanese involvement and due complementarity. For example, it has funded a smart community project in Manchester, as well as other projects across Europe.

Current projects that converge with construction are in the field of infrastructure asset management. For example, it has a research partnership with Tokyo University investigating the early warning potential of replacing tunnel wiring with carbon wire, which makes it possible to install sensors to monitor performance, pinpoint problems more accurately and plan maintenance more efficiently, thereby minimising disruption when things go wrong. It also has a project to help inspectors to evaluate corrosion damage in pipes through image analysis using deep learning via the cloud.

It has a cross-sectoral IoT acceleration lab specialising in sensors, analytics and secure data storage. It hosts innovation

SenrigaN

Currently under development by Konica Minolta Inc[48], SenrigaN (which means "clairvoyance" in Japanese) is an IoT system that allows AI-supported non-destructive inspection of ageing infrastructure. First conceived in one of Konica Minolta's five Business Innovation Centers (three in Asia, one in North America and one in Europe), which were established in 2014, the concept is supported by NEDO.

Konica Minolta's research revealed that there are 700,000 bridges in Japan. Eighteen per cent of road bridges are over 50 years old. By 2025, that proportion will have gone up to 42 per cent; by 2035, 70 per cent. The same pattern exists for railway bridges. In short, the bridge infrastructure in Japan is ageing quickly and, either because of construction defects, degradation, breakages, or salt damage, at increasing risk of collapse. Needless to say, the impact of bridge failures is particularly severe, as evidenced in recent catastrophic failures in Myanmar[49] and Italy[50].

Konica Minolta's SenrigaN system is designed specifically to streamline the enormous task of monitoring this public infrastructure liability, which relies either on destructive testing or on the naked eye. A hand-held or machine-mounted electromagnetic sensor scans reinforced concrete structures for discontinuities in the reinforcement, capturing the data instantaneously, sending it to the cloud for quick AI analysis. The data can be used to update digital models of the bridge.

The benefits are significantly more accurate, faster and simpler monitoring and better predictive ability. The product, which obviously has global potential, has been trialled on a bridge in Myanmar and will probably go to market at the end of 2019. Its applications are not limited to bridges, able to extend to any reinforced concrete asset, including buildings.

[48] https://www.konicaminolta.com/eu-en/corporate/outline.html
[49] https://www.irrawaddy.com/news/burma/ministry-blames-fatal-bridge-collapse-outdated-design.html
[50] https://www.bbc.co.uk/news/world-europe-45193452

Collaboration Potential

NEDO has some experience in active buildings and battery storage and indicated interest in collaboration with the Active Building Centre since their strategic objectives are similar.

The delegation agreed that, as elsewhere in the world, the UK has an ageing infrastructure and that technologically-viable solutions to effectively monitor it to pre-empt problems and minimize disruption were highly desirable. The prospect of collaboration merits follow-up, for example with the CDBB and Centre for Smart Infrastructure and Construction.

NEDO indicated that offsite manufacturing of buildings was eligible for funding where it overlapped with their technology-specific interests and offered win-wins to all parties. The delegation agreed to pursue possible collaborations with the UK's Advanced Manufacturing Working Group and the High Value Manufacturing Catapult.

NEDO expressed some frustration that, despite several fact-finding missions from the UK in the past and high-level political commitments to collaborate, very little had materialised so far. As NEDO is well-aligned to UK R&D approaches, the potential to work together merits close attention.

"matching events", one of which was won by Konica Minolta with their SenrigaN product (see case study).

2.7.2 JBIC - Japan Bank for International Cooperation

The JBIC is wholly-owned by the Japanese government and steered by policy from the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), the Ministry of Finance, and the Ministry of Economy, Trade and Industry (METI).

Areas of Interest

JBIC's mission is to:

- Promote overseas development and secure resources that are important to Japan.
- Maintain and improve the international competitiveness of Japanese industries.
- Promote overseas businesses whose purpose is to protect the environment.
- Prevent or respond appropriately to disruptions to international financial order.

Their main areas of interest are in natural resources and infrastructure. They also have a strong interest in smart cities, smart homes, advanced manufacturing, smart grids, IoT, and autonomous vehicles[51].

Although JBIC operates all around the world, their primary focus is in Asia. As part of their i-Construction strategy (see section 3.3), MLIT, which influences JBIC, is briefed to find new markets for construction and infrastructure companies, particularly in Africa, where growing populations and economies make it an important long-term target. That said, JBIC invests in Europe including the UK, where they have, for example, supported residential development in London[52], wind farms in the Moray Firth, projects in the pharmaceutical sector, and high speed rail with Hitachi.

Financial Instruments

It has several financial instruments:

1. **Export loans:** Loans to foreign parties to help to buy Japanese exports – usually machinery, equipment, tech in developing countries. These loans are sometimes awarded under the Japanese government's policy of "partnership for quality infrastructure", where the higher risks are counterbalanced by the potential for the social or environmental good.
2. **Import loans:** Loans for Japanese importers or foreign exporters of natural resources, including energy and mineral resources.
3. **Overseas investment loans:** Loans to Japanese companies making foreign investments, overseas Japanese affiliates (including JVs) and foreign governments or financial institutions. Recipients are mainly Japanese SMEs, who can also use the loans to set up foreign offices or transact M&A activity.
4. **Untied loans:** Usually awarded to foreign governments or financial institutions, these loans are used to:
   - protect Japanese supplies of energy or mineral resources
   - promote Japanese business activities
   - maintain and expand direct investment from Japan
   - finance projects that benefit the environment or international financing.
5. **Equity participations:** These are essentially match financing agreements, directly or through a fund, for Japanese companies investing abroad. They are also used to help Japanese companies to acquire interests in foreign companies, either separately or by entering into a consortium with JBIC.

