CONSTRUCTION PLANNING EFFICIENCY AND DELIVERY TIME PERFORMANCE: ANALYSING FAILURE IN TASK-LEVEL 'HIT RATES'

Construction project delivery is considered successful by contracting firms if scope, time, cost, and quality outputs are attained, with any shortcomings in one or more of these representing a failure of sorts. Focusing only on the criteria of 'time', it is noticeable that more recent research efforts have been concentrated on poor time predictability and performance aggregated at construction 'industry-level', but minimal attention is retained on planning efficiency at individual 'project-level'. Yet it is precisely because time performance enactment of individual 'projects', and their 'project phases', 'work packages', and 'construction tasks' remains unsatisfactory that predictability of time at an industry level is also recorded as poor. The main aim of this work therefore was to advance the discussion of construction planning efficiency via an analysis of time performance on a small range of recently, and nearly, completed construction projects. Data were obtained from a convenience sample of several major UK contracting organisations, which allowed quantitative analysis to be employed by measuring planning- and delivery- efficiencies. The paper contributes through an explanation of the methods used, and discussion of the findings, which show how in this sample, planning and delivery efficiency is worse than previously considered, with an average of only 38% of project activities starting on and finishing on time. Evidencing such time-performance failure should inform further project-level predictability and productivity research.

Keywords: Construction planning, Failure, Measurement, Planning efficiency, Predictability, Productivity.

INTRODUCTION

Project success is evaluated when considering the attainment of: longer-term, more strategic 'outcomes', and short-term, more tactical, 'outputs'. Outcomes would variously include the realization of project benefits, impact, relevance, and sustainability aspirations, as well achieving stakeholder satisfaction (Craik, 2018; Davies, 2017). In contrast, outputs are those elements that are measured immediately post-delivery, against set scope, time, cost, and quality targets. Depending upon the stakeholders' requirements, project failure has variously occurred when one or more of these criteria does not meet with expectations. In the construction sector, where the underperformance of on-site project delivery efforts, particularly regarding 'predictability' remains a principle concern (Crotty, 2012; Love et al., 2011; de Melo et al., 2016), for contractors, shortcomings in meeting one or more of the 'Iron Triangle' criteria of 'time', 'cost', or 'quality', more viscerally represents project failure. Being more easily measured than quality, 'predictability' of project- and construction-cost and time performance is presently quantified and recorded annually via industry standard key performance indicators (KPI's) with project-level data aggregated and reported at industry-level. Table 1 presents results of these indicators from 2007 - 2017.

Table 1: Overall project-level time cost and time predictability for years 2007 - 2017 - percentage of projects delivered on target or better. (Table adapted from Constructing Excellence, 2017).

KPI	2007	2008	2009	2010	2011	2012	2013/14	2015	2016	2017
Predictability Time: Project	58	45	45	43	45	34	45	40	41	66
Predictability Cost: Project	46	49	48	52	63	61	69	69	68	65

This work, which focuses on the criteria of 'time', differs from prior research concentrating on poor time predictability and performance at aggregated 'industry-level' (Gledson, 2017; Gledson and Greenwood, 2017, 2016), as instead, attention is fixed on construction planning efficiency at individual project-level, specifically in the delivery of the on-site construction duration of such projects. Although data relating to the time predictability of the 'construction phase' level of projects are also captured and reported on in industry standard KPIs (again, aggregated at industry-level, see Table 2) it has nonetheless historically remained difficult to access performance data on individual projects. Nor has it been possible to 'drill-down' to review performance of individual tasks that collectively contribute toward the performance of distinct project phases or work packages. To begin to address this concern, the present work makes further use of, and builds upon, the only known method existing within construction planning literature, of recording task-level planning efficiency. This was established by Dawood (2009:2010) who refers to planning efficiency as the planning 'hit rate'.

Table 2: Construction-level time predictability for years 2007 - 2017 - percentage of projects and phases delivered on time or better. (Table adapted from Constructing Excellence, 2017).

KPI	2007	2008	2009	2010	2011	2012	2013/14	2015	2016	2017
Predictability Time: Construction	65	58	59	57	60	42	67	48	55	67

"If you can't measure it, you can't improve it" (frequently attributed to Peter Drucker).

