

A Framework for Examining and Improving the Accounts Payable Process in
Construction

by

Riphay Al-Hussein

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Department of Civil and Environmental Engineering
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Abstract

This research focuses on the accounts payable function in construction firms. The cash conversion cycle includes accounts payable and accounts receivable support functions. Research objectives focus on mapping the existing accounts payable processes in construction, building a model to represent this process and validating the model. The map is able to calculate process cost and cycle time, and demonstrate the feedback loops present in the verification process. A computer simulation model using the Symphony.NET framework is built on this map. Once validated, the model provides a system for sensitizing key input variables to see their effect on outputs, such as processing cost and cycle time of invoice approval. Finally, a case study using the model is presented to demonstrate the model's ability to facilitate sensitivity, scenario and financial analyses. A firm in the steel manufacturing sector provided access to project managers and accounting professionals, in addition to project data.

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1 Chapter 1: Introduction¹

1.1 Background and Problem Statement

One important challenge in the field of project management in general, and in construction specifically, is the cash flow problem. Navon (1996) pointed out that “cash is the most important of the construction company’s resources” due to the fact that its mismanagement leads to more company failures than any other resource. Cash flow has been studied at the company level (Navon 1996), at the multi-project level (El-Abbasy et al. 2012) and at the single-project level (Akpan and Igwe 2001). Due to a gap in the literature, this thesis’ scope focuses on a lower level—the individual invoice. Construction industry participants vary in size and scope from one-operator subcontractors to multi-billion-dollar integrated energy companies, and each of these participants are connected hierarchically through contracts exchanging materials or services for money. Invoices make the second part of this exchange possible, and as the number of projects and participants grows for a firm, the number of invoices increases.

Company cash flow management begins and ends with the individual invoice. Accounts payable (AP) is the organizational function responsible for

¹ A version of this chapter has been published. Al-Hussein, R., AbouRizk, S. 2014. Understanding and Modeling Invoicing Challenges in Construction. CSCE 2014 General Conference, Canadian Society of Civil Engineers, Halifax, NS, Canada.

paying a firm's bills. Fundamentally, the accounts payable process consists of accepting invoices, matching and checking them against purchase orders (P/O), coordinating approvals from project managers and finally processing payments. Accounts receivable (AR), on the other hand, is responsible for collecting a firm's revenue. Its process can be similarly divided into the following steps: create the invoice, check invoice against rate sheets and contractual agreements, ensure work has been completed and labourers/suppliers have been paid and finally send invoice and collect payment. At a high level, each of these functions' steps roughly corresponds to the others', as shown in Figure 1.1. Taken together, the above processes may be called the "pay-to-pay" cycle or the cash conversion cycle. "If either one of the two core functions [...] within the payables realm is inefficient, effectively an organization's ability to accurately forecast [sic] its financial position is also compromised" (Tyagi 2012, p. 1).

Accounts Receivable		Accounts Payable
Create Invoice		Receive invoice
Check against contract		Match with P/O
Ensure work completion	↔	Obtain approval from PM
Send invoice / Receive payment		Process payment

Figure 1.1 Comparison of Accounts Payable and Accounts Receivable Processes

The key problem to be solved is how to model the accounts payable process to enable improvement analysis. Further, this research must develop a methodology to quantify the improvements to the AP department.

1.2 Purpose of Study

This research has a few key goals. First, to develop a simulation model to facilitate analysis of support functions such as accounts payable. Second, the model will provide more information for construction companies on a potentially large source of overhead that may reduce cost and increase competitiveness. This research will contribute to the academic literature by developing a simplified framework for modeling accounts payable processes, but also tie it to the expected effect on accounts receivable departments at corresponding firms. Further research may build on this work to develop potential single-project invoicing solutions as a means to reform outdated practices slowly.

1.3 Expected Contributions

1.3.1 Academic Contributions

The following is a summary of the expected academic contributions:

1. Map the accounts payable process in a construction firm and document it such that it may be used in further research.
2. Model the process an invoice undergoes from receipt to approval using discrete event simulation.

1.3.2 Industrial Contributions

The following is a summary of the expected contributions to industry:

1. To bring the best practices from the relevant literature pertaining to accounts payable from across industries to the construction industry.
2. Demonstrate how one may quantify the relevant costs and cycle times associated with the accounts payable process.
3. Provide suggestions for improvement with documented metrics demonstrating effectiveness of the improvements using statistical tools.

1.4 Research Methodology

The research was conducted using the following methodology:

1. Conduct a literature review to understand the state of knowledge of the cash conversion cycle, with a focus on accounts payable in the construction industry where possible.
2. Map an existing accounts payable process in a construction firm using discussions with industry professionals.
3. Build a simulation model, based on the literature review, the process map and data available from the industry participant, which is able to track outputs such as cycle time and processing cost.
4. Conduct a sensitivity analysis on the key input variables to determine their effect on AP cycle time and cost.

5. Construct improvement scenarios based on the results of the sensitivity analysis and test them in the model to determine their effectiveness.

1.5 Thesis Organization

This thesis is organized into the following five chapters:

1. Chapter 1: Introduction

Provides background on the issue to be studied in addition to the goals sought and methods used.

2. Chapter 2: Literature Review

Focuses on surveying the existing body of knowledge with regards to the cash conversion cycle and accounts payable, both specific to construction and in general. Further, this section documents the problem as observed by key professionals in the industry using data where available.

3. Chapter 3: Modeling Methodology

Discussion of the methodology used to conduct the research.

4. Chapter 4: The Simulation Model

Discussion of the construction of the simulation model in Symphony and the model validation.

5. Chapter 5: Results and Analyses Case Study

Demonstration of the model's data and analytical abilities.

6. Chapter 6: Conclusion

Concluding remarks and suggestions for further research.

2 Chapter 2: Literature Review²

2.1 Background

2.1.1 Late Payments

As discussed in Chapter 1, construction industry participants are varied in size and scope. However, each has to find some solution to the accounts payable problem. Large firms may resort to enterprise resource planning software such as SAP while small firms may rely on manual processes. The challenge is to manage the paperwork necessary to process all of these invoices and return payments on time, in a cost-effective manner. However, this goal is not achieved with sufficient frequency regardless of the company's scale.

The construction industry is notorious for late payments, to such a great degree that many jurisdictions—including the European Union (EU) and United States of America (USA)—are beginning to recognize the problem and to impose prompt payment legislation. Gwyn (1996) details the efforts in various US states to curb overdue invoice payment in commercial transactions. At the time of his writing, 37 states, as well as the District of Columbia, had enacted legislation “specify[ing] the number of days within which the prime contractor is required to

² A version of this chapter has been published. Al-Hussein, R., AbouRizk, S. 2014. Understanding and Modeling Invoicing Challenges in Construction. CSCE 2014 General Conference, Canadian Society of Civil Engineers, Halifax, NS, Canada.

pay its subcontractors on public projects” (p. 61). In the private sector, subcontractors and prime contractors had legislative protection in 19 and 13 jurisdictions, respectively. Further, many jurisdictions had mandated interest penalties for late payment ranging between 9% and 21%.

The European Union has been combating tardy payments for over a decade (EU Directive 2011/7/EU). Most recently, the EU harmonized provisions across member countries in Directive 2011/7/EU. Public authorities must pay within 30 days in most circumstances, while private entities must pay within 60 days. Further, interest penalty for late payment is set at no less than 8% above the European Central Bank’s reference rate. Member states were given until March 26, 2013 to legislate this directive into law. Further, this directive is a guideline for minimum protections given to creditors—member states are free to enact stronger defenses for creditors than outlined in 2011/7/EU.

To stress the prevalence of late payment in construction, Younes et al. (2013) found that “between 2008 and 2010 approximately 45% of the processed invoices were overdue, i.e., had not been paid within the pay term” (p. 4), based on data from their industry partner. Further, “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” (Younes et al. 2013, p. 5). This analysis indicates that many accounts payable functions are inflexible in their operations.

As further evidence of inflexibility, research (Younes 2013) has demonstrated that some firms are unable to shorten their accounts payable

processes easily, even when offered prompt payment discounts (PPD) by their suppliers. This work detailed email and phone correspondences discussing the possibility of capturing a prompt payment discount. Prompt payment discounts are the most common type of trade credit (Kouvelis and Zhao 2012), and substantial efforts were needed to fast-track invoice processing (Younes 2013). Al-Hussein et al. (2013) defined a prompt payment discount as “an invoice that offers a payer the option to pay early for a small discount in price” (p. 2), and explained why contractors offered prompt payment discounts should accept them, in most cases. A generic tool, the prompt payment discount nomograph, was provided as part of their work, as well as a mathematical basis for modeling with this type of trade credit. Pezza (2011a) finds that “Best-in-Class enterprises are 2.3 times as likely as others to have negotiated discount terms in place for their purchases.” This is possible due to more frequent discount arrangements in combination with the ability to process invoices quickly enough to take advantage of the discount. 64% of Best-in-Class firms negotiate fixed discount terms compared to 36% of Industry Average firms and only 17% of Laggard firms.

Younes (2013) also discusses the reputational impact on owners that are frequently delinquent in invoice payment. The author argues that over the long run, costs are transferred back to the owner. One contractor’s effort to catalog owner payment dilatoriness in a database is evidence that the industry takes this problem seriously (Younes 2013):

This contractor updates the status of overdue invoices for owners on monthly bases. For a one-year history of

overdue invoices, the chart shows the dollar amount of the invoices that have been delayed for 30, 60, and 90 days. This information enables the contractor to update the owner's KPI as a part of bidding procedures, and to quantify the financial loss associated with overdue invoices to be considered in future bidding. (p. 32)

2.1.2 Invoice Processing Cost

Invoice processing is a core function at every construction firm, and as such, a necessary overhead cost. Kemmer et al. (2009) explain that although lean thinking in construction operations has a vast body of knowledge, “study of the administrative flows that happen inside a company’s office and between the office and its construction sites is often overlooked” (p. 43). This deficiency has been realized in the last several years. In particular, Younes (2013) studied a major Canadian homebuilder based in Alberta, Canada. He found that invoice processing was inefficient and plagued with rework. This finding shows that complicated (and likely expensive) processes are not necessarily effective processes.

One study led by the Abardeen Group (Pezza 2011b) set out to benchmark accounts payable performance across industries and geographies. The study used surveys to establish best practices, as well as steps to success. The respondents were separated into three performance groups: “Best-in-Class,” “Average” and “Laggards,” representing the top 20%, middle 50% and bottom 30%, respectively.

Figure 2.1, below, lists some key statistics the Abardeen study established for each of the performance groups.

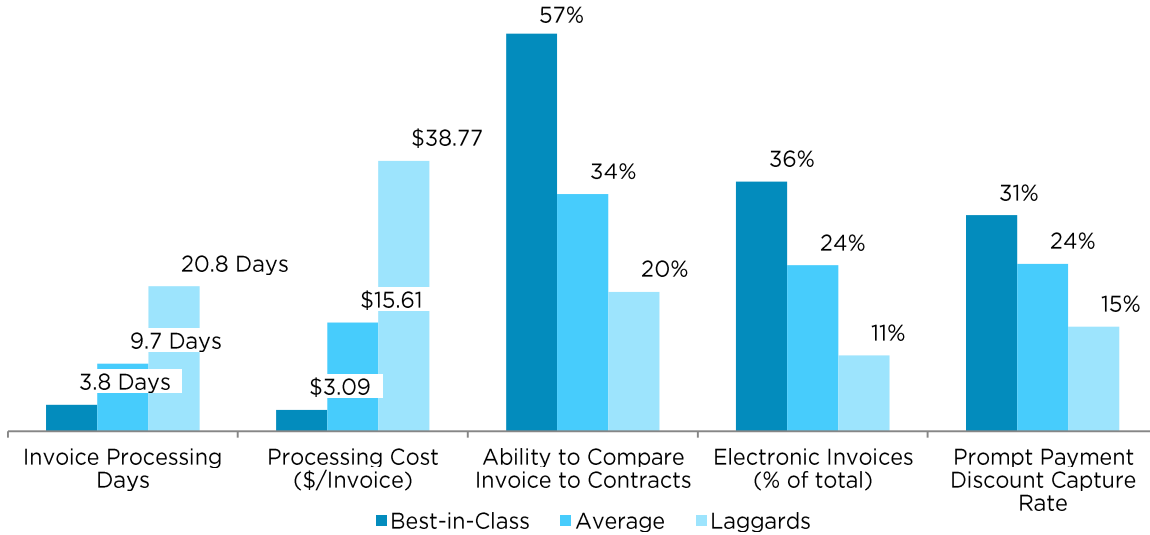


Figure 2.1 Accounts Payable Performance Benchmarks (Pezza 2011b)

These are only a few of Pezza’s key metrics, but they reveal the large differences between each of the performance classes. It takes a Best-in-Class AP department only 4 days and \$3.09 to process an invoice, whereas a Laggard takes nearly 21 days and \$38.77. If a construction company receives 100,000 invoices in a year, this represents a cost difference of over \$3.5 million simply in processing cost. In addition, the Laggard company will be unable to benefit from prompt payment discounts; Laggards capture half as many prompt payment discounts as Best-in-Class. Another important statistic is the ability to compare invoices to contracts. Any effort spent in procurement may only be realized if accounts payable checks invoices against contracts. This is not to say contractors or materials suppliers renege on negotiated terms, but it is imprudent to expect an error-free accounts receivable function from every firm one has a relationship

with. Finally, one key reason that Best-in-Class firms perform so well is that electronic invoices make up a much larger proportion of their total.

Accounts payable effectiveness not only impacts the direct overheads associated with this function, it is also vital in realizing benefits from an effective procurement department. Stated otherwise, “successful negotiations in procurement result in favorable pricing and payment terms, but it is up to AP to ensure that those prices are accurately invoiced, and that the process is efficient enough to capitalized [sic] on those available terms” (Pezza 2011a, p. 13).

Pezza suggests many key technologies that Best-in-Class firms use; a select few are listed below in order of importance (Pezza 2011b):

- Document imaging
- Cash management
- Electronic approval workflow
- Supplier portals
- Comprehensive AP automation
- Spend analytics / business intelligence

Noting that most firms will fall within the “Average” performance category, Pezza lists a few important steps Average firms should take in order to improve towards Best-in-Class level (2011b):

- Automate invoice matching against contracts and purchase orders.
- Integrate accounts payable with procurement and contract administration.
- Build a searchable database of past invoices to aid procurement.

Further, Pezza (2011a) finds that although firms are seeing reduced reliance on paper volume over the past decade, accounts payable continues to be a manual process despite the ongoing promise offered by technology. Mitchell and DeGraw (2011) discuss possible solutions to the purchase-to-pay (P2P) efficiency problem that range from electronic invoicing and procurement to full-scale procurement alignment models. Mainly, this work focused on the benefits of process ownership with clear scope and accountability. In another cross-industry study, Pezza (2011a) examines the benefits of electronic invoicing (e-invoicing). Using the same nomenclature of firm ranking as above, Pezza finds that 100% of Best-in-Class firms have post-settlement audits to double check the AP process and 56% have “well-defined metrics, incentives and penalties applied to payments” (p. 10) while those rates are 69% and 14% respectively for laggards (2011a). Further, Pezza argues that duplication of effort and transit time of physical documents are easily remedied by having a centralized process for e-invoicing—even if the physical invoices must be manually digitized.

Importantly, the study notes that there are high adoption rates of key AP technologies such as document imaging and electronic approval workflow among both Best-in-Class companies and others. However, realizing the full benefits of e-invoicing comes not only from adopting various technologies, but also ensuring that the technological solutions are correctly chosen and are matched with a complementary underlying process (Pezza 2011a).

2.2 The Accounts Receivable Challenge

A construction company's viability is dependent on its ability to receive cash promptly. The longer the firm waits for income, the more it becomes dependent on debt financing for its projects, and it may increasingly become risk averse. Accounts receivable is the department responsible for collecting money that is owed by the firm's clients. However, as will be demonstrated below, AR faces many challenges in collecting on its invoices.

2.2.1 Specific Obstacles to Cash Collection

Data collected by the author on accounts receivable notes for recent invoices demonstrates the difficulties a receivables team faces in collecting income. This dataset was provided by a Canadian steel manufacturer under condition of anonymity. The firm is trying to record the efforts made by the AR department to collect the firm's outstanding invoices. Each time someone communicates with the client about a specific invoice, a brief note is recorded in this log file. This log serves as a tool to explore some of the challenges that accounts receivable departments must deal with. Additional details come from discussions that the author had with industry professionals (2013).

The log provides details of the efforts to collect on a dozen individual invoices representing 10 different clients. The invoice amounts were not provided as part of the data set. Some invoices had logged as many as 6 distinct attempts to collect by a member of the AR team; however, many challenges, which are

structural in nature, prevent the smooth payment process. For example, one entry notes the following issue:

*“There was a problem with the PO (purchase order) and submitting this invoice in SAP. Had to be submitted, again, by email.”*³

Problems like this arise frequently and without notice; it is the accounts receivable team’s job to follow up and ensure that the company will be paid. This particular case demonstrates that each client has a differing expectation for the format of the invoice to be received. Some want a standard invoice faxed or emailed to their AP department, others (usually larger clients, as shown above) request that someone key invoice information into their enterprise resource planning (ERP) software using an online gateway. There seems to have been a mismatch between the information on the client’s purchase order (PO) as logged into their SAP software and what was keyed in by the accounts receivable department in the case above. The line below is another example of the fastidiousness of the data entry needed with some clients.

“Entered into SAP February 2, 2012. Waiting for approval. Change line item number and resubmitted into SAP February 23. Still waiting for approval.”

³ Log entries are presented as written except to correct spelling and remove identifying details

Different levels of disclosure are required for each contract. For example, some require detailed labour, equipment and materials (LEM) expense reports to be submitted with invoices. Others require work to be broken down into specific groups. This author observed one invoice where a steel manufacturer was required to break its work down into individual parts—as if the corresponding accounts payable team were classifying it as a material supplier. Although this particular case is an exception, these types of clerical requirements are a material cost and source of frustration for construction industry participants.

However, where contractors are not required to pay their subcontractors first, some opt for a policy of waiting to be paid by the owner before paying their subcontractors. This creates another challenge where subcontractors at the bottom of the project hierarchy must wait for an invoice at the top of the hierarchy to be processed and for this money to make its way down, possibly facing delays at each firm along the way. The dataset reflects this issue in some of the comments:

“Emailed asking [name redacted] for payment status update, because we are waiting for [client redacted] to get paid before they will pay us.”

“[Client redacted] is not obligated to pay us until they receive payment from [owner redacted] as per the PO.”

And even when payment was received by the client from the owner, clerical issues persisted:

“[Name redacted] told me that the invoice [number redacted] was going to be on a chq that we received last

week, it was not. Emailed her asking why and when we can expect payment for the overdue invoice.”

Clients often request a statutory declaration that labour and material expenses have been paid in order to prevent fraud by a contractor. Although larger firms may have the resources to hire a notary public, small subcontractors must hire one for each invoice, which is both expensive and time consuming. On the other hand, small companies often have an advantage in knowing which payables have been paid; the larger the firm the more challenging it is for its staff to determine whether labour and materials that are tied to a specific invoice have been paid.

Even with these onerous requirements, sometimes different project managers from the same client firm may request different disclosures along with the invoice. This only serves to increase the challenge to keep up with what is required and when.

2.2.2 Techniques to Speed up Payment

Of course it is the goal of a firm to be paid as soon as possible. One subcontractor shared that rather than keeping track of which documents are required to accompany invoices with which client, it simply sends every available document with each invoice. This is done in the hopes that all bases will be covered and the client will not reject the invoice for lack of information.

In certain circumstances, contractors have been able to “jump the queue” and receive payment sooner simply by having their project manager ask for it.

“[PM redacted] spoke with his contact at [client redacted], and he is following up with the AP department to ensure that invoice gets processed asap. [PM] will call back next week to get a chq run date or chq number.”

Industry professionals have conveyed that this practice not only yields results, but is a common tool to be paid on time, if used sparingly.

2.2.3 Conclusions from Accounts Receivable

The advantage of understanding the challenges of an accounts receivable department that deals with a number of clients is that it is akin to a high level survey of accounts payable processes at various industry firms. Through examining log data and discussing with AR professionals, the above characterization of the industry comes to light. AP processes are inconsistent and often require abundant paperwork that may not add value, or may even hinder the ability to pay legitimate invoices.

2.3 Mapping the Existing Accounts Payable Process

Through discussions with professionals working for one industry partner, a Canadian steel manufacturer, the AP process was mapped. Figure 2.2 depicts this process.

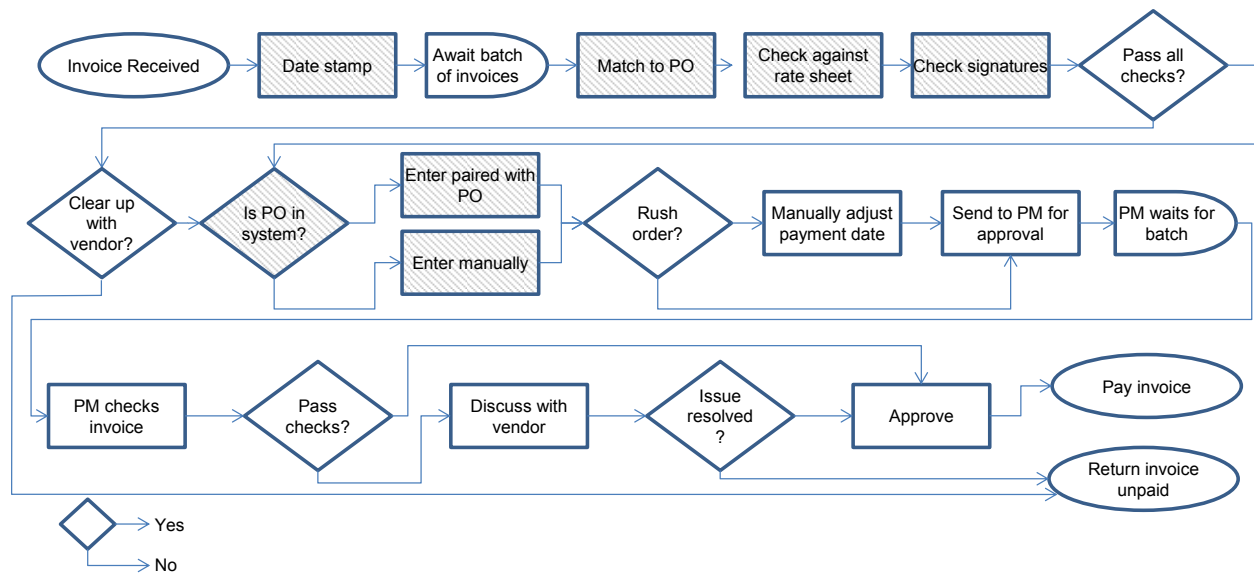


Figure 2.2 Accounts Payable Process Map

Once an invoice is received, it is immediately date stamped. Once a sufficient batch of invoices accumulates, accounts payable personnel begin the clerical tasks of matching the invoice to the correct purchase order or packing slip. Each vendor has rate sheets that reflect negotiated prices; invoices are checked against these rate sheets. If the invoice has been signed by the correct signing authority from the vendor, it is entered into the system. Manual entry results in fewer details being stored.