[51] Evidence heard in meetings with the British Embassy and MLIT
[52] Evidence from the meeting with the British Embassy referring to Mitsui Fudosan

Except where there is a social or environmental good at stake, when they will accept more risk, they prefer to invest in proven revenue streams to secure reliable long-term returns.

Their remit extends to how to modernise the construction sector (including asset management) to keep up with fierce foreign competition, especially through the field of sustainable technology such as battery storage (they are already in talks with the Department for International Trade and BEIS on that front) and clean energy. They are in discussions with Taisei Corporation, one of the five big construction contractors, to discuss how they might export and monetise their knowledge in new energy management systems for buildings.

They regard the national competence in tunnelling, earthquake engineering, AI, and timber construction as world-leading, and have authorised loans to manufacturers in China and India on the strength of this expertise.

Collaboration Potential

JBIC is interested in investing in the UK and wants to find projects for mutual benefit. They invited approaches from UK parties with specific opportunities for Japanese companies in the UK, and will help to match them with appropriate Japanese partners.

They would welcome and could potentially finance involvement from British companies in third countries (in Africa, for example). An example of technology where British help might be useful is in microgrid technology, a strength of the ABC.

They warned that they cannot support demonstration or R&D projects.

2.7.3 JETRO – Japan External Trade Organisation

JETRO is a government trade and investment agency that invites inward foreign direct investment and matches Japanese start-ups to foreign ones in Japan. It has helped more than 16,000 overseas companies, ten per cent of which have gone on to set up operations in Japan successfully. Its strategy for the next four years is to:

- Help Japanese start-ups to expand abroad. (It is currently supporting 92 companies, all with the potential to become unicorns.)
- Support foreign start-ups to set up in Japan through its Invest Japan Business Support Centre.
- Help Japanese corporates or SMEs to innovate or become more interested in innovation. Its Global Acceleration Hub is a programme that promotes business collaboration between Japanese companies and companies in Silicon Valley and Boston in the USA.

Collaboration Potential

JETRO offers opportunities for British companies looking to open markets in Japan.

Internet of Things in Japan

The Internet of Things (IoT) has an important role to play in the future transformation of construction, and so the delegation was interested to hear evidence from ITR,[53] a market research consultancy that works with JETRO, about the state of play in IoT development in Japan.

IoT is regarded as one of the key technologies for improving national productivity and forms a core part of the Society 5.0 vision. Commitment to IoT is epitomised by the Japanese telecommunications corporation NTT Docomo[54], which is running a demonstration project on the remote island of Yonagumi to prove the societal benefits of putting IoT sensors on everything.

To support its IoT development, Japan is rolling out its 5G mobile network, regarded as a necessary precondition for many IoT applications because it eliminates the time lag characteristic of current systems. Japan is also strengthening its satellite positioning capability, aiming to improve accuracy down to 1 cm.

Japanese IoT maturity

According to ITR annual IoT maturity survey results for 2018, about 90 per cent of all Japanese companies, including Obayashi Corporation visited by the delegation (see 4.1), are pursuing IoT proof-of-concept R&D, a massive increase on the previous year. The investments are spread across sectors, with smart logistics, factories, transportation and healthcare topping the table. "Smart home and building" comes just behind "smart finance and insurance".

The R&D focus is on developing sensors of all kinds, led by the materials science research. Most applications are for positioning/presence/proximity and action/movement/speed, but there are many others, including for temperature, acceleration/tilt, and sound/vibration. There is even active research into smelling sensors.

The commercial challenges include a lack of skills and data security as well as uncertainty around the market solutions and business case.

Hand-in-hand with the development of the IoT, there is a predicted "death of the cellphone", potentially to be replaced by:

- smart or augmented reality glasses
- 5G glasses to guide blind people
- mind-to-text applications
- neurolink (Elon Musk's "living in the cloud")
- smart contact lenses
- rollable screens.

Although there are projects looking at IoT in robotics and autonomous vehicles, ITR predicts that the most likely IoT applications relevant to construction in Japan will be in the fields of human resources or health and safety.

[53] https://www.itr.co.jp/english.html
[54] https://www.nttdocomo.co.jp/english/

3. Overview of Japan's Construction Sector

The Japanese construction industry contributed JPY28.4 trillion (roughly £193.5 billion) to Japan's GDP in 2018. By comparison, the UK's construction industry contributed £138 billion to the UK economy in 2017. A quarter of all construction orders - £41 billion - were for housing.[55]

The Japanese construction sector has boomed since then, growing by 10 per cent in 2018, spurred by the forthcoming 2019 Rugby World Cup and 2020 Olympics. It is predicted to grow by a further one per cent in 2019 and, with the Olympic legacy of improved infrastructure assets across the country, there is the potential for new growth in the real estate market. By contrast, construction costs escalated 2.8 per cent in 2018 and are predicted to increase by a further 4 per cent in 2019.[56]

3.1 Labour Shortages

The boom is exacerbating labour shortages in a country already struggling to recruit new workers into the sector. Evidence from Komatsu showed that Japan is projecting a 40 per cent shortfall (equivalent to 1.3 million people) by 2025. Even now, 25 per cent of construction workers are over the age of 60.[57] Because older workers are less productive than younger ones, the issue is a threat to the continued success of the industry, which, like the UK, suffers from comparatively poor levels of productivity compared to other sectors.

3.2 Productivity Strategy

The delegation heard evidence that the government is tackling the issue of poor productivity by encouraging investment in automation (digitalisation, robotics, IoT, AI), relaxing restrictions on immigrant labourers (a politically sensitive issue[58]) and attracting the young to the industry through marketing campaigns. Companies are also looking to restructure salaries to promote skills and capabilities in contrast to the cultural norm, which has traditionally been to reward loyalty and seniority.

