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Overdue invoice management: a Lean and post-Lean simulation approach

Bashar Younes[1], PhD candidate; Ahmed Bouferguène[2], PhD, Associate Professor; Mohamed Al-Hussein[1], PhD, Professor; Haitao Yu[3], PhD, Ziad Ajweh[1], MSc student
[1]University of Alberta, Department of Civil & Environmental Engineering
[2]University of Alberta, Campus Saint-Jean
[3]Landmark Group of Builders

Abstract: Construction contractors stipulate payment terms for invoices submitted. These terms are often ignored, in which case invoices are paid late, leading in the long-term to lost profit and compromised relationship and reputation for both contractors and owners. Two particular challenges are identified in this research: (1) delayed payment of invoices and (2) inefficient processing of invoices. Considering that for a typical construction firm invoice processing involves a number of full-time employees and several stages, the effect of inefficient invoice processing on project cost cannot be ignored. From the construction owner's perspective, ensuring on-time payment of invoices, even when funds are available, can be a challenging exercise because of the variety, volume, and the unpredictable nature of demand for the invoices to be processed. As a result, it is paramount for owners to implement not only processing protocols which will ensure efficient treatment of invoices but, more importantly, quality assurance procedures which will minimize the amount of rework in the process. The approach proposed in this paper considers invoice processing as a supply chain to which Lean manufacturing principles and simulation are applied in order to reduce (or ideally, eliminate) waste in the process, thereby achieving a steady-state supply chain with minimal queuing and processing time.

1 Introduction

Invoices can be issued to construction owners by consultants, material suppliers, construction contractors, inspectors, or internal contractors. The pay term—the targeted period of time within which an invoice is to be paid—can range based on the given contract from immediate (upon submission of invoice) to within 30 days (as in the vast majority of cases). Such a range in invoice pay terms compounds the challenges faced by construction owners seeking to pay invoices on time. In contrast, contractors submit their invoices based on tasks performed according to a predetermined schedule. Contractors usually stipulate the method of invoicing and the pay term, plan their cash flow, and will accordingly expect their invoices to be paid within the pay term. Failure to meet this basic requirement will eventually place a financial burden on the contractor. As a result, the focus from the contractor's perspective is typically on improving collection strategies for outstanding receivables (Zeng et al. 2008) and improving invoice processing (Erdmann et al. 2010). To this end, researchers have applied the "Define, Measure, Analyze, Improve, Control" (DMAIC) approach as a roadmap within a Lean Six Sigma context in order to minimize invoice lead time and invoice processing time. Invoice lead time is the period (usually in days) from the time the invoice is received to the time it is paid. The invoice processing time (in minutes) is the time required for the invoice to be processed along all stations without waiting. (Further discussion with regard to these two key process metrics will be offered later in this paper.)

Invoice processing is by nature highly dynamic and variable. Slomp et al. (2009) have illustrated how Lean manufacturing principles can be successfully implemented on high-variety/low-volume products. Patients accepted in emergency departments, analogously, can be considered as high-variety/low-volume products. Dickson et al. (2009) proved that the adoption and implementation of Lean principles by an emergency department led to an improvement in the value of delivered emergency care. Rai (2007) described other challenges, such as unpredictable demand due to uncertainty or variety in terms of personnel skills if the process is manually-driven, as in the process for a document production business. Another key challenge is ensuring managerial staff buy-in to Lean implementation. Tennessen and Tonkin (2007) have discussed that, when utilizing Lean principles to improve a non-manufacturing process, commitment by management personnel to a never-ending improvement process is the key to successful implementation.

Value Stream Mapping (VSM) as a Lean visualization tool cannot respond effectively to the dynamic and uncertain nature of production processes (invoice processing, in this case). Wang et al. (2009) have described how the variability and high uncertainty of the production process are a result of product uniqueness, a high level of variation between products, frequent rework, and changes in demand due to urgent client needs. Such challenges underscore the value of simulation as an efficient tool to model the system. The utilization of simulation allows for evaluation of the efficiency of the proposed process design (Lian and Van Landeghem 2007). Abdulmalek and Rajgopal (2007) have also demonstrated that simulation can validate the decision to implement Lean, which in turn motivates decision-makers to adapt Lean in order to improve processes.

In terms of the legal aspects of invoice processing, several regulative measures have been adopted to address payment problems. Andrew (2004) has referred to the Late Payment of Commercial Debts (Interest) Act in the United Kingdom (1998), which legislates a payment delay interest penalty of 8% on top of the base interest rate. Andrew has also emphasized that this Act is still not sufficient to solve the problem contractors face with respect to cash flow. Nielsen (2004), in a later study, demonstrated the rights of project participants as per the standards of payment provisions in the United States, where an owner must pay the contractor within a specified timeframe unless the contractor’s application for payment is refused by the owner’s engineer on the grounds of the contract not having been fulfilled. In the United States, prompt payment provisions have been applied as a remedy in most states, although the terms vary from one state to another, particularly with regard to payment period, late payment interest penalty, the issue of whether or not the act extents to subcontractor/s, and the limit on the amount of retention. Payment periods range from 14 days in Iowa to 90 days in Arkansas (Gwyn 1996).These provisions require the owner to pay the contractor within a given number of days from the receipt of each payment; in the case of failure to meet these conditions, the owner faces late payment interest penalties that vary from 9% per year in Maryland to 21% per year in North Dakota. In Alberta, Canada, The Public Works Creditors Payment Act (Province of Alberta 1964) requires the owner to pay a 5% penalty for delay in payment in cases in which no contractual pay term is in place.

