Shaky Foundations: The Tradeoff between Structural Safety and Financial Security

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A Thesis

Presented to

The Faculty and the Honors Program

Of the University of San Diego

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2015

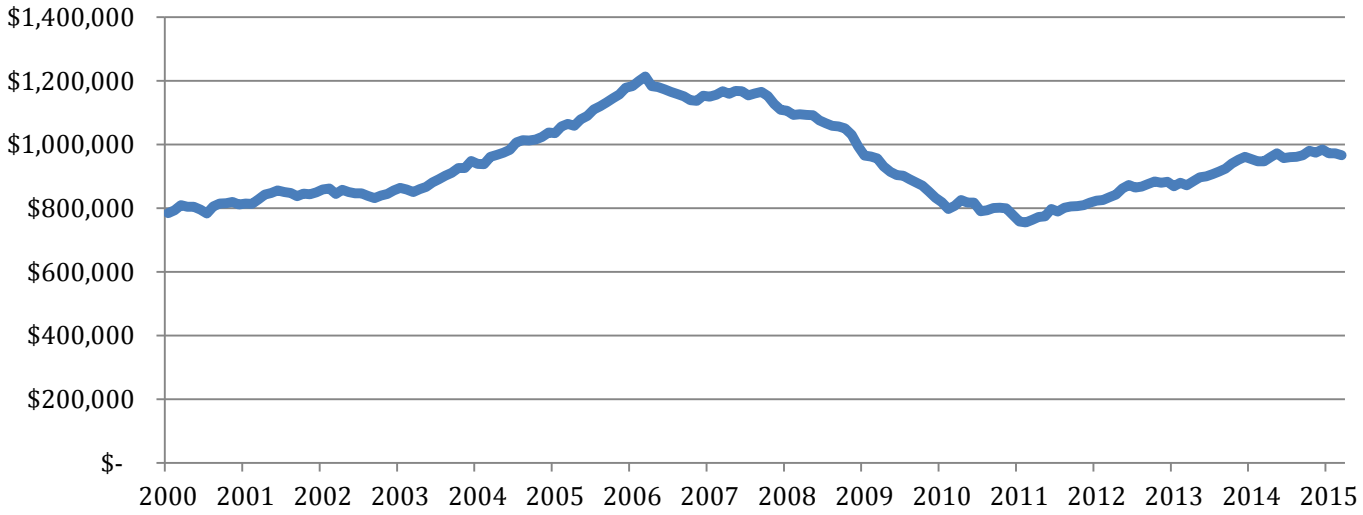
Abstract

This paper investigates the relationship between the financial positions of a subcontractor and their performance on the construction site. Financial default by a subcontractor can cost general contractors additional time and expense, as they try to find replacements and keep the projects on schedule. This highlights the importance of vetting subcontractors before awarding a bid. This study attempts to bridge the gap between the subjective nature of construction quality and the more technical financial analysis in determining the overall quality of subcontractors. Safety measures are also incorporated into performance ratings. Data is collected for the years 2009 through 2014 from JE Dunn Construction's private databases. A panel least squares regression is used to estimate subcontractor score. Results do not demonstrate any consistent relationship between financial health and performance quality, but do provide a foundation for further analysis and research.

I. Introduction

The construction industry is a leading indicator of economic development in the United States. In 2013, the construction industry was responsible for roughly 3.82% of the annual U.S. GDP, twice the size of the entire agricultural industry (BEA 2015). As the U.S. continues to recover from the Great Recession, the construction industry struggles to reach a full recovery. The unemployment rate within the construction industry remains at 9.5%, compared to the national average, which fell back to 5.6% (FRED 2015). While the construction unemployment rate remains stubbornly high, spending is beginning to heat up again, as seen in Figure 1. Total spending on construction in March 2015 nearly reached $967 billion, approaching its prior monthly peak at $1.2 trillion in January 2006.

Figure 1. Total Construction Spending (Millions of $)



Source: Federal Reserve Economic Data (FRED), St. Louis Federal Reserve Bank
Note: Author's figure

During this fragile recovery period, financial default for construction firms is increasingly common. The growth phase occurring in the construction industry creates an environment that is extremely risky for general contractors. These firms are plagued by some of the lowest profit margins of any sector at 3.9% (Yahoo! Business 2015), hence even small delays or unforeseen costs can turn a profitable project into a loss. This necessitates taking proactive measures to protect the bottom line. The large, national general contractors are implementing Risk Management departments responsible for subcontractor prequalification to defend their profitability in this unpredictable economic environment.