3.3 Industry Priorities: i-Construction

The Japanese equivalent to the UK's Construction Sector Deal is called the i-Construction[59] strategy, overseen by MLIT[60]. Announced in 2016, i-Construction promotes the use of ICT across every production process from the first survey to final inspection. The government is pursuing the policy aggressively with various subsidies and pushing for i-Construction to be mandatory in all publicly-funded projects.[61]

3.3.1 Encouraging BIM

The lead tactic is to encourage (but not mandate) the uptake of BIM (Building information modelling, the term used for building projects) and CIM (Construction information modelling, the term used for the same technology in civil engineering projects) by publishing official guidelines. An MLIT pilot project using BIM produced 77 per cent savings in working hours during the design phase and about 50 per cent during the construction phase. Although it is not clear how this was measured or the benchmark, this pilot is being cited to encourage the industry's adoption of BIM.

MLIT recognises the many other potential benefits of BIM, including better visualisation, accuracy, and faster decision making. It also wants to promote using the cloud to centralise construction output data for easy sharing.

Collaboration Potential

The Japanese industry's conception and adoption of BIM is significantly less mature than in the UK, suggesting another avenue for possible future partnerships or collaboration.

[55] Construction industry: statistics and policy, House of Commons Library Briefing Paper Number 01432, 27 December 2018
[56] Turner & Townsend International Construction Market Survey 2019
[57] Evidence from meeting with NEDO
[58] Evidence from meeting with the British Embassy
[59] https://www.decn.co.jp/?p=56467
[60] http://www.mlit.go.jp/en/index.html
[61] Evidence heard from Mitsui & Co Ltd

3.3.2 Standardisation

MLIT is also encouraging (but not mandating) the industry to standardise sizes of construction elements for infrastructure projects through the central Japanese Construction Council and three industry associations (for major, local, and specialist contractors). (The delegation thought this applied merely to precast concrete elements rather than whole-building systems.) The objective concerns the logistics of transportation of such elements as well as the cost and efficiency gains from standardisation. These discussions specifically exclude offsite housing manufacturers, since their market is competitive and self-regulating.

3.3.3 Autonomous Vehicles and Smart Cities

MLIT's areas of interest include autonomous construction vehicles and smart cities. They see value in autonomous construction machines such as those being developed by Komatsu (see section 4.2) that are connected through the cloud to the BIM plan. Smart cities link very well with the Society 5.0 vision, as exemplified by the Futako Tamagawa "transit-oriented development" outside of Tokyo.

Collaboration Potential

MLIT was open to the idea of looking at technological innovation in the field of autonomous construction vehicles from UK companies.

3.3.4 Barriers to i-Construction

Although the Japanese construction industry wants to engage with the i-Construction drive, it faced several barriers, including the lack of digitisation, low levels of BIM adoption and sophistication, a lack of skills and education, and an attitude to employment that is at odds with increases in productivity.[62]

3.3.5 Expanding International Markets

MLIT's brief also includes extending markets for Japanese companies abroad in Asia and elsewhere. They have a special interest in Africa, where exporting Japanese expertise and capability in infrastructure not only helps to meet the UN's Sustainable Development Goals but also anticipates Africa's rising economies. Japanese companies would apparently be open to collaborating with UK construction consultants and building professionals in third countries, especially in Africa.

Collaboration Potential

UK experts were invited possibly to help to inform policy direction in sub-markets such as nuclear decommissioning, circular economy, industrial decarbonisation, localised energy storage and distribution.

3.3.6 Attitude to Sustainability

Japan is committed to limiting greenhouse gas emissions, boosting energy efficiency and protecting the environment, with a national ambition to "lead the world in sustainability". However, it is not clear that this talk is being translated into convincing action in real projects. Circular economy thinking is entirely absent from the conversation.

Contractors working in Japan must make their "best efforts" under the Act on Rationalisation of Use of Energy, Etc. to save energy in accordance with the national standard for large-scale buildings. The recommended target is a "net zero-energy building". It is unclear how this is defined. Some local governments (for example, the Tokyo Metropolitan Government) also issue local regulations that require large-scale office developments to meet high carbon emissions standards.[63]

At various times during the year, the Japanese government incentivises private home buyers to choose energy-efficient houses by awarding grants to applicants.[64]

Collaboration Potential

This lack of practical action is a potential opportunity to export British services and products. Specific ideas included helping the Japanese industry and relevant government agencies with their environmental and decarbonisation plans.

[62] Evidence heard from Mitsui & Co Ltd
[63] https://uk.practicallaw.thomsonreuters.com/9-630-4982?transitionType=Default&contextData=(sc.Default)&firstPage=true&comp=pluk&bhcp=1
[64] Evidence heard from Sekisui House

3.4 The Japanese Housing Market

Lessons from the Japanese residential sub-sector are particularly pertinent to the UK, where, despite high demand, the industry cannot supply the requisite number of homes viably. The UK government is promoting modern methods of construction, particularly offsite construction, as a technological solution to overcoming this market failure. Japanese expertise in this area is therefore of great interest.

3.4.1 Historical Context

The Japanese housebuilding market is defined partly by the destructive effects of natural disasters but more especially by the country's post-second world war circumstances.

The second half of the twentieth century saw a period of rapid housebuilding to recover from the devastation of war and to cope with spikes in population. The poorly-built, mass-produced homes that followed set the tone for how the market developed subsequently. While this put Japan at the technological forefront of what we now call offsite construction, it also depressed the market for second-hand homes, since people generally resisted moving into a property known to be of poor quality. It was common and habitual for new owners to demolish and rebuild instead, and for plots to be rebuilt every thirty years or so. This is in stark contrast to UK home-owners, who regard houses as appreciating assets.

3.4.2 Current State of Play

Along with the large local population, this has kept the housebuilding market comparatively buoyant at over a million new homes built every year. The latest figures from the Ministry of Land, Infrastructure, Transport and Tourism indicate that there were 965,000 new dwelling units started in 2017, with a total floor area of 77.5 million square metres, averaging 80 square metres/unit. Roughly a third of these new starts were privately owned.[65] Approximately 15-20 per cent of new homes, perhaps as many as 190,000, were constructed offsite from mass-customisable kits in 2018.

