Management and Production Engineering Review
Volume 13 • Number 2 • June 2022 • pp. 61–70
DOI: 10.24425/mper.2022.142055

An Empirical Examination of The Relationship between Capability Maturity and Firm Performance across Manufacturing and IT Industries

Louise HAYES, Jing LU, Davar REZANIA

Department of Management, Gordon S. Lang School of Business and Economics, University of Guelph, Canada

Received:10 May 2021
Acepted: 24 May 2022

Abstract
We investigate the effect on firm performance of the motivation for applying maturity models in manufacturing and information technology organizations. We expect the association between profitability and maturity models to be less if motivated by external contract requirements (e.g., for certain government contracts), than if motivated internally to improve processes. Using a sample of firm-year observations for 1,105 SEC registrants in the manufacturing (Standard Industry Classification (SIC): 3600∼3812) and IT industries (SIC: 7370∼7374) for 2017 and 2018, and CMMI information from the CMMI institute published appraisal results system, it is observed that 28 public firms (17 IT firm-years and 23 manufacturing firm-years) in the sample had CMMI appraisals between 2017 and 2018. We use logistic regression to test if the likelihood of CMMI appraisal is positively associated with government sales. The results support for the manufacturing industry, but not for the IT industry, prior research's assertion that maturity is a source for competitive advantage.

Keywords
Capability maturity, quality management, certification, maturity model.

Introduction

Quality management shapes organizational performance as it emphasizes process improvements aligned with an organization's strategic objectives (Sztorc & Savenkovs, 2020). Recent reviews confirm the currency of continuous improvement for business success (Santos et al., 2021). Capability maturity models, which were developed first in the software industry by the Software Engineering Institute at the Carnegie Mellon University, emphasize incremental and structured enhancements to processes and performance. Their success in the software industry popularized them and other industries such as manufacturing and services adopted and tailored them to their needs. Examples include Capability Maturity Model Integration, and Software Process Improvement and Capability determination.

The Capability Maturity Model (CMM) provides a framework for achieving continuous process improvement through five evolutionary levels. At level 1, the Initial Level, an organization has few standard practices and projects do not operate on planned procedures. At this level, performance is more dependent on individuals not of the organization. At level 2, the Repeatable Level, an organization is more "disciplined" as standards and policies for managing a software project are established. This enables the organization to track cost schedule and functionality of projects and use data and observations of previous projects to develop realistic project commitments. At level 3, the Defined Level, standards are institutionalized through organization wide training programs. At this stage management has good insight into technical progress on all projects. At level 4, the Managed Level, the organization emphasizes quantification and predictability as it sets quantitative quality goals for both software products and processes. Quantification enables projects to narrow the variation in their process performance and ensure it falls within acceptable quantitative boundaries. At level 5, the Optimizing

Corresponding author: *D. Rezania – Gordon S. Lang School of Business and Economics, University of Guelph, Department of Management, Macdonald Hall (RM209), 50 Stone Rd E, Guelph, ON, N1G 2W1, phone: +1 519-824-4120 Ext. 54257, e-mail: drezania@uoguelph.ca*

Level, the entire organization is focused on continuous improvement. The focus is on double loop learning as the causes of defects are identified and controlled, and lessons learned are disseminated to other projects.

These five maturity levels enable an organization to assess its capability maturity and take actions to improve it. Kosieradzka and Ciechanska (2018) relate best practices in Lean Manufacturing, Total Quality Management, Total Productive Maintenance, Theory of Constraints, Six Sigma, and Kaizen production management systems to these five levels. In spite of the recognition of the importance of capability maturity for a firm's performance, and the continuing development of maturity models, including specialized models such as project management maturity models (Grant & Pennypacker, 2006) and digital maturity models (Sandor & Guban, 2021), few studies have examined the relationship between capability maturity and financial performance. This study extends quality maturity management research by studying the association between firm performance and the motivation for applying maturity models. We explore whether the motivation for maturity model application affects firm financial performance. Survey evidence (Thibodeau, 2013; White, 2018), suggests that external government contractual requirements are driving the propensity for maturity model certification. Consistent with this conjecture, we ask (1) is there a positive association between maturity and government sales and (since we expect the motivation for maturity model certification will differ by industry) (2) will a positive association between firm performance and maturity proxy depend on industry?