Sometimes vendors request quicker payment of an invoice. Although this may occur at any stage of the process, it is shown here for illustrative purposes. This possibility was discussed above under AR techniques to speed up payment. Since so much of the AP process is manual with this firm, it is possible to agree to such a request.

After these steps, the invoice is sent to the appropriate project manager for project-specific approvals. The PM also waits for a sufficient batch of invoices to

accumulate before checking them all at once. The PM may recheck many of the same things that the AP staff checked. However, certain discrepancies that the AP staff may have flagged are sometimes reconciled by knowledge held exclusively with the project manager. Many times change orders occur too quickly and frequently to alert accounts payable staff to the change. The PM may discuss other discrepancies with the vendor and at that point decide to either approve the invoice or reject it and ask the vendor to resubmit. Approved invoices await payment through the automated payment system. Payment is issued on the cheque date following due payment.

The parts of the process highlighted with diagonal lines represent the stages that would be automated most simply. As cited above from the Abardeen Group study, automating some of the routine checks is one of the highest impact steps an Average company can do to become Best-in-Class (2011).

2.4 Concluding Remarks

Although the accounts payable process has been documented in many industries, it is clear that there has been no systematic methodology established for analyzing this function. Clearly, a framework is needed with which this and other support functions may be analyzed and documented.

3 Chapter 3: Modeling Methodology

3.1 A Systems Approach to Accounts Payable Process Mapping

From a systems engineering perspective, the only way to understand a system's current state fully and to experiment effectively with the system is to model it. Oliver et al. (1997) describe an approach to modeling complex systems. This work identifies the need for a systematic method of modeling processes such as the invoice approval process described above. Accounts payable is a subsystem of a firm, and as such, any model must "receive the context" (p. 243) for its work from the main system.

3.2 Simulation as a Modeling and Decision-Making Tool

In order to facilitate the research objectives, the existing AP processes must be mapped and well understood. Computer-based discrete event simulation (DES) is a powerful and versatile tool for process improvement within the context of systems analysis. Younes (2013) used DES to analyze a similar invoicing process and describes simulation as "an efficient system-modelling tool" for production processes that "include product uniqueness, high level of variation between products, frequent rework, and changes in demand due to urgent client needs." AbouRizk (2010) detailed how simulation has taken on an important role in the construction industry, including tunneling projects, claim analysis for pipelines, fabrication shops, module yards, and many examples of process streamlining. Also, simulation is most effective when "problems are characterized

by uncertainty,” “problems are technically or methodically complex,” “repetition is evident,” “flexibility in modeling logic and knowledge is required to formulate a model,” “an integrated solution is required,” or “detail and accuracy matter” (AbouRizk 2010). Accounts payable process modelling is well suited to simulation due to the uncertainty and repetitiveness of the process, as well as the need for minute detail.

Other successful construction applications of simulation include:

- Optimizing usage of heavy lift cranes in a module yard for PCL (AbouRizk et al. 2011).
- Developing a special purpose template to be used in underground tunnel construction (Ruwanpura et al. 2001).
- Scenario analysis for underground tunnel construction in the City of Calgary (AL-Battaineh et al. 2006).
- Using real-time project data in a simulation model in order to revise model inputs and to provide updated analysis (Xie et al. 2011).

Boskers and AbouRizk (2005) used simulation to enhance the financial analysis of construction projects. This research found that financial metrics such as the internal rate of return or net present value of a project are typically deterministic in execution or at best “analysts apply Monte Carlo methods to the costs to account for some of this uncertainty” (p. 1501). However, the cash flows of a project are uncertain not only in magnitude, but also in timing, due to variance in activity durations. The authors used simulation (continuous and Monte Carlo) to test these two uncertainties simultaneously. Statistical analysis was then

used to turn the simulation results into useful risk data with a variety of confidence intervals. Further, the authors developed a special purpose simulation tool, or template, to help optimize and analyze capital investment projects. This template provides a graphical user interface, is reusable, and reproduces the analysis demonstrated in the paper.

3.3 Building the Accounts Payable Model

AbouRizk (2010) describes four key steps in building a simulation model for any given process. First is the product abstraction phase where the final product being built is identified; the product in this work is a compliant and paid invoice. The next step is process abstraction and modelling, where the processes, resources and constraints required to complete production are logically laid out and modelled. The experimentation phase is where the simulation is done and scenarios are tested. Finally the decision making phase constitutes analysis and assessment of the results in order to make business and engineering decisions.

A Canadian steel manufacturing company supported the research to build a process map of the accounts payable function. This process map, illustrated in Figure 2.2, needed to be abstracted into a process that could be simulated. The solution was to consider the system from a higher level than simply the accounts payable perspective. The model was designed beginning with project entry and projects would be the drivers of invoice delivery.

However, in order to complete this model, specific details regarding durations and quantities during the AP process were needed. Since quantitative

data, from which this information could be taken, was not available, the author decided to conduct directed discussions with project managers (PM) and AP staff. One method in particular for quantitative risk analysis (QRA) was considered. This method, described in AbouRizk-Newstead (2013), attributes quantitative distributions to spoken phrases such as “likely” and “very likely.” Unfortunately, it was found that this particular methodology was not ideal for the types of questions that would have to be asked. Instead, discussions were more candid and conducted with experienced professionals. Discussions with project managers focused on types and amount of projects they handle. Information on the number of invoices each type of project will generate on a regular basis was needed, as well as the amount of time spent verifying and approving each invoice. Finally, the frequency that project managers experience difficulties in processing change orders and cost capture in invoice approval was necessary. Accounts payable personnel were asked about the time needed to process each invoice and the frequencies that clarification was needed on any given task.

4 Chapter 4: The Simulation Model

The simulation model was built to benchmark two key indicators: invoice processing cycle time and invoice processing cost. The model needed to replicate personnel utilization as well as specific task timing. In keeping with the systems approach discussed in Section 3.1, the model is divided into two segments, the project distribution and advancement segment (main system) and the accounts payable segment (subsystem).

4.1 The Project Distribution and Advancement Segment

The project distribution and advancement section begins with projects of three different types commonly used in the steel manufacturing industry: supply, supply and erect, and erect. Each project has a unique identifier, an integer difficulty rating attributed to it and a duration. The difficulty rating is a number used to ascribe how much of a project manager's attention will be needed on the project; this is done to reproduce the realities of a project manager's workload (i.e. a PM may have 2 very difficult projects or 10 relatively simple projects or anything in between). Supply projects have a difficulty between 1 and 3, supply and erect between 1 and 12 with a mode of 4, and erect projects between 1 and 8 with a mode of 3. Each project is then assigned to one of four project managers, each of whom may take on projects with an aggregate difficulty rating up to 20. The project is assigned to the PM with the lowest aggregate difficulty rating; and if there is a draw the assignment is random. This part is shown in Symphony.NET in Figure 4.3. In order to be generalized, the project types and durations must be

changed for the type of construction projects that a certain participant encounters. Further, the difficulty ratings must be changed such that the project managers are assigned the correct range of projects (see 4.4.3 Event Validity for more)

Once assigned, the project progress loop begins. Every 0 to 5 days, the project either calls attention to its PM for a certain task, or produces invoices at a rate between 0 and 4 with a mode of 1.5 (rounded down to 1). Once the project is completed, the PM is freed to take on more projects. The goal of this loop is to simulate progress as well as provide outputs for the accounts payable subsystem with the required regularity. In this case a number of invoices must be output at an average of every 10 days. Since the mean of the progress loop (0 – 5) is 2.5, then one quarter of the time invoices are produced. Given more detailed data on invoice outputs, this part may be tailored further. This system is detailed in Figure 4.1 below.

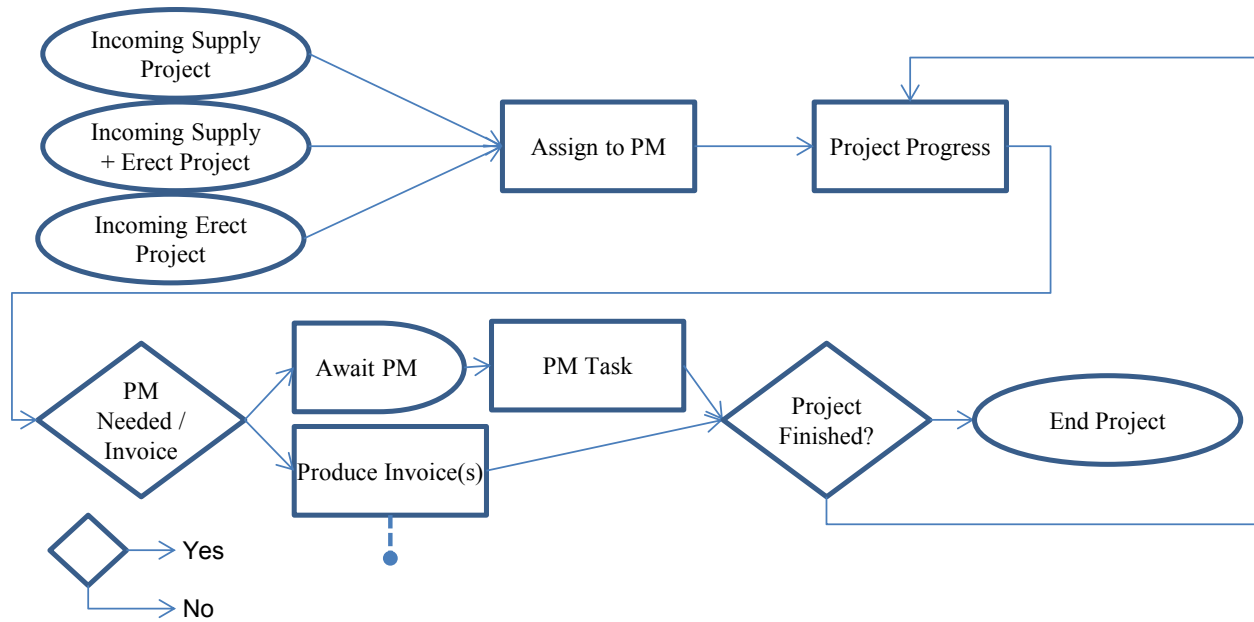


Figure 4.1 Project Segment of Simulation Model

Figure 4.2 shows the different types of resources used in the simulation model. The PM resource (PM 1 – 4) is the resource that embodies the PM’s overall workload; it contains enough servers to take on several projects based on their difficulty (20 servers, one per difficulty rating the PM may take on). The PM Time resource is what governs the specific task to which the project manager is attending at the time; a PM may only perform one task at a given time. The AP Staff resource is the resource needed to facilitate approvals of invoices (to be discussed below). This technique may be used for any construction firm, however the number of servers for the PM resource should be adjusted to reflect the aggregate difficulty a PM may hold.

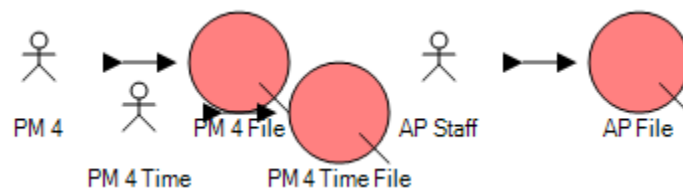


Figure 4.2 Symphony Resources

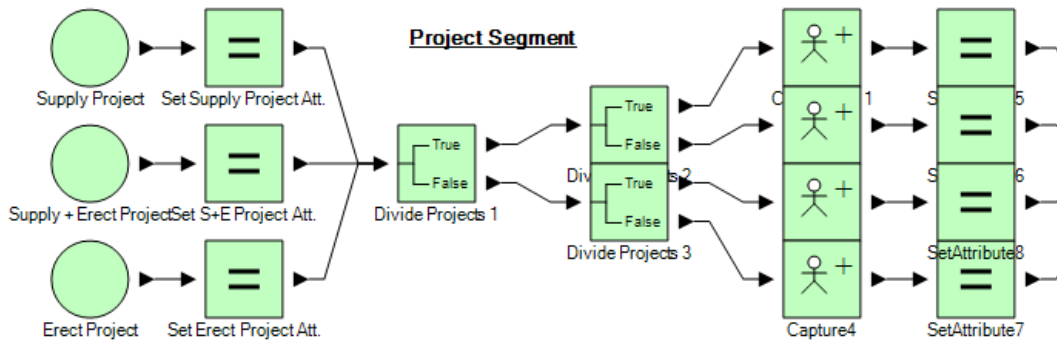


Figure 4.3 Project Segment Symphony Model (1/2)

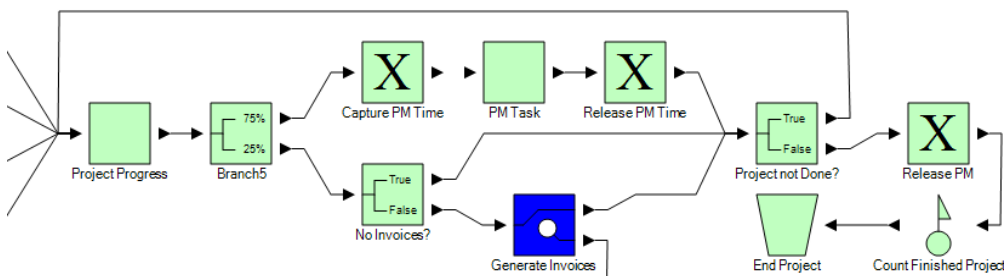


Figure 4.4 Project Segment Symphony Model (2/2)

The project segment, as modeled in Symphony, is shown in Figure 4.3 and Figure 4.4. Projects of different types enter the firm at pre-established frequencies, and they are given unique identifiers, durations and difficulties immediately. Using branches, the projects are given to the project manager who is most free to take on the additional duties. Afterwards, the loop described above begins.

4.2 The Accounts Payable Segment

The accounts payable section of the model follows much of the logic presented in Figure 2.2. It takes its inputs from project invoices, as described above, and from overhead invoices, which arrive five at a time every two weeks. Invoices are assigned a unique identifier as well as an invoice credit term (the

time by which the invoice must be paid), the due date of the invoice. The frequency of different credit terms is adapted from existing research (Younes 2013), based on data from a major Canadian energy company; and it is summarized below in Table 4.1.

Table 4.1 Credit Term Frequencies (Younes 2013)

Credit Term	Frequency
2/10 net 30	1.0%
Net 30	52.0%
Net 25	17.0%
Net 15	10.0%
Net 10	2.0%
Net 7	0.5%
Immediate	17.5%

The frequency for immediate payment term was reduced from 19% to 17.5% to accommodate rounding in the original work. The first credit term, “2/10 net 30,” represents a prompt payment discount, whereby the merchant may take a 2% discount if the invoice is paid within 10 days; otherwise the full amount is due within 30 days. After the invoice arrives, either by mail, fax or email, it queues for accounts payable staff. There are two staffers in this fictitious firm and each may look at no more than one invoice at a time. The staffer spends between 3 and 4 hours checking a project invoice; and due to their regularity, 30 to 60 minutes checking an overhead invoice. Nevertheless, fully half the invoices received require further clarification from the vendor. Clarification is usually done by email and may take between one and three weeks; in the meantime, the staffer may handle other tasks. To be generalized, users of this model must change the credit term frequencies, the number of staff dedicated to AP, the time it takes

them to check an invoice, the frequency with which clarification is needed and finally the time it takes to clarify an average invoice.

Once checked, project invoices are sorted for project manager approval and overhead invoices are marked as ready to be paid. Once per week, the project managers receive their batch of invoices to be approved. The project manager checks an invoice for between 30 seconds and five minutes and this is sufficient for the majority of invoices. However, about 5-10% of supply invoices and 20-30% of other invoices involve challenging change order and/or cost capture elements—these invoices take an additional 15 to 30 minutes each. About 4% of these invoices (less than 1% of all invoices) are returned to the supplier unpaid due to errors in the invoice. Returned invoices reappear at the beginning of the process one to three weeks later. Approved invoices are handed back to accounts payable staff and are re-sorted and marked as ready to be paid. Generalization here requires one to change the time a PM needs to check an invoice, both normal and challenging, the frequency of challenging invoices, and the proportion of unpaid invoices.

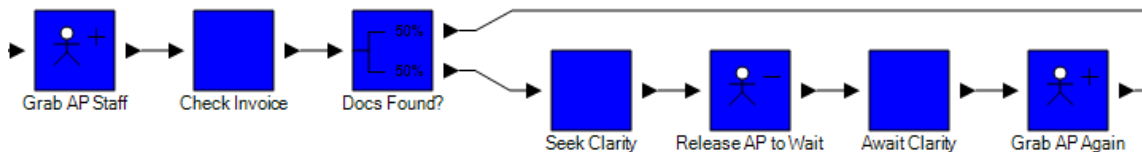


Figure 4.5 Accounts Payable Segment Symphony Model (1/2)

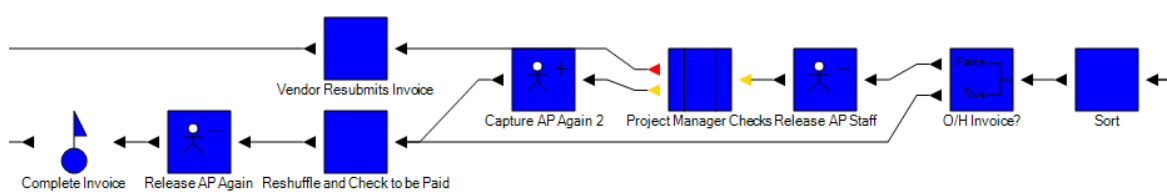


Figure 4.6 Accounts Payable Segment Symphony Model (2/2)

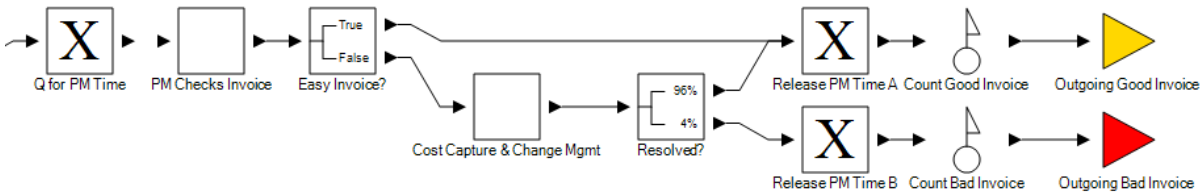


Figure 4.7 Accounts Payable Project Manager Checks

Figure 4.5 and Figure 4.6 show the Symphony model of the accounts payable segment. It begins with the invoice having already arrived and given a unique identifier as well as a credit term, and then proceeds along the course plotted by the model. Project invoices are routed through checks by the PM, as shown in Figure 4.7.

4.3 Data Collection in the Model

Model data was gathered in a few ways, using traces, charts and statistics. At many project and invoice checkpoints, trace data is sent that shows the current time, the type of entity (project or invoice), the ID of the entity, the event, and a few Boolean indicators to ease analysis (invoice start / end, project manager begin / end checks). Some sample traces can be found in Appendix A: . The charts and statistics collection track much of the same data, and allow the user to access it in a different way. They report, track and modify entity attributes as the entity moves through the model.

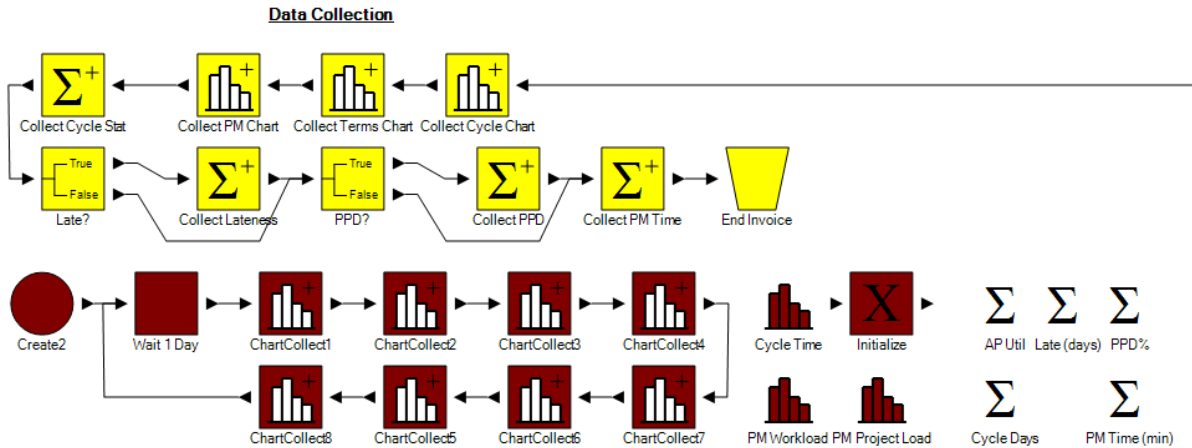


Figure 4.8 Data Collection in Symphony Model

4.4 Model Validation

Model validation is needed before any analysis may be attempted. Schlesinger et al. (1979) define model validation as the “substantiation that a computerized model within its domain of applicability possesses a satisfactory range of accuracy consistent with the intended application of the model.” And it is within this context that validation is approached. This section leans heavily on the work done by Sargent (2003) on validating and verifying simulation models. Several techniques for validation are described, and this model is able to implement five of them. Below is a summary of the validation results.