3.4.3 Changing Housing Market

Urbanisation, a shrinking population, and a concern for resource efficiency and sustainability are changing that picture. As more people move to cities, pre-existing homes are in the wrong place, with many in the provinces abandoned rather than rebuilt, and effectively worthless.[66] The shrinking population means the housing market is also shrinking. Finally, there is a growing awareness of the waste and carbon cost of short-lived housing, which, while boosting the market for second-hand homes, will likely decrease the size of the housebuilding sector. Evidence from Panasonic Homes of declining sales indicates that these factors are beginning to take their toll on the housebuilding sub-sector as demand wanes.

Collaboration Potential

With mature, successful expertise and shrinking housing markets, there is a clear alignment of interest for Japanese offsite housebuilders to collaborate with the comparatively immature offsite housebuilders in the UK.

3.5 Procurement

Participation in procurement is reserved for Japanese contractors. However, there is a good market for foreign consultants, including architects and engineers. Japanese contractors also actively encourage partnerships from UK consultants in third countries.[67]

Building and civil engineering/infrastructure are thought of as distinct and separate sub-sectors of construction, with buildings apparently being delivered by the private sector as turnkey developments responding to market need and financial opportunity.[68] Infrastructure, specifically roads and public spaces, would appear to have significant public sector influence. Communication, energy and rail subsectors appear to be in the private sector. Thirty-to-forty per cent of construction activity overall is paid for by the public sector.[69]

The public sector accounts for 90 per cent of the spend on civil engineering output.[70]

Most of Obayashi Corporation's projects are design and build, and they are pursuing "enterprise models" for construction procurement. Mitsui & Co Ltd referred to NETIS (New Technologies Information System), the MLIT's public database of approved cutting-edge construction technologies in line with the i-Construction policy (see section 3.3). Although there is some confusion, it appears that bids for public contracts that propose to use NETIS-registered technologies score extra points. In this way, NETIS encourages innovation.

A variant of this idea holds promise for improving construction in the UK context.

[65] https://www.stat.go.jp/english/data/nenkan/68nenkan/index.html
[66] https://edition.cnn.com/2018/12/05/asia/japan-vacant-akiya-ghost-homes/index.html
[67] Evidence heard from the British Embassy
[68] Evidence heard from MLIT
[69] Evidence heard from MLIT
[70] Evidence heard from Mitsui & Co Ltd

3.6 Players

3.6.1 The Big Five Contractors

The Japanese construction industry is very fragmented, comprising some 451,000 companies employing 3.5 million people. It is dominated by five large contractors with an extensive international presence: Shimizu Corporation,[71] Takenaka Corporation,[72] Kajima Corporation,[73] Taisei Corporation,[74] and, the one that the delegation met, Obayashi Corporation.[75] Otherwise, the construction sector comprises a majority of micro or "mama and papa"[76] companies with sales of less than JPY6 million and with few resources available for R&D.

Many of the big five's operations are vertically-integrated, with property development, offsite manufacturing, design, engineering, and asset management departments. They all have in-house R&D departments. Their engagement in innovation appears to be centred on Silicon Valley in California, USA, in collaboration with venture capital partners such as Borealis[77]/Bricks & Mortar[78] (Obayashi) and Plug and Play[79] (Kajima, Shimizu, Takenaka).

3.6.2 Offsite Housebuilders

There are several dominant offsite construction companies, which include Daiwa House Industries, Panasonic Homes, and Sekisui House, companies that the delegation met. Considerably smaller than the big five, the focus of their output has traditionally been in housing. The market has been able to support investment in networks of sophisticated offsite facilities exploiting advanced manufacturing processes to produce kit buildings in a factory setting.

Customer Focus

These companies are intensely focused on the customer, able to take people from showroom concept to moving in in a matter of months (see sections 3.3 and 3.4). Their aftercare is also impressive, with 20-year warranties (in the case of Sekisui House), call centres dedicated to dealing with snags, and some early IoT capabilities to monitor energy usage and the performance of equipment. There is no equivalent in the UK.

Diversification and International Expansion

Driven by waning demand for new housing, these offsite experts are increasingly seeking markets abroad and diversifying into other building types, with mixed success. Panasonic Homes reported that their forays into Asian housing markets, making up less than 1 per cent of sales, were not yielding great returns. Sekisui House is having more luck, with notable successes in timber-framed detached homes in Australia. Half of Daiwa House Industries' annual turnover comes from non-residential construction work.

3.7 Disruption

With comparatively little innovation investment by businesses central to the delivery of construction, players from the fringes of the sector are seeing an opportunity to take advantage. For example, the global industrial vehicle and equipment manufacturer Komatsu (see section 4.2), one of the companies that the delegation met, has (with JV partners) developed LandLog, a common data platform with an open API for use by the construction industry all along the project timeline – see LandLog case study on p. 19.

Collaboration Potential

This picture of several very large companies dominating a sector that otherwise comprises lots of micro-businesses is similar to the UK's. However, the extent of vertical integration and expertise in offsite construction is far less well developed in the UK.

[71] https://www.shimz.co.jp/en/
[72] https://www.takenaka.co.jp/takenaka_e/
[73] https://www.kajima.co.jp/english/
[74] https://www.taisei.co.jp/english/
[75] https://www.obayashi.co.jp/en/
[76] As described by Mitsui & Co Ltd in meeting with the delegation
[77] http://www.borealisventures.com/
[78] https://brickmortar.vc/
[79] https://www.plugandplaytechcenter.com/

4. Evidence of Innovation

The following section summarises the evidence of innovation activity from visits that the delegation made to eight commercial organisations in Japan. These were:

1. Obayashi Corporation, one of the "big five" building contractors
2. Komatsu Ltd, a large heavy vehicle manufacturer for mining and construction operations
3. Sekisui House, an offsite housebuilder
4. Daiwa House Industries, a builder heavily invested in offsite manufacturing
5. Panasonic Homes, an offsite housebuilder
6. Mitsui & Co Ltd, a large multi-sectoral group company
7. Hankyu Hanshin Holdings Inc, a private rail operator and property developer
8. Muscle Corporation, a robotics software developer.

