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SUPPLY CHAIN PRODUCTIVITY IN CONSTRUCTION

TRANSFORMING CONSTRUCTION NETWORK PLUS

DIGEST SERIES, NUMBER 3

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RESEARCH PROGRAMME

TRANSFORMING CONSTRUCTION NETWORK PLUS

The Transforming Construction Network Plus (N+) mobilises a new movement in the construction community, bringing together experts from a range of disciplines to tackle the most pressing problems across the digital, energy, construction, and manufacturing space.

The N+ is funded by UK Research and Innovation, an investment supported by the Industrial Strategy Challenge Fund. The N+ is a joint project between The Bartlett, UCL Faculty of the Built Environment, Imperial College London and WMG, University of Warwick.

The N+ research team is working to contribute to the body of knowledge that informs future construction practice and policy. As well as the digest series, the team will be developing academic papers and case studies exploring business model and industry change. We hope you find this digest useful, and welcome any questions or feedback you may have. You can reach the team at **enquiries.tcnetworkplus@ucl.ac.uk.**

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INTRODUCTION
WHY SUPPLY CHAIN PRODUCTIVITY?

All too often, construction firms focus on improving their own productivity at the expense of the other firms they work with. This reflects their tendency to not engage with a collaborative approach in which all firms involved in a construction project are working together. This reduces overall productivity, so projects overrun on cost and time[1,2]. This is further exacerbated by a low rate of technological innovation, poor communication and coordination, and the inefficient use of resources[3].

Borrowing from manufacturing, and adopting an end-to-end approach to supply chain management, could improve productivity in the construction sector. However, there are some key challenges that have to be overcome. Unlike manufacturing, construction is a 'low volume – high variety' industry. The fluid and emergent designs that we see in construction typically call for supply chain flexibility, while manufacturing emphasises supply chain efficiency. Nevertheless, there are circumstances in which construction firms and projects can make use of some of the tools from manufacturing to enhance productivity and profitability.

This digest shows how productivity improvements based on supply chain management used in manufacturing could be applied to improve the performance of construction. It presents three considerations for improving productivity in construction:

1. Building end-to-end supply chain integration
2. Achieving 'economies of repetition'
3. Adopting digital technologies to improve supply chain planning

We know that one size doesn't fit all, so this digest aims to help firms understand when to focus on supply chain flexibility and when to seek economies of repetition. In this way they will stand a better chance of radically improving productivity across projects and programmes.

WHAT IS A SUPPLY CHAIN?

There is no single definition of what we mean by the term supply chain, but definitions tend to align with one of three perspectives:

- Network perspective: describes a supply chain as an organisation of customers (downstream) and suppliers (upstream) who are part of the supply chain; this also includes suppliers of any raw materials needed for production and any final consumers of the products and services.
- Flow perspective: considers the movement of materials, information and money between suppliers, manufacturers, logistics providers, and customers.
- Process perspective: articulates the core processes that link different functions in a supply chain – i.e. planning, purchasing, manufacturing, logistics, and the reverse flow of materials at end of life.

Combining these perspectives, a common definition of the supply chain is: **'a set of three or more entities (organisations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer'[4].**

What is supply chain management?

The planning and management of supply chains is commonly referred to as 'supply chain management' (SCM) – this term originates from the manufacturing sector[5]. One of the core concepts underlying SCM is to take an extended view of the entire supply chain. According to the Council of Supply Chain Management professionals (CSCMP), SCM is: **'an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high-performing business model'[a].**

SCM aims to increase transparency, integration of business processes, and alignment throughout supply chains, regardless of functional or organisational boundaries.

[a]https://cscmp.org/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms.aspx

CONSTRUCTION SUPPLY CHAINS WITH FUNCTIONAL APPROACH

Classed as a complex sector, construction deals with a range of different types of projects including infrastructure, housing, domestic – renovation, maintenance and improvement (RMI) and local, social and commercial construction. It can be further broken down into two broad areas: projects established to design and deliver buildings and infrastructure, and operations to upgrade, repair, maintain and provide services.