We contribute to the discourse on the importance of capability maturity for the firms by examining whether the likelihood of Capability Maturity Model Integration (CMMI®) appraisal is increasing in government sales for both IT and manufacturing firms. This would suggest that profitability may be driven not only by maturity, but also by higher sales due to securing government contracts. An important contribution of this exploratory study is its empirical examination, using publicly available data, of the relationship between financial performance and maturity. Our finding adds to the inconclusive evidence linking project management maturity to project success in prior studies (Grant & Pennypacker, 2006; Ibbs & Kwak, 2000; Jugdev & Thomas, 2002). However, by suggesting that the motivation for application of maturity models may explain the industry differences in our study, we contribute to the project management maturity literature and provide a foundation for further studies.

Literature review

While quality maturity management improves organizational performance (Van der Wiele, Brown, Millen, & Whelan, 2000), Hardie (1998) cautions that those studying the link between quality and business performance must consider how definitions, measures of quality, and business outcomes vary from organization to organization. In addition, for project-based organizations, because the definitions, measures of quality and business outcomes of projects may differ from those of the organization as a whole, studying capability maturity may shed light on the "uncertainty associated with the causal chain from quality to business performance" (Hardie, 1998, p. 76). The Project Management Institute (PMI) defines a project as a time bounded endeavor undertaken to create a unique product or service (PMBOK, 2008). Effective project management enables organizations to carry out large-scale projects on time, within budget and with minimal disruption to the rest of the business. According to a PricewaterhouseCoopers – 2012 global survey of CEOs entitled "Insights and Trends: Current Portfolio, Programme, and Project Management Practices", 97% of respondents agreed project management is critical to business performance and organizational success and 94% agreed that project management enables business growth. More recently, over 45% of respondents to global survey of project management practitioners, reported that their organization has "a formal process to mature existing project/portfolio management practices" (Langley, 2018, p. 24).

For manufacturing and IT industries, the potential of project management as a way of organizing work for value creation is well recognized (Laursen & Svejvig, 2016; Winter & Szczepanek, 2008). However, there are many risks associated with projects. It is recognized that standardization approaches to project management is important for risk management and successful delivery of the project outcomes (Milosevic & Patanakul, 2005). No wonder the project management literature has paid so much attention to conceptualization of project management maturity models and the impact of standardization of project management practices as an internal control mechanism on project management performance (e.g. Liu, Chen, Chan, & Lie, 2008).

The proliferation of PMMMs beginning in the 1990s (Grant & Pennypacker, 2006) triggered many academic studies of project maturity and PMMM assessment (e.g., Andersen and Jessen, 2003; Mullaly, 2006), PMMM organizational impacts (e.g., Ibbs &

Kwak, 2000; Yazici, 2009), and project management maturity as a potential source of competitive advantage (Jugdev & Thomas, 2002). While early research provided insights into the development, assessment, industry differences and benefits of PMMMs (Albrecht & Spang, 2014), more recent literature has focused on the variations and shortcomings of PMMM (Brookes, Butler, Dey, & Clark, 2014; Mullaly, 2014) and the need for greater consideration of organizational and contextual factors (e.g., Aubry, 2015; Backlund, Chronéer, & Sundqvist, 2015; Görög, 2016; Mir & Pinnington, 2014; Sanchez, Micaelli, Bonjour, & Monticolo, 2019).

According to the resource-based view (Barney, 1991), differences in competitive advantage are fundamentally due to the distinctive resources and capabilities that are valuable, rare, inimitable and nonsubstitutable. Competitive advantage is sustained when a firm implements a strategy that cannot be duplicated. Project management as a part of a firm's resource portfolio and its relationship with firm performance has been subject of several studies (Jugdev, 2004; Jugdev, Mathur, & Fung, 2007; Rezania & Ouedraogo, 2014). Jugdev & Thomas (2002) examine project management maturity models as indicators of a firms' project management practices and their potential for a source of competitive advantage. They indicate that project management maturity can lead to temporary competitive advantage.