The group also visited a home materials, fittings and equipment showroom operated by LIXIL Group Corporation.

4.1 Obayashi Corporation

The Obayashi Corporation is one of the five big building contractors. Although it has no direct labour, it employs 14,359 people worldwide and has a turnover of USD19 billion, steadily up from USD12.5 billion in 2012. They have enjoyed healthy profits over recent years, which stood at 12.3 per cent in 2018. Seventy-five per cent of net sales are from Japan.

The corporation has an office in the UK established in 2018, but otherwise, their presence in Europe is weak. Their presence elsewhere in the world is much stronger, especially in Australasia and North America, where their group of companies includes Webcor.[80]

First and foremost building contractors, Obayashi also offer many complementary services, including urban planning, architectural, structural, MEP design, renewable energy, and real estate management. They think of themselves as deploying "all construction processes in one company". The company had an automated building construction system factory (now sold) that produced modular structural elements.

They have begun to diversify into other sectors, selling renewable energy from PV, biomass and offshore wind farms, and a foray into agriculture producing cherry tomatoes.

4.1.1 Innovation Investment

Obayashi invests in R&D and has their own research facilities – the Technical Research Institute in Japan. Their 260 researchers conduct research into construction technology, materials, structural engineering, environmental tech, and geotechnical engineering. The complex itself is a low-energy exemplar. They describe it as an "energy positive building" that is certified to the CASBEE[81] and WELL[82] standards. It has a smart grid across the site, with battery storage.

Continuing a long history of innovation, the company's business strategy, which anticipates their 150th anniversary in 2042, includes a USD200 million forward innovation investment programme along with a USD100 million M&A programme to secure a sustainable long-term future.

Obayashi's innovation is centred in Silicon Valley, California, where their R&D ecosystem includes Stanford University,[83] partner organisations, and venture capital agencies Bricks & Mortar and Borealis. Focusing on finding solutions to the most pressing problems, they run challenge events to attract start-ups.

Their R&D projects in various stages of development include:

- Mobile on-site welding robots
- On-site AGVs to move materials where they are needed, perhaps overnight (collaborating with a US software start-up)
- Powered clothing that relieves fatigue in workers
- Exo-skeleton suits
- Advanced, "one-model" BIM technology that combines design, structural and MEP information (in collaboration with MIT Systems Design and Management)
- Highly accurate positioning technology for GPS-denied environments
- "Mixed" or augmented reality tech that superimposes the 3D BIM model on the "as is" reality through a smart tablet
- Quality detection interfaces
- Wearable sensors to monitor for heat stroke that link with supervising smartphones over the IoT (partnership with NTT Docomo[84])
- AI assistance for crane operators.

[80] https://www.webcor.com/
[81] http://www.ibec.or.jp/CASBEE/english/
[82] https://www.wellcertified.com/certification/v1/standard
[83] https://cee.stanford.edu/programs/sustainable-design-construction/stanford-construction-institute
[84] https://www.nttdocomo.co.jp/english/

Collaboration Potential

Obayashi's commitment to R&D and general attitude to, as they put it, "break out of the Obayashi castle", is impressive.

Obayashi is actively looking for collaboration partners to develop innovation in the following fields:
- cheaper IoT sensors for monitoring buildings and infrastructure with life-long power sources
- 3D printing for autonomous construction systems using appropriate materials to shorten the total lead time for clients
- new durable, easy-to-manufacture, cheap structural materials
- infrastructure and facilities for the mobile society, including automatic battery charging.

4.2 Komatsu

Komatsu manufactures heavy vehicles and other machinery for the mining and construction sectors. They had net sales of JPY2.5 trillion in 2017 and as of March 2018 had 227 consolidated subsidiaries and about 60,000 employees worldwide, two-thirds of whom are not Japanese.

They have a close "co-venture" relationship in six countries with Mitsui & Co Ltd, a giant corporate group with a construction and mining solutions division.[85]

Komatsu's biggest market is North America. They have a smaller but still extensive presence in Europe, including several bases in the UK. They own a factory near Newcastle, where their main products are large and medium-sized hydraulic excavators, as well as a sales and customer service base.

Quality and reliability are the cornerstones of their offer. As well as heavy vehicles, they produce a range of industrial machines including forging and stamping presses and sophisticated lithography light-source for semiconductor manufacturing.

4.2.1 Innovation Investment

Komatsu is committed to R&D and innovation epitomised by their versatile "smart construction" app (see Komatsu case study) that connects people, machinery and ground conditions from start to finish through ICT. It allows remote supervision of sites and the rapid updating of plans where needed. The app embodies a strategy that has the potential to reduce costs while improving efficiency, productivity, accuracy, carbon emissions, and health and safety, meeting many of the industry's challenges. The app brings together many separate products and services under five broad headings:

- **3D data collection support:** This includes drone and laser scanner measurement systems.
- **3D data utilisation support:** This includes 3D viewers, point cloud viewers, data superimposition software, and 2D to 3D data conversion software.
- **Construction planning support:** This includes live dashboards and truck operation simulation.
- **Construction support:** This includes construction progress dashboards, the "Everyday Drone" survey system, and a construction site operations tracking system.
- **Inspection support:** Software that compares point cloud data to design data and highlights differences.

Komatsu's pilot projects suggest that adopting the smart construction app can speed up operations by up to 50 per cent and increase productivity 1.4 times on road construction, 1.9 times on land formation works, and 2.3 times on new building foundation work.