At JE Dunn Construction, Risk Analysts evaluate the financial statements of subcontractors and factor in performance reviews from Project Managers and safety ratings. While the lowest bidder is the most desirable option to keep project costs low, they are frequently the subcontractors at highest risk of default. For this reason, Risk Analysts tend to recommend an alternative, albeit slightly more expensive, subcontractor. Project Managers would rather hire the lowest bidder and face the default risk, so there can be a conflict of interests between the two departments when awarding bids. This paper seeks to find a relationship between financial health of the subcontractor and

performance quality to substantiate the Risk Management department's claim that the lowest bidder is not always the best option.

II. Literature Review

There is much research surrounding the issue of financial default, a topic which is even more relevant in light of the Great Recession. Economists spend time exploring default at the institutional, individual, and firm levels, but most of the recent literature surrounds bank portfolios in an effort to learn from the financial crisis of 2007-2008. Little research on default concentrates on the construction industry, despite the fact that subcontractors are three times more likely to default in a period of economic recovery than at any other time[1]. There is also much debate surrounding the best way to study financial default, because each study deems a different set of financial ratios important, and each uses a different empirical framework.

Cheng and Shimerda (1981) recognize that a universal set of financial ratios does not exist for econometric analysis on default. Every study has its own set of ratios, each with a different focus. Cheng and Shimerda (1981) examine over 100 ratios and find that most can be classified as one of seven categories: Return on Investment, Capital Turnover, Financial Leverage, Short-Term Liquidity, Cash Position, Inventory Turnover, and Receivables Turnover. Similarly, Tserng et al. (2012) sort 21 financial ratios into five categories: Liquidity, Leverage, Asset Utilization or Turnover (Activity), Profitability, and Market Value. Both studies agree that a single variable from each group can provide value to predictive models while avoiding overlap of information. Tserng et al. (2012) suggest selecting one from each category, to give a comprehensive view of a firm's financial position.

Tserng et al. (2012) include a market value factor to explore the effects of market factors on the probability of financial default in American construction firms. They find the book-to-market ratio significantly improves the predictive power of each of their logit models, suggesting external factors may be somewhat responsible for the financial

[1] Wolfe Jr, S. (2014, September 2.) Why Subcontractors Fail and What to Do About It. Retrieved February 18, 2015 from http://enewsletters.constructionexec.com/riskmanagement/2014/09/why-subcontractors-fail-and-what-to-do-about-it/

viability of a firm. Bottazzi et al. (2011) use the probit model instead to predict financial default in Italian firms across many industries, accounting for both financial and economic variables. The results indicate economic factors, such as labor productivity and profitability, have significant negative relationships with firm default. This follows their hypothesis that a productive and profitable firm is less likely to experience financial distress. Firm size is also significant, but demonstrates a positive relationship with default. The paper suggests that although larger firms may have higher chances of default, these firms also have established banking relationships and are more likely to survive brief periods of financial hardship than small firms. Revenue growth exhibits a positive relationship but is hardly significant. Bottazzi et al. (2011) also find the cost of debt to be the most important financial ratio, whereas Tserng et al. (2012) determine return on assets to be the most useful. While this disagreement is common in these analyses, it is generally agreed that no one variable can accurately predict default and a holistic approach must be taken.

Altman (1968) employs multiple discriminant analysis to determine which characteristics distinguish bankrupt firms from non-bankrupt firms. Altman (1968) suggests that predictions could accurately be made 2 years prior to default, which he successfully does 94% of the time in his samples. Tserng et al. (2012) settle on this exact timeframe as well, although they do acknowledge that predictions can be reasonably made up to 3 years prior. Bottazzi et al. (2011) do not specify a time period, but suggest both economic and financial variables are significant in the long and short term.

There is hardly any research on financial default that considers variables outside of the firm's financial or economic environment. In the construction industry, however, the safety of its workers is paramount to a firm's reputation and overall success. Companies that receive citations for failing to meet safety regulations face hefty fines, which has obvious financial implications. Weil (1992) explores the effect of labor unions on the enforcement and efficacy of the Occupational Health and Safety Administration (OSHA). His results indicate that workers are more easily able to exercise their rights in unionized firms and that OSHA inspectors spend more time on unionized sites. Weil (1992) concludes unions play a significantly positive role in workplace quality for construction workers, which in turn has positive effects on the firm's reputation.