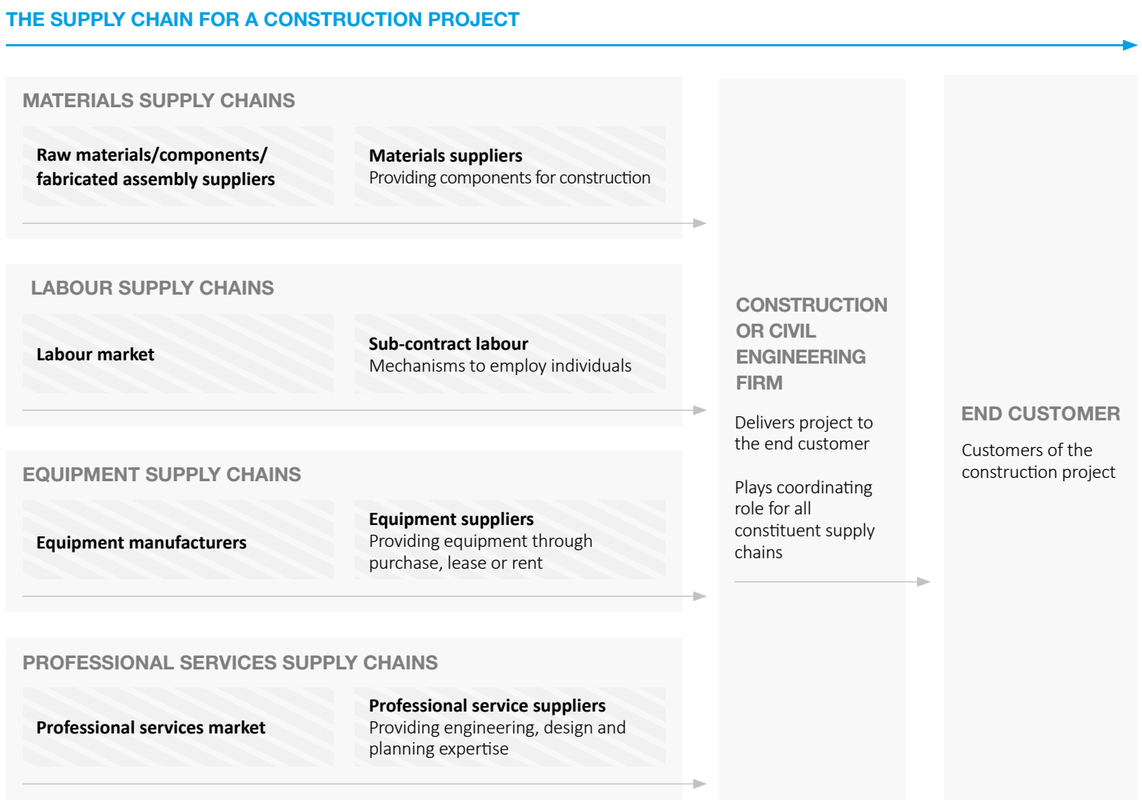
Delivery of a construction project is usually co-ordinated by a construction or civil engineering firm. They take the design requirements for the project (demand), and turn it into a set of requirements for materials, labour, equipment and professional services (supply).

Compared to manufacturing supply chains, construction supply chains tend to be more temporary in nature. Typically, for each project, a new supply chain is formed to fulfil the client's (end customer's) requirements - with organisations coming together to fulfil the needs of a project, and then disbanding. Projects are rarely similar, and the construction products used are also often one-off and bespoke. This is wholly unlike manufacturing where products tend to be standardised and high volume. That said, an underlying belief that every project is different – or 'uniqueness bias' – has effectively served to impede the construction industry from pursuing improvements in productivity. Research has shown that many construction projects contain processes and procedures that are repeatable across projects, enabling improvements in performance obtained by economies of repetition.

The configuration of typical supply chains for a construction project is complex (Figure 1). The firms involved in the construction supply chains typically adopt a functional approach to business organisation. This creates 'silos' which make decisions for individual functions, rather than supply chain flows. By adopting an end-to-end supply chain perspective, construction firms would necessarily have to view their supply chain as an end-to-end business process that builds links from customers to suppliers. Shifting from the 'functional' to 'process' approach is the first critical step to build productive end-to-end supply chain.

A further complicating factor in construction supply chains is the high degree of sub-contracting within each supply chain. This makes end-to-end co-ordination and optimisation within the supply chain more challenging, exacerbated by the temporary nature of construction projects.

Figure 1: Typical supply chains in a construction project



Adapted from Cox and Ireland[6]

TRANSFORMATION FROM FUNCTIONAL TO PROCESS APPROACH

To gain productivity advantages from supply chain management, there needs to be a major change in the way that construction industry organises their supply chains. The transformation from a functional to process approach is critical. This transformation is guided by changing strategies in four key areas (Figure 2):

- Firm-level organisational structure (how activities are organised to achieve business goals)
- Planning (process of planning supply chains to deliver a project)
- Visibility (visualising supply chains and making decisions based on timely and accurate data)
- Buffer management (managing inventory and capacity through supply chains)[7]

Successful transformation to a process approach will build an end-to-end integrated supply chain with integrated planning, improved flows (material, information, finance and labour) and better communication.