Komatsu's current project is called LandLog (see case study). It is also pursuing autonomous vehicle systems to automate the construction site or to allow the remote control of machinery by human operators. Research is developing well. GPS links are apparently good enough to achieve accuracy of +/- 3 cms, and they think they have resolved cybersecurity risks.

[85] Evidence from Mitsui & Co Ltd

Komatsu smart construction innovations

Komatsu has developed and launched a number of innovative products and services centred on their "smart construction" app. These include:

- **Komtrax:** Komtrax (the Komatsu machine tracking system) optimises life cycle costs of Komatsu machines by monitoring service history, machine position, working record, fuel consumption, and so on through the cloud, where the data is monitored by either Komatsu, the customer, or the distributor.
- **Autonomous Haulage System:** The AHS is a system for controlling fleets of driverless haulage vehicles to prepare a construction site for building. Navigation is precisely controlled from an onsite master link using GPS technology, with vehicle paths to designated dumping grounds or crushing machines automatically choreographed. Safety is assured with millimetre wave radar sensors that can detect and respond to obstacles. Trials demonstrate that the system cuts time and costs by half, with very accurate results.
- **The Everyday Drone system:** This system comprises a drone that scans the site and sends 3D scan data to the "Edge Computer", a base unit that processes the data quickly on site before sending the results to the smart construction app in the cloud. The system allows sites to be scanned in 3D in as little as 20 minutes, hugely faster than previous technologies, which would typically have taken 24 hours.
- **Stereo camera sensing viewer:** This system assists human operators to be more accurate. Stereo cameras capture accurate topographical data in real-time and overlay it as augmented reality on a 3D design model to guide what and where to dig. The 3D design model is connected through the cloud to the smart construction app and so can be continuously updated to reflect any design changes.
- **Site tracking system:** A drone system tracks the relative position of machinery and people on sites via the cloud to smartphone apps. With predictive analytics, it can improve safety and efficiency.

LandLog[86]

Launched in 2017 in collaboration with partners NTT Docomo[87], SAP[88], and OPTIM[89], LandLog is a cloud-based IoT platform with an open API, a central plank of its "smart construction" strategy. Controlled by Komatsu, third parties are free to use its open API to share and enhance project-related data in a way that can be shared from stage-to-stage through the entire life-cycle of a building project and on into operation in a process that Komatsu calls horizontal integration.

LandLog collects and processes data on a daily basis from all relevant construction stages using ISO 15143-1[90], including land surveys, measurements, design, construction machinery, drones, weather forecasts, operations and maintenance. All this processed data is made available in a user-friendly format. Komatsu anticipates that doing so will improve productivity and safety further by integrating what has up until now been thought of as discrete processes. They have high hopes that it will become the industry standard.

The industry is beginning to take advantage of it. For example, Mitsui & Co Ltd are using the platform for their "fuel as a service" app. The product's full potential depends on every aspect of the construction process being digitalized and the advent of the 5G network.

[86] Evidence from Mitsui & Co Ltd
[87] https://www.nttdocomo.co.jp/english/
[88] https://www.sap.com/corporate/en/company.html
[89] https://www.optim-corp.com/
[90] ISO 15143-1:2010 Earth-moving machinery and mobile road construction machinery - Worksite data exchange - Part 1: System architecture, https://www.iso.org/standard/37406.html

4.3 Sekisui House

Osaka-based Sekisui House was established in 1960 to build prefabricated houses. They build 50,000 homes a year, amounting to a grand cumulative total of 2.29 million homes. Turnover in 2017 was USD18.5 billion, 85 per cent of which came from Japan and 67 per cent of which came from building homes.

Taking full responsibility from start to finish of the 15,000 detached houses they build annually, Sekisui has an absolute focus on quality for the customer. Once the design is agreed with the customer, it takes about one month to produce the kit of parts and a further three months to build it. The company has a network of customer service centres all over Japan to ensure rapid responses before, during and after completion.

The split of functions among its 22,300 employees worldwide reflects their customer focus. It is as follows:

- Factory: 10 per cent
- Sales/customer service: 30-40 per cent
- Site: 10 per cent
- After-sales: 10 per cent
- The rest in design/R&D.

They have developed their own kaizen-inspired quality standards, manual, and complementary training programme.

With an eye on Japan's ageing population and making buildings that last, Sekisui's designs incorporate features that are friendly to older people. Because of the high spec, their houses are pricier than traditionally-built alternatives, very much in contrast to consumer preferences in the UK, where prefabs are thought to have a stigma.

Working out of five factories in Japan, Sekisui's detached houses are built completely in-house with automated supply lines. They have two house systems:

1. Beta: flexible steel-framed model where stacked floor plates can be different, with columns where you want them. All to suit customer need.
2. Shawood: a timber model customised to need.

In stark contrast to what is available in the UK, they offer customers a 20-year warranty, which is capable of being extended, serviced from a country-wide network of customer care centres.

Managing supply capacity and demand for offsite manufactured homes is challenging but possible through early warnings from their sales team.

Their work includes 4-5 storey "commercial" buildings. It is unclear whether this means non-residential or just speculative. Sekisui's business strategy includes expansion overseas with single houses and mixed-use residential developments, with significant forays into China (where the market prefers steel-framed systems), and Australia (where they prefer timber frames). They also operate in Singapore and the USA, building high and low-rise condominiums. They have no plans to build factories overseas. Importantly, they are testing the UK market to assess its readiness for Sekisui products.

4.3.1 Innovation Investment

Innovation is important to Sekisui. Not only does their R&D centre feature seismic testing facilities, their innovation activity includes brain-machine interfaces and technology that converts seismic energy into useful indoor heating.

The company has a strong focus on sustainability, having produced a so-called "Green First" zero-energy model of house in 2013 that includes, among several technologies, PV panels and an energy management system. This is the model selected by 90 per cent of their buyers of detached homes.