4.4.1 Comparison to Other Models

Younes (2013) provides an excellent opportunity to compare the model to an existing model for a very similar process. Younes’ model uses the same simulation technique and software as this research, discrete event simulation using Symphony.NET. From a high level, both models follow similar logic; however, this model builds on Younes’ work by adding the ability to track invoice

processing time by credit term, invoice lateness, prompt payment discount capture rate and overhead invoice separation. Another difference is that the process Younes models has a mean processing time of 26 days, while this model is at 9 days. The difference may be ascribed to the fact that each model was taken from different companies that employ different accounts payable processes. Figure 4.9 is taken from Younes (2013) demonstrating the proportion of late invoices by payment term; this information was taken from real-world data. Figure 4.10 is an output from this model's simulation showing the same information. The results differ in magnitude due to the difference in processing time described above; however, both show inverse proportionality between credit term and tardiness.

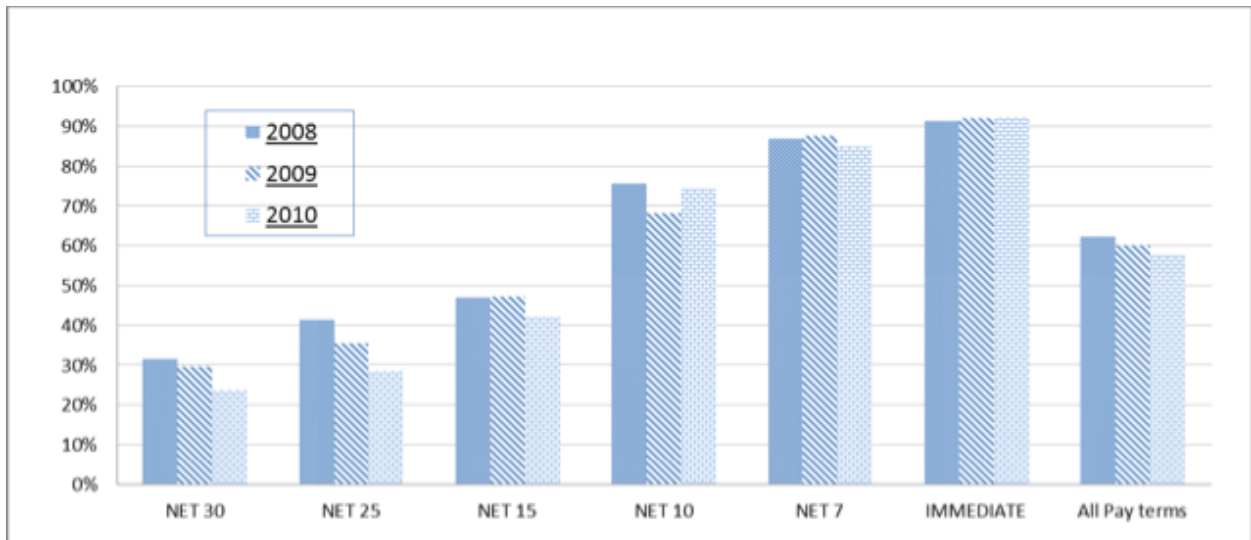


Figure 4.9 Conditional Distribution of Overdue Invoices by Pay Term (Younes 2013)

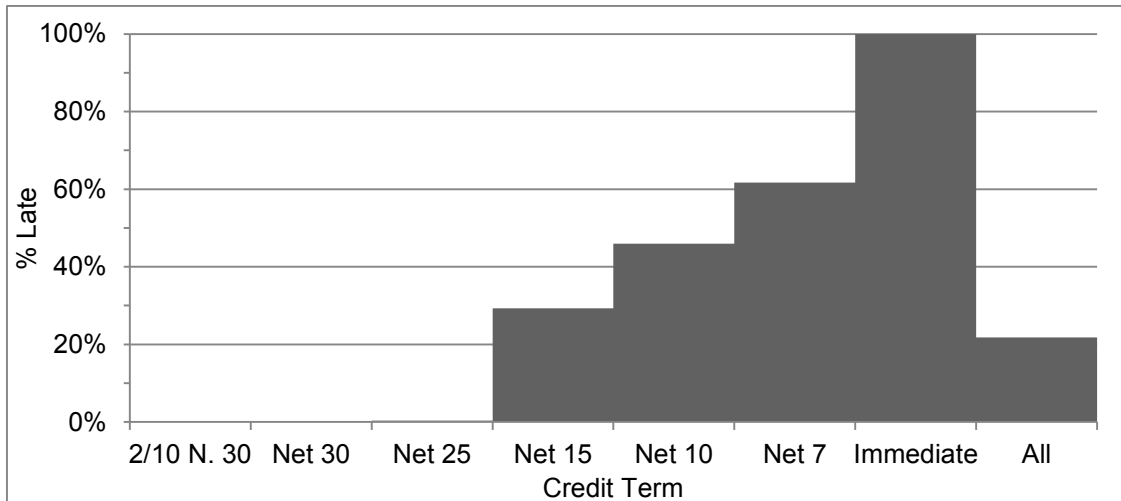


Figure 4.10 Proportion of Late Invoices by Pay Term from Simulation Model

4.4.2 Degenerate Tests

Another test for model validity is the degenerate test. In this test, input parameters are changed to see if outputs behave as expected. The table below summarizes a few of these tests.

Table 4.2 Summary of Degenerate Tests

Change in Input Variable	Output Response	Expected Outcome?
Decrease AP staff from 2 to 1	Increase invoice wait time ~230 days	✓
	Average cycle time ~550 days	✓
	96% of invoices paid late	✓
	Similar number of invoices received	✓
Increase incoming project rate	No material effect on measured output variables	✗
Decrease PM capacity	Fewer projects completed	✓
	Fewer invoices received	✓
	AP staff utilization down	✓

Three degenerate tests were performed to assist in validating the model. The first one decreased the accounts payable staff from two people to one. In response, invoice processing time was impacted dramatically. One accountant on

staff was unable to handle the growing work load, and the average invoice cycle time increased to a staggering 550 days and most invoices were paid late. As expected, this change had no impact on the number of invoices received or the number of projects completed.

Another degenerate test was to increase the incoming project rate. This had no effect on the output variables. One might expect that an increase in the number of projects would lead to an increase in the number of invoices or the invoice cycle time; however, this was not the case. The reason was that the incoming project rate was already above the point where the model was dependent on this variable. Presently, the project managers are working at capacity for the majority of the simulation and the incoming project rate is already too high to be fully accommodated—projects are being turned down based on PM capacity. One key difference is that the initial ramp up in projects is much quicker. This could result in a more realistic simulation where PM capacity is fully booked from earlier in the run. The fact that no material impact was seen in the response variables implies that the enhanced realism is not necessary. Moreover, the project phase of this simulation model is simply used to trickle invoices into the accounts payable phase.

The third test performed was to decrease the project capacity of the project managers. This had the expected effect of the firm completing fewer projects, and therefore, fewer invoices. There was a reduction in AP staff utilization; it may be possible to reduce the staff to one in this circumstance.

4.4.3 Event Validity

Testing event validity entails comparing events in the model to events occurring in reality. The number of projects a project manager handles at any one time is one event that may be tested. Figure 5.1b shows the number of projects each project manager handles over one run of the simulation. Project managers in this run have between two and ten projects at any one time. This distribution matches data from the participating company where PM's may have two complex projects or as many as ten simpler ones. Further, the number of invoices each project generates is taken directly from distributions given by the PMs themselves. The invoice cycle time in the benchmark case has an average of 9 days and a maximum of 31 days. This matches the actual results of the steel manufacturer, where every adequate invoice is able to be approved and paid within 45 days.

4.4.4 Extreme Test Conditions

Extreme test conditions are a way to stress test a simulation model. One extreme condition tested was to increase AP processing time on project invoices tenfold. The model responded by decreasing the percentage of invoices completed. AP staff utilization rose significantly, as well as the invoice cycle time. Importantly, the project manager utilization was not significantly affected.

4.4.5 Trace Analysis

Event traces were built into each step of the model. Unique project and invoice identifiers were created in order to track progress through the model.

Project traces originated at entity creation where project type and difficulty are announced. Next, the project declares to which project manager it has been assigned. Once the project begins cycling through, it will announce the time left for the project, as well as the number of invoices released and project manager requests.

Invoice traces begin once an invoice is created by a project entity, or it appears as an overhead invoice. Each invoice has a unique identifier in the form of “AAAABBB” where the A’s are the invoice number and the B’s correspond to the project number from which it originated; overhead invoices have a project number “000.” Further, the invoice credit term is given using a numbered code to correspond to each of the credit terms studied. This entity will declare when it has requested, received and released an AP staff, whether it needs further clarification and when its initial check is done. Next, project-related invoices output their usage of PM time and whether this check is successful or not. Finally, the traces indicate when this invoice has recaptured an AP staffer and is ready to be paid.

These traces were output to Microsoft Excel for analysis. A single run of the model may contain over 190,000 individual traces; however, once sorted by entity and by time, it was possible to analyze the data for logical flow and data accuracy. Events proceeded in the order expected by design for both projects and invoices.

5 Chapter 5: Results and Analyses Case Study

5.1 Simulation Results

5.1.1 Project Delivery Results

Each simulation run was designed to simulate ten years. Over 100 runs, the average number of projects completed in each run was 142 with a minimum and maximum of 109 and 168, respectively. On a typical run, project managers had between two and ten projects at any given time; however, their workload, as measured by aggregate project difficulty, remained generally high throughout. Figure 5.1 shows project manager workload and project load over the course of one run, and Figure 5.2 for 100 runs. The single run data is interesting, because it shows variance in work and project load a PM will experience over the course of the simulation. A project manager may have as many as ten projects ongoing at any given time, such as PM 3 during year 6 of the example run. Even when the number of projects decreases for a PM, the corresponding workload still remains relatively high. On average, project manager workload remains near the set limit and the number of projects is between four and five. The behaviour demonstrated in the single run resembles what was described in discussions with project managers for this research. Since the key focus of this study is on the accounts payable portion of the simulation model, the project segment simply needs to work sufficiently for the rest of the model to produce valid results.

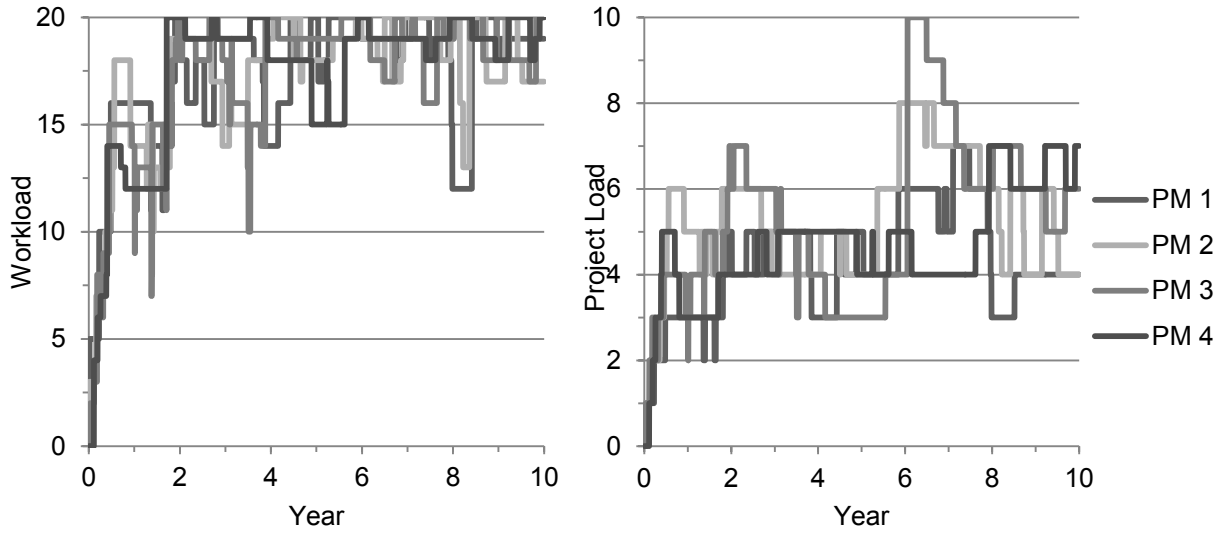


Figure 5.1 Project Manager Workload (a) and Project Load (b) Over One Run

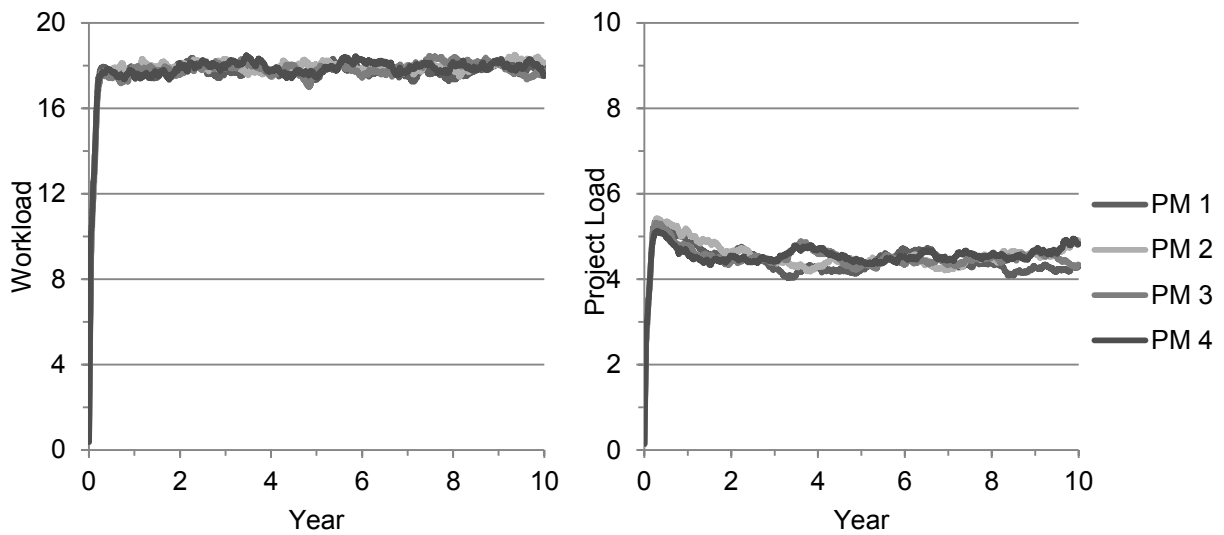


Figure 5.2 Project Manager Workload (a) and Project Load (b) Over 100 Runs

5.1.2 Invoice Cycle Time

Approximately 10,000 invoices were processed in each run. The average cycle time for each invoice was 8.8 days with a standard deviation of 7.2 days. Maximum processing time was 31 days. Figure 5.3 below shows the distribution

of processing time for 100 runs, and Table 5.1 gives more detailed cycle time statistics. The majority of invoices were able to be processed very quickly.

Each invoice came with a given credit term, with which analysis on overdue payments could be done. Approximately 19% of invoices were paid an average of 8 days late. The prompt payment discount capture rate, the proportion of invoices with a credit term of 2/10 net 30 that are processed in 10 days or less, was only 54%. These invoices are only marked as overdue if they are processed past 30 days.

Table 5.1 Invoice Cycle Time Statistics

Invoice Cycle Time Statistics (100 Runs)				
	Average	St. Dev.	Min.	Max.
Invoices Received	10036	458	8644	10903
OH Invoices	1813	N/A	N/A	N/A
Project Invoices	8223	953	6006	10561
Invoices Returned	24	5	13	38
Invoices Paid	9991	456	8604	10850
Completion Rate	99.6%	N/A	N/A	N/A

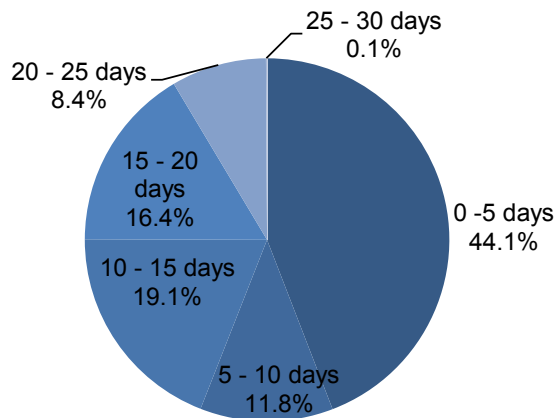


Figure 5.3 Invoice Processing Time Distribution

5.1.3 Invoice Processing Cost

In order to calculate the invoice processing cost, certain assumptions had to be made. First, two accounts payable staff were employed by the firm in the base model. Since this resource was idle, a substantial portion of the time (~35%), it was assumed that the rest of the time would be filled with other unrelated tasks. Realistically, it is expected that their time would be filled up to 80%; that is, up to 20% of the AP staff's time would be idle. Their salary, including benefits, was assumed to be \$50,000 per year, and the proportion of their time spent on invoice processing will be allocated to accounts payable. Project manager time was tracked by the minute as they were needed to approve invoices. This research assumed that the market rate for a project manager was \$125 per hour. No adjustment was made for inflation over the ten year course of the model—everything is in today's dollars. The average project invoice carried a project manager approval cost of \$8.95 (average of total invoices was \$7.37). Since the average number of invoices paid was 9991 and two AP staff worked on these for ten years, the AP cost was \$75.44 per invoice. This brings the total invoice processing cost to \$82.82 per invoice.

5.2 Sensitivity Analysis

In order to assess possible opportunities to improve the existing accounts payable process, the existing process must be analyzed to find the most impactful improvements. A sensitivity analysis of several key variables in the model was chosen as the method of study. The variables chosen are: found documents rate,

difficult invoice rate, time to clarify invoice, project manager processing time and accounts payable processing time and shuffling.

Several key outputs were tested:

- Cycle time: The time an average invoice needs to be fully processed and marked ready for payment.
- Late payments: The frequency with which invoices are paid late based on the payment terms they have, and the average number of days the invoices are late.
- Prompt payment discounts: The rate with which the firm is able to take advantage of prompt payment discounts (a special type of credit term) offered to it.
- Accounts payable staff utilization and invoice processing cost: The proportion of time that AP staff spend on invoicing, and the invoice processing cost made up of the cost from AP staff and the cost from PM time.

5.2.1 Testing Central Limit Theorem

In order to facilitate a thorough sensitivity analysis, the input variables that were previously distributions, such as waiting times and task durations, must be reduced to their means. Since this study is only concerned with the means of its output statistics, this transformation may be possible. The central limit theorem asserts that “the distribution of a sum or average of many small random quantities is close to normal [...] even if they have different distributions” (Moore and

McCabe 1993, p. 399). The implication here is that the mean of the results will be normally distributed. Since this study is only concerned with the means of the outputs, reducing the input distributions to their means should not impact the mean of the outputs. Distribution data for the outputs may be adversely affected, but this should not affect the results.

The central limit theorem should be tested before proceeding with the sensitivity analysis. Two scenarios were created in the simulation model, one with distributions for all of the tasks and one with only the mean. The results of 30 runs from each scenario are compared in Table 5.2. Most of the results are very close; the biggest discrepancies lie in the average lateness and the prompt payment discount capture rate. Although the differences are somewhat material as a percent (11% and 13%, respectively), it is likely attributable to variance in the runs. All of the other relevant outputs are nearly identical, giving confidence to proceed.

Table 5.2 Comparison of Means- and Distribution-Based Simulations

	Means	Distributions
Invoice Completion Rate	99.4%	99.5%
AP Staff Utilization	61.8%	60.2%
Avg. Inv. Wait Time (h)	1.7	1.7
Avg. Processing Cost (\$/invoice)	\$84.39	\$84.09
Avg. Cycle Time (days)	8.6	8.6
Max Cycle Time (days)	28.8	30.2
Late Invoice	22.4%	21.3%
Avg. Lateness (days)	7.2	8.0
PPD Capture Rate	50%	57%

5.2.2 Found Documents Rate

The found documents rate represents the percentage of invoices for which supporting documentation is found and the invoice substantially matches this

documentation. Accounts payable staff is responsible for matching a given invoice to rate sheets, contracts and purchase orders. In the base model, only 50% of invoices are effectively matched to their documentation. Change orders, field-level procurements and invoicing errors are common reasons for failing to find or to match documents. Further causes include invoices that do not include requisite signatures, statutory declarations of payment to labour and subcontractors, or missing labour-equipment-materials (LEM) sheets. The model was adjusted to rates of 60%, 70%, 80%, 90%, 95%, 99% and 100% to determine the effect this variable has on the outputs of the simulation.