Previous studies either examine the financial and economic factors influencing a firm's success or failure, or the effects of legislation and unionization on workplace safety. These studies fail to integrate financial variables with other qualitative measures of healthy firms, like the safety of its workers or quality of work performed. The following study will combine financial ratios and safety ratings to predict an overall qualitative score for each subcontractor. The Project Management and Risk Management teams at JE Dunn Construction can use these scores to guide decisions when selecting subcontractors for upcoming projects.

III. Empirical Framework

A. Empirical Methodology

This paper explores the components of the score, *Score*, JE Dunn uses to rank subcontractors. The hypothesis is that financially healthy subcontractors will receive higher scores than their financially shaky counter-parts . Scores are determined by Project Managers overseeing each project, who complete a ten question survey regarding their experience with each subcontractor. The Project Manager ranks the quality of each topic from 1 to 5, where 1 is "Excellent" and 5 is "Poor." The ten scores are then averaged together. The best average score a subcontractor could receive is 1, therefore a negative relationship is expected between most financial ratios and score, so that as ratios increase in value, the numeric score decreases and approaches "Excellent."

The survey questions primarily focus on safety, schedule, price, and quality of the subcontractor's construction team. These factors affect the way Project Managers perceive the quality of a subcontractor and influence their decision to rehire the firm for future projects. On the other hand, the Risk Management department assesses subcontractors on the merits of their financial statements. Both teams consider safety ratings, as these can affect cash flow, time-to-completion, lost workdays, and profit margin on a project. Since the decision to award a bid is reached by a joint effort of both the Risk Management and Project Management teams, a combination of these factors must be considered when quantifying the quality of a subcontractor.

As the old adage goes, cash is king. Cash flow is one of the primary factors considered when selecting a subcontractor. Most subcontractors incur the bulk of their

materials and labor costs up front and are paid once they achieve certain benchmarks. This requires a healthy cash flow to stay afloat throughout the contract. Since a subcontractor with weak cash flows may be unable to pay its workers on time, there is a greater chance its laborers will not report to the jobsite, resulting in a delay of the project. Potential delays diminish the general contractor's profit margin. Thus, Risk Analysts consider various financial ratios to assess the health of a subcontractor's cash flow. These financial ratios are lagged by two years to reflect the information lag between the time a bid is awarded and the completion of the same project, when the survey is completed and a score is determined.

One of such ratio is the current ratio, *CurrentL2*, which is a quick test to gauge how well a firm can cover its current debt, given the liquid assets it has on hand. It is calculated by dividing current assets by current liabilities, such that a value greater than 1 indicates the company can pay off any debt that is currently due. Risk Analysts prefer subcontractors with current ratios well above 1 and become quite cautious when it dips below this threshold. Therefore, a negative relationship is expected between *CurrentL2* and *Score*, because firms with higher current ratios are less likely to have cash flow problems and are thus expected to receive scores closer to 1, or "Excellent." Another indicator of effective cash management is a firm's profit margin, *ProfitL2*, which measures net income against revenues. This is also expected to be negative, for similar reasons as the current ratio.

Current debt represents the payments a company must make within the next year, giving insight into where and how much of a firm's cash will be tied up in the coming year. Current debt is composed of current portions of long-term debt, like current payments on loans, lines of credit, or notes payable. Current debt is scaled against total debt, *DebtRatioL2*, to account for the range in size of firms included in this study. It is expected that as the current debt percentage increases, the firm will receive a less favorable score, as more of a firm's cash flow will be unavailable for use in its operations. There is the possibility that some subcontractors are making final payments on long-term debt and have not incurred any new debt. In these cases the current debt to total debt ratio would be very high, but the firm may be quite healthy financially if it does

not have a need for additional long-term debt. For these reasons the variable could carry a positive or negative sign.

The final financial variable included in the equation is *LnCashL2*, which represents the amount of cash in a subcontractor's account. This is the most liquid asset and can ease the cash flow constraints placed on a firm. High levels of cash also make a subcontractor a more attractive loan or bond candidate. *LnCashL2* is predicted to have a negative relationship, as firms with larger amounts of cash are less likely to experience financial difficulty and result in a more favorable score, closer to the 1 of "Excellent." The natural log is taken to account for the difference in size of subcontractors.