Although payment protection regulations are in place, construction owners still tend to delay processing and payment of contractors’ invoices. Contractors, meanwhile, have limited options since it is in their own interest to seek and maintain strong relationships with construction owners. Wu (2011) referred to a survey conducted in 2009, the results of which show that contractors tend not to take legal action in cases of delayed payments, primarily due to their commitment to maintaining a good relationship with the owner. Therefore, the options that are available to the contractor include but are not limited to:

1) adding cost allowance to the project bid price to accommodate the risk of late payment;
2) offering incentives to owners who pay invoices within or early in the pay term; and
3) allocating resources to track overdue invoices being held by construction owners.

Owners themselves face their share of impacts in terms of cost and reputation. For instance, any relevant costs to the contractor will be transferred to the owner as project costs, not counting the costs of excessive invoice processing time due to rework and waste in the invoice processing. In addition, continuous delaying of invoice payments by a given owner could have a subsequent effect on the reputation of that owner in the eyes of contractors; the financial effect of negative image is difficult to quantify, but some contractors do consider overdue invoices as a criterion in a given owner's Key Performance Index (KPI).

This paper focuses on invoice processing on the owner side. Real case studies have been undertaken with North American-based construction owners. The collected data is analyzed to identify points of weakness and strength in the system. Impacts on the company are quantified, and opportunities for improvement are highlighted. Some details related to the data have been slightly altered in order to maintain confidentiality. Based on the results of the studies, this research proposes a Lean manufacturing-based methodology to streamline the invoice payment process. The research utilizes Discrete-Event Simulation (DES) to support informed decision making prior to implementation of process improvements.

2 Definitions

We begin our analysis with an overview of the basic definitions and terminology encountered with respect to invoicing and invoice processing. Parties are bound contractually to a specific pay term ($\mathbf{P_t}$) that specifies the time needed to pay an invoice, which is calculated satisfying Equation 1. The length of time the invoice is circulated (processed) in the organization is referred to in this research as invoice lead time ($\mathbf{I_{lt}}$), which is calculated satisfying Equation 2. An invoice is considered overdue if it has not been paid by the pay term due date (Figure 1); the invoice age time ($\mathbf{I_{at}}$) is thus calculated as per Equation 3.

[1] $\mathrm{P_t = T_B - T_A}$

[2] $\mathrm{I_{lt} = T_C - T_A}$

[3] $\mathrm{I_{at} = T_C - T_B}$

Where $\mathrm{T_A}$ is the time at which the invoice is received, $\mathrm{T_B}$ is the time within which the pay term is due, and $\mathbf{T_C}$ is the time at which the invoice is paid.

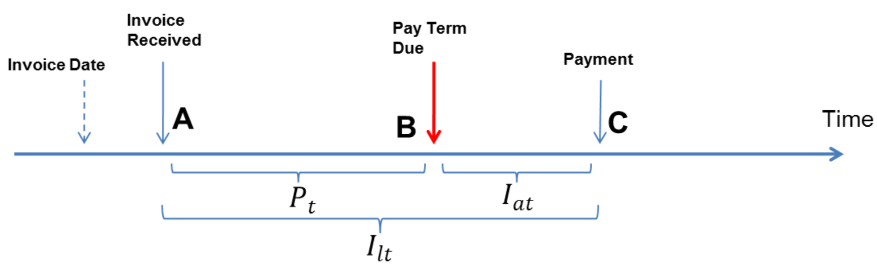

Figure 1: Invoice lead time

Invoices typically move between different personnel in the organization for different purposes, including receiving, photocopying, checking, and reviewing, with payment as the last station. The invoice processing time ($\mathbf{I_{pt}}$) can be calculated as per Equation 4, which combines cycle times for all stations along the production line from receipt of invoice to payment (Figure 2).

[4] $\mathbf{I_{pt}} = \sum_{i=1}^{n} \mathbf{I_{Ct_i}}$

Where $\mathbf{I_{Ct_i}}$ is the invoice cycle time for station $\mathbf{i}$, and $\mathbf{n}$ is the number of stations along the invoice process.