Helped by an RFID-tagging system to track inventory, they aim for zero waste in the construction process.

Standard house models have green tech bolt-on options (including battery storage) that allow private home buyers to take advantage of the government's green grants. Sekisui incentivises purchases further with discounts.

Sensors monitor PV performance on behalf of Sekisui's customers, responding to faults proactively on warranty.

They have just announced a joint venture with KDDI Corporation[91] and Hitachi Ltd[92] to establish "an inter-enterprise information-sharing platform that will enable companies to share proprietary data in a highly secure (blockchain) environment, and to create new services by pooling data from different industries." This is to streamline real estate rental transactions for the benefit of tenants, in line with the Society 5.0 vision. Verification tests began in April 2019.

[91] https://www.kddi.com/english/#category_corporate
[92] https://www.hitachi.com/

4.4 Daiwa House Industries

Daiwa House Industries builds many kinds of buildings, from small detached houses to large-scale commercial buildings in many sub-sectors. It is also beginning to get involved in civil engineering work, building roads in Japan.

Sales for the year 2018 amounted to JPY4 trillion, equally-split between residential and non-residential work, including hotels, shopping malls, warehouses, and office blocks. They produce about 1,000 detached homes (all steel-framed) per month from two plants, which last year accounted for 10 per cent of their residential sales.

Customers have plenty of flexibility to customise standard Daiwa templates to their taste. The structural system allows modules to be subdivided, although that adds time and cost.

After the design, it takes Daiwa one month to make the kit of parts and two months to assemble it on site. Green features such as PV are optional extras although energy management systems come as standard. They collect energy usage data remotely, data that is also shared with the owners/tenants.

As well as detached houses, they also use standard modules to build low-rise residential and non-residential buildings. The company has a contract with the convenience store brand 7-11, for whom they have developed a standard shop module. (They also build tall buildings, but the market cannot support standardised modules for this building type.)

4.4.1 Innovation Investment

Daiwa House has a sophisticated integrated capacity to build offsite from eight plants in Japan, with extensive use of robotic equipment capable of making different customised components.

Their frame factory includes automated cutting and boring machinery and robot welders for all but the most complex components. Infill wall panel manufacturing is a more labour-intensive process. That said, it is controlled by ICT and with readout onto the shop floor to give workers instructions with details about the individual house under construction. MEP is not integrated into panels but manufactured offsite as separate units.

4.5 Other Visits

The delegation met with other companies which held less collaboration potential.

4.5.1 Panasonic Homes

Based in Osaka, Panasonic Homes is the offsite housebuilding arm of Panasonic. They build nearly 600 homes a month, putting them in the second rank of housebuilders in Japan.

Their offsite factories are automated, producing two models of steel-framed houses that offer customers plenty of choice. One is a detached “eco-house” and the other designed for small urban plots that can easily extend upwards.

They are active in Indonesia and Malaysia as well as Japan and have diversified into speculative work, for example, the Fujisawa Sustainable Smart Town, a 19-hectare development of 1,000 homes, condominiums (in Taiwan), and house refurbishment.

Their representative indicated that the market for housing is very competitive and that sales are on the decline internationally and domestically. They have very little R&D budget, which is directed to short-term projects. Past innovations included a high quality pre-cast concrete wall panel system that is 50 per cent quicker to build, and a home ventilation and air filtration system to maintain good indoor air quality.

4.5.2 Muscle Corporation

The Muscle Corporation is a company specialising in software systems for robotics (“artificial muscle”). Starting with applications in healthcare and social care, the Muscle Corporation then moved on to “fun” applications for marketing and promotion purposes.

Despite high-profile support from Prime Minister Shinzo Abe, they reported low levels of VC support in Japan, implicating risk aversion.

The Muscle Corporation has identified the construction sector as ripe for innovation in robotics and is working on projects in that field but could not divulge any details to the delegation.

4.5.3 Hankyu Hanshin Holdings Inc

Hankyu Hanshin Holdings Inc, a rail operator active in Osaka, is notable for diversifying into property development as a natural extension of its investments in train stations. It has been involved in various smart city developments along its rail lines, most notably in the middle of Osaka, where its Grand Front project features a free transit bus service and an integrated approach to asset management.

Mass-customised housing and consumer choice

The delegation visited the LIXIL showroom in Tokyo informally, an experience that emphasised the importance that the Japanese system housebuilders place on customer convenience.

Established in 2011 through a merger of five of Japan's most successful building materials and housing companies, LIXIL makes products for homes and builds houses, among other services. The company employs over 70,000 employees in more than 150 countries worldwide.

Faintly resembling an Apple store, their Tokyo showroom displayed a comprehensive range of interior and exterior materials, fittings and equipment options, some of them incorporating simple IoT functionality, to allow people to buy and customise their LIXIL homes then and there, all in one visit. Selections made, LIXIL then incorporates them into their standardised home models. On agreement, the design is then manufactured and built.

The experience is unlike anything available in the UK. However, it suggests a model that could help to dispel the UK market's resistance to offsite-manufactured homes by offering consumer choice.

5. Market Synergies

The delegation recognised that the Japanese construction sector is facing similar challenges to the UK's, albeit that the market conditions and contexts are different, and felt that there was enough commonality of purpose to actively encourage collaboration.