Figure 2: Transformation from functional approach to process approach

	ORGANISATIONAL STRUCTURE	PLANNING	VISIBILITY	BUFFER MANAGEMENT
Benefits of process approach	Seamless process	Integrated planning	Better visibility	Effective buffer management
From functional...	Business organised around functions	Decentralised planning	Unable to visualise real-time situation	Managed by individual functions
... to process	Business build around linkages following supply chain flows	Integrated planning across supply chain	Able to visualise real-time situation across supply chain	Managed collaboratively across supply chain
How to transform	Organise business around functional linkages and integrate all stakeholders	Collaborate with the network and integrate planning and segmentation	Integrate real-time situation visibility across end-to-end supply chain	Employ coordinative approach across the supply chains to right size the buffers

Adapted from Vrijhoef and Koskela[8]

ROLE OF SUPPLY CHAIN MANAGERS IN CONSTRUCTION SUPPLY CHAINS

There are four very different functional roles that a supply chain manager can perform within construction supply chains, i.e. those in which multi-tier suppliers are aligned with the client (Figure 3)[8]. These are described in outline below.

Supplier or supply base management

This focuses on the improvement of the supply chains for specific items, such as equipment. In-depth cost and fulfilment time analysis are crucial for identifying potential improvements in this role. The basis of this improvement is a reduction in transportation, inventory and production costs.

Resource flow management

Here, improving the supply chain flows (materials, equipment, finances, labour and information) between suppliers and construction firm to deliver the construction project is the priority. In this way, the manager also aims to redesign the supply chain structure to eliminate bottlenecks.

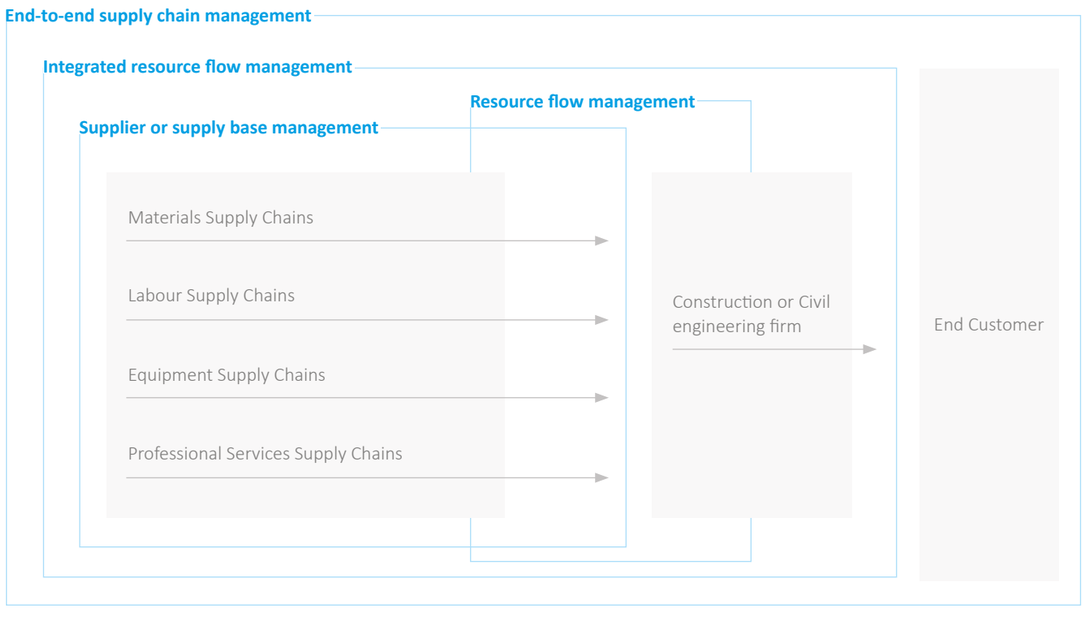
Integrated resource flow management

This perspective merges aspects of the previous two, i.e. by combining supplier and resource flow management. It places an emphasis on integrated management of the supply chains and the elimination of bottlenecks.

End-to-end supply chain management

This focuses on the needs of the end customer, by taking a much more integrated approach to resource flow management for a given end-to-end construction supply chain.

Figure 3: Four roles that a supply chain manager can perform within construction supply chains



In construction, the most common approach used by firms is to create supply chain management roles that focus on supplier management and resource flow management (also called materials management)[9].

Only a few firms adopt an end-to-end perspective to managing the supply chain. Where they do, it allows the balancing of demand and supply across their supply chains to create efficient flows.