Externally imposed demands for certification and its effect on firm performance is an organizational and contextual factor that has not been explored in PMMM research. In contrast, as shown by Sampaio et al.'s (2009) literature review, the benefits, barriers and drawbacks to ISO 9001 certification have been extensively studied. Extant literature shows (Sampaio, Saraiva, & Rodrigues, 2009) that seeking certification for external motivations (e.g., contractual reasons) is associated with achieving mostly external benefits (e.g., market share improvement), while seeking certification for internal reasons (e.g., process improvement) is associated with achieving mostly internal benefits (e.g., internal organization and competitive advantage improvement). Based on their literature review, Sampaio et al. (2009, p. 48) conclude that when "firms simply react to external pressures for getting certified, they may face ISO 9001 registration as a prime objective of itself, adopt a minimalist approach to achieve it, and thus achieve limited internal performance improvements."

In this study, we explore whether the motivation for maturity model application affects firm performance. Capability Maturity Model Integration (CMMI®) is the successor to the CMM, which was developed by the Software Engineering Institute of Carnegie-Mellon University three decades ago to help organizations improve their software processes. CMMI captures more than project management maturity. It is a model used to assess an organization's ability to perform, control, and improve its performance in a process area. Nonetheless, the presence or absence of CMMI in this study can be considered a proxy for PMMM for several reasons. First, Albrecht and Spang's (2016, p. 19) qualitative content analysis of PMMMs include CMM and the observation that CMM "served as a blueprint" for many process-based maturity models. Also, project management processes are integrated in CMMI. Second, CMMI is widely used, particularly to assess software development maturity, the context in which most PMMM studies have been undertaken (Brookes et al., 2014). Third, information on CMMI appraisals is publicly available (an organization is appraised, not certified in CMMI). Finally, anecdotal evidence suggests that some companies seek a CMMI appraisal because of government contracting concerns rather than to invest in process improvement.

In response to Chrissis et al. (2003, p. 28), a respondent observed, "Adopting CMMI simply keeps our government customers happy. The value to our process improvement effort is minimal", a sentiment echoed by others in this and other surveys (Thibodeau, 2013). CMMI appraisal, a lengthy process that includes being appraised by an independent expert, is frequently required in order to bid on government contracts (Thibodeau, 2013; White, 2018)[1]. This leads to our first hypothesis:

H1: The likelihood of CMMI appraisal is positively associated with government sales.

While Grant and Pennybaker (2006) find that project management maturity is similar across industries, Ibbs and Kwak (2000) note that project management maturity for hi-tech manufacturing is high relative to information systems projects. Irrespective of maturity levels, we expect that the motivations for CMMI appraisal will vary by industry. This leads to our second hypothesis:

H2: The association between CMMI appraisal and profitability depends on industry.

[1]While the CMMI Institute no longer publishes maturity levels, we observed in the past that many companies chose to limit the assessment to a level 3 review. This may be because they are just at level 3 or this may suggest that the main purpose of certification was to obtain contracts rather than as part of a plan to improve processes.

Methodology

The CMMI Institute began posting CMMI v1.3 appraisal results in 2017. Our sample is comprised of firm-year observations for 1,105 SEC registrants in the manufacturing (Standard Industry Classification (SIC): 3600∼3812) and IT industries (SIC: 7370∼7374) for 2017 and 2018. We obtain financial and customer segments data from the Compustat database through Wharton Research Data Services (WRDS). The Compustat Segment Customer database reports any customer accounting for more than 10% of the total sales of a firm and classifies major customers as (1) corporate customers, (2) government customers (including domestic government agencies, foreign government agencies, state government agencies, local government agencies), or (3) market customers. Our sample is comprised of the 2,061 firm-year observations (1,132 IT firm-years and 929 manufacturing firm-years) with complete revenue, net income, and total asset data. The sample includes 73 companies with major government customers (35 IT firm-years and 86 manufacturing firm-years) and 1,032 companies without major government customers (1,097 IT firm-years and 843 manufacturing firm-years). We collect CMMI information from the CMMI institute published appraisal results system (PARS). We find that 28 public firms (17 IT firm-years and 23 manufacturing firm-years) in the sample had CMMI appraisals between 2017 and 2018. Table 1 reports firm-years with and without CMMI appraisals for the full sample (2,061 firm-years) and the subsample of firm-years with (121) and without government customers (1,940) by year.