Return on assets, *ROAL2*, is included based on Tserng et al.'s conclusion that it is the financial ration with the strongest predictive power. Return on assets is measured as income over total assets and indicates how efficiently a company converts its assets into profit. *ROAL2* is expected to carry a negative sign because a higher ratio suggests more effective resource allocation.

Backlog, *LnBacklog*, is the amount of work a subcontractor has contracted but not yet completed. This can include projects in progress for which they have not received payment and future projects not yet started. Backlog is not limited to a calendar or accounting year, as many projects span lengths of time greater than this. Backlog is an important variable to consider because it indicates what kind of commitments the subcontractor faces. A growing backlog represents an increasing workload, which increases the chances of manpower shortages or project delays. With burgeoning commitments, the firm will experience increased financial stress. The natural log is taken to account for the wide range in size of subcontractors, as local firms will have a much smaller backlog than large, national subcontractors. This variable is not lagged because it is the current backlog that impacts the firm's performance on the jobsite. Due to this theoretical analysis, a positive relationship is expected between *LnBacklog* and *Score*.

Safety ratings are accounted for in a subcontractor's Experience Modification Rating, *EMRL1*. It is a multiplier used by insurance companies to determine premiums for a construction subcontractor. An EMR of 1 indicates the subcontractor is on par with the rest of the industry. A score well below 1 is desired, as safety violations can result in serious injuries, lost workdays, higher premiums, and expensive claims for the general

contractor. An EMR that approaches the 0.9 territory is considered risky and is closely managed by project management teams and safety staff on the job site. Firms with an EMR above 1 are rarely considered for a bid because of the high risk they carry. Thus it is predicted that there will be a positive relationship between *EMRL1* and *Score*, for an increasing EMR will be reflected unfavorably in the safety portion of the Project Managers' survey. The variable is lagged one year to reflect the score available to the Risk Management and Project Management teams when awarding bids.

Two dummy variables are included to provide additional information about the safety policies of subcontractors. *SafeProg* = 1 if the subcontractor has a written safety policy, 0 if not. Similarly, *SafeNew* = 1 if the subcontractor provides safety training to its new hires, and 0 if it does not. Companies who have a written safety policy and provide training to recently hired employees demonstrate an intentional and proactive approach to reducing risk at the construction site. These companies are also expected to have lower EMR scores, so it is possible there may be some multicollinearity between these three variables. For these reasons it is hypothesized that both *SafeProg* and *SafeNew* will carry negative signs.

Past performance is often considered to be indicative of future behavior, so the subcontractor's score from the prior year is included as *ScoreL1*. A subcontractor who has consistently scored poorly is likely to continue to score poorly in future surveys, unless there has been a change to the company's management team or company policies. Both Project Managers and Risk Analysts consider past scores when reviewing bids, and it is not uncommon to call the Project Manager from a past project to hear their opinion. Thus a positive relationship is expected between *ScoreL1* and *Score*, so that a higher score closer to 5 is likely to indicate a subcontractor which would score poorly again in the future.

The population equation is as follows:

$$Score_{it} = \beta_0 + \beta_1 CurrentL2_{it} + \beta_2 ProfitL2_{it} + \beta_3 DebtRatioL2_{it} + \beta_4 LnCashL2_{it} + \beta_5 ROAL2_{it} + \beta_6 LnBacklog_{it} + \beta_7 EMRL1_{it} + \beta_8 SafeProg_{it} + \beta_9 SafeNew_{it} + \beta_{10} ScoreL1_{it} + \alpha_i + u_{it}$$

Variable definitions and data sources can be found in Table 4 in the appendix.

The Hausman test rejects the null that random effects are preferred, hence fixed effects are used in Equations 1. Equation 2 uses an OLS estimation to include the effects of the safety dummies. Some multicollinearity is expected between the three safety variables, but proves not to be an issue, as seen in the correlation matrix in Table 2. This is further supported by the VIF test, which returns values below 1.82 for all variables. Serial correlation is not a concern because the data is considered a micro-panel, only spanning the years 2009-2014. Lagged variables further remove the chances of any minor serial correlation. Heteroskedasticity is detected and corrected for using White's robust standard error in Equations 1. Alternatively, the variance-covariance matrix clustered standard errors are used in Equation 2, clustered at the firm level.