5.2.2.1 Cycle Time

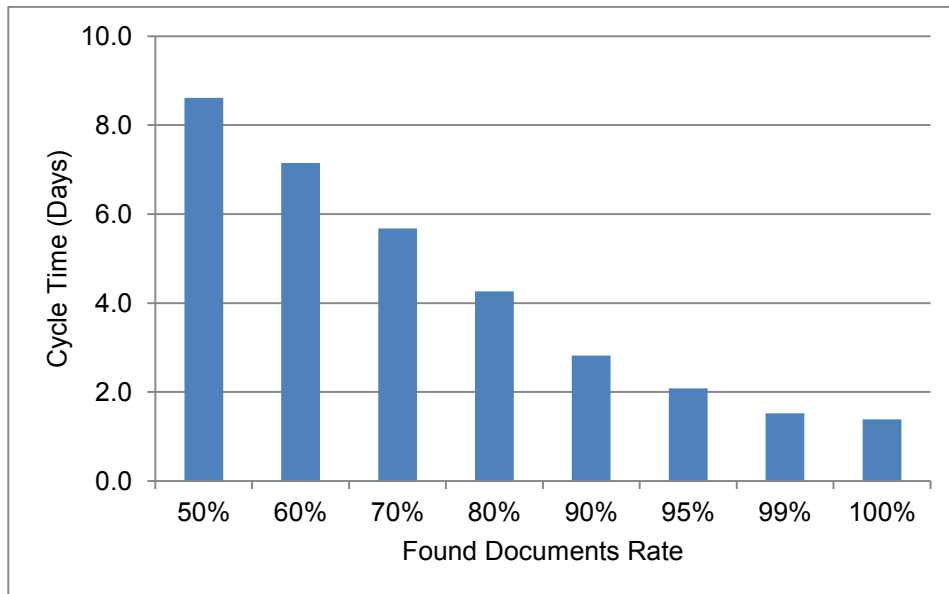


Figure 5.4 Found Documents Rate Cycle Time

This particular variable has a very substantial impact on the average cycle time of an invoice. Every ten percent increase in the found documents rate results in a corresponding decrease in cycle time of around 1.4 days. Every time an

invoice's documentation is not found or matched properly, clarification needs to be found from either the vendor or site foreman.

5.2.2.2 Late Payments

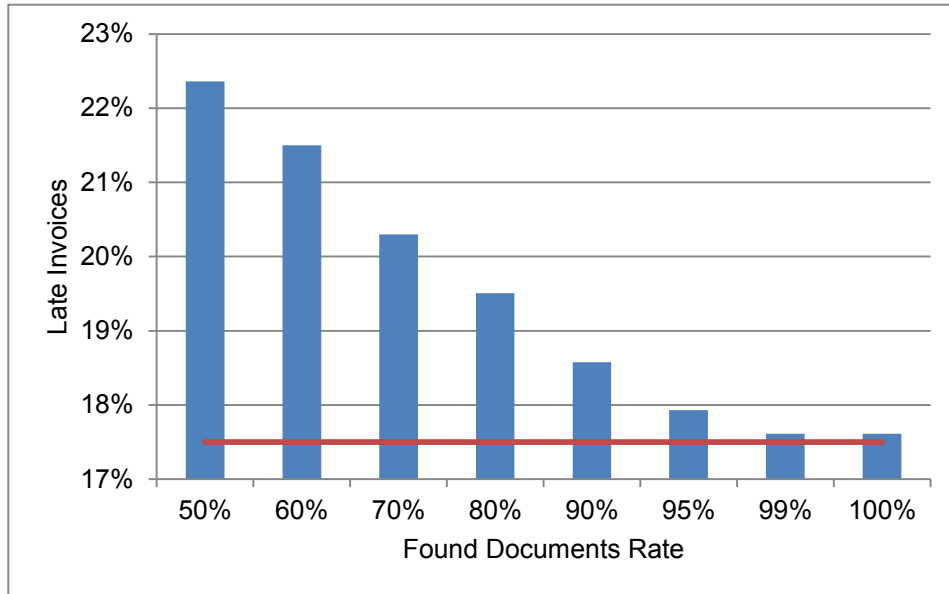


Figure 5.5 Found Documents Rate Late Invoices

As the cycle time decreased, so did the late payments. Figure 5.5 demonstrates how the late payments rate decreases with an increase in the found documents rate. The red line represents the theoretical minimum late invoice rate. 17.5% of invoices come with payment term “immediate” as described in section 4.2; these invoices are marked as late no matter what their processing time is. Figure 5.6 shows the average lateness. Each ten percent increase in found documents decreases the average days late an invoice is paid by more than a day.

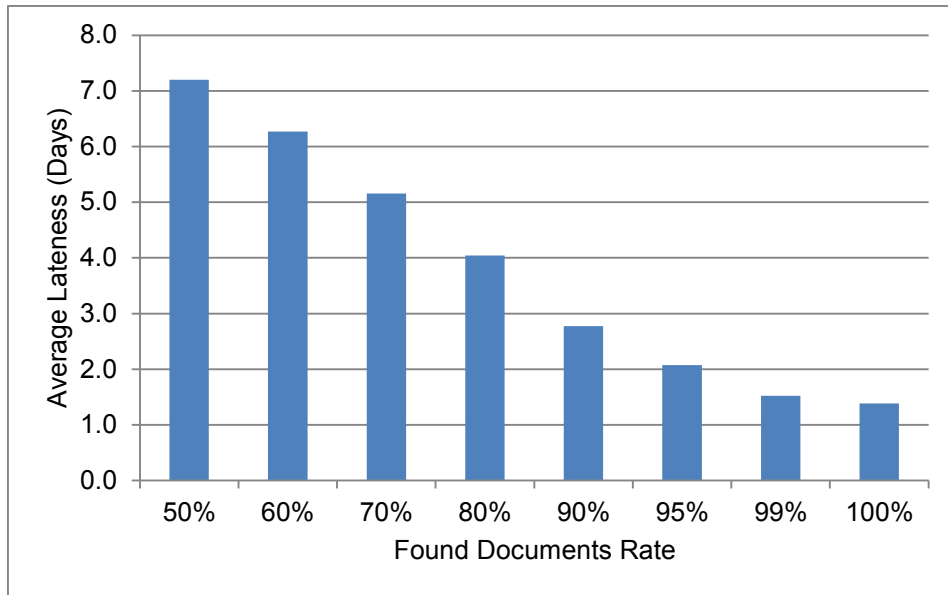


Figure 5.6 Found Documents Rate Average Lateness

5.2.2.3 Prompt Payment Discounts

The ability for the simulated firm to capture prompt payment discounts increased significantly with the found documents rate, as shown in Figure 5.7.

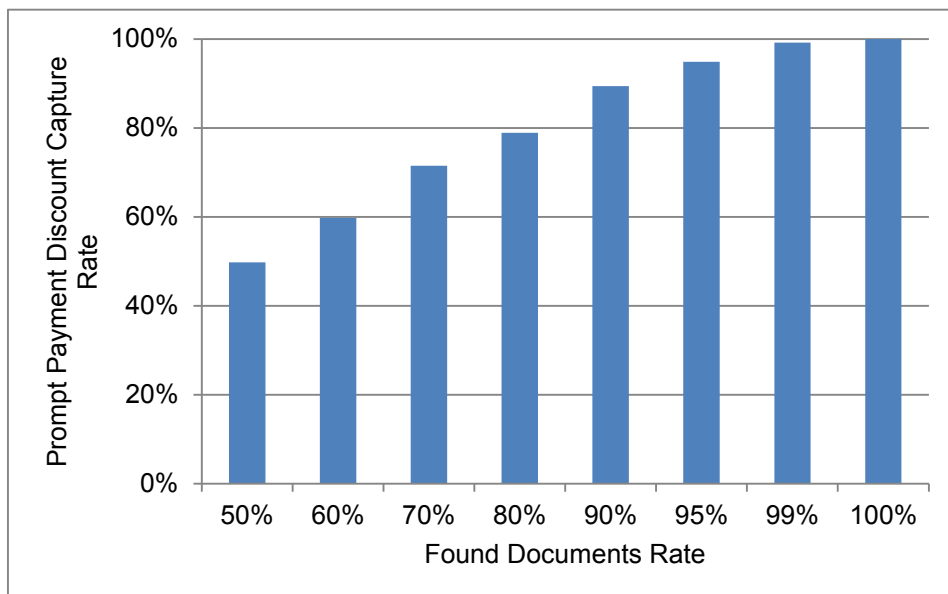


Figure 5.7 Found Documents Rate Prompt Payment Discount Capture Rate

5.2.2.4 Accounts Payable Staff Utilization and Invoice Processing Cost

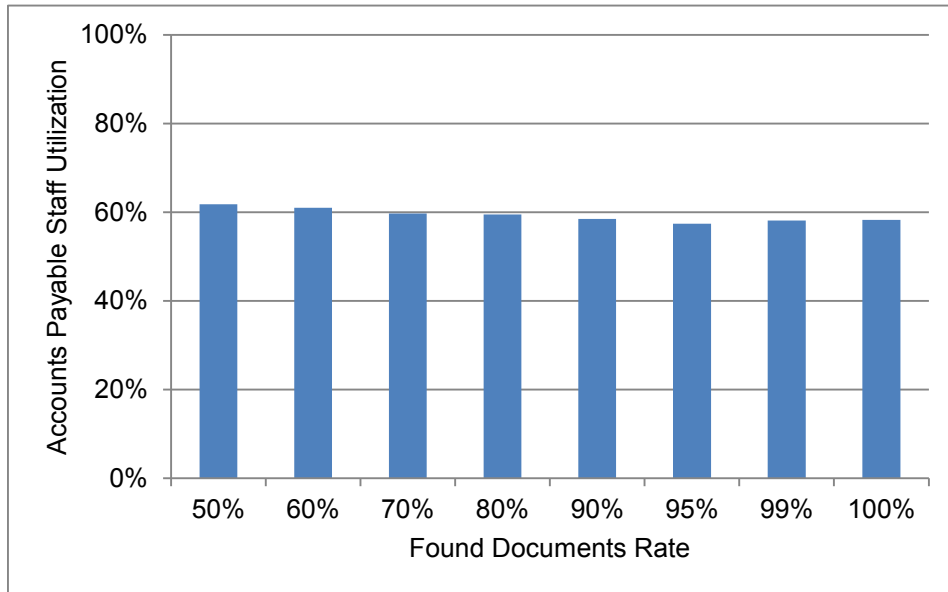


Figure 5.8 Found Documents Rate AP Staff Utilization

This particular variable had an insignificant effect on the AP staff utilization. The statistic decreases but not strongly. Similarly, the effect on invoice processing cost is also small, decreasing from \$82.82/invoice to \$78.58/invoice.

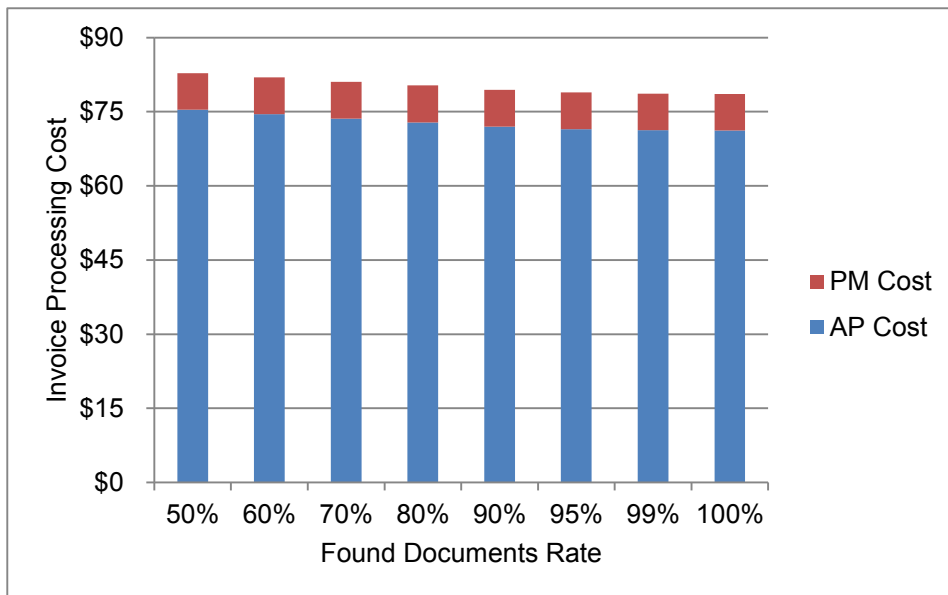


Figure 5.9 Found Documents Invoice Processing Cost

5.2.3 Clarification Time

If an invoice does not match the documentation properly or the documentation is not found, then clarification must be sought from either the vendor or the construction foreman. Detailed reasons for needing clarity are described in 5.2.2. In the base case, clarification involves writing an email detailing the problem (twenty minutes) and a response is received between one and three weeks later (average of ten business days). The invoice must wait for the additional documentation from the vendor or an explanation for the field team before processing resumes. The response times tested are: 8 days, 6, days, 4 days and 2 days. The time to write an email was not sensitized.

5.2.3.1 Cycle Time

The clarification time has a material impact on the cycle time, as shown in Figure 5.10. Every two days decrease in clarification time corresponds to a decrease in cycle time of 1.4 days. At two days clarification time, the invoice cycle time is 3.1 days.

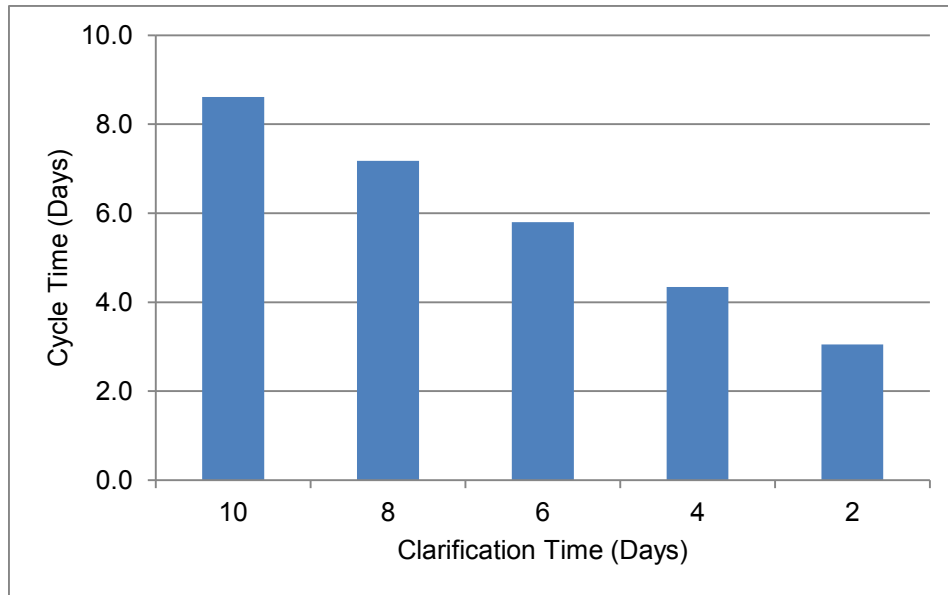


Figure 5.10 Clarification Time Cycle Time

5.2.3.2 Late Payments

The decrease in cycle time also corresponds to a decrease in late invoices. The greatest impact is seen between ten and eight days; this clarification period seems to have some critical effect on the late invoice rate dropping from 22.4% to 18.8%. Thereafter, the rate falls to the minimum threshold of 17.5%. The average number of days late also drops from 7.1 days to 3.1 days.

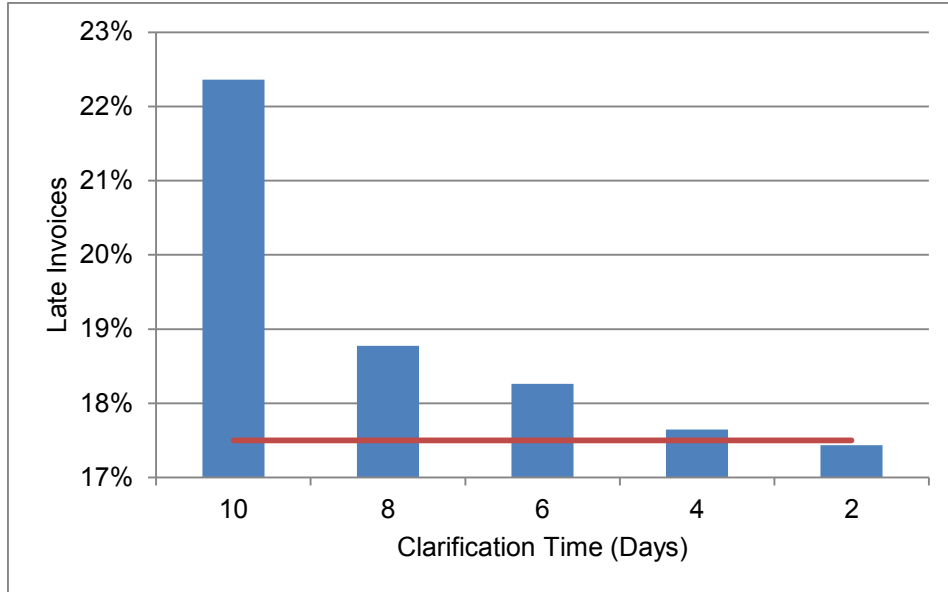


Figure 5.11 Clarification Time Late Invoices

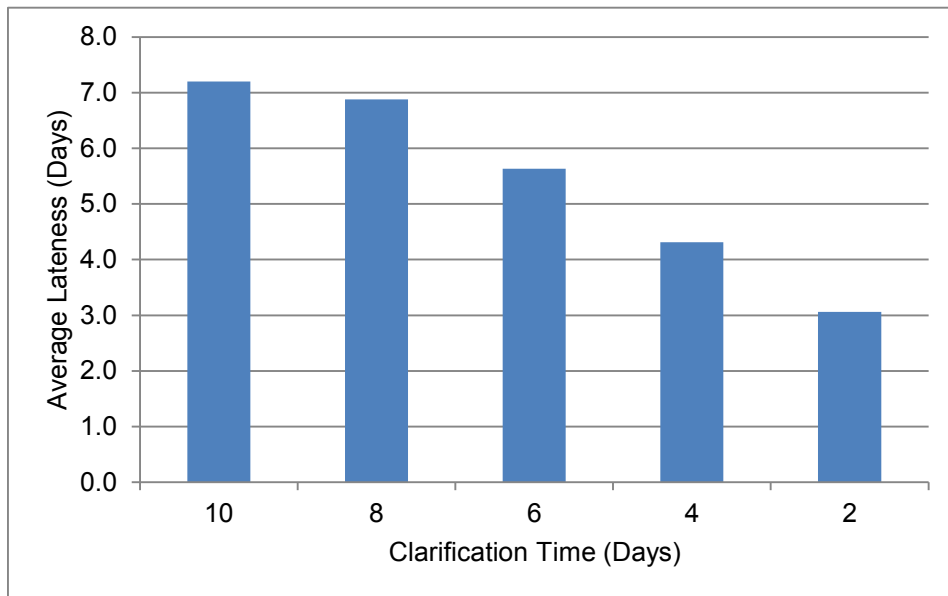


Figure 5.12 Clarification Time Average Lateness

5.2.3.3 Prompt Payment Discounts

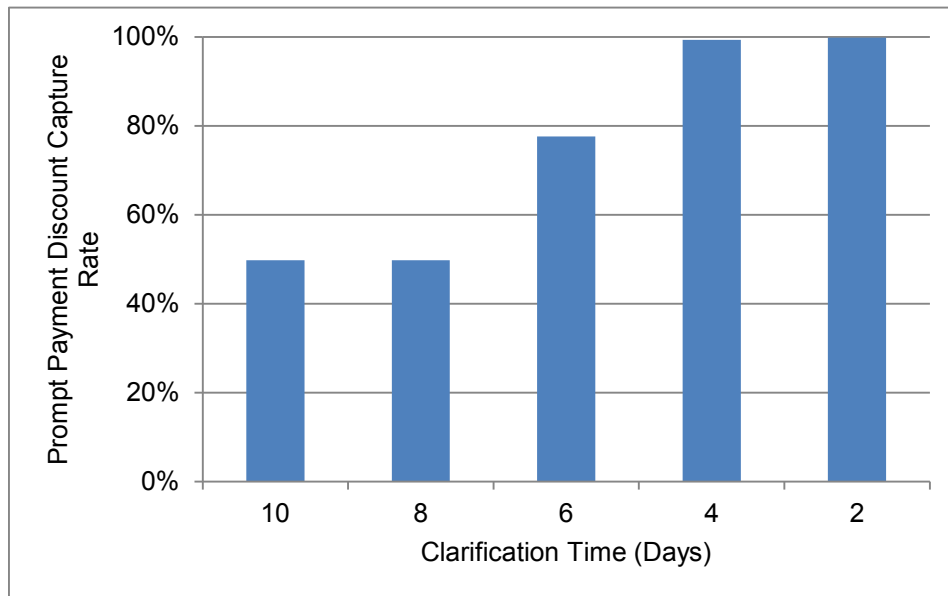


Figure 5.13 Clarification Time Prompt Payment Discount Capture Rate

Similarly, since the invoice cycle time is decreased, many more prompt payment discounts are able to be captured. This is reflected in Figure 5.13. As the clarification time falls to four days, nearly 100% of prompt payment discounts are captured.

5.2.3.4 Accounts Payable Staff Utilization and Invoice Processing Cost

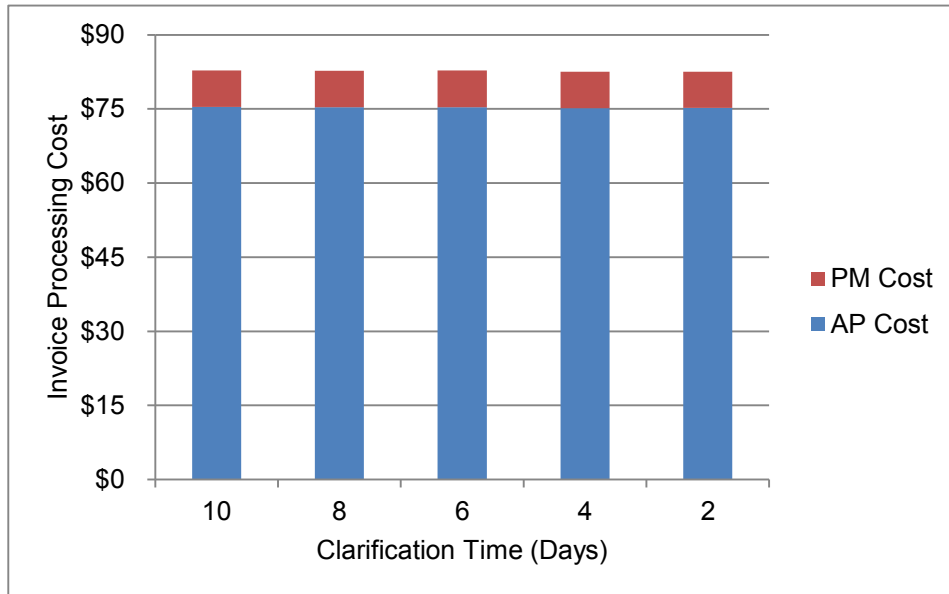


Figure 5.14 Clarification Time Invoice Processing Cost

Neither the accounts payable staff utilization rate, nor the invoice processing cost was materially affected by this variable.