As evidenced from tables 1 and 2 above, the overall time predictability and performance of construction projects (at project- and construction- level) can be considered to be both variable, and less than satisfactory. This has also been discussed at both 'macro' (e.g. Gledson, 2017) and 'micro' (e.g. Ballard, 2000; Dawood, 2010) levels, where researchers have considered how productivity issues affect individual construction task, work package, and construction project 'phase' performance, and therefore overall project time performance. Kenley (2014), advises that efforts to improve productivity and process are perhaps the "holy grail of construction research", yet within literature, reports of widespread measurement of task-level time performance seems limited, and equally in practice, little evidence exists of any dramatic improvement in this area.

Ballard (2000) sought to combat this with the development of the Last Planner System (LPS), by identifying a range of problems that typically affect task conformance against schedule and argues that the achieved 'planned percentage complete' (PPC) of individual construction tasks (prior to applying LPS) is typically 50%. In this, the work of Ballard contributes as much to productivity research, as to the overall Lean Construction movement. Similarly, the Lean Construction Institute (LCI) aims also to improve productivity in construction management, reinforcing why LPS was considered a useful addition, thus: “traditional project planning was unable to produce predictable workflow: only 54% of the assignments made by foremen to be completed in the week were actually completed” (LCI, no date). Unfortunately to date, widespread use of LPS is not apparent. Nor presently are other planning process innovations advocated within wider construction planning literature, as being useful for addressing this concern. These include the likes of probabilistic task duration calculation methods (Baldwin and Bordoli, 2014; Morris, 1997; Winch, 2010), the critical chain method (Goldratt, 1997; Herroelen and Leus, 2001), location-based planning methods (Seppänen et al., 2010, 2014), and 4D BIM (Dawood, 2010; Gledson and Greenwood, 2017; Hartmann and Fischer, 2007). Arguably, adoption and use of any individual or combination of these methods should result in improvements in planning efficiency, however just like time predictability itself, the adoption of process related planning innovations remains a concern (Gledson and Phoenix, 2017; Lindgren and Emmitt, 2017; Shibeika and Harty, 2015).

Returning, however, to the issue of measurement of task-level time performance, leads to the work of Dawood and associates (2009: 2010), who devised a means of calculating planning efficiency on construction projects. These researchers believe that 'traditional' planning, undertaken without use of the types of planning process innovations listed above, yields an average industry task percentage reliability of around 55 per cent, meaning that for only 55% of the time, there is zero variance in the planned start dates or planned finish dates of construction activities or work packages. Dawood and Sikka (2009, p.445) further identify that a “critical success factor for a construction project is the reliability of the commencement date for each activity as per the planning schedule”. Inspired by this approach, a version of the method was applied to analyse the planning and delivery-efficiencies across a small range of recently- and nearly- completed projects undertaken by several major UK contracting organisations, in order to provide comparator data. The subsequent sections report on how this was done, and what was revealed.

METHODOLOGY AND METHOD

The work is grounded in the research philosophy of pragmatism, and it should be considered as case study research, as it allows for investigation of an in-context phenomena (Fellows and Liu, 2008; Proverbs and Gameson, 2008) by drawing on, and triangulating multiple sources of evidence, then seeking to provide meaning (Remenyi et al., 2002).

To analyse time performance, quantitative secondary data from 720 completed construction tasks were reviewed. The data were obtained from a convenience sample of three finished and 'handed over' projects (Projects A-C) and one partially finished project (Project D), constructed by three different 'top ten' UK constructors. Secondary data is that which has already been collected by someone else for an initial, different purpose. In this case, the data were originally collected by construction team members to facilitate the site progress reporting function. Here, the data obtained from the following four projects, affords analysis of task-level time predictability:

Project A performed by Company A. £27 million, comprising of 4 Nr. NHS accommodation blocks for children with learning disabilities.

- Substructure: Concrete raft and pad foundations.
- Superstructure: Four number timber frame and one steel frame build.
- Finishes: Robust anti-ligature requirements.

Project B, also performed by Company A. £6 million, NHS adult mental health learning facilities.

- Substructure: Concrete raft foundation.
- Superstructure: Timber frame, mixture of brickwork and cladding and a 'Kalzip' roof system.
- Finishes: Robust anti-ligature requirements.

Project C performed by Company B. £11 million, NHS cottage hospital.