While there are many financial aspects considered by Risk Analysts, the ones included are limited to those with available data. Aside from credit or bid spreads, which are unavailable for this study, all aspects of the decision-making process are represented in the equation.

B. Data and Descriptive Statistics

Financial and safety data was collected from JE Dunn Construction's Subcontractor Management System (SMS), which is maintained by the company's Risk Management department. This dataset is combined with the JE Dunn Project Manager survey results at the close of each construction project. One survey is completed for each subcontractor that works on a project. Some subcontractors complete multiple projects in one calendar year, so the scores are averaged into one score for the year. The data is pooled and spans the years 2009 – 2014.

To mimic the time lag that occurs between the decision to hire a subcontractor and contract completion, financial variables are lagged by two years. For example, assuming a 12-month contract, a survey completed in 2011 would correspond with a decision date in 2010. Unfortunately, the most recent financial statements available to Risk Analysts at the time are those from the prior year, which would be 2009 in this example. EMR rates are typically available for the current decision year, so EMR is only lagged by one year. Subcontractors that report quarterly financial data or no long-term

debt were removed to preserve consistency in the dataset. With these parameters, there are 199 unique companies and 280 observations.

The natural log of Backlog is taken to scale the variable creates a smaller range with less variation. The current ratio and the natural log of the second lag on Cash exhibit a wide range with fairly large standard deviations. This could be a side effect of the self-reported nature of the data. Some subcontractors may choose to round, omit, or otherwise alter some values, which could cause some of the unusual values seen in the data.

Table 1. Descriptive Statistics of the Data Set

Variable	Obs.	Mean	Std. Dev.	Min	Max
Score	3526	2.312	0.624	1	5
CurrentL2	655	4.271	12.946	-11.889	256.45
ProfitL2	656	0.116	1.038	-0.317	25.659
DebtRatioL2	528	0.537	0.357	0.000	1.086
LnCashL2	623	12.875	2.488	0.000	21.297
ROAL2	657	0.079	0.275	-2.412	3.781
LnBacklog	1762	11.203	3.052	0.000	17.774
EMRL1	670	0.885	0.155	0	1.620
SafeProg	3556	0.976	0.154	0	1
SafeNew	3543	0.947	0.225	0	1
ScoreL1	1462	2.230	0.510	1	4.5

Source: JE Dunn Construction
Note: Author's calculation

Table 2. Correlation Matrix

	Score	CurrentL2	ProfitL2	DebtRatioL2	LnCashL2	ROAL2	LnBacklog	EMRL1	SafeProg	SafeNew	ScoreL1
Score	1										
CurrentL2	-0.072	1									
ProfitL2	-0.066	-0.023	1								
DebtRatioL2	0.110	0.017	-0.093	1							
LnCashL2	0.014	-0.012	-0.038	-0.182	1						
ROAL2	-0.027	0.023	0.649	-0.123	0.067	1					
LnBacklog	0.004	-0.041	-0.171	0.029	0.231	-0.178	1				
EMRL1	0.066	0.070	0.099	0.061	-0.258	-0.013	-0.113	1			
SafeProg	-0.145	0.018	-0.095	0.019	0.061	-0.004	-0.055	-0.144	1		
SafeNew	-0.086	0.013	0.043	-0.105	0.159	0.010	-0.041	-0.039	0.283	1	
ScoreL1	0.425	-0.131	-0.005	0.068	0.012	-0.057	-0.019	0.033	-0.130	0.016	1

Source: JE Dunn Construction
Note: Author's calculation

IV. Empirical Results

Both OLS and fixed effects regressions were tested, but the following discussion will focus primarily on the results of the fixed effects equation. The model has an R-squared of 0.271, indicating it explains about 27.1% of the variation in score for each subcontractor over time. While it cannot account for the full variation, it does provide valuable insight into the relationship between quality of work performed and the firm's financial position.