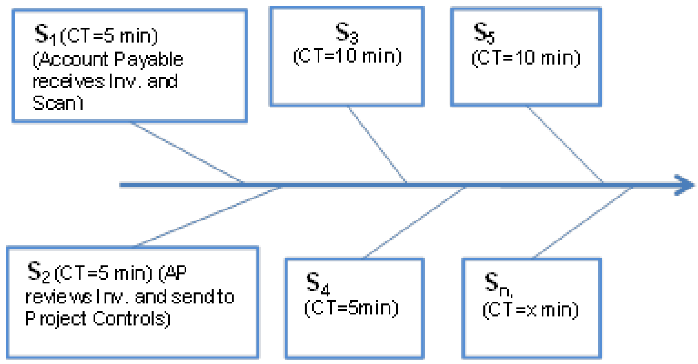

Figure 2: Invoice processing time

3 Exploratory data analysis

In order to provide a clearer idea of the extent of the overdue invoice problem, we offer a summary of some descriptive statistics as obtained in the case study for this research. It should be noted that although these statistics are specific to a single case, the overdue invoice issue encountered in the case study is typical of many sectors of the construction industry. The unknown, however, is the extent of the issue and its impact on profit and reputation. Based on the data collected from one of our industry partners, it was found that between 2008 and 2010 approximately 45% of the processed invoices were overdue, i.e., had not been paid within the pay term. Table 1 summarizes the number of invoices received during each of these years and the corresponding number of overdue invoices.

Table 1: Number of overdue invoices between 2008 and 2010 for the industry partner

Year	No. Invoices	Ratio of Overdue Invoices	% Amount of Overdue Invoices
2008	77,349	47%	42%
2009	89,606	46%	60%
2010	70,008	42%	50%

Based on the data in Table 1, although some improvement was achieved in terms of invoice processing efficiency, the rate of overdue invoices was still at an alarming level in 2010. It should be noted that for this particular partner the observed improvement was essentially achieved by the introduction of an electronic system. However, it must be emphasized that the utilization of an electronic system only allowed for a marginal gain since the processing flow remained unchanged.

In 2010, 44 pay terms were used, 8 of which are presented in Figure 3 with the ratio of invoices received for each pay term. The pay terms presented in Figure 3 represent 98% of invoices received. No significant change in ratio of invoices received by pay term was found from year to year.

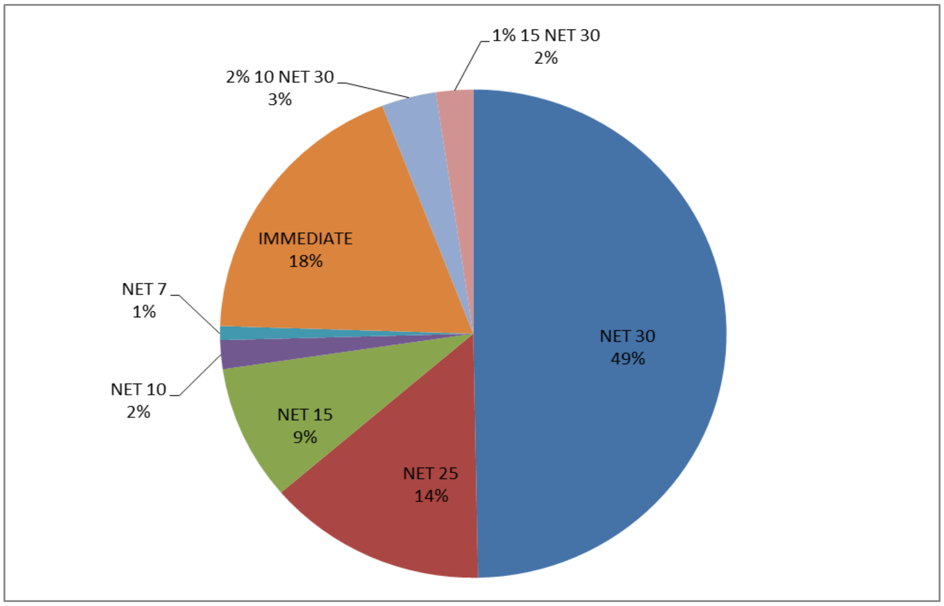

Figure 3: Ratio of invoices by pay term

A pay term of “2% 10 net 30” (see Figure 3 above) means that 2% of the invoice amount can be credited to the owner if the invoice is paid within the first 10 days of the 30-day pay term. This is an example of the strategy mentioned above, whereby contractors offer an early payment incentive to construction owners in order to avoid greater financial loss later due to invoice payment delay on the owner side.

In order to provide further insight into the risks associated with shorter pay terms, the available historical data is segregated according to the invoice pay terms; the distribution of overdue invoices within each category is shown in Figure 4. As can be inferred from Figure 4, the risk of overdue invoices is considerably higher for shorter pay terms than for longer pay terms. This observation can be explained by the fact that invoices are processed without regard for their respective pay terms. The practical implication of this result is of importance since it is instructive to owners—especially those who do not have a fast track invoice processing protocol—about the dangers of short pay term contracts.