- Substructure: Concrete ground bearing slab.
- Superstructure: Pre-cast concrete frame building with stone cladding, curtain walling and acrylic render.
- Finishes: Internal partitions with suspended and MF ceilings.

Project D performed by Company C. £9 million, Energy Centre.

- Substructure: Continuous flight auger piled foundation.
- Superstructure: Steel frame, block work, SFS and cladding.

It should be noted here that although the projects were planned using computer aided planning and scheduling software, none of them made use of any of the planning process innovations listed above (probabilistic task duration calculations; critical chain; location-based planning, or application of 4D BIM), thus they could be considered to evidence 'typical' approaches to construction project planning (Gledson and Greenwood, 2017). As discussed, Dawood's (2010) prior research posited that there was an average industry hit rate percentage of 55 percent for 'traditional' planning, undertaken without use of the types of such planning innovations, and the method for calculating planning efficiency, known as the planning 'hit rate' established variously in Dawood and Sikka (2009) and Dawood (2010) was the basis for this work. Dawood (2010) advises that: "Hit rate percent indicates the percentage reliability of the commencement date for each activity or package(s) by comparing the planned programme against the actual programme". However, Dawood (2010) does also go on to show that achieving planned completion dates are equally as important to the calculation of planning efficiency. Thus, 'hit rate', is measured as the percentage of activities which both started, and completed 'on time', as specifically, this is contrasted against the percentage of activities which: (1) started early and finished late, (2) started early and finished early, (3) started late and finished late, and (4) started late and finished early. The present research team used a similar method of data analysis to consider Dawood's 5 existing performance measures, but then also expanded on this by considering 4 other possibilities to see whether an activity had increased or decreased in duration. These 9 measures now listed in full can help to establish the percentage of time activities:

1. Start on time AND finish on time, meaning *planning is truly efficient* (i.e. the 'Hit Rate' is achieved).
2. Start on time AND finish early, meaning a decreased activity duration.
3. Start on time AND finish late, meaning an increased activity duration.
4. Start early AND finish early, meaning duration may or may not be different from planned.
5. Start early AND finish on time, meaning an increased activity duration.
6. Start early AND finish late, meaning an increased activity duration.
7. Start late AND finish early, meaning a decreased activity duration.
8. Start late AND finish on time, meaning a decreased activity duration.
9. Start late AND finish late meaning duration may or may not be different from planned.

The following information therefore needed to be extracted from the project planning data files provided by the research contacts in order to truly establish the planning hit rate percentage:

- Task ID, and Task name (as identifiers, for classifying the activity into one of the three construction phases).
- Planned start date.
- Actual start date.
- Planned finished date.
- Actual start date.
- Planned duration in days.
- Actual duration in days.
- Start variance: This being the actual start date, minus the planned start date. (Note that an activity with zero variance indicates that the activity has started on time, positive variance indicates the activity has started late, and negative variance indicates that the activity started earlier than the planned duration).
- Finish variance: As above, but for the finish date.
- Total variance: the sum of the start and finish variance.

The researchers also sought to undertake further performance analysis by classifying the data into one of three usual, separate construction phases:

- Substructure: works below the ground, typically foundations and ground supporting elements of a building.
- Superstructure: structure or frame of the building above ground level and the external envelope.
- Finishes: internal finishing trades within a watertight building.

This was done for a secondary purpose, to test a common construction ‘maxim’ which holds that major contractors are able to perform satisfactorily during the ‘substructure’ and ‘superstructure’ phases, but not the ‘finishes’ phase of a project.

Table 3 shows the planning efficiency measures and formulas used to calculate the planning efficiency 'hit rate' percentages, and additional measures for each project and stage in the project lifecycle. When calculating the average percentages of all four projects, the researchers used a weighted arithmetic mean calculation; this takes into account that some projects contribute more than others to the overall mean value, due to the difference in the number of activities analysed.

Table 3: Planning efficiency measures and formulae.