Variables

We use a dummy variable *CMMI* to indicate whether firms have CMMI appraisals. Variable *CMMI* equals 1 if a firm has passed a CMMI appraisal (any level and category) published by CMMI institute in that specific year and 0 otherwise. We define a dummy variable *ITFirm*, which equals 1 if a firm is in IT industry and 0 if a firm is in manufacturing industry. We use *net income* (in millions) as the proxy for profitability. We calculate the percentage of sales from government customers (*GovSales*) by dividing major government customer sales from the Compustat segments data (e.g., US federal government, state and local governments, department of defense, medicare and medicaid services, and military) by total revenue. We measure *size* using natural logarithm of total assets.

Table 2 Panel A shows descriptive statistics by year for the full sample and in the subsample of firm-years with government sales. Panel B reports descriptive statistics by industry for the full sample. Panel B reports that firm-years in the IT industry are smaller and have lower net income and percentage of government sales than firm-years in the manufacturing industries ($p < 0.01$). The likelihood of CMMI appraisal is similar in both industries. Panel C compares IT and manufacturing firm-years in the subsample of companies with government customers. Panel C reports that firm-years in the IT industry are marginally smaller ($p < 0.01$) and have lower net income and a greater percentage of government sales ($p < 0.01$) than firms in the manufacturing industries. The percentage of companies with CMMI appraisals in both industries is similar ($p > 0.7$). Table 3 reports that all pairwise Pearson correlation coefficients are below 40 percent.

Methods

We use logistic regression to test *H1,* that the likelihood of CMMI appraisal is positively associated with government sales

We use OLS regression to test *H2*, that the association between CMMI appraisal and profitability depends on industry.

Table 1
Sample

	IT		Manufacturing		Subtotal		IT		Manufacturing		Subtotal		Total
	No CMMI	CMMI	No CMMI	CMMI	No CMMI	CMMI	No Gov	Gov	No Gov	Gov	No Gov	Gov	
2017	592	9	478	12	1070	21	580	21	439	51	1,019	72	1,091
2018	523	8	428	11	951	19	517	14	404	35	921	49	970
Total	1,115	17	906	23	2,021	40	1,097	35	843	86	1,940	121	2,061

Table 2
Descriptive statistics

Panel A	Full Sample					Sample with government sales					
	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max	
CMMI	2,061	0.02	0.14	0	1	121	0.19	0.39	0	1	
Net Income	2,061	388.47	2,481.14	–4,864	59,531	121	556.07	1,516.52	–1,264	10,460	
GovSales	2,061	0.03	0.13	0	1	121	0.44	0.32	0.02	1	
Size	2,061	5.67	2.88	–6.21	13.17	121	6.81	2.68	0.37	11.81	
Panel B: Full Sample	IT					Manufacturing					
	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max	*t*-test
CMMI	1,132	0.02	0.12	0	1	929	0.02	0.16	0	1	–1.60
Net Income	1,132	240.18	1,704.93	–3,445	30,736	929	569.16	3,172.26	–4,864	59,531	–3.00***
GovSales	1,132	0.02	0.12	0	1	929	0.04	0.14	0	0.97	–3.03***
Size	1,132	5.38	2.87	–6.21	12.46	929	6.01	2.87	–2.26	13.17	–4.91***
Panel C: Sample with Government sales	IT					Manufacturing					
	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max	*t*-test
CMMI	35	0.17	0.38	0	1	86	0.20	0.40	0	1	–0.33
Net Income	35	84.33	158.58	–100	581	86	748.05	1,762.91	–1,264	10,460	–2.22**
GovSales	35	0.58	0.39	0.06	1	86	0.38	0.27	0.02	0.97	3.17***
Size	35	6.07	2.51	0.37	9.10	86	7.11	2.71	1.73	11.81	–1.97*

Panel A shows descriptive statistics in full sample and sample with government sales. Panel B divides the full sample into IT and manufacturing industries. Panel C divides the sample with government sales into IT and manufacturing industries. ***, **, and * denote significance levels at 1%, 5%, and 10% (two-tailed).