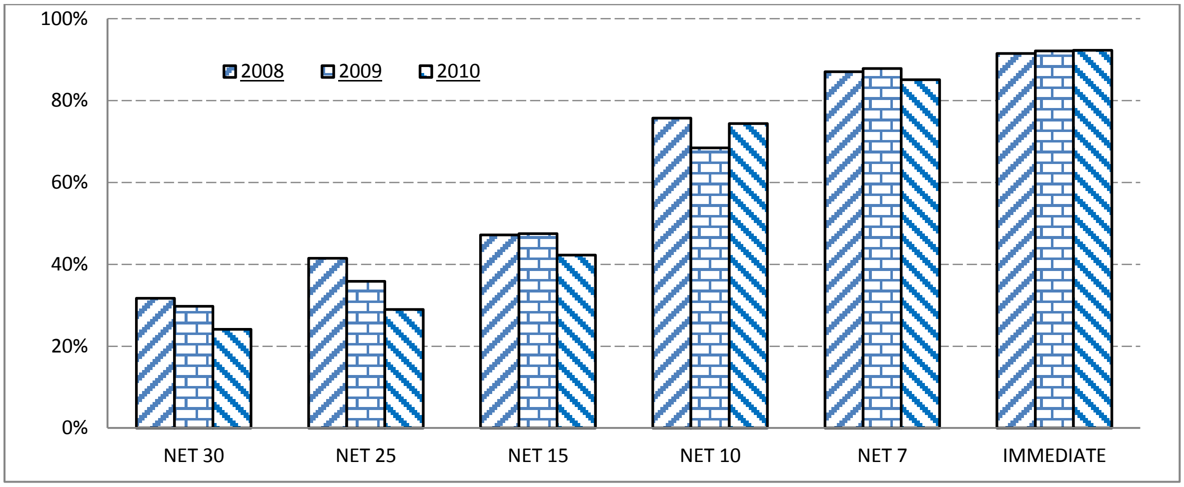

Figure 4: Distribution of overdue invoices by pay term

The construction industry is vulnerable to the negative impacts of seasonality. This reality is particularly evident in the Alberta context, where severe weather conditions (cold winters) are synonymous with a decrease in the number of new projects, (especially those requiring workers to be exposed to the elements). We thus proceeded with an investigation of the number of invoices as a function of seasonality. The rationale for this component of the investigation was two-fold. First, forecasting the number of documents which need to be processed in a given month allows managers to request the appropriate level of resources to keep processing flowing smoothly (minimizing the number of overdue invoices). Secondly, in addition to resource-leveling and redistribution, studying the impact of seasonality on the number of invoices will also provide an approximate idea of the extent of cash demand, which is a crucial factor in the survival of any organization. An analysis of the data obtained from one of our industry partners, covering the period 2008-2010, is depicted as a time series in Figure 5.

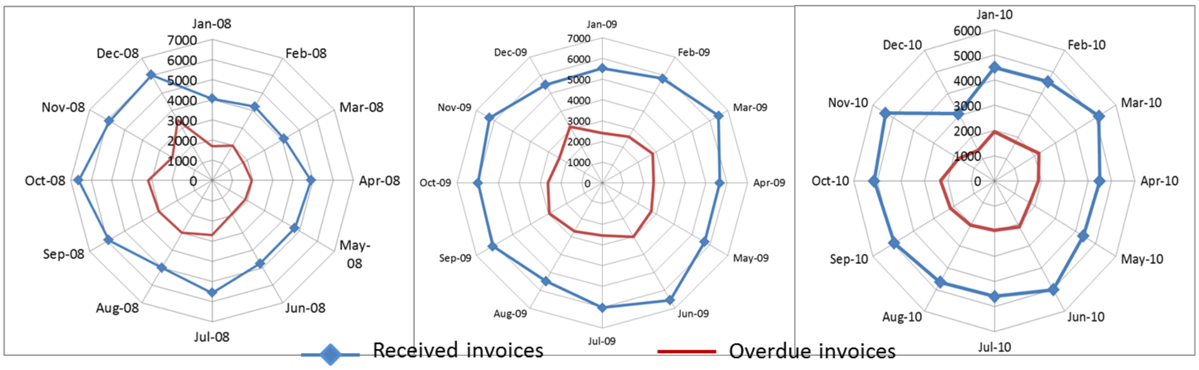

Figure 5: Net-15 invoices processed monthly between 2008 and 2010

According to Figure 5, peaks in overdue invoice ratios follow peaks in received invoices, which is indicative of the high correlation between overdue invoices and the volume of invoices received. In other words, there does not seem to be any planned change to the document processing protocol as a response to increases in demand. If a chart similar to that in Figure 5 could be forecasted, resources and possibly process design could be better planned. In this regard, predictions of future demand (number of invoices received) can be achieved using statistical tools such as regression. Simic et al. (2009), for instance, used eight years of invoice history to predict invoices and cash outflow. Of course, in order to increase the accuracy of the regression model it is important to have a sufficiently large dataset (more than three years), but, more importantly, data which is descriptive of the same general economic situation is also required. In this respect, the spike (economic boom time) that occurred in Alberta between 2005 and 2008 can be considered an outlier.