Percentage of activities which started on time and finished on time*	(Total number of activities ÷ Total number of activities having zero total variance value) x100
Percentage of activities started early and finished late	(Total number of activities ÷ number of activities which started early and finished late) x 100
Percentage of activities started early and finished early*	(Total number of activities ÷ number of activities which started early and finished early) x 100
Percentage of activities started late and finished late	(Total number of activities ÷ number of activities which started late and finished late) x 100
Percentage of activities started late and finished early	(Total number of activities ÷ number of activities which started late and finished early) x 100
Percentage of activities which started on time and finished late	(Total number of activities ÷ number of activities which started on time and finished late) x 100
Percentage of activities which started on time and finished early*	(Total number of activities ÷ number of activities which started on time and finished early) x 100
Percentage of activities which started early and finished on time*	(Total number of activities ÷ number of activities which started early and finished on time) x 100
Percentage of activities which started late and finished on time	(Total number of activities ÷ number of activities which started late and finished on time) x 100
Number of activities with no change in duration	(Total number of activities ÷ Total number of activities having zero start and finish variance value) x100
*Hit Rate percentage	The weighted arithmetic mean, of the planning scenarios highlighted with an *. These are activities, which started early/on time and finished early/on time.

SUMMARY RESULTS, ANALYSIS AND DISCUSSION

As discussed above, the critical success factor in any project delivery is the reliability of starting and finishing an activity per the programme or schedule. This is referred to here as the 'hit rate' percentage to establish planning efficiency. Summary ‘descriptive’ data of all four projects is first presented in Table 4, which reveals: two of the projects (A and B, with 23% and 30% respectively) showed planning efficiency to be much worse than thought by Dawood (2009; 2010); one project was comparable (Project D with 59%); and one project performed slightly better (Project C with 70%) When averaged across all projects, the results are that a typical 38% 'hit rate' is achieved, thus being worse than the 55% believed by Dawood (2009: 2010).

Figure 1 shows planning efficiency by project phase across all four projects. However, despite the 'maxim' discussed above, this study revealed no significant trends in the 'hit rate' of activities within certain project phases.

Table 4: Summary analysis of time performance across all tasks on all four projects (A-D)

PROJECT	A		B		C		D		Overall	
Number and % of activities	No.	%	No.	%	No.	%	No.	%	No.	%
Analysed	427	-	67	-	175	-	51	-	720	-
That had no change in duration	209	49	24	36	145	83	43	84	421	58
Started early and finished late	14	3	9	13	0	0	1	2	24	3
Started early and finished early*	80	19	5	7	1	1	6	12	92	13
Started late and finished late	270	63	24	36	13	7	19	37	326	45
Started late and finish early	9	2	0	0	0	0	0	0	9	1
Started on time and finished late	27	6	13	19	40	23	1	2	81	11
Started on time and finished early*	5	1	1	1	2	1	3	6	11	2
Started early and finished on time*	1	0	2	3	0	0	0	0	3	0
Started late and finished on time	7	2	1	1	0	0	0	0	8	1
Started and finished on time*	14	3	12	18	119	68	21	41	166	23
*Hit Rate	100	23	20	30	122	70	30	59	272	38