5.2.4 Difficult Invoice Rate

The difficult invoice rate represents the proportion of invoices that project managers have to double check for cost capture, change management or discrepancies. Cost capture refers to the need for project managers to pass costs onto general contractors through strict purchase orders. The PM only has a certain amount of funds that may be allocated for each particular purchase order; and a purchase order may correspond to many magnitudes of scope. Change management is another important challenge the PM will face in invoice processing. Change is known to be very common in construction, and part of change management is identifying how actual expenditures differ from budgeted

expenditures. Budgeted expenditures are reflected in the vendor purchase order, as well as the corresponding client purchase order. The PM must reconcile the differing invoice with supporting documentation, which may require approvals, updated budgets or reasons justifying the change. Finally, discrepancies in the invoice that were not caught by accounts payable staff may be a reason for the PM to spend more time on the invoice—this is a rare occurrence.

In the base scenario, 92.5% of invoices coming from supply projects are simple (not difficult) invoices and 75% of invoices coming from erect and supply and erect projects are simple. The sensitivity analysis tested the following improved scenarios: 95%/80%, 96%/85%, 97%/90%, 98%/95%, 99%/99% and 100%/100% (supply-only project simple invoice rate / erect project simple invoice rate).

5.2.4.1 Cycle Time

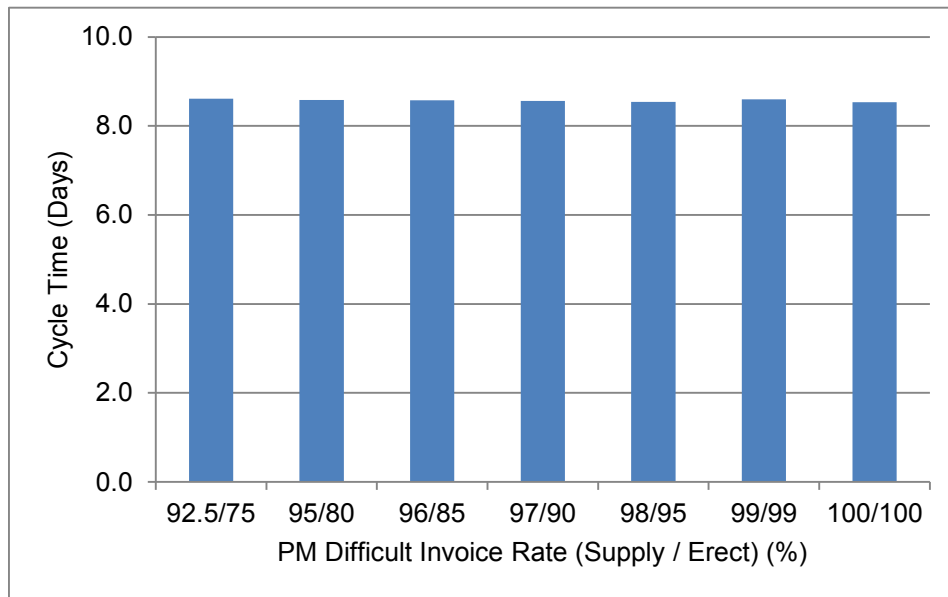


Figure 5.15 Difficult Invoice Rate Cycle Time

The difficult invoice rate has a negligible effect on the overall cycle time, because the project manager accounts for a small proportion of the processing time.

5.2.4.2 Late Payments

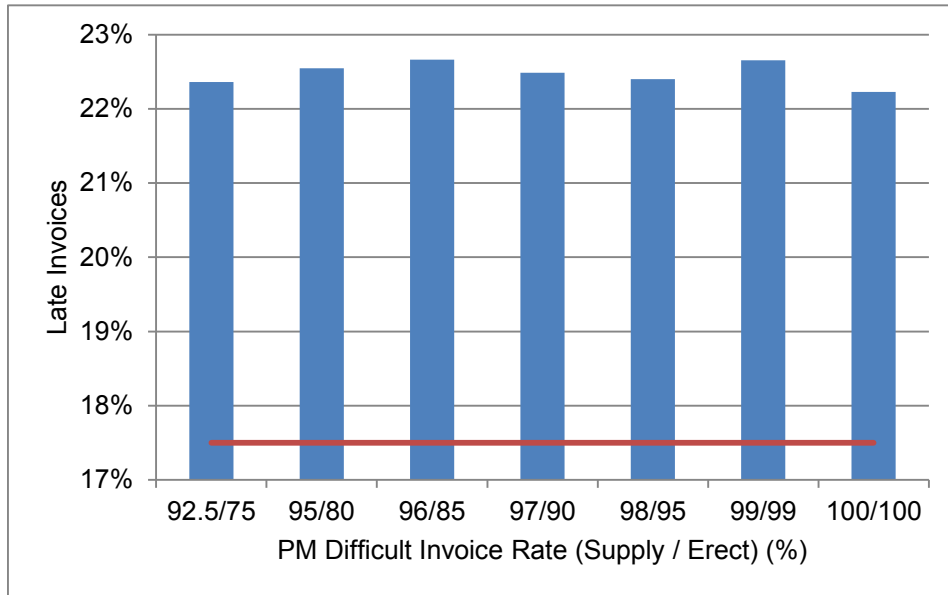


Figure 5.16 Difficult Invoice Rate Late Invoices

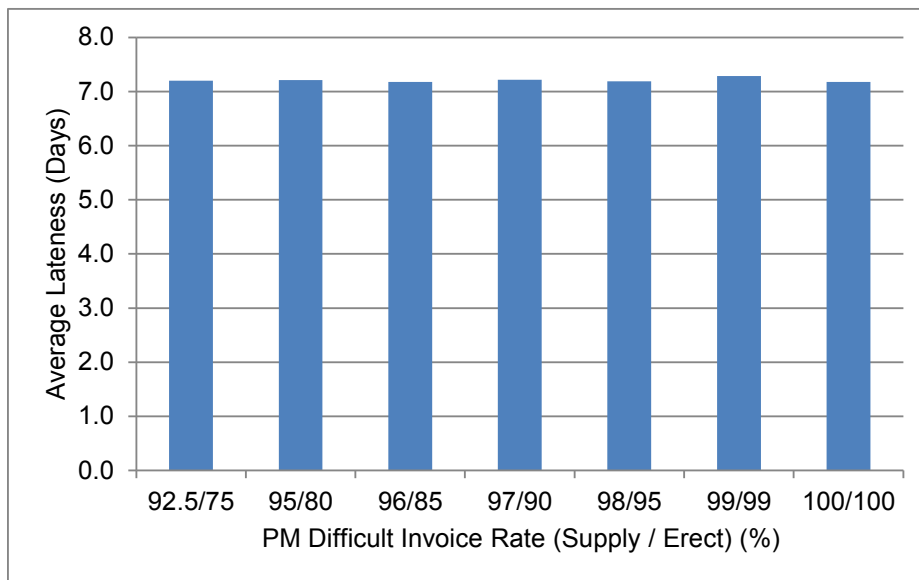


Figure 5.17 Difficult Invoice Rate Average Lateness

Since this particular variable has no effect on cycle times, late payments did not change. The red line in Figure 5.16 signifies the theoretical minimum late invoice rate.

5.2.4.3 Prompt Payment Discounts

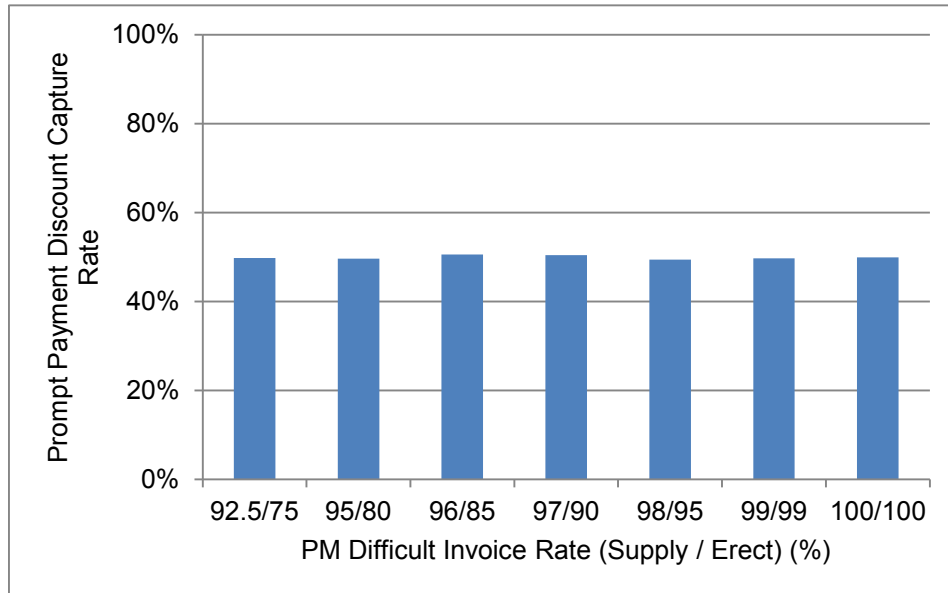


Figure 5.18 Difficult Invoice Rate Prompt Payment Discount Capture Rate

There is no effect on prompt payment discount capture rate from the difficult invoice rate.

5.2.4.4 Accounts Payable Staff Utilization and Invoice Processing Cost

Accounts payable staff were not affected by this variable; however, invoice processing cost was decreased. As shown (Figure 5.19), the processing cost from the project manager end decreased with this variable. Project managers in the base case spend an average of 4.3 minutes per invoice; this time is reduced to 2.3 minutes in the 100/100 case. Invoice processing cost falls from \$82.82/invoice to \$78.89/invoice.

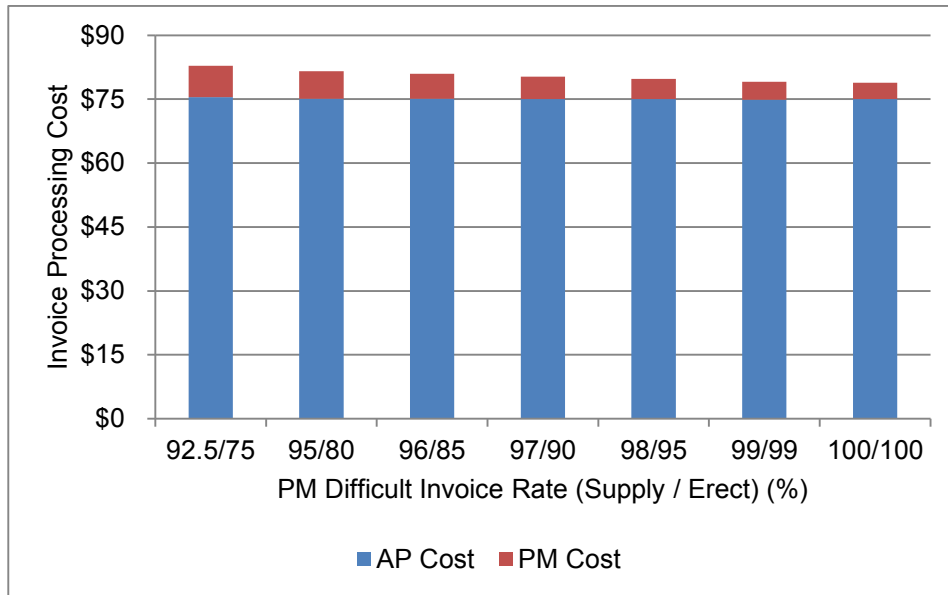


Figure 5.19 Difficult Invoice Rate Invoice Processing Cost

5.2.5 Project Manager Processing Time

The project manager processing time is the time needed for a PM to check a difficult invoice. As described in 5.2.4 above, the PM must consider cost capture elements and change orders. In the base case, each difficult invoice takes 22.5 minutes; the sensitivity analysis tests 2.5 minute intervals down to 2.5 minutes.

5.2.5.1 Cycle Time

The cycle time of the invoices is unaffected by this variable. The project manager's double checking the invoice does not represent a bottleneck in the invoice processing value chain.

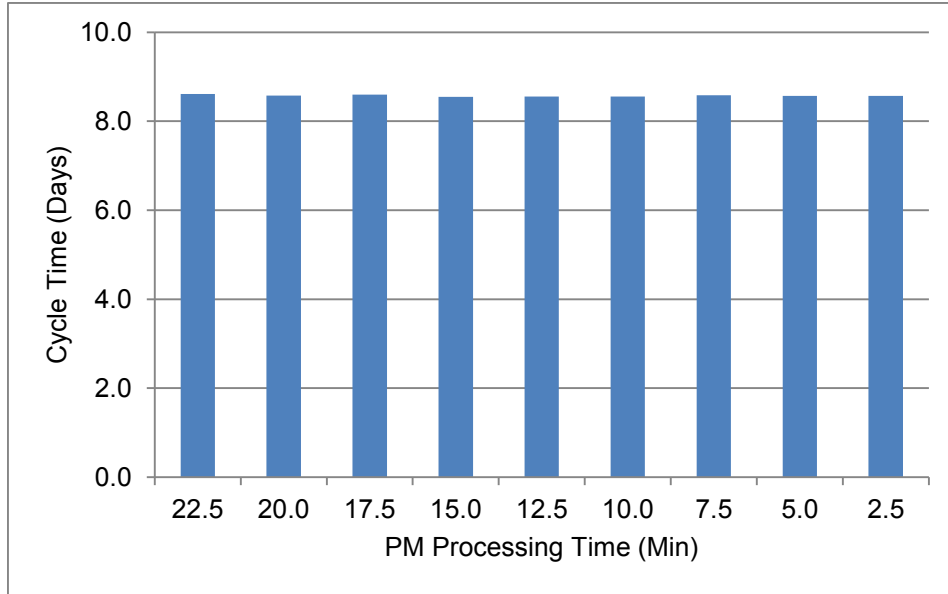


Figure 5.20 PM Processing Time Cycle Time

5.2.5.2 Late Payments

As the cycle time was unaffected, late payments were also not improved.

The lateness rate and duration remain the same as the base case.

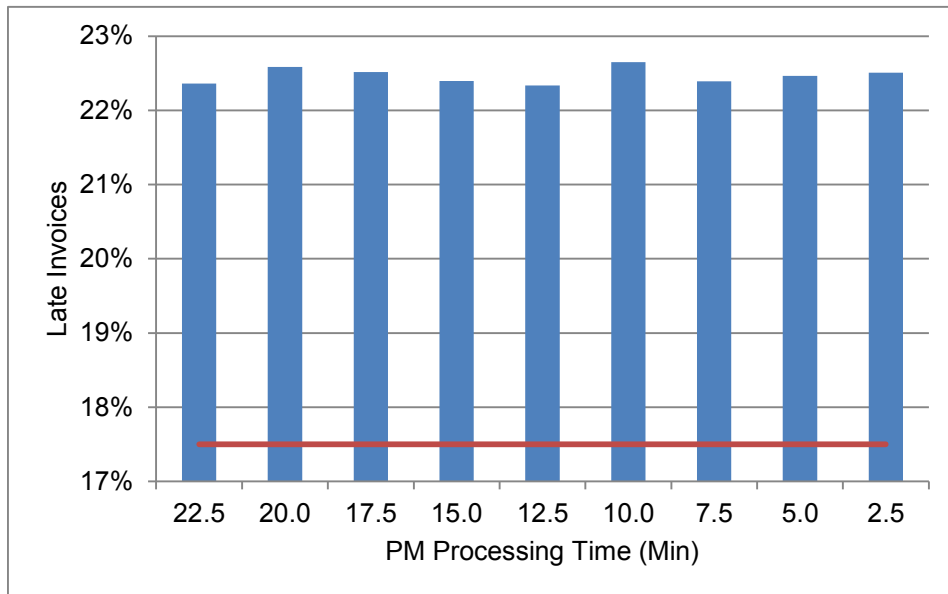


Figure 5.21 PM Processing Time Late Invoices

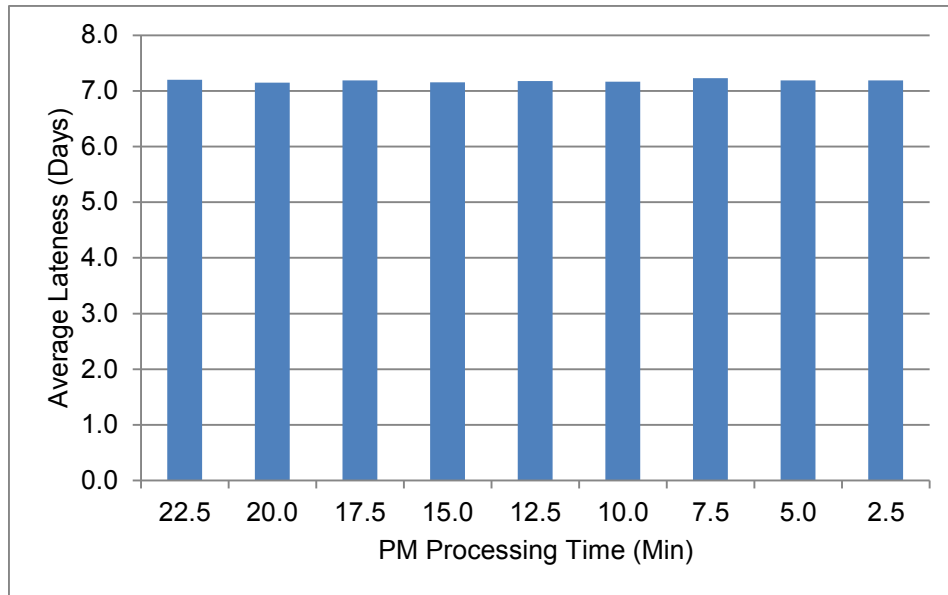


Figure 5.22 PM Processing Time Average Lateness

5.2.5.3 Prompt Payment Discounts

The prompt payment discount capture rate was not affected by this variable due to its negligible effect on the invoice cycle time.

5.2.5.4 Accounts Payable Staff Utilization and Invoice Processing Cost

The invoice processing cost was decreased slightly by the efficiency gained from the project manager having to spend less time per invoice. Between the base case and the 2.5 minutes case, \$3.20 per invoice is saved from the project manager's time. Figure 5.23 records the overall processing cost in every tested scenario. The accounts payable staff utilization rate was unaffected by this variable.

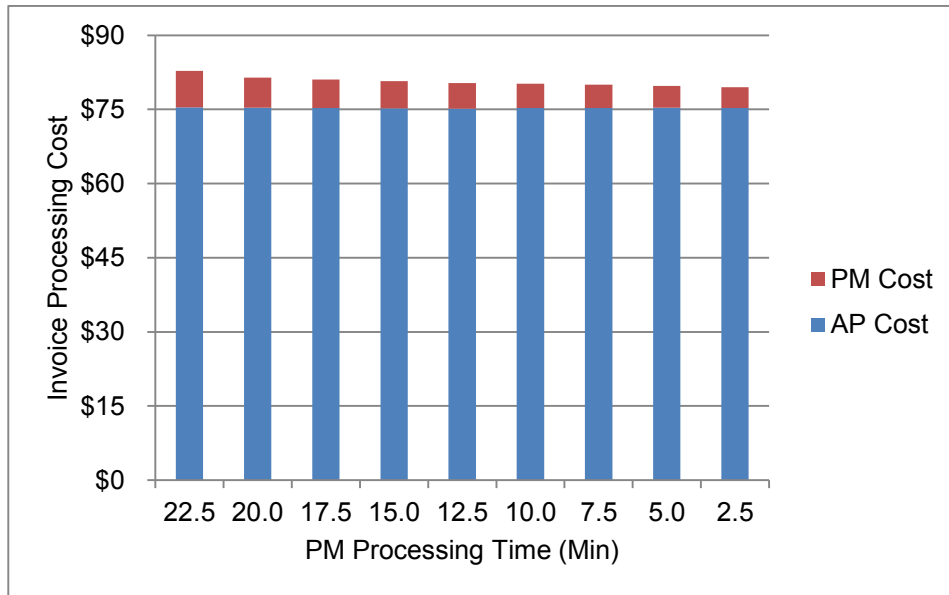


Figure 5.23 PM Processing Time Invoice Processing Cost

5.2.6 Accounts Payable Processing Time and Shuffling

The accounts payable processing time is the time it takes an AP staff member to check an invoice for completeness and accuracy. In the base model, overhead (OH) invoices take 45 minutes to check, while project invoices take an average of 210 minutes to check. The time was reduced for each type simultaneously—by 5 minutes for OH invoices, and by 20 minutes for project invoices, down to 5 minutes and 50 minutes, respectively. Another scenario, no shuffling, was also tested in this series. Before PM receives a project invoice, it must be shuffled into a pile for that particular PM, and when it returns, it must be reshuffled into sequence. Removing the shuffle time is a way to test the possibility of removing the need for hard copies. It appears in the charts as “NS.”