4 Processing improvement using integrated Lean manufacturing and simulation

A Lean manufacturing approach, which involves eliminating waste in order to create value, will be applied to segregate the value-adding from non-value-adding activities in the invoice process. Invoice processing is considered in this research to be similar to manufacturing (assembly line production) due to the following parallels:

- The invoice is like a manufacturing product in that it moves from one station to another along the process line until it is delivered (paid). It has its own lead time and processing time, and is subject to potential rework at any given station.

- Invoices can be of different types (material supply, installation, internal contractor), each with their own components; the checking of these components parallels the installation of components along an assembly line.

Due to these similarities between invoice processing and manufacturing, VSM as a Lean manufacturing tool is utilized in this research. The advantages of VSM have been summarized by Rother and Shook (2003) as follows:

- it provides an effective tool for clear communication by visualizing the actual material and information flow;
- it exposes waste through mapping and Lean measurements;
- it becomes the blueprint of Lean transformation by integrating Lean principles and techniques into the future map, with management review and reporting incorporated; and
- it is a qualitative tool which effectively describes the quantitative details of the flow.

The main system process is illustrated in Figure 6. The aim of applying Lean manufacturing to invoice processing is to achieve a Lean invoice process that leads to minimum invoice lead time and processing time; establish a quality control system that monitors process behaviour with respect to waste, queue time, and other Lean parameters; and to create a float in invoice lead time to be utilized as a cash flow management strategy. Application of Lean begins with development of the current-state VSM (CSVSM), which is improved upon in order to reach the future-state VSM (FSVSM). Simulation is used to validate the improvement strategies, and a sensitivity analysis is conducted. These steps need to satisfy certain criteria, such as the company's organizational structure, the technology in use, the product (invoice) type, and the pay terms applied. The required inputs are the Lean parameters, such as queue size and location, along with rework volume by station.

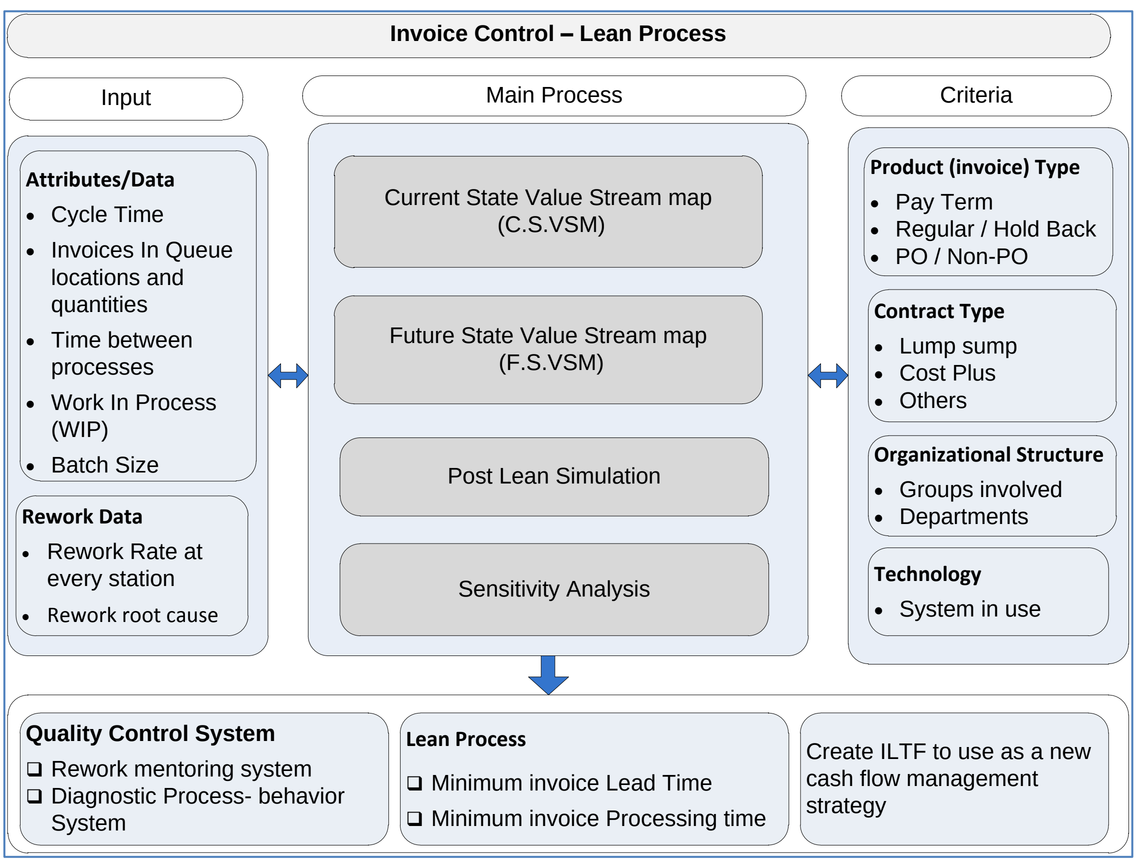

Figure 6: Lean invoice – main system process

5 Case study and analysis

Meetings and interviews were carried out with the accounting team to build the process chart. Templates were distributed for data collection of processing time, lead time, and rework rate at each station in order to build the CSVSM shown in Figure 7. It should be noted that the VSM presented in Figure 6 reflects only one branch of the process (icons in grey – Level 1) and does not reflect the impact of rework. In order to address these shortcomings and to reflect the dynamic and probabilistic nature of the process, the process has been modeled in this research using Simphony.NET, a discrete-event-based simulation tool developed by the Construction Engineering & Management group at the University of Alberta (see Figure 8).