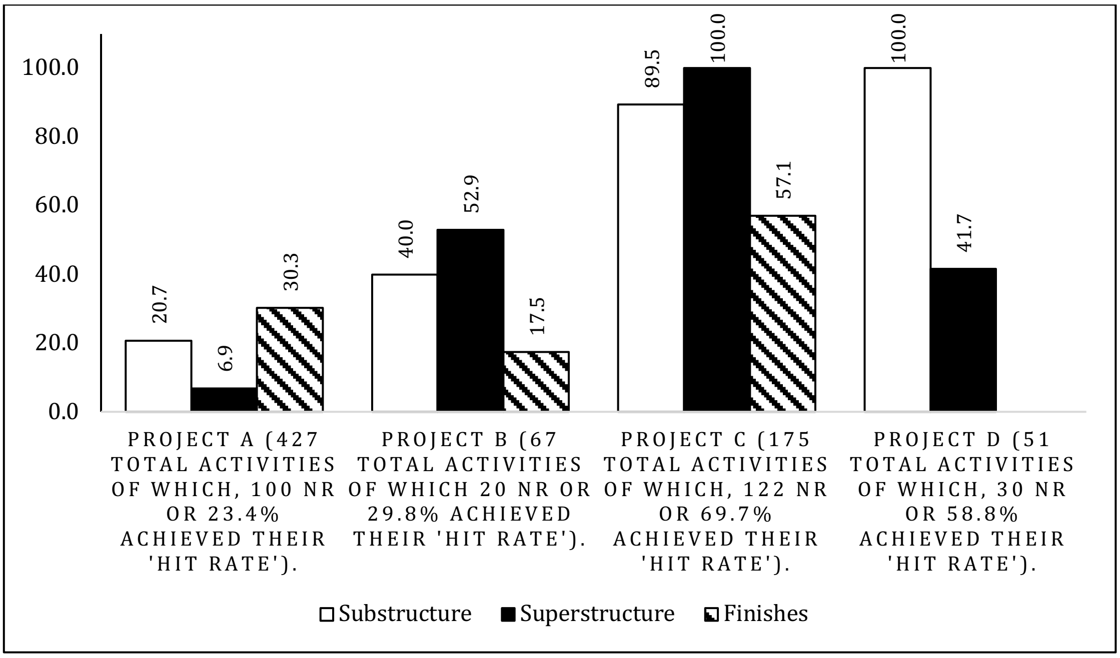

Figure 1: Projects A-D, Planning efficiency by project phase (percentages shown).

CONCLUSIONS

The objective of the data analysis was to examine the performance of a sample of past construction projects in an attempt to consider what typical levels of effectiveness in the planning and delivery of time performance in the UK construction sector might be. Whilst no significant trends in the 'hit rate' of activities across the four projects were observed, analysis has enabled several key conclusions to be drawn, which are:

1. The average planning efficiency data across all four projects is lower at 38% when compared with Dawood's assertions of 55%.
2. Planning activity appears to be somewhat effective at predicting the duration of activities, with an average accuracy of 58% recorded in this sample.
3. In contrast, planning efforts appear poor at forecasting the exact timings of when activities will actually occur (i.e. start and finish dates), as an average of only 23% was achieved in this sample.
4. Out of all the possible planning and delivery outcomes for the 720 activities analysed in this sample, the most frequent outcome was that on average 45% of activities started late and finished late.
5. In this sample, activities tend to start on time and finish on time more frequently only within the earliest, substructure phases of a project. Thereafter no such trends were observable in the reaming project phases.

The quality of planning and delivery time performance appears variable across the separate projects analysed in this study. In general, planning quality will always be affected by a range of issues including the complexity and technological difficulties of each distinct project, the skill level of the project planners themselves, the time and information available at the time of planning, and the media used to communicate the formulated plans (Gledson, 2017). Upon construction commencement, the quality of delivery also affects time performance, particularly as projects are always prone to be subjected to the various delays and disruptions of site activity. Furthermore, either strategically or tactically, on some occasions, contractors may decide to expedite specific, usually early-stage and less complex activities, to build in additional time-contingency for later more complex activities. The scope of this research project did not focus on any of these aspects, yet through a straightforward measurement and assessment exercise, several valuable conclusions have still been drawn. Some of these are perhaps tacitly ‘known’ in industry but effectively they are being ‘proven’ here. Not least is that in this convenience sample, construction planning efficiency and delivery time performance - or 'time predictability', seems poor, certainly when performance data is considered at individual task level. The low averaged 'hit rate' recorded here of 38% is a particular concern, and further, similar research efforts performed on a diverse range of projects also using 'traditional' methods of construction planning would be welcomed either to support or reject these findings. Similarly, future research comparing the results of 'hit rates' achieved with projects that use 'traditional' methods of construction planning, against projects that instead make use of planning process innovations including the likes of 4D BIM, would also do much to further inform construction predictability and productivity research.

REFERENCES

Baldwin, A. and Bordoli, D. (2014), *A handbook for construction planning and scheduling*, Wiley-Blackwell, Oxford, UK, 1sted.

Ballard, G. (2000), *Last Planner System of Production Control*, University of Birmingham.

Constructing Excellence. (2017), *UK Industry Performance Report 2017. Based on the UK Construction Industry KPI's*, available at: https://www.glenigan.com/wp-content/uploads/2017/11/UK_Industry_Performance_Report_2017_vF.pdf.

Craik, D. (2018), "Iron discipline", Project. The voice of the project management community, Vol. Summer No. 295, pp. 30–32.

Crotty, R. (2012), *The Impact of Building Information Modelling: Transforming Construction*, SPON Press, Oxon.