5.2.6.1 Cycle Time

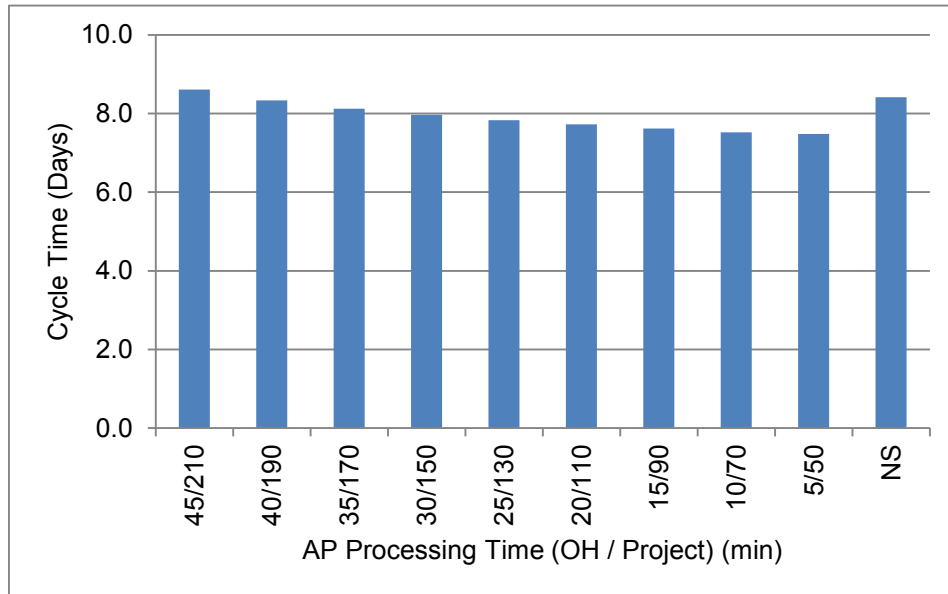


Figure 5.24 AP Processing Time Cycle Time

Reducing the AP processing time has an impact on the cycle time, but it is not substantial. Between the 45/210 case and the 5/50 case, one day is reduced from the average cycle time. The shuffling has a negligible effect.

5.2.6.2 Late Payments

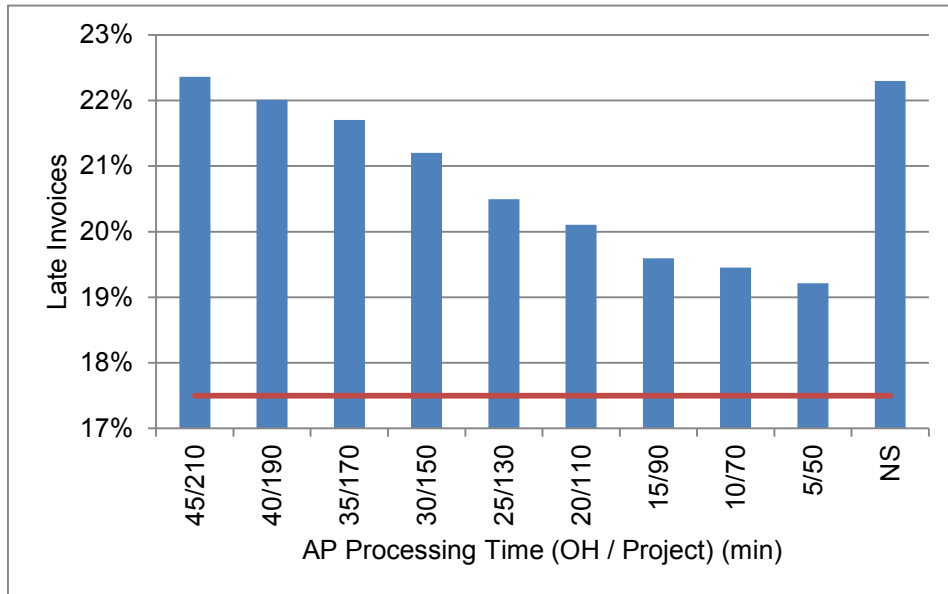


Figure 5.25 AP Processing Time Late Invoices

Despite reducing cycle time by only one day, this variable is able to cut late invoices by over 3% (22.4% to 19.2%). The average days late statistic was not affected, however. This discrepancy might be attributable to a critical threshold that exists in the distribution of late invoices. Perhaps reducing the cycle time slightly has an exaggerated influence on the late invoice rate. Distribution data, including standard deviation, was very limited for the cycle time. Shuffle time had no impact on late payments.

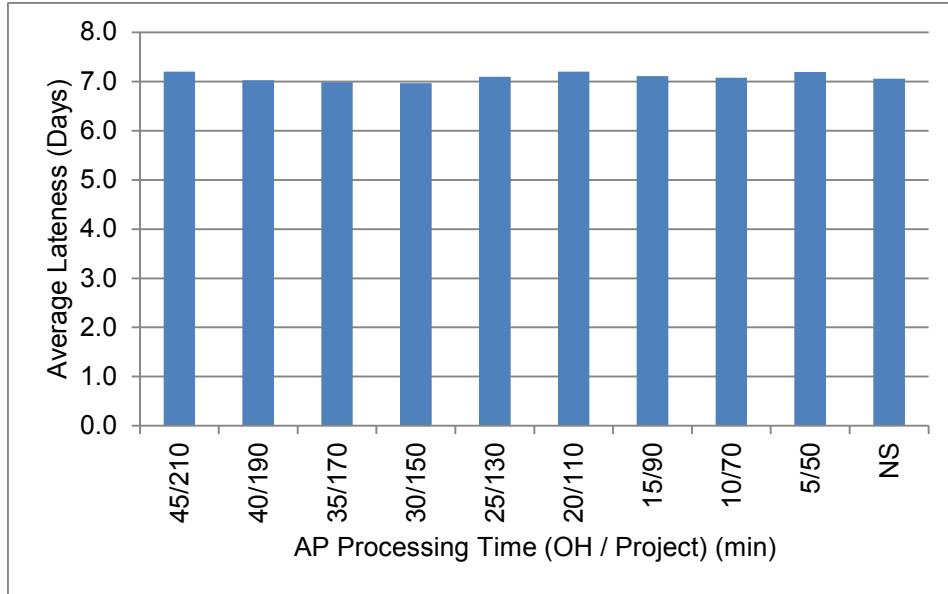


Figure 5.26 AP Processing Time Average Lateness

5.2.6.3 Prompt Payment Discounts

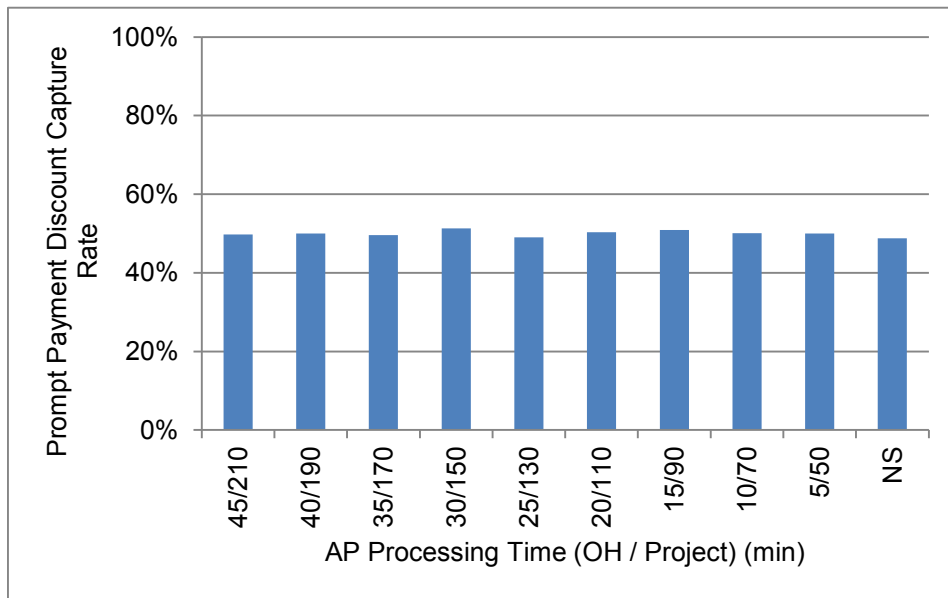


Figure 5.27 AP Processing Time Prompt Payment Discount Capture Rate

Due to the small impact on cycle time, neither of these variables had a substantial impact on the prompt payment discount capture rate.

5.2.6.4 Accounts Payable Staff Utilization and Invoice Processing Cost

The AP processing time has the greatest impact on the staff utilization and the invoice processing cost. Staff utilization levels reach 20% in the 5/50 case. Due to the method of calculating the processing cost, reducing staff levels has no impact on cost per invoice. As stated above, AP staff utilization is normalized to 80%; stated another way, it is assumed that AP staff will have other duties outside of accounts payable available to them to fill up to 80% of their time. Thus, reducing the staff level will double their utilization and the invoice cost will net to be the same. Where this assumption breaks down is that it may be easy to have additional work to fill a staff member's time from 60% to 80%; but in reality, this is much more difficult to do from 20% to 80%. Thus, this reduction does provide the opportunity to reduce staffing, but for the purposes of this analysis, it will have no measurable impact. Shuffling has a small impact on staff utilization levels. Figure 5.29 shows the invoice processing cost. Between the base 45/210 case and the 5/50 case, processing cost is cut by 60% from \$82.82/invoice to \$32.16/invoice. Clearly, this variable is key to any substantial reduction in overhead cost resulting from accounts payable. Removal of the need to shuffle invoices reduces costs to \$76.26/invoice.

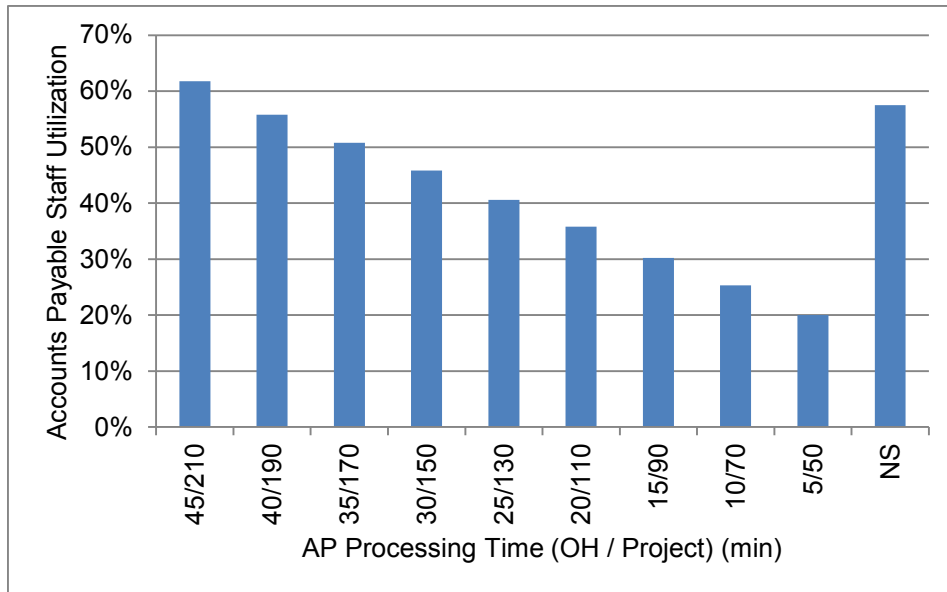


Figure 5.28 AP Processing Time AP Staff Utilization

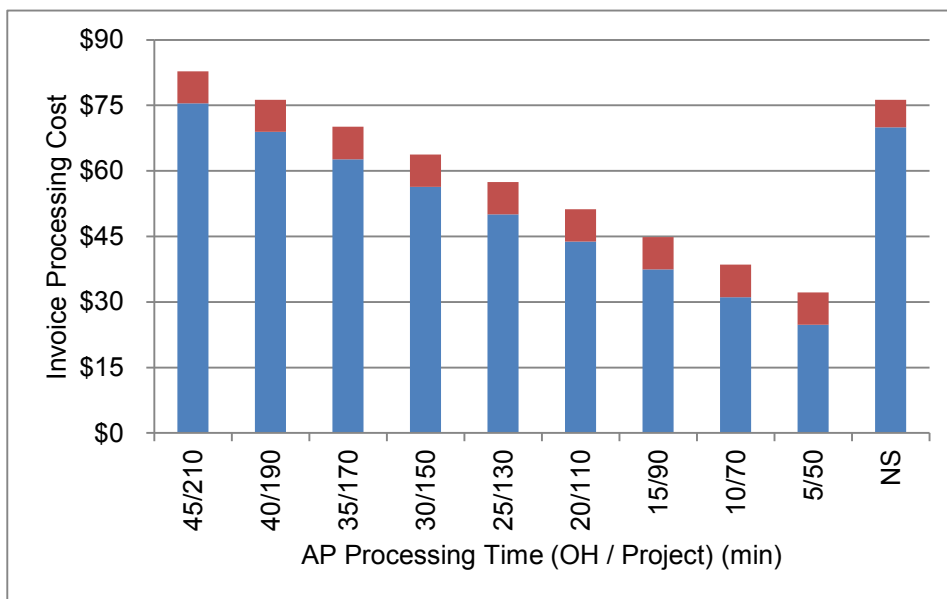


Figure 5.29 AP Processing Time Invoice Processing Cost

5.2.7 Conclusions from Sensitivity Analysis

Each of the variables had a different effect on the output variables tested. The cycle time and late payments were most strongly influenced by those variables that had an effect on either the need to clarify an invoice, or the time it takes to clarify an invoice. The found documents rate, the frequency with which

invoices are matched to their proper documentation, had a substantial impact on the cycle time. If invoices are ready for approval more readily, then the lengthy process of clarifying them is not needed. Further, if the clarification time is reduced, this has a material impact on the cycle time and late payments.

The clarification time did not have much of an impact on the processing cost. The variable that had the biggest impact was the accounts payable processing time. This is not surprising because most of the costs associated with invoice processing are related to the AP checks. When the time needed to process an invoice is reduced, staffing requirements decrease, and so does the cost to process.

5.3 Scenario Analysis

A few scenarios will be setup in order to test methods for increasing the effectiveness of the accounts payable department and reducing the department overhead. The sensitivity analysis established that the key to reducing cycle times is to reduce either the time needed to clarify an invoice or the frequency with which invoices need clarification. Furthermore, accounts payable time is crucial to reducing invoice processing cost. Introducing an electronic invoice system is one possible method of making these changes. Mitchell and DeGraw (2011) believe that an “e-invoicing project might have the potential to generate an ROI based on process efficiencies alone.” However, the challenge with this approach is that many industry participants continue to operate with paper-based accounts receivables departments. Is it possible for one firm to accomplish this conversion

independently? Tyagi (2012) explains that “this is no ordinary task,” (p. 3) because existing suppliers are not motivated to change from the status quo. Accounts payable staff “not only need to educate suppliers on the benefits of electronic submission but must also allocate their own resources to help with the installation and training in some cases of an electronic portal” (Tyagi 2012). Tyagi believes that benefits of document management and financial transparency outweigh the cost of installation and time needed to train suppliers.

Two scenarios will be discussed: one where the firm under study will take on the sole charge of electronic conversion of its AP department and one where the whole industry has converted to electronic invoicing. Where possible, the scenarios will be built into the simulation model to determine their effectiveness.

5.3.1 Scenario 1: Independent Firm-level Implementation

This approach is the simplest for a firm to make the decision to implement. In this scenario, a firm could build procurement and invoice processing into its ERP system. Functioning together, procurement documents will provide corroborative support to the invoice documents. Pre-matching of documentation will make for fewer exceptions that need to be managed in the form of clarifications.

Client firms and subcontractors would be invited to supply their invoices electronically and they will automatically be entered into the ERP software. Software rules can be designed to assist clients in ensuring their invoices are complete and accurate. The documentation and authorization needs from each

client and subcontractor can be programmed and reviewed job-to-job (i.e. number of signatures, documents such as LEM sheets and statutory declarations). The system can automatically check the invoice entered against procurement rate sheets and quantities. Discrepancies will be highlighted for clients to review before submission; in this way, the burden of double checking is placed on the client's accounts receivable team. Provisions must be created to allow for change orders; however, additional documentation must be provided to justify the change.

To test this scenario, the simulation model must be modified to reflect the expected inputs that this will achieve. First, the need for paper shuffling is eliminated entirely. Once invoices have been received into the electronic system, AP personnel are still needed to double check the submission for completeness. This scenario will hold the assumption that this will take an average of fifteen minutes for overhead invoices and one hour for project invoices. Clarification rate assumption will plummet to 5% because invoices will come with documentation already accounted for, and rudimentary checks automatically complete.

Introducing this system will create some up-front work for AP staff. Every project that is undertaken will have to be entered into the new AP system before invoices may be accepted for it. The model will add a thirty-minute task for AP staff to complete upon initiation of any project. To prevent erroneous submissions to finished projects, an AP staff member will have to close out the project in the system (a 10-minute task). Further, many vendors, especially infrequently used vendors, may encounter difficulties entering invoice information. The AP department will have to respond to email and telephone calls seeking help with

entering the invoice information. This complication will be modeled as 20% of invoices that need assistance for an average of twenty minutes; if a call is received, one staff member will have to stop their current work in order to help immediately.

5.3.2 Scenario 2: Preferred Vendor Implementation

Another possibility is to partner with the most frequently used vendors and create a streamlined invoicing process with them. Firms may find that a relatively small number of firms will form a material proportion of the invoices they receive—a form of the 80/20 rule. Upon reviewing invoice data from the steel manufacturer over the past six months, this pattern is apparent. The dataset includes 4501 invoices from 364 vendors; the top twenty-five vendors represent 54% (2431) of the total number of invoices received. These partners could be set up with a fast-tracked electronic process in exchange for a promise to receive payments sooner, with more transparency and fewer difficulties for their corresponding accounts receivables departments.

This could be modeled by making similar modifications to the process as described in Scenario 1, with a few key changes. Only 54% of the invoices received will go through the streamlined process. However, since these invoices come from preferred vendors, they will take less time to check: overhead invoices ten minutes and project invoices forty-five minutes. Once again, all of the projects will need to be set up for electronic submissions, but this task will take an average of twenty minutes now; closeout time remains the same. Once again some of

these invoices will need assistance from the AP department to be completed; however, the rate assumption will be reduced to 10%.

5.3.3 Simulation Results Discussion

Scenario 1 and Scenario 2 were both built into the model, as described above, and the simulation was run so that the results may be compared to the base model. Figure 5.30 shows the cycle times of the base model along with Scenarios 1 and 2. Scenario 1 has the most dramatic impact on cycle time, reducing it from an average of 8.6 days to 1.0 days; Scenario 2 cycle time is 4.3 days. The distribution of each cycle time is also important. Figure 5.31, Figure 5.32 and Figure 5.33 illustrate the different distributions of cycle times achieved in each scenario. The original distribution displays bi-modal inclination. Those invoices encountering no difficulties throughout the approval process either from rejection by the project manager or from need for clarification from accounts payable staff are completed in a very timely manner; these invoices are approved quickly, most in fewer than five days. The invoices that encounter difficulties take much longer before approval, and it is these that fill out the distribution. Scenario 1 sees the instances of difficulties in invoice processing drop dramatically. Nearly 95% of invoices are approved in fewer than five days. It is no coincidence that, as discussed above, the clarification rate assumption put into the model was 5% - it is these invoices whose processing time is distributed greater than five days. Scenario 2 also demonstrates greater proportion of invoices approved in fewer than five days.

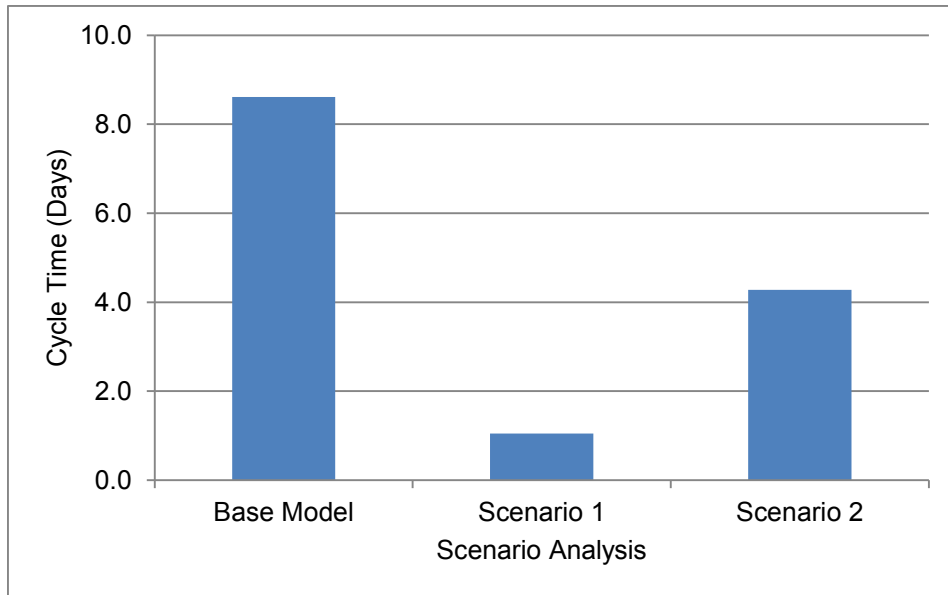


Figure 5.30 Scenario Cycle Time

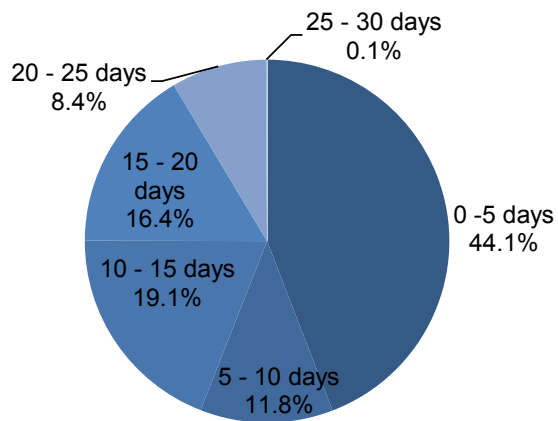


Figure 5.31 Base Scenario Cycle Time Distribution

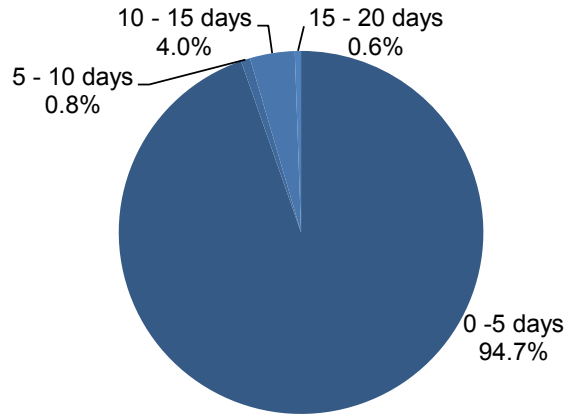


Figure 5.32 Scenario 1 Cycle Time Distribution

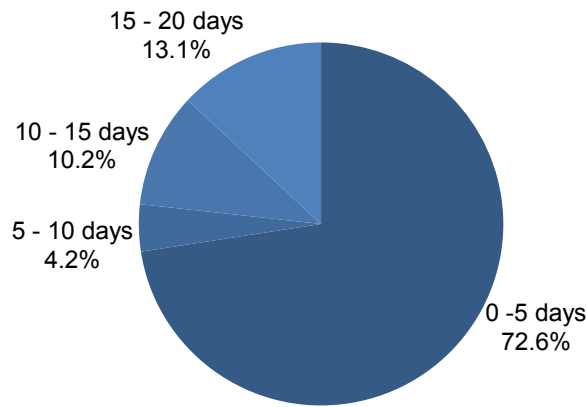


Figure 5.33 Scenario 2 Cycle Time Distribution

Each scenario dramatically reduces the late invoice rate, as shown in Figure 5.34. Scenario 1 is barely above the minimum threshold, while Scenario 2 may still be improved. Over the long run, the prompt payment discount capture rate (Figure 5.35) corresponds very closely to distribution of invoice with cycle time under 10 days. This rate is 50% for the base model, 95% for Scenario 1 and 76% for Scenario 2. One possibility for improving Scenario 2 could be to have all vendors that provide prompt payment discounts route their invoices through the

electronic system; however, this endeavor may be too costly relative to its marginal benefit.