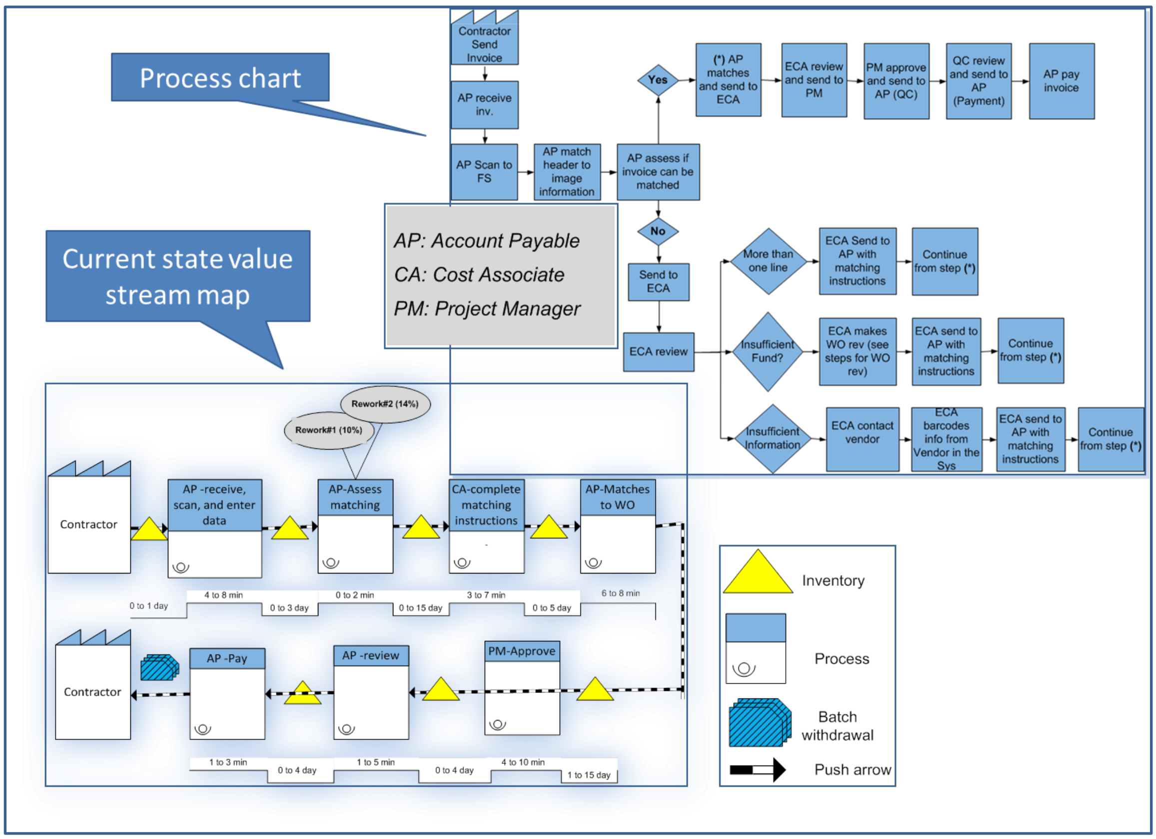

Figure 7: Invoice current-state value stream map (CSVSM)

At each station, the processing time and lead time are calculated. Meanwhile, the impact of inconsistent flow and rework are quantified in terms of processing and lead times. For validation purposes, the distribution of invoice lead time from the simulation results is also compared to its distribution in the historical data (see Figure 9). The figure shows a similar distribution, with just slight differences in the mean and the standard deviation. These differences, which are considered acceptable, are due to assumptions pertaining to the interviews with subject experts where real data could not be collected.