For example, healthcare projects, NHS ProCure 21, 21+ and 22 administered by the Department by Health (UK), are built on the principles of end-to-end supply chain management[10]. These projects present frameworks for design and construction services to create an environment in which clients, supply chain partners, and their supply chains, are incentivised to drive increased efficiency and productivity at low costs in the long term.

In general, the potential benefits of taking an end-to-end approach include:

- Better supply chain integration (synchronisation of information and material flows, management of critical resources and configuration of the supply chain).
- Establishment of more stable partnerships with suppliers and customers.
- Supply chain design that is more flexible to meet the needs of a given project or client.
- Development of better relations with suppliers, customers, and distributors.
- Better control of flow (material, information, finance and labour) involving all supply chain members.
- Continuous improvement in all aspects of the entire supply chain.
- Greater innovation (incentivisation around the desired outcome shared down the supply chain).

THE IMPORTANCE OF SUPPLY CHAIN PLANNING

Supply chain planning seeks to enhance the effectiveness and efficiency of resource flows by coordinating business activities. Importantly, this is not just about the planning of material flows (i.e. resource flow planning). It is a more strategic capability that could be highly beneficial to a temporary and project-oriented industry, like construction.

In essence, it is the 'glue' that holds a supply chain together. For example, in a construction project, supply chain planning enables effective strategic planning in managing contractors to procure (the right resources), build, commission, and handover the project on time and to cost, thereby fulfilling the client's requirements. Importantly, an enhanced strategic planning capability is required, to enable firms to move away from a procurement-focused approach towards a demand-led (or outcome-aligned) end-to-end supply chain approach. Construction firms will need to develop such capabilities to recognise project type and demand profile (predictability and repeatability) – commonly known as project demand profiling. This can benefit the overall project or programme productivity.

Project demand profiling is a critical activity that helps firms prioritise better, and avoids unnecessary re-prioritisation. A demand profile is based on two factors:

- Intermittence of demand (frequency of demand)
- Lumpiness of demand (the size of the demand when it occurs)

Using these profiles, construction projects can be divided into four major project demand profile types or groupings (Figure 4).

Single project management (SPM)

Usually unique or innovative, these single projects are often large or strategic in nature; the demand profile is characterised by a high lumpiness that occurs only once.

Multiple project management (MPM)

A series of one-off (low intermittence), small projects (low lumpiness), that are managed as a group of unrelated, often quite routine, projects.

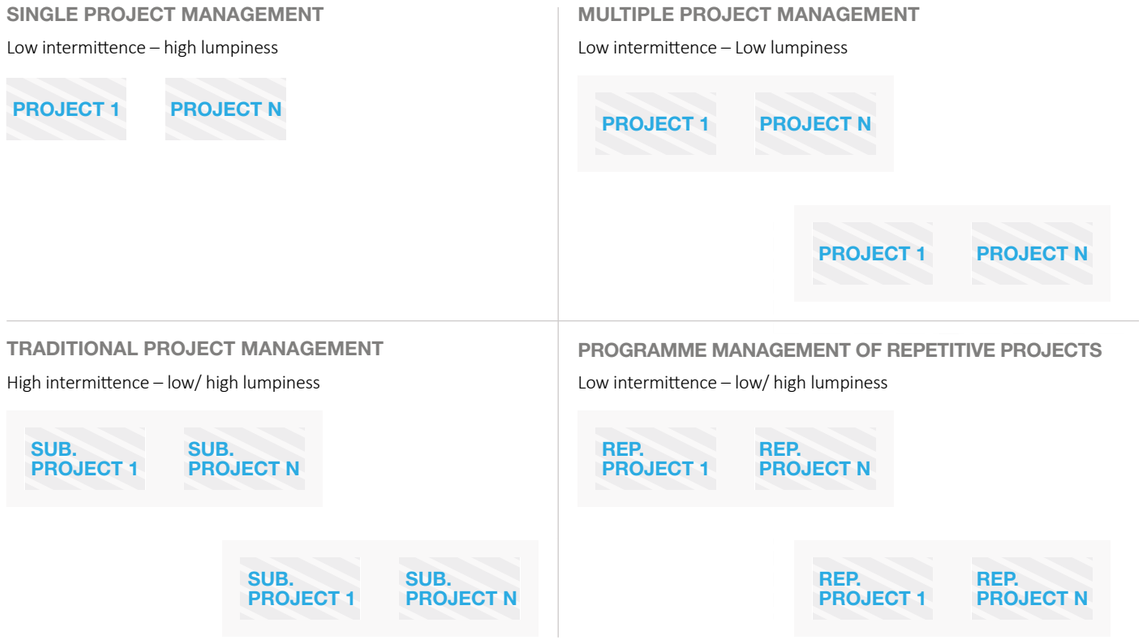
Traditional programme management (TPM)

A set of projects linked to a strategic goal. Individual projects are discrete (low intermittence), but may vary in size (low/high lumpiness).