It is important to remember when interpreting coefficients that a negative sign suggests an improvement in *Score* as it nears the 1 of "Excellence" and a positive relationship is actually a worsening in *Score* as it moves closer to the 5 of "Poor" quality. Only two of the financial variables are significant in the model, conflicting with the hypothesis that finances impact the quality of a subcontractor. The *CurrentL2*, *DebtRatioL2*, and *LnCashL2* variables are statistically insignificant across all models. *ProfitL2* is significant at the 1% level and has the expected negative relationship with *Score*. For every 1% increase in the subcontractor's lagged profit margin, their survey score can be expected to improve by nearly two-thirds of a point. It becomes insignificant in the OLS estimation in Equation 2, however.

ROAL2 reacts in an opposite fashion, changing from insignificant in Equation 1 to significant at the 10% level in Equation 2. The positive sign conflicts with expectations, implying that as the return on assets ratio increases by 1%, scores will actually worsen by 0.182 points. This counteracts the idea that return on assets acts as a proxy for effective cash management. It is possible that this result is characteristic of cost cutting. When management cuts costs, they will have a higher net income, so that the numerator in the ratio will increase while the total assets denominator remains the same, thereby increasing the return on assets. While this is a reasonable and common practice, it is possible that management is sacrificing quality of materials or foregoing experienced workers in favor of cheaper options. If this is the case, then a positive coefficient can be justified.

LnBacklog is dropped from Equation 1 due to multicollinearity. Backlog is expected to vary some year over year, but subcontractors want to maintain relatively stable levels of future work as this is their source of revenue, suggesting that backlog is

more time invariant than previously thought. It is insignificant in the OLS equation, suggesting the size of a subcontractor's upcoming workload does not affect the financial stress felt by the firm and thus does not have a significant impact on the qualitative score it receives.

EMRL1 displays a significant negative coefficient in Equation 1, so that a 1-point drop in EMR would improve the subcontractor's score by 1.33 points. It becomes insignificant in the OLS equations, however. The other two safety variables, *SafeProg* and *SafeNew*, are dropped from the panel regression due to multicollinearity. While it is possible that a firm did not have a written safety program or provide safety training to its new hires and later changed its policies, there were not enough of these cases to avoid multicollinearity. This suggests that a firm's safety policies, and by extension its attitude toward safety, remains consistent over time within each subcontractor.

SafeProg is significant at the 1% level in the OLS model, indicating that a subcontractor with a written safety program will have a score 0.46 points better than a subcontractor without one. *SafeNew* is not significant but does have the expected negative coefficient. Although these three safety variables are never simultaneously significant, these results can somewhat affirm the hypothesis that safety programs and a culture of safety do improve the overall quality of a subcontractor.

ScoreL1 is significant for both models, but differs from expectations in Equations 1 with a negative sign. A subcontractor with a score that is 1 point worse in the prior year can be expected to improve their score by almost a third of a point. This result suggests firms that receive unsavory scores have incentive to improve their performance in the future, knowing they will not win bids if they have a poor reputation within the industry. Conversely, *ScoreL1* is significantly positive in the OLS estimations in Equation 2. As discussed earlier in this paper, it is possible that subcontractors who have scored poorly in the past are likely to score poorly again in the future unless some meaningful change occurs in their management or construction teams.

Table 3. Regression Results

	(1)	(2)
	Fixed Effects, Robust	**OLS, VCE Clustered SE**
CurrentL2	-.008 [.010]	-.002 [.003]
ProfitL2	-.657*** [.231]	-.242 [.190]
DebtRatioL2	-.033 [.187]	.133 [.093]
LnCashL2	-.033 [.041]	.011 [.014]
ROAL2	.540 [.622]	.182* [.109]
LnBacklog	-	-.002 [.010]
EMRL1	-1.334*** [.501]	.263 [.224]
SafeProg	-	-.463*** [.173]
SafeNew	-	-.159 [.164]
ScoreL1	-.304** [.124]	.516*** [.084]
Constant	4.568*** [.823]	1.299** [.500]
Adj. R-squared	.271	.212
Root MSE	.177	.530
Obs.	280	280
Number of Companies	199	

*p<.1, **p<.05, ***p<.01
Note: Standard errors in brackets

V. Conclusion

This paper determines the impact of financial stability on the overall quality of a firm. Previous literature determines financial default can be predicted up to three years in advance by considering a variety of financial ratios. Other research has determined safety regulations have a positive impact on the overall welfare of construction workers, and by extension the reputation of the firm for which they work. This study does not predict financial default, but instead hypothesizes that financial stress will negatively impact the quality of a subcontractor. Several financial ratios are combined with safety and quality of work variables to examine the characteristics that lead to a highly rated firm.