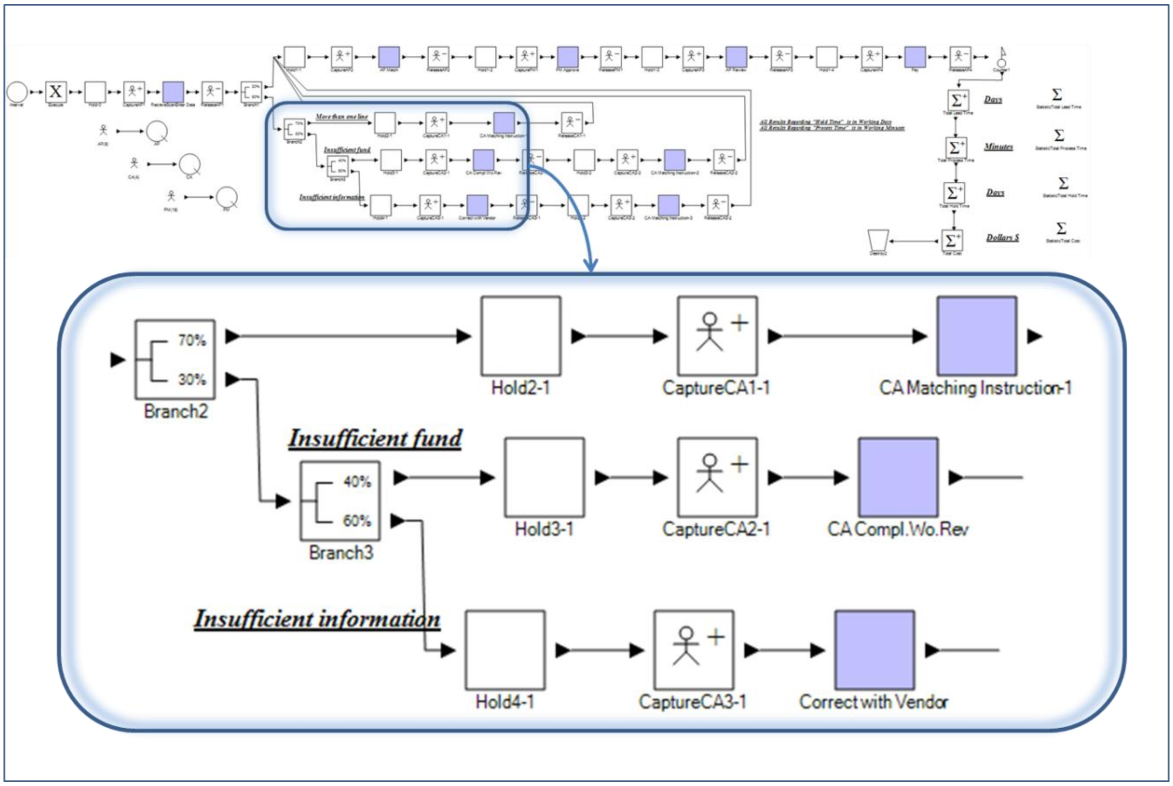

Figure 8: Invoice simulation model using discrete-event-based simulation tool

Based on the developed invoice process chart and the associated simulation model, the collected data is fed to the model, resulting in the following inferences:

- The average processing time resulting from the simulation model is 38 minutes per invoice, which is equivalent to approximately 50,000 hours/year for an estimated invoice volume of 80,000 invoices/year. This includes time spent by staff—including accountants, project controllers, and project managers—on processing, approving, reviewing, and signing invoices.

- The average invoice lead time in the simulation is 26.3 days (compared to an actual average of 27.9 days). The distribution of invoices by lead time is shown in Figure 9.

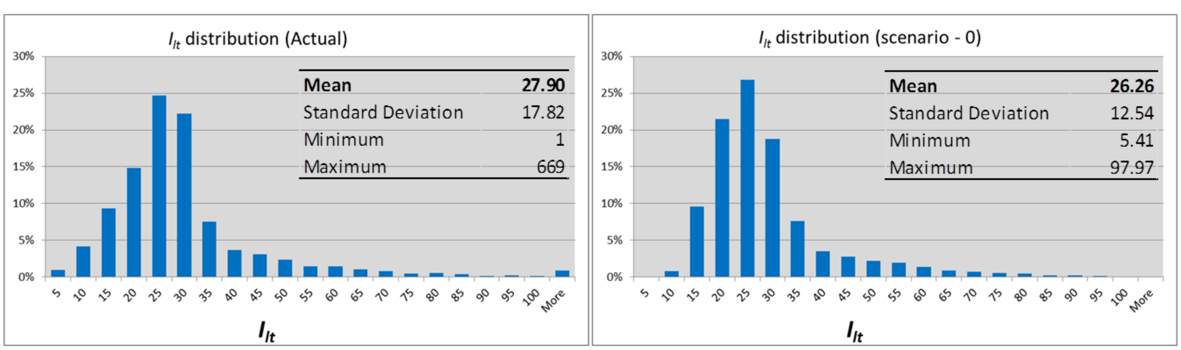

Figure 9: I_{lt} distribution resulting from historical data and simulation output

The next step is to analyze the invoice CSVSM in order to identify and quantify waste in the invoice processing time ($\mathbf{I_{pt}}$) and the effect of waiting time on invoice lead time ($\mathbf{I_{lt}}$). One type of waste analyzed in this study is waste due to rework. Rework in the invoice process can result from a number of factors, such as (1) insufficient information submitted by the vendor, and (2) inaccurate estimates and/or a lack of consistent forecasting, a problem which requires an increase in the work order value following invoice issuance. In this regard, further analysis can be carried out with respect to process design, resource utilization, and bottleneck allocation.