5.1 National Priorities are Aligned

In general, the UK and Japan's construction sectors are aligned in many important ways. The construction sector:

- Makes significant contributions to the national GDP, and so its development through innovation plays a critical role in the countries' future economic success.
- Comprises a small number of large players complemented by a large number of small players, which limits the availability of R&D efforts. Both nations have identified the need for the government to play a coordinating role to encourage innovation by other means, opening the door to collaboration.
- Faces labour and skills shortages, threatening the long-term capacity of the construction sectors in both countries. Strategies, on the one hand, to recruit new talent into the sector and, on the other, to improve productivity are in both nations' interests. In particular, productivity improvement depends crucially on technological innovation, which can be jointly developed for mutual advantage.
- Has been slow to take up technological advances from the fourth industrial revolution[93]; while Japan's is ahead of the UK when it comes to offsite construction techniques, Japan's is behind the UK's when it comes to BIM implementation. Sharing learning and collaborating on solutions in both has a balanced complementarity of outcomes.
- Has a commitment to environmental protection, particularly to developing a low-carbon economy and a stable energy supply, albeit that the UK's implementation in projects are more mature and sophisticated. The matched political wills to tackle climate change for the global good is a sound basis for fluid knowledge exchange and constructive innovation.
- Has a national sectoral strategy to accelerate change for the better, albeit that Japan's is more laissez-faire and restricted to just infrastructure than the UK's. While the strategic methodologies are different, their end-goal is very similar, improving opportunities for mutually beneficial collaboration, partnership and trade.
- Has an extensive, critical, and ageing public infrastructure in need of a long-term maintenance and replacement programme. With infrastructure assets as critical engines of value-add, once again there is potent mutual interest in collaborating to accelerate both countries' world-leading strengths to find effective technological solutions.

This alignment of national interests is fertile ground for future collaboration. Provided there is genuine complementarity, there are strong reasons for interested parties from both countries to work together to find common solutions.

5.2 Critical Contextual Factors

However, the delegation also heard evidence that the countries have some significant differences:

- Japan's attitude to collaboration or engagement with other businesses, research centres and universities is less well-developed than the UK's. The paths to innovation, especially at early stages of market-readiness, are thus relatively constrained.
- Japan's attitude to investment in R&D is perhaps more risk-averse and cautious than the UK's. This is a barrier to full complementarity, potentially restricting access to Japanese skills and, indeed, the Japanese market. On the other hand, it could attract Japanese construction sector companies to the UK's more entrepreneurial ecosystem.
- Japan's approach to employment appears to be a drag on profitability for commercial businesses and a factor in the productivity challenges Japan faces, albeit that it produces very low unemployment figures. This is an ingrained cultural difference between the two countries, potentially posing a barrier to collaboration.
- As discussed in section 3.4, the size and nature of Japan's housing market is fundamentally different to the UK's, a critical factor affecting the viability, for example, of adopting Japanese offsite practices in the UK.
- The two nations speak different languages, which can lead to confusion, inaccuracy and misunderstanding. Since good collaboration, especially in complex technical fields, depends critically on clear and transparent communication, this can be seen as a significant barrier.
- The specific needs of the two countries' construction sectors do not entirely overlap. For example, a significant proportion of Japanese R&D is directed at structural design for seismic resistance, a factor that is less critical in the UK context.

[93] https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/

Annex 1

List of UK Participants

Active Building Centre (ABC)[94]

Advanced Manufacturing Research Centre (AMRC)[95]

Centre for Digital Built Britain (CDBB)[96]

Construction Innovation Hub (CIH)[97]

Construction Leadership Council (CLC)[98]

Construction Scotland Innovation Centre (CSIC)[99]

Department for Business, Energy and Industrial Strategy (BEIS)[100]

Imperial College London[101]

Industrial Strategy Challenge Fund Transforming Construction[102]

Innovate UK[103]

Knowledge Transfer Network[104]

Manufacturing Technology Centre (MTC)[105]

Saint-Gobain UK and Ireland[106]

Transforming Construction Network Plus[107]

[94] http://www.activebuildingcentre.com/
[95] https://www.amrc.co.uk/
[96] https://www.cdbb.cam.ac.uk/
[97] https://constructioninnovationhub.org.uk/
[98] http://www.constructionleadershipcouncil.co.uk/
[99] http://www.cs-ic.org/
[100] https://www.gov.uk/government/organisations/department-for-business-energy-and-industrial-strategy
[101] https://www.imperial.ac.uk/
[102] https://www.ukri.org/innovation/industrial-strategy-challenge-fund/transforming-construction/
[103] https://www.gov.uk/government/organisations/innovate-uk
[104] https://ktn-uk.co.uk/
[105] http://www.the-mtc.org/
[106] https://www.saint-gobain.co.uk/
[107] https://www.ucl.ac.uk/bartlett/construction/about-us/transforming-construction-network-plus

Annex 2
Abbreviations

ABC	Active Building Centre
AGV	Automated guided vehicle
AI	Artificial Intelligence
AMRC	Advanced Manufacturing Research Centre, University of Sheffield
API	Application programming interface
BEIS	Department for Business, Energy and Industrial Strategy
BIM	Building Information Management
CASBEE	Comprehensive Assessment System for Building Environmental Efficiency
CDBB	Centre for Digital Built Britain
CIH	Construction Innovation Hub
CIM	Construction Information Management
CLC	Construction Leadership Council
CSIC	Construction Scotland Innovation Centre
DfT	Department for Transport
DIT	Department for International Trade
EU	European Union
FDI	Foreign direct investment
GDP	Gross domestic product
GHG	Greenhouse gas
I3P	Infrastructure Industry Innovation Platform
ICT	Information and Communication Technology
IoT	Internet of Things
ISCF	Industrial Strategy Challenge Fund
IUK	Innovate UK

JBIC	Japan Bank for International Cooperation
JETRO	Japan External Trade Organisation
JPY	Japanese yen
JV	Joint venture
KTN	Innovate UK Knowledge Transfer Network
M&A	Mergers and acquisitions
MEP	Mechanical, electrical, and plumbing
METI	Ministry of Economy, Trade and Industry
MEXT	Ministry of Education, Culture, Science & Technology
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
MTC	Manufacturing Technology Centre
NEDO	New Energy Development Organisation
NETIS	New Technologies Information System
PV	Photovoltaic
R&D	Research and development
SME	Small and medium size enterprises
USD	United States dollars
VC	Venture capital


ktn