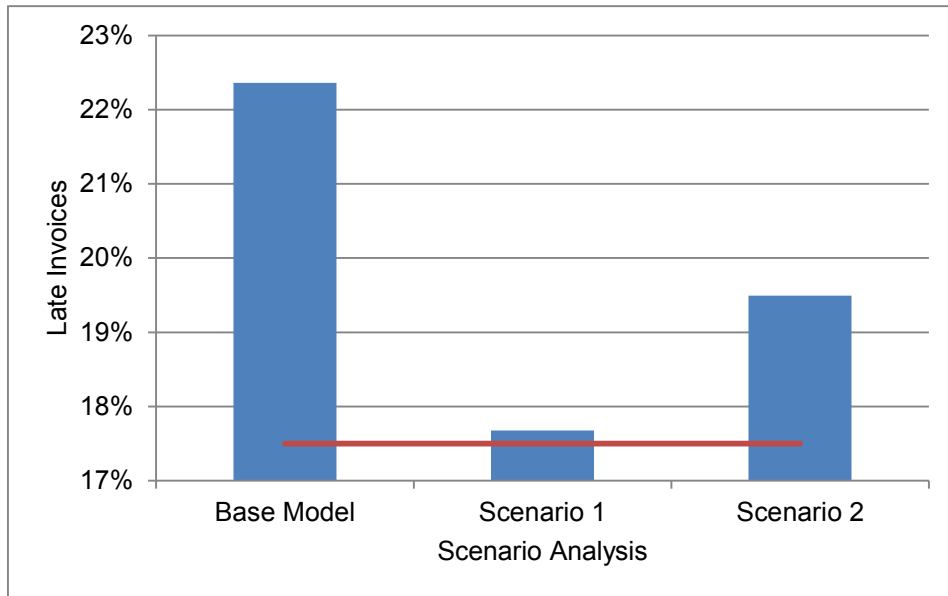


Figure 5.34 Scenario Late Invoice Rate

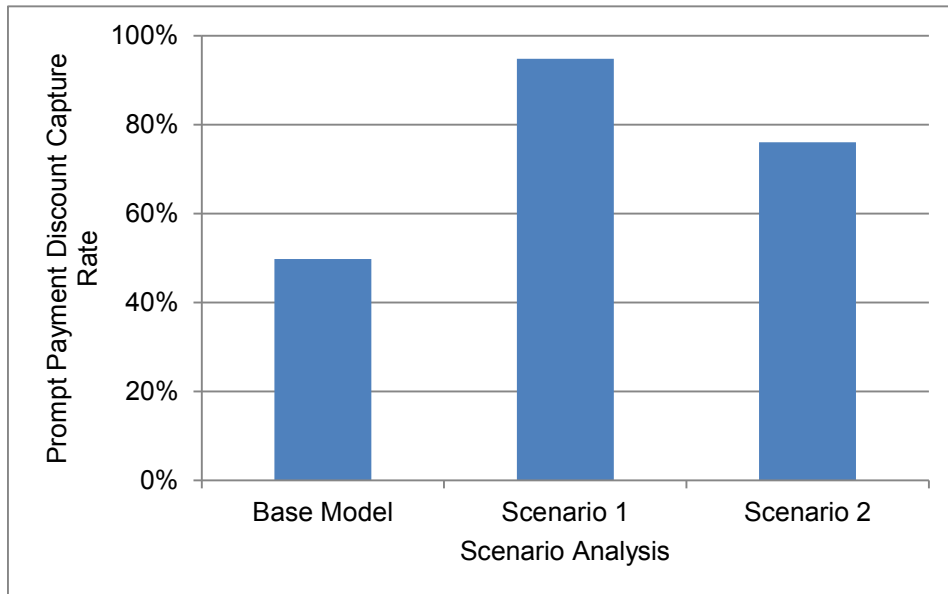


Figure 5.35 Scenario Prompt Payment Discount Capture Rate

Scenario 1 achieves lower utilization rates and processing costs than any of the sensitivity analyses. This is primarily because of the substantial reduction

in processing effort needed from AP staff in addition to much lower rework rates. Figure 5.36 shows the utilization rates for AP staff: Scenario 1 is at 18% and Scenario 2 is at 35% (62% base). The low level of utilization may require management to reallocate resources away from accounts payable and into other departments. The processing cost of each scenario can be seen in Figure 5.37. Scenario 1 reduces the processing cost from \$82.82 / invoice to \$29.35 / invoice and Scenario 2 reduced the cost to \$50.73 / invoice.

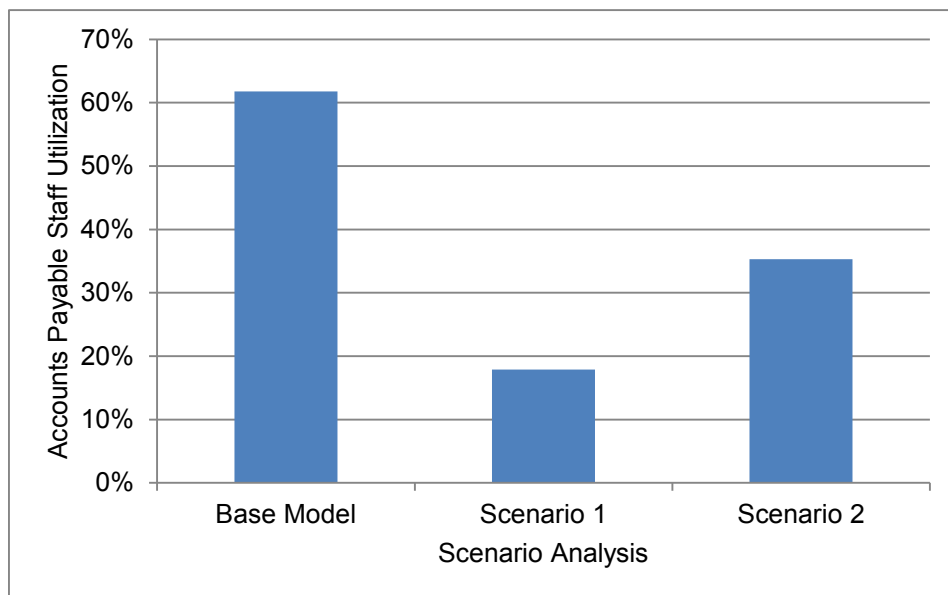


Figure 5.36 Scenario Analysis AP Staff Utilization Rate

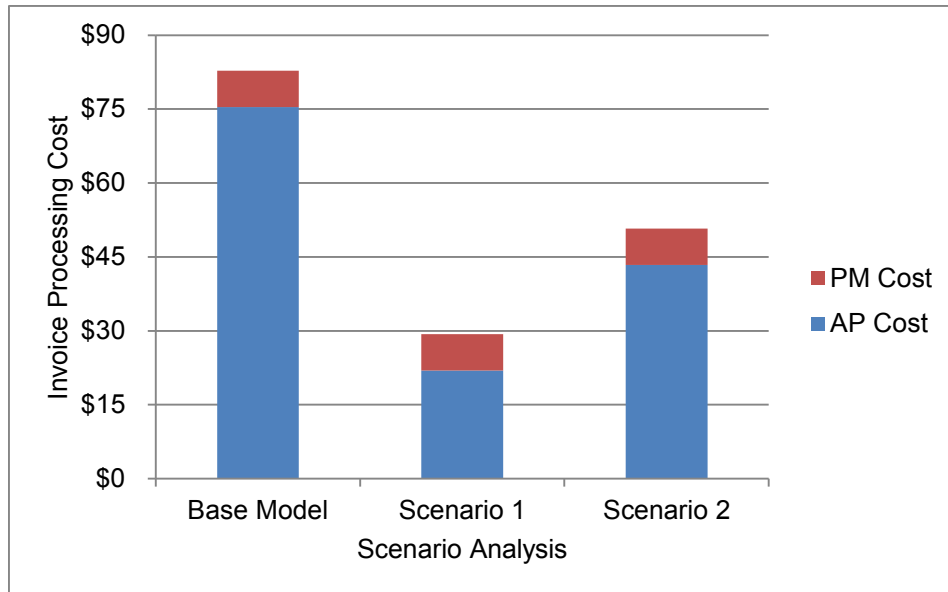


Figure 5.37 Scenario Analysis Processing Cost

5.4 Scenario Financial Analysis

In order for the scenario analysis to be helpful, certain financial metrics must be calculated. Two metrics were considered: rate of return and net present value. Rate of return analysis calculates the implicit interest rate (or return rate) within a stream of cash flows. Stated otherwise, this is the rate of growth the investment in accounts payable is expected to generate. The implied assumption in this type of calculation is that any cash inflows are reinvested at the given rate of return. For example, if a project has a calculated rate of return of 20% and receives \$10,000 in cash flow in a given month, then this analysis assumes that the \$10,000 is reinvested at 20%; otherwise the rate of return is overstated. Furthermore, rate of return analysis requires an estimate of the upfront costs of any project (or in this case process improvement).

Net present value (NPV) analysis requires the assumption of a discount rate by which future cash flows are discounted to present value. Often, a nominal

rate of 10% is used to evaluate projects; however, this assumption may be sensitized. NPV analysis is enhanced by, but does not require, the assumption of upfront costs. Similar to rate of return analysis, NPV assumes that any cash flows are reinvested at the chosen discount rate. This assumption is less onerous because the discount rate for a given positive-NPV project will always be less than its rate of return, thus finding further investments at this rate easier. For these reasons, NPV analysis was chosen to determine the financial impact of the two scenarios.

As described above, this work assumes a ten-year lifecycle to ease analysis and give a sufficient amount of time to assure significance. The net present value analysis will also use ten years as the time horizon. The case against this choice is that cost savings past ten years will not be included in the evaluation, and these can be significant (accounting for nearly 40% of total savings using a 10% discount rate). However, this researcher believes that any realistic process improvement has a given lifecycle before further refinement is needed and new technologies are introduced. Ten years is a reasonable assumption for the lifecycle of the accounts payable process improvements described in this investigation, as it is unknown how the needs of the organization and the industry at large change over such a long term.

The discount rate is another important assumption needed to undertake an NPV analysis. The discount rate can be thought of in many ways: a cost of capital, a hurdle rate or a risk premium. The weighted average cost of capital (WACC) is calculated using the cost of funding for the firm. If funding is

financed through debt and equity, then a weighted average of these values is used. Sometimes this figure is considered at the margin. The hurdle rate approach considers the discount rate as the minimum acceptable rate of return (MARR) that a firm will undertake for a project. This rate may change subjectively based on project risk perception and capital requirements. The market risk premium ascribes a discount rate commensurate with similarly-risky assets available in the market place. Subjectivity herein lies with the measures of risk used to relate a project to market asset. It is this author's view that the accounts payable process improvement cost savings face uncertainty mostly in their measure, rather than in their likelihood. A discount rate between 10% and 15% is what an industry practitioner may use; however, rather than attempt to estimate the appropriate discount rate, this study will simply sensitize it in the range of 7.5% to 20%.

The analysis will use 1020 invoices per year as the average number of invoices processed, as taken from the base scenario. Another source of value for this project is the increased prompt payment discount capture rate. Additional assumptions are needed for this part of the analysis. On average, 10 prompt payment discounts are received per year. The reason that this portion yields far less certainty is that one must project revenues for the firm in order to calculate the magnitude of the discount. If this firm goes through \$50 million in costs per year, then the average invoice has a value of approximately \$50,000; and each 2% discount offered has a value of \$1000. The prompt payment discount value will be considered in aggregate for a \$50 million firm, and as a rate of value per dollars of invoice cost processed.



Figure 5.38 Scenario 1 Present Value of Accounts Payable Savings

Figure 5.38 demonstrates the present value of possible cost savings from Scenario 1 at different discount rates. At the 10% discount rate, this scenario represents \$335,000 in cost savings over ten years. This can be interpreted as \$335,000 spent today to implement this solution would result in zero net savings from direct processing cost over the ten-year life of the process. Importantly, this figure is relevant only for the hypothetical firm under study. A firm receiving ten times more invoices will also see the savings grow proportionately. As a proportion, this represents a saving of nearly 65% in the processing cost per invoice. Figure 5.39 shows the present value of the savings resulting from marginal prompt payment discounts captured for Scenario 1. This is done by comparing the PPD capture rates between the base model and the scenario. As discussed above, the average invoice was assumed to be \$50,000. At 10% the PV of marginal discounts is \$27,650. This sum is relatively small, even as a percentage of total cost (Figure 5.40). If a firm receives a greater proportion of its

invoice credit terms as prompt payment discounts, then this saving becomes more material. Regardless, as noted in 2.1, almost any prompt payment discount offered should be accepted from a financial standpoint.



Figure 5.39 Scenario 1 Present Value of Marginal Prompt Payment Discounts Realized

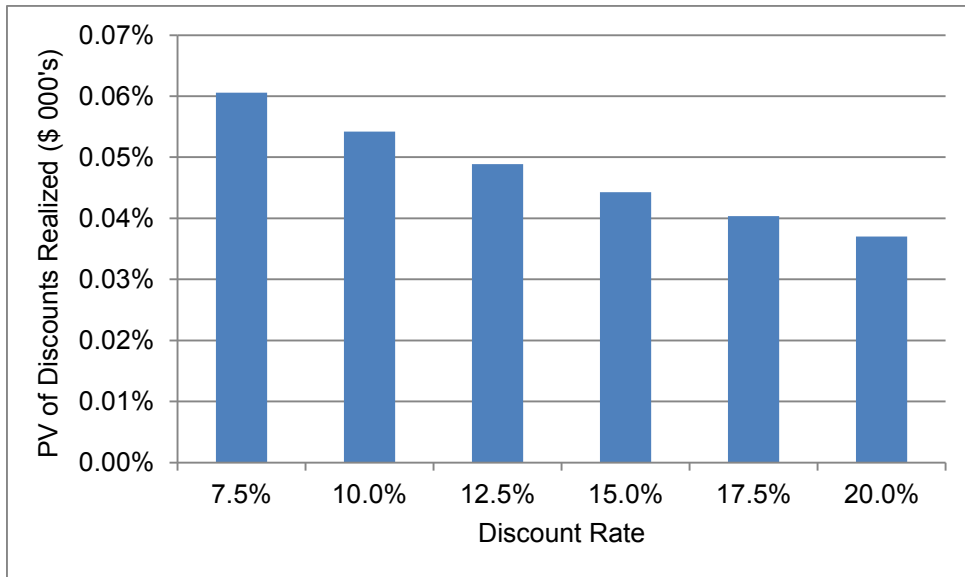


Figure 5.40 Scenario 1 PV of Marginal PPD Realized as Percent of Total Invoice

Similarly, Figure 5.41 and Figure 5.42 show the present value of accounts payable savings and marginal prompt payment discounts. At a 10% discount rate, the AP savings are worth \$201,072 and the prompt payment discounts are worth an additional \$16,098. As a proportion, this scenario reduces processing cost by nearly 39% per invoice.

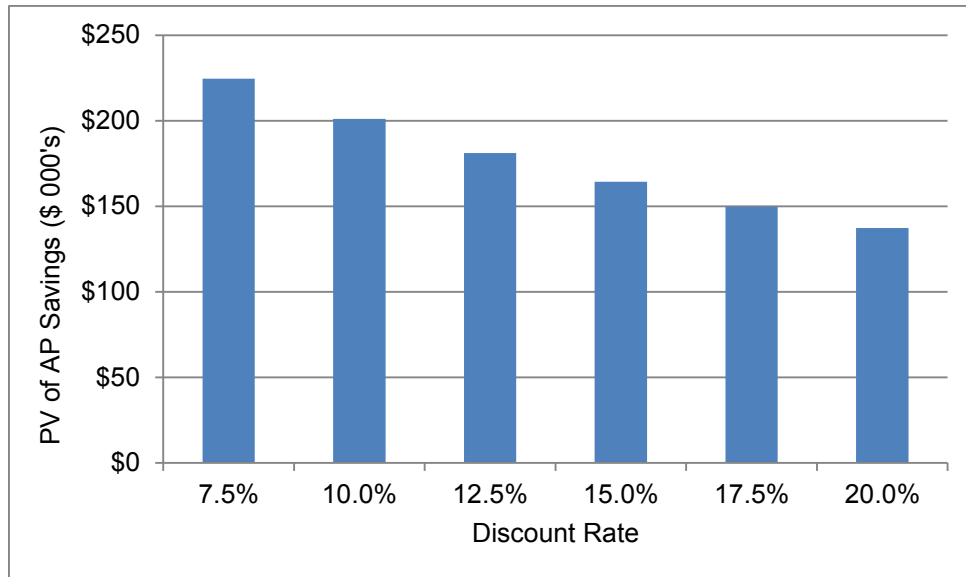


Figure 5.41 Scenario 2 Present Value of Accounts Payable Savings

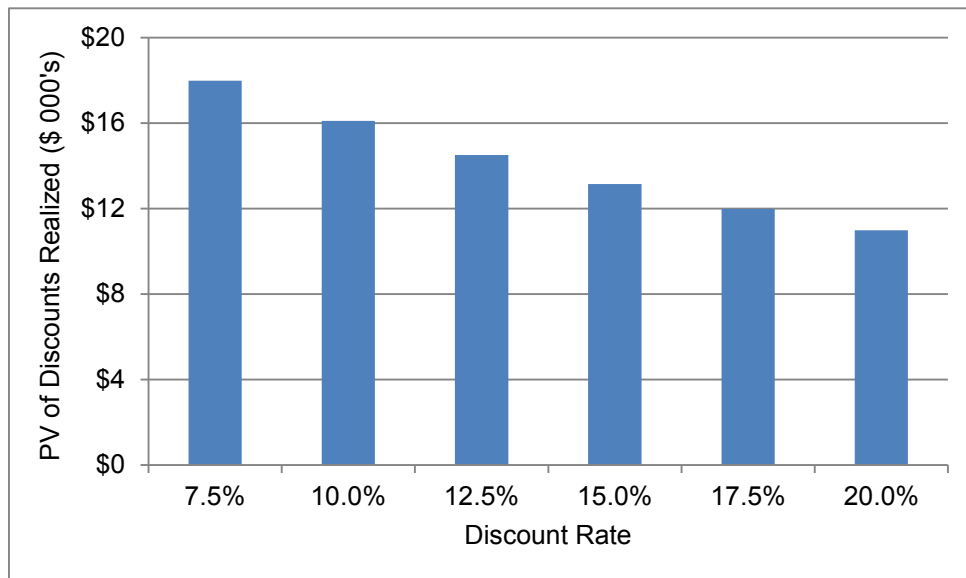


Figure 5.42 Scenario 2 Present Value of Marginal Prompt Payment Discounts Realized

5.5 Possible Implementation Plans

The firm could undertake implementing either scenario in different ways. Primarily, the decision must be made either to purchase and to take ownership of a software solution or to outsource much of its accounts payable processing needs. The simulation work done in this research assumes that the solution is done in-house, thus the time savings for AP staff are modest. Organizations undertaking such a change must account for costs coming from software, training, learning curve effects, vendor communication and maintenance. These expenses can be substantial, and must be studied carefully in the context of that specific organization before any decision is to be made. The outsourcing alternative, to which Scenario 1 lends itself better, may be a unique way for the organization to solve this problem. Firms may be able to pay a third party for accounts payable processing per invoice. If a firm has sufficient bargaining power (i.e. its vendors value its business), then it may be able to allocate this cost to its vendors

5.5.1 Possible Third Scenario: Project-level Approach

A third possibility is to work with the firms involved in longer-duration projects, for example, projects scheduled to last longer than 18 months. As part of the construction planning stage, all of the major firms involved in the project could agree to a fast-tracked approach to invoicing. This approach may take one of two forms. The first is to create an electronic payment system to process all invoices and purchase orders throughout the project. Accounts payable, accounts receivable, procurement and sales teams alike will have to make use of this

system to document their project work. Personnel-linked signatures and approvals could provide accountability throughout the process. The downside of this method is that it requires a costly up-front investment, and selling an owner on its value as part of a bid package would be challenging.