The results of this research suggest that financial stability is not necessarily an attribute of "excellent" subcontractors. While profit margin and return on assets have some significance, neither is dependable in both equations. Thus the claim that financially stable subcontractors are preferred lacks an empirical foundation. It is important to remember that survey scores are a reflection of the subcontractor's performance on the jobsite, and do not directly incorporate the effects of financial stress or instances of default. We can conclude that the quality of construction work is not dependent upon healthy financial statements. Many subcontractors are small operations with a few very experienced construction workers who are masters of their craft. The subcontractor may not have experience balancing the books or compiling financial statements, which would explain the phenomenon of a financially unstable firm scoring well in its Project Manager surveys.

It is determined that subcontractors that place an emphasis on safety do tend to score more favorably than those that do not. While no one safety variable can conclusively determine the strength of the relationship between a culture of safety and overall firm quality, both lowering EMR and creating a written safety program can improve subcontractor quality to some degree. JE Dunn's emphasis on hiring subcontractors with outstanding commitments to the safety of their workers can be reasonably justified and should be continued.

While there is not much of a quantifiable relationship between the financial state of a firm and the quality of work it performs, this paper does not advocate hiring the lowest bidder in every instance. A holistic approach should be taken to build a

comprehensive risk profile by considering all facets that could affect any part of the construction cycle. This will require more open channels of communication between the Risk Management department and Project Managers. The two departments will continue to focus on their areas of expertise, but need to work in tandem to effectively minimize both construction and financial risk.

Tension arises between the two departments because Risk Management targets default risk, while the Project Management team seeks out subcontractors who can provide quality work at the lowest price. There seems to be a misalignment in definition of the term "quality subcontractor." When Risk Analysts use the term, they are referring to the financial position of the firm, whereas Project Managers assign the phrase to subcontractors who build correctly and cheaply. Both departments need to redefine their notions of a "quality subcontractor" to include both financial stability and performance of work. This will result in alignment between the two departments' goals, so that one type of risk management is not sacrificed in favor of the other.

While this research begins to shed light on the characteristics that affect subcontractor quality, there are a few shortcomings. The data in this study is self-reported by subcontractors, so some error is expected within this process. Risk Analysts are able to bypass this problem by using audited financial statements, but these were not available for this study. Thousands of companies are stored within JE Dunn's SMS database, but observations are a small fraction of this due to a lack of continuity in the data. The frequency with which firm information is updated is inconsistent, because it relies on a subcontractor taking the initiative to respond to automated prompts to update its accounts. Contact information for these system-generated reminders are not always accurate, so there are many obstacles to obtaining useful data. Information regarding the demographics of a firm was also unavailable, making it difficult to control for some firm attributes.

Future research should aim to use audited financial statements. A balanced panel should also be used, with several years of data for each subcontractor included in the study. Control variables should be included to reflect the type of subcontractor, years in business, size, and operational regions. A variable indicating past default could be useful as well. It would be interesting to expand this research to predicting default of a

subcontractor or to explore factors beyond financial health and safety ratings that affect overall firm quality. With some expansion, this research could be quite insightful and used to guide department policy when awarding bids and analyzing the overall risk of a project.

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Appendix

Table 4. Variable Definitions

Variable	Definition	Source
Score	Subcontractor's average annual score from Project Manager surveys	SMS database
CurrentL2	Second lag of the current ratio	SMS database
ProfitL2	Second lag of profit margin	SMS database
DebtRatioL2	Second lag of current debt as a percent of total debt	SMS database
LnCashL2	Second lag of the natural log of cash account	SMS database
ROAL2	Second lag of the return on assets ratio	SMS database
LnBacklog	Natural log of backlog	SMS database
EMRL1	First lag of Experience Modification Rating	SMS database
SafeProg	Dummy variable indicating whether or not the subcontractor has a written safety program, 1=Yes, 0=No	SMS database
SafeNew	Dummy variable indicating whether or not the subcontractor provides safety training to newly hired employees, 1= Yes, 0= No	SMS database
ScoreL1	First lag of Score - the subcontractor's score from the previous year	SMS database

Note: All data spans the years 2009 – 2014. Return on assets is a calculation of net income divided by the sum of cash, accounts receivable, and current assets, all of which are sourced directly from the SMS database.