Davis, K. (2017), "An empirical investigation into different stakeholder groups perception of project success", International Journal of Project Management, Elsevier Ltd, Vol. 35 No. 4, pp. 604–617.

Dawood, N. (2010), "Development of 4D-based performance indicators in construction industry", *Engineering, Construction and Architectural Management*, Vol. 17 No. 2, pp. 210–230.

Dawood, N. and Sikka, S. (2009), "Development of 4D based performance indicators in construction industry", *Engineering, Construction and Architectural Management*, Vol. 16 No. 5, pp. 438–458.

Fellows, R. and Liu, A. (2008), *Research methods for construction*, Wiley-Blackwell, West Sussex, 3rded., available at: http://www.loc.gov/catdir/toc/ecip088/2008002534.html.

Gledson, B. (2017), *Innovation Diffusion within the UK Construction Sector: a study of the adoption of 4D BIM*, Northumbria University, available at: http://nrl.northumbria.ac.uk/32529/.

Gledson, B. and Phoenix, C. (2017), "Exploring organisational attributes affecting the innovativeness of UK SMEs", *Construction Innovation: Information, Process, Management*, Emerald, Vol. 17 No. 2, pp. 224–243.

Gledson, B.J. and Greenwood, D. (2017), "The adoption of 4D BIM in the UK construction industry: an innovation diffusion approach", *Engineering, Construction and Architectural Management*, Vol. 24 No. 6, pp. 950–967.

Gledson, B.J. and Greenwood, D.J. (2016), "Surveying the extent and use of 4D BIM in the UK", *Journal of Information Technology in Construction*, Vol. 21.

Goldratt, E.M. (1997), *Critical Chain*, *America*, The North River Press Publishing Corporation, Great Barrington, MA, Vol. 8, available at: http://www.amazon.com/Critical-Chain-Eliyahu-M-Goldratt/dp/0884271536.

Hartmann, T. and Fischer, M. (2007), "Supporting the constructability review with 3D/4D models", *Building Research & Information*, Vol. 35 No. 1, pp. 70–80.

Herroelen, W. and Leus, R. (2001), "On the merits and pitfalls of critical chain scheduling", *Journal of operations management*, Vol. 19, pp. 559–577.

Kenley, R. (2014), "Productivity improvement in the construction process", *Construction Management and Economics*, Vol. 32 No. 6, pp. 489–494.

Lindgren, J. and Emmitt, S. (2017), "Diffusion of a systemic innovation A longitudinal case study of a Swedish multi-storey timber housebuilding system", *Construction Innovation*, Vol. 17 No. 1, pp. 25–44.

Love, P.E.D., Edwards, D.J., Han, S. and Goh, Y.M. (2011), "Design error reduction: toward the effective utilization of building information modeling", *Research in Engineering Design*, Vol. 22 No. 3, pp. 173–187.

de Melo, R.S.S., Do, D., Tillmann, P., Ballard, G. and Granja, A.D. (2016), "Target value design in the public sector: evidence from a hospital project in San Francisco, CA", *Architectural Engineering and Design Management*, Vol. 12 No. 2, pp. 125–137.

Morris, P.W.G. (1997), *The management of projects*, Thomas Telford.

Proverbs, D. and Gameson, R. (2008), "Case study research", in Knight, A. and Ruddock, L. (Eds.),*Advanced research methods in the built environment*, Wiley-Blackwell, Oxford, pp. 99–110.

Remenyi, D., Money, A., Price, D. and Bannister, F. (2002), "The creation of knowledge through case study research", *Irish Journal of Management*, Irish Academy of Managment, Vol. 23 No. 2, p. 1.

Seppänen, O., Ballard, G. and Pesonen, S. (2010), "Combination of Last Planner System and Location-Based Management System", *Lean Construction Journal*, pp. 43–54.

Seppänen, O., Evinger, J. and Mouflard, C. (2014), "Effects of the location-based management system on production rates and productivity", *Construction Management and Economics*, Vol. 32 No. 6, pp. 608–624.

Shibeika, A. and Harty, C. (2015), "Diffusion of digital innovation in construction: a case study of a UK engineering firm", *Construction Management and Economics*, Vol. 33 No. 5–6, pp. 453–466.

Winch, G. (2010), "Managing construction projects : an information processing approach", Blackwell Pub., Ames, Iowa.