Programme management of repetitive projects (PMRP)

A set of repeatable projects, with a strategic objective, but typically routine and repeatable (high intermittence and low lumpiness).

Figure 4: Types of project demand profiles in construction



Adapted from Godsell, Masi, Karatzas, and Brady[11]

The ability to recognise the demand profile and thus be able to characterise the 'project type group' into which an individual project can be classified could help firms to manage repeatable vs non-repeatable projects. The repeatable projects could be planned in such a way as to provide the stability through which the supply chain can improve efficiency. Such projects will achieve 'economies of repetition', whether this repetition occurs in design, materials, components, equipment, implementation plans or commissioning processes. It will allow construction firms to deliver a series of similar projects more effectively, while taking advantage of the learning opportunities that this offers. This could help to reduce costs, de-risk supply chains, and increase productivity.

CASE STUDY:
APPLICATION OF STRATEGIC PLANNING IN A UTILITY COMPANY

The focus of this case study is on the application of demand profiling in a utility company (UC). UC provides water and wastewater services, and engages with construction supply chains for the improvement and maintenance of its water infrastructure. Quite often the improvement and maintenance projects are long-term projects.

To improve performance of the water infrastructure supply chains, the Water Services Regulation Authority has extended Asset Management Periods (AMPs) to five years. Under each AMP, supply chain is structured in a way that the lead contractor/number of contractors have a five year period to complete the required work. Having a five year planning horizon provides UC with the opportunity to plan differently to increase effectiveness (i.e. doing the 'right' infrastructure projects) and efficiency (i.e. executing the projects in the most efficient way).

Among UC's infrastructure projects, there will always be unexpected or emergent work (30%). This can be dealt with in a more reactive way. However, the majority of the work (70%) can be defined in advance. Research has found that 95% of construction projects are repeatable, i.e. it is essentially the same project or its elements are repeated[11]. For defined and repeatable work, UC can identify the economies of repetition and view it as a programme of repetitive projects (PMRP). This will enable UC to:

+ Plan in advance (avoids need for re-planning);
+ Plan effectively (more efficient execution);
+ Provide visibility and continuity of demand to its supply chain over a five year time horizon.

THE ROLE OF DIGITAL TECHNOLOGIES IN ORGANISING SUPPLY CHAINS

Planning practices improve supply chain productivity, but without the adoption of digital technologies, construction firms may be unable to fully utilise the power of effective supply chain planning, and therefore miss out on the opportunity to develop seamless process flows, integrated planning, visibility, and effective buffer management.

Digital technologies can support the implementation of planning practices in the construction industry in four key areas[12]:

+ Digital data, collection and analysis of data across supply chain.
+ Automation, adopting digital technologies to create autonomous systems.
+ Connectivity, connection and synchronisation of activities across supply chains.
+ Digital access, access to data across supply chains.

However, compared with other industries, construction has been slow in shifting towards becoming a digitised industry. Adopting digital technologies in the planning of supply chains will allow construction firms to:

+ Connect more effectively with suppliers and customers
+ Integrate supply chain to enhance organisational competitiveness
+ Improve service level to customers
+ Reduce supply chain costs

Importantly, this is not just about utilising a new set of different information and communication tools, rather it can change the way construction firms work. Digital tools can enable firms to access real-time data, build connections with key players and create integrated supply chain flows to gain greater visibility, from a more integrated end-to-end supply chain and utilise resources, all in a more sustainable way.

Considered in combination, this means construction firms can avoid value loss in the supply chain and improve overall project or programme productivity.

CONCLUSION

SUPPLY CHAIN PRODUCTIVITY IN CONSTRUCTION

Supply chains are a powerful means to translate strategy into reality. So, it is time to re-examine productivity in construction supply chains, to avoid consistent overruns in cost and time on projects and programmes.

We know that construction projects can be complex, but good supply chain planning practices, like demand profiling can help decide on an appropriate supply chain management strategy that is right for the project or programme in hand.

What's more, if this is combined with the adoption of an end-to-end supply chain management approach, firms can really start to build the strategic and operational capabilities required to leverage economies of repetition and achieve improvements in productivity. The good news is that there are digital technologies such as blockchain, Internet of things and robotic process automation available to help firms make this transition.

In conclusion, supply chain planning can help construction firms to begin to solve the productivity puzzle. A leap in aggregated productivity is possible – provided firms in construction supply chains can start to think of others, and not just themselves.

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