Quantification of waste is achieved by conducting a sensitivity analysis using the simulation model in conjunction with a thorough task investigation carried out along the process. The outcomes can be seen in Figure 10, where improvement suggestions are introduced to the simulation model as scenarios. In Figure 10 an improvement in invoice lead time can be noted between Scenario 0 (original) and Scenario 1 (no rework). The no-rework scenario eliminates the root causes of rework by (1) changing the instructions to the vendor to ensure that sufficient information is attached to the submitted invoices; and (2) establishing a forecasting system that is proactive enough to take timely remedial measures, such as increasing the work order amount before the relevant invoices enter the system. Figure 10 also exhibits the decrease in invoice processing time as a result of the proposed improvement plan.

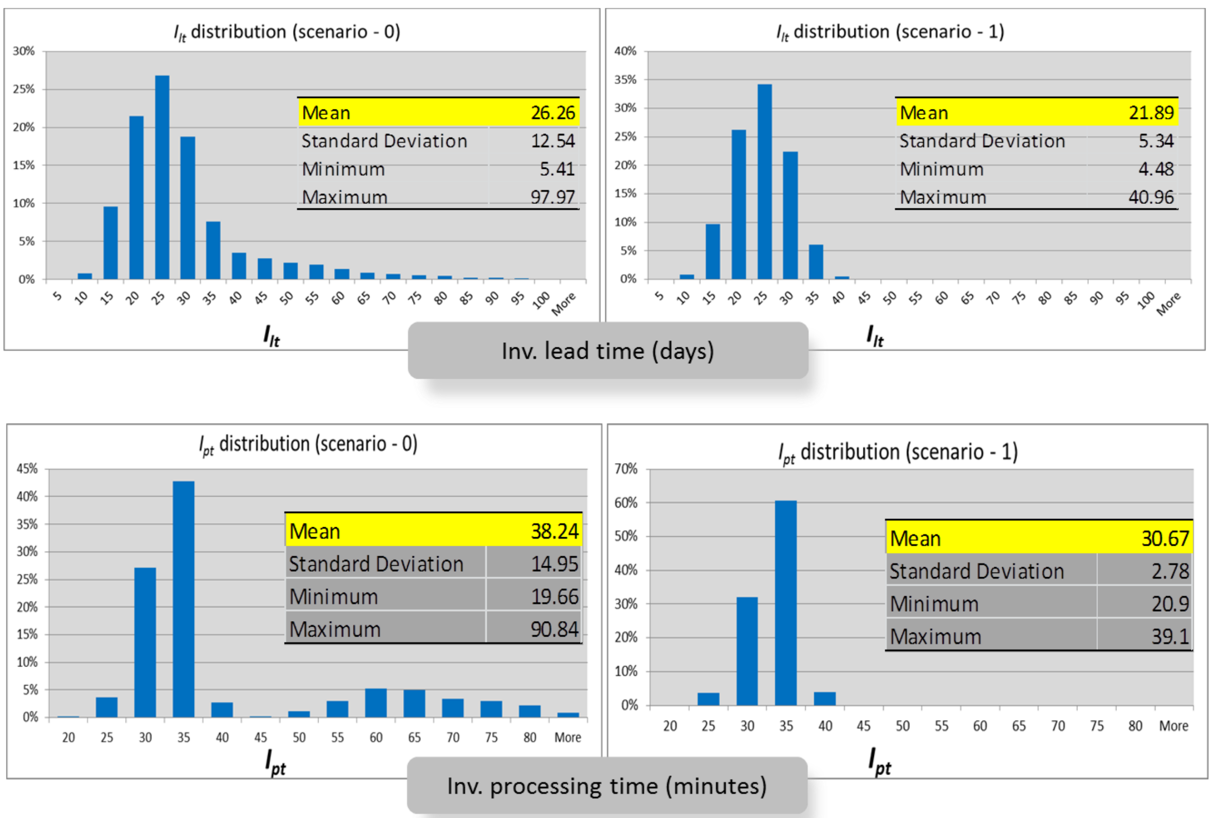

Figure 10: Simulation outcomes showing decreases in $\mathrm{I_{lt}}$ and $\mathrm{I_{pt}}$

6 Conclusion

The establishment of a streamlined invoice processing approach which minimizes processing time as well as instances of overdue invoices is beneficial to both the construction owner and the contractor. This study has thus proposed combining Lean manufacturing and simulation as an approach to enhance invoice processing within an organization, treating invoice processing as a production system from the time the invoice enters the process until it is paid. It follows the Lean manufacturing framework in shifting the process from the current-state to the improved future-state, and then uses post-lean simulation in order to test the effectiveness of the proposed changes prior to implementation of the improvement plan. The study shows the potential to reduce processing time by 17% and lead time by more than 20% just by eliminating rework. Although it is worth mentioning that waste in the invoice payment process differs from one company to another, the methodology presented in this paper is believed to be applicable to many invoice payment processes within the construction industry.

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