Shifting the payment cycle to digital is not the only way to realize this design. It could also be as simple as agreeing to standardized forms for purchase orders, invoices and supporting documentation. In this way, approvals could be made simpler, but the speed and accountability inherent in the electronic method is lost. In either circumstance, this approach requires an unprecedented level of pre-construction planning and alignment with all parties involved. Further, the decreased cost of invoice processing enjoyed by accounts payable departments may be borne unto accounts receivable and procurement teams now having to adjust their methods and forms. Because of the exogenous effect on cost, this method will not be tested in this research. This researcher believes that the impact of such an approach will be marginal at best, and the costs substantial. In order to fully appreciate the effect of this scenario, a more fulsome model is needed, and this may be a problem for future research.

6 Chapter 6: Conclusion

6.1 Summary of Work

This research set out to map and to improve the accounts payable process at a construction firm. Literature on the subject was incomplete, especially pertaining to the construction industry. Much of the previous work has focused on modeling cash flows and improving the understanding of the cash flow problem for construction projects. With the help of a steel manufacturer, sufficient data was collected to create a process map of the accounts payable process. Additionally, challenges with accounts payable across many companies were identified with the help of the staff of the accounts receivable department at this supporting industry company.

This research demonstrated that a model could be built using discrete event simulation to replicate the accounts payable process in a construction firm. The benchmark model was built with two outcomes in mind. The first, to calculate invoice processing time and with it the frequency of late invoices as well as the prompt payment discount capture rate, and second, to track the cost of invoice processing over the long term. Both of these outcomes were realized. The model was validated using five documented validation techniques for simulation models: comparison to other models, degenerate tests, event validity, extreme test conditions and trace analysis.

A sensitivity analysis identified that invoice rework was one of the key areas that helped to improve the cycle time. Rework stems from poorly

documented or erroneous invoices coming from the supplier, unmatched procurement documentation for AP staff to check against or other reasons. Processing cost was best reduced when the time taken to check each invoice by accounts payable staff and project managers was lessened. Easy access to documentation, standardization of invoice formats and automatic error checking are key methods of reducing the time staff needed to approve an invoice.

With this in mind, two scenarios were built into the simulation model to test their value. The first scenario was to force all suppliers and subcontractors to submit their invoices electronically. The second scenario was to partner with the most recurrent vendors and build a framework to digitize invoicing. Each scenario came with its challenges; however, since Scenario 1 assumed the involvement of all vendors, its effects on cost and cycle time were greater than those of Scenario 2. Finally, a net present value analysis was conducted on each scenario to demonstrate its possible cost savings to the simulated firm.

6.2 Contributions

This research achieved the following:

- Mapped the accounts payable process at a steel manufacturing firm and documented the challenges an accounts receivable department with a broad base of clients faces on a daily basis.
- Developed a framework for analyzing the support functions of a construction firm using discrete event simulation. The simulation model was broken into two key phases: the project phase and the

support function phase. Since all construction firms are reliant on projects to generate work for many support functions such as accounts payable, it follows that any attempt to model these departments must first begin with a work project. This framework can be used in both academia and industry to simulate other support functions that rely on project delivery results for their workload.

- Built a model of the accounts payable process at a construction firm that may be used in further research work or as a benchmark for industry participants
- Created scenarios based on the results of the sensitivity analysis run on the accounts payable model. These scenarios show the possible cost saving in improving an accounts payable process using automation and e-invoicing.
- Contributed to the academic understanding of accounts payable's importance in the field of construction. From identifying how late payments are damaging to the industry's reputation to demonstrating how overhead costs can be reduced substantially by improving the invoice approval process.

6.3 Suggestions for Further Research

The following are possible topics for further research:

- Mapping the complete procurement to pay process and assessing it for possible improvements. This expands the possibilities for process improvement studies and could bring a more fulsome understanding of the benefits of an electronic procurement and accounts payable programme.
- Understanding how electronic invoicing could decrease project costs for every participant in a project. This will require mapping the accounts receivable process and linking the entire cash conversion cycle together firm by firm.
- Creating a generic tool with which industry participants may easily benchmark their existing AP processes and determine specific courses of action for improving them.

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Appendix A: Sample Simulation Traces

Below is a trace output from the Symphony model. 350 lines were given as a sample for brevity. One typical model run may output as many as 200,000 lines. The table below is a legend of the information presented in the traces.

Table 0.1 Description of Trace Data

Column	Description
Time (min)	The current simulation time, in minutes
Type	The type of entity sending the trace data, project or invoice
Entity ID	The unique ID number of the entity <ul style="list-style-type: none"> - Projects labeled sequentially starting from 1 - Invoices labeled sequentially with the last 3 digits equal to project ID (000 are overhead invoices)
Event	Current event sending trace <ul style="list-style-type: none"> - Project initiation shown as project type (1 for Supply, 2 for Supply + Erect, 3 for Erect) Project difficulty rating - Invoice arrival indicated either with “Arrive #” or “O/H #” the first referring to a project invoice and the second to an overhead invoice; the # is the credit term based on those discussed in 4.2
I/V Start	Initiation of invoice approval, Boolean for ease of analysis
I/V End	Conclusion of invoice approval, Boolean for ease of analysis
I/V PM A	Initiation of PM checking invoice, to track PM costs
I/V PM B	Conclusion of PM checking invoice, to track PM costs

Time (min)	Type	Entity ID	Event	I/V Start	I/V End	I/V PM A	I/V PM B
3244.87	Project	1	1 2				
3244.87	Project	2	1 3				
3244.87	Project	3	1 2				
3244.87	Project	1	Assigned to PM3				
3244.87	Project	2	Assigned to PM1				
3244.87	Project	3	Assigned to PM3				
3484.92	Project	4	2 2				
3484.92	Project	5	2 10				
3484.92	Project	6	2 3				
3484.92	Project	4	Assigned to PM2				
3484.92	Project	5	Assigned to PM2				
3484.92	Project	6	Assigned to PM2				
4444.87	Project	1	Request PM3				
4444.87	Project	2	Request PM1				
4444.87	Project	3	Request PM3				
4444.87	Project	1	Captures PM3				
4444.87	Project	2	Captures PM1				
4654.87	Project	1	Release PM3				
4654.87	Project	2	Release PM1				
4654.87	Project	1	Time Left: 090348				
4654.87	Project	2	Time Left: 148255				
4654.87	Project	3	Captures PM3				
4684.92	Project	6	Request PM2				
4684.92	Project	4	Create Invoices: 1				
4684.92	Project	5	Create Invoices: 2				
4684.92	Project	4	Time Left: 210372				
4684.92	Project	5	Time Left: 139202				
4684.92	Project	6	Captures PM2				
4684.92	Invoice	1004	Arrive 4				1
4684.92	Invoice	2005	Arrive 7				1
4684.92	Invoice	3005	Arrive 3				1
4684.92	Invoice	1004	Wait for AP				
4684.92	Invoice	3005	Wait for AP				
4684.92	Invoice	1004	Capture AP				
4684.92	Invoice	3005	Capture AP				
4719.92	Invoice	2005	Wait for AP				
4800	Invoice	4000	O/H 2				1
4800	Invoice	5000	O/H 2				1
4800	Invoice	6000	O/H 2				1

4800	Invoice	7000	O/H 3	1	
4800	Invoice	8000	O/H 3	1	
4800	Invoice	4000	Wait for AP		
4800	Invoice	7000	Wait for AP		
4800	Invoice	8000	Wait for AP		
4835	Invoice	5000	Wait for AP		
4835	Invoice	6000	Wait for AP		
4864.87	Project	3	Release PM3		
4864.87	Project	3	Time Left: 069606		
4894.92	Invoice	1004	First Check Done		
4894.92	Invoice	3005	First Check Done		
4894.92	Project	6	Release PM2		
4894.92	Project	6	Time Left: 230991		
4894.92	Invoice	3005	Clarity Needed		
4899.92	Invoice	1004	Send to PM		
4899.92	Invoice	2005	Capture AP		
4899.99	Invoice	1004	Request PM2		
4899.99	Invoice	1004	Capture PM2	1	
4902.74	Invoice	1004	Good Invoice		1
4902.74	Invoice	1004	Wait for AP again		
4917	Invoice	1004	Capture AP Again		
4927.42	Invoice	4000	Capture AP		
4927.42	Invoice	1004	Ready to pay	1	
4972.42	Invoice	4000	First Check Done		
4987.42	Invoice	7000	Capture AP		
4987.42	Invoice	4000	Ready to pay	1	
5032.42	Invoice	7000	First Check Done		
5047.42	Invoice	8000	Capture AP		
5047.42	Invoice	7000	Ready to pay	1	
5092.42	Invoice	8000	First Check Done		
5107.42	Invoice	5000	Capture AP		
5107.42	Invoice	8000	Ready to pay	1	
5109.92	Invoice	2005	First Check Done		
5109.92	Invoice	2005	Clarity Needed		
5132.42	Invoice	6000	Capture AP		
5152.42	Invoice	5000	First Check Done		
5152.42	Invoice	5000	Clarity Needed		
5177.42	Invoice	6000	First Check Done		
5177.42	Invoice	6000	Clarity Needed		
5854.87	Project	1	Request PM3		
5854.87	Project	2	Create Invoices: 1		

5854.87	Project	1	Captures PM3		
5854.87	Project	2	Time Left: 147055		
5854.87	Invoice	9002	Arrive 2	1	
5854.87	Invoice	9002	Wait for AP		
5854.87	Invoice	9002	Capture AP		
5884.92	Project	4	Request PM2		
5884.92	Project	5	Time Left: 138002		
5884.92	Project	4	Captures PM2		
6064.87	Invoice	9002	First Check Done		
6064.87	Project	1	Release PM3		
6064.87	Project	3	Request PM3		
6064.87	Project	1	Time Left: 089148		
6064.87	Project	3	Captures PM3		
6069.87	Invoice	9002	Send to PM		
6069.99	Invoice	9002	Request PM1		
6069.99	Invoice	9002	Capture PM1	1	
6072.74	Invoice	9002	Good Invoice		1
6072.74	Invoice	9002	Wait for AP again		
6073	Invoice	9002	Capture AP Again		
6082.74	Invoice	9002	Ready to pay	1	
6094.92	Project	4	Release PM2		
6094.92	Project	6	Request PM2		
6094.92	Project	4	Time Left: 209172		
6094.92	Project	6	Captures PM2		
6274.87	Project	3	Release PM3		
6274.87	Project	3	Time Left: 068406		
6304.92	Project	6	Release PM2		
6304.92	Project	6	Time Left: 229791		
7054.87	Project	2	Request PM1		
7054.87	Project	2	Captures PM1		
7084.92	Project	5	Request PM2		
7084.92	Project	5	Captures PM2		
7118.99	Project	7	3 2		
7118.99	Project	8	3 3		
7118.99	Project	9	3 4		
7118.99	Project	7	Assigned to PM4		
7118.99	Project	8	Assigned to PM4		
7118.99	Project	9	Assigned to PM4		
7264.87	Project	2	Release PM1		
7264.87	Project	1	Request PM3		
7264.87	Project	2	Time Left: 145855		

7264.87	Project	1	Captures PM3		
7294.92	Project	5	Release PM2		
7294.92	Project	5	Time Left: 136802		
7294.92	Project	4	Create Invoices: 2		
7294.92	Project	4	Time Left: 207972		
7294.92	Invoice	10004	Arrive 2	1	
7294.92	Invoice	11004	Arrive 2	1	
7329.92	Invoice	10004	Wait for AP		
7329.92	Invoice	11004	Wait for AP		
7329.92	Invoice	10004	Capture AP		
7329.92	Invoice	11004	Capture AP		
7474.87	Project	1	Release PM3		
7474.87	Project	3	Request PM3		
7474.87	Project	1	Time Left: 087948		
7474.87	Project	3	Captures PM3		
7504.92	Project	6	Request PM2		
7504.92	Project	6	Captures PM2		
7539.92	Invoice	10004	First Check Done		
7539.92	Invoice	11004	First Check Done		
7544.92	Invoice	10004	Send to PM		
7544.92	Invoice	11004	Send to PM		
7544.99	Invoice	10004	Request PM2		
7544.99	Invoice	11004	Request PM2		
7684.87	Project	3	Release PM3		
7684.87	Project	3	Time Left: 067206		
7714.92	Project	6	Release PM2		
7714.92	Project	6	Time Left: 228591		
7714.92	Invoice	10004	Capture PM2	1	
7717.67	Project	10004	Difficult Invoice		
7740.17	Invoice	11004	Capture PM2	1	
7740.17	Invoice	10004	Good Invoice		1
7740.17	Invoice	10004	Wait for AP again		
7740	Invoice	10004	Capture AP Again		
7742.92	Invoice	11004	Good Invoice		1
7742.92	Invoice	11004	Wait for AP again		
7743	Invoice	11004	Capture AP Again		
7750.17	Invoice	10004	Ready to pay	1	
7752.92	Invoice	11004	Ready to pay	1	
8318.99	Project	7	Request PM4		
8318.99	Project	8	Request PM4		
8318.99	Project	9	Request PM4		

8318.99	Project	7	Captures PM4	
8464.87	Project	2	Create Invoices: 1	
8464.87	Project	2	Time Left: 144655	
8464.87	Invoice	12002	Arrive 2	1
8464.87	Invoice	12002	Wait for AP	
8464.87	Invoice	12002	Capture AP	
8494.92	Project	5	Request PM2	
8494.92	Project	4	Create Invoices: 1	
8494.92	Project	5	Captures PM2	
8494.92	Project	4	Time Left: 206772	
8494.92	Invoice	13004	Arrive 3	1
8528.99	Project	7	Release PM4	
8528.99	Project	7	Time Left: 117239	
8528.99	Project	8	Captures PM4	
8529.92	Invoice	13004	Wait for AP	
8529.92	Invoice	13004	Capture AP	
8674.87	Invoice	12002	First Check Done	
8674.87	Invoice	12002	Clarity Needed	
8674.87	Project	1	Create Invoices: 1	
8674.87	Project	1	Time Left: 086748	
8674.87	Invoice	14001	Arrive 2	1
8674.87	Invoice	14001	Wait for AP	
8697.37	Invoice	14001	Capture AP	
8704.92	Project	5	Release PM2	
8704.92	Project	5	Time Left: 135602	
8738.99	Project	8	Release PM4	
8738.99	Project	8	Time Left: 239410	
8738.99	Project	9	Captures PM4	
8739.92	Invoice	13004	First Check Done	
8739.92	Invoice	13004	Clarity Needed	
8884.87	Project	3	Request PM3	
8884.87	Project	3	Captures PM3	
8907.37	Invoice	14001	First Check Done	
8912.37	Invoice	14001	Send to PM	
8914.92	Project	6	Request PM2	
8914.92	Project	6	Captures PM2	
8914.99	Invoice	14001	Request PM3	
8948.99	Project	9	Release PM4	
8948.99	Project	9	Time Left: 207595	
9094.87	Project	3	Release PM3	
9094.87	Project	3	Time Left: 066006	

9094.87	Invoice	14001	Capture PM3		1
9097.62	Project	14001	Difficult Invoice		
9120.12	Invoice	14001	Good Invoice		1
9120.12	Invoice	14001	Wait for AP again		
9120	Invoice	14001	Capture AP Again		
9124.92	Project	6	Release PM2		
9124.92	Project	6	Time Left: 227391		
9130.12	Invoice	14001	Ready to pay		1
9600	Invoice	15000	O/H 4	1	
9600	Invoice	16000	O/H 2	1	
9600	Invoice	17000	O/H 2	1	
9600	Invoice	18000	O/H 2	1	
9600	Invoice	19000	O/H 2	1	
9600	Invoice	15000	Wait for AP		
9600	Invoice	16000	Wait for AP		
9600	Invoice	15000	Capture AP		
9600	Invoice	16000	Capture AP		
9635	Invoice	17000	Wait for AP		
9635	Invoice	18000	Wait for AP		
9635	Invoice	19000	Wait for AP		
9645	Invoice	15000	First Check Done		
9645	Invoice	16000	First Check Done		
9645	Invoice	16000	Clarity Needed		
9660	Invoice	17000	Capture AP		
9660	Invoice	15000	Ready to pay		1
9664.87	Project	2	Time Left: 143455		
9667.5	Invoice	18000	Capture AP		
9694.92	Project	4	Request PM2		
9694.92	Project	4	Captures PM2		
9705	Invoice	17000	First Check Done		
9712.5	Invoice	18000	First Check Done		
9717.42	Invoice	3005	Clarity Found		
9720	Invoice	17000	Ready to pay		1
9725	Invoice	3005	Send to PM		
9725	Invoice	19000	Capture AP		
9727.5	Invoice	18000	Ready to pay		1
9728.99	Project	7	Create Invoices: 2		
9728.99	Project	7	Time Left: 116039		
9728.99	Invoice	20007	Arrive 2	1	
9728.99	Invoice	21007	Arrive 2	1	
9728.99	Invoice	20007	Wait for AP		

9728.99	Invoice	20007	Capture AP		
9729.99	Invoice	3005	Request PM2		
9763.99	Invoice	21007	Wait for AP		
9770	Invoice	19000	First Check Done		
9770	Invoice	19000	Clarity Needed		
9792.5	Invoice	21007	Capture AP		
9874.87	Project	1	Request PM3		
9874.87	Project	1	Captures PM3		
9904.92	Project	4	Release PM2		
9904.92	Project	5	Request PM2		
9904.92	Project	4	Time Left: 205572		
9904.92	Invoice	3005	Capture PM2	1	
9907.67	Project	5	Captures PM2		
9907.67	Invoice	3005	Good Invoice		1
9907.67	Invoice	3005	Wait for AP again		
9932.42	Invoice	2005	Clarity Found		
9938.99	Invoice	20007	First Check Done		
9938.99	Project	8	Request PM4		
9938.99	Invoice	20007	Clarity Needed		
9938.99	Project	8	Captures PM4		
9961	Invoice	3005	Capture AP Again		
9971.49	Invoice	3005	Ready to pay	1	
9974.92	Invoice	5000	Clarity Found		
9976.49	Invoice	2005	Send to PM		
9979.99	Invoice	2005	Request PM2		
9991.49	Invoice	5000	Ready to pay	1	
9999.92	Invoice	6000	Clarity Found		
10002.5	Invoice	21007	First Check Done		
10007.5	Invoice	21007	Send to PM		
10009.99	Invoice	21007	Request PM4		
10014.92	Invoice	6000	Ready to pay	1	
10084.87	Project	1	Release PM3		
10084.87	Project	1	Time Left: 085548		
10117.67	Project	5	Release PM2		
10117.67	Project	5	Time Left: 134402		
10117.67	Invoice	2005	Capture PM2	1	
10120.42	Invoice	2005	Good Invoice		1
10120.42	Invoice	2005	Wait for AP again		
10120	Invoice	2005	Capture AP Again		
10130.42	Invoice	2005	Ready to pay	1	
10148.99	Project	8	Release PM4		

10148.99	Project	8	Time Left: 238210		
10148.99	Project	9	Create Invoices: 2		
10148.99	Invoice	21007	Capture PM4		1
10148.99	Project	9	Time Left: 206395		
10148.99	Invoice	22009	Arrive 2	1	
10148.99	Invoice	23009	Arrive 2	1	
10148.99	Invoice	22009	Wait for AP		
10148.99	Invoice	23009	Wait for AP		
10148.99	Invoice	22009	Capture AP		
10148.99	Invoice	23009	Capture AP		
10151.74	Invoice	21007	Good Invoice		1
10151.74	Invoice	21007	Wait for AP again		
10294.87	Project	3	Request PM3		
10294.87	Project	3	Captures PM3		
10324.92	Project	6	Create Invoices: 3		
10324.92	Project	6	Time Left: 226191		
10324.92	Invoice	24006	Arrive 3	1	
10324.92	Invoice	25006	Arrive 2	1	
10324.92	Invoice	26006	Arrive 2	1	
10324.92	Invoice	24006	Wait for AP		
10358.99	Invoice	22009	First Check Done		
10358.99	Invoice	23009	First Check Done		
10359.92	Invoice	25006	Wait for AP		
10359.92	Invoice	26006	Wait for AP		
10363.99	Invoice	22009	Send to PM		
10363.99	Invoice	23009	Send to PM		
10364	Invoice	21007	Capture AP Again		
10363.99	Invoice	24006	Capture AP		
10364.99	Invoice	22009	Request PM4		
10364.99	Invoice	23009	Request PM4		
10364.99	Invoice	22009	Capture PM4		1
10367.74	Invoice	23009	Capture PM4		1
10367.74	Invoice	22009	Good Invoice		1
10367.74	Invoice	22009	Wait for AP again		
10370.49	Invoice	23009	Good Invoice		1
10370.49	Invoice	23009	Wait for AP again		
10374	Invoice	22009	Capture AP Again		
10373.99	Invoice	21007	Ready to pay	1	
10384	Invoice	23009	Capture AP Again		
10383.99	Invoice	22009	Ready to pay	1	
10393.99	Invoice	25006	Capture AP		

10393.99	Invoice	23009	Ready to pay	1	
10504.87	Project	3	Release PM3		
10504.87	Project	3	Time Left: 064806		
10573.99	Invoice	24006	First Check Done		
10578.99	Invoice	24006	Send to PM		
10578.99	Invoice	26006	Capture AP		
10579.99	Invoice	24006	Request PM2		
10579.99	Invoice	24006	Capture PM2	1	
10582.74	Invoice	24006	Good Invoice		1
10582.74	Invoice	24006	Wait for AP again		
10603.99	Invoice	25006	First Check Done		
10603.99	Invoice	25006	Clarity Needed		
10626	Invoice	24006	Capture AP Again		
10636.49	Invoice	24006	Ready to pay	1	
10788.99	Invoice	26006	First Check Done		
10788.99	Invoice	26006	Clarity Needed		
10864.87	Project	2	Request PM1		
10864.87	Project	2	Captures PM1		
10928.99	Project	7	Request PM4		
10928.99	Project	7	Captures PM4		
11074.87	Project	2	Release PM1		
11074.87	Project	2	Time Left: 142255		
11104.92	Project	4	Time Left: 204372		
11138.99	Project	7	Release PM4		