Table 3
Pearson correlation coefficients

	(1)	(2)	(3)	(4)
(1) CMMI	1			
(2) ITFirm	–0.04 (0.11)	1		
(3) Net Income	0.06*** (0.01)	−0.07*** (0.00)	1	
(4) GovSales	0.40*** (0.00)	−0.07*** (0.00)	0.02 (0.34)	1
(5) Size	0.17*** (0.00)	−0.11*** (0.00)	0.31*** (0.00)	0.09*** (0.00)

***, **, and * denote significance levels at 1%, 5%, and 10% (two-tailed), respectively, numbers in parentheses are *p*-values

Results

Table 4 reports the results of logistic regression with standard errors clustered by firm. In model [1] full sample, we find that firms with higher percentage of sales from government ($\beta = 4.81$, $p < 0.01$) and large firms ($\beta = 0.59$, $p < 0.01$) are more likely to get CMMI appraisals. Figure 1 reports the diagnostic ability of our logistic model in a receiver operating characteristic (ROC) chart (92.27%). When we split the sample by industry, we find consistent results that government sales and size are the two driving effects associated with CMMI appraisal. In model [2] for the IT industry, we find a positive association between government sales percentage ($\beta = 4.11$, $p < 0.01$), firm size ($\beta = 0.62$, $p < 0.01$) and the likelihood of CMMI. Similarly, in the manufacturing industry (model [3]), government sales ($\beta = 5.71$, $p < 0.01$) and firm size ($\beta = 0.58$, $p < 0.01$) are positively linked with the CMMI likelihood. When we limit the sample to companies with government sales (model [4]), our results are consistent with the results of the full sample. We find that government sales ($\beta = 3.98$, $p < 0.01$) and size ($\beta = 0.81$, $p < 0.01$) are positively related to CMMI appraisal. In the subsample of IT companies with government sales (model [5]), we find that firm size is marginally linked to the likelihood of CMMI ($\beta = 1.86$, p<0.10). In model [6], manufacturing industries with government sales, we find

Table 4
Logistic regression

Dependent Variable: CMMI	Full Sample						Sample with Gov Sales					
	[1]		[2]		[3]		[4]		[5]		[6]	
	Full Sample		IT		Manufacturing		Sample with Gov Sales		IT		Manufacturing	
	Coef.	z	Coef.	z	Coef.	Z	Coef.	z	Coef.	z	Coef.	z
ITFirm	0.07	0.17					–0.53	–0.59				
GovSales	4.81	8.25***	4.11	5.63***	5.71	5.69***	3.98	3.19***	6.19	2.58**	3.61	2.50***
Size	0.59	7.72***	0.62	5.12***	0.58	5.79***	0.81	3.22***	1.86	1.85*	0.72	3.30***
Constant	–9.12	–11.10***	–9.12	–9.00***	–9.17	–8.42***	–9.83	–4.00***	–20.86	–2.80***	–8.91	–3.78***
Obs.	2,061		1,132		929		121		35		86	
Chi-squared	110.85		48.75		52.00		18.34		15.06		14.31	
Pseudo R-squared	38.27%		31.20%		44.63%		42.40%		56.78%		38.99%	
Log Likelihood	–121.79		–60.72		–59.68		–33.89		–6.93		–26.09	
AROC	92.27%		90.19%		94.14%		91.61%		95.40%		89.86%	

Significance levels at < 1%, unless indicated by **, and * which enote significance levels at 5%, and 10% (two-tailed) respectively. Standard errors are clustered by firm.

CMMI is associated significantly with two variables, government sales ($\beta = 3.61$, $p < 0.01$) and firm size ($\beta = 0.72$, $p < 0.01$). Overall, our results in Table 4 indicate that larger companies with more government sales are more likely to get CMMI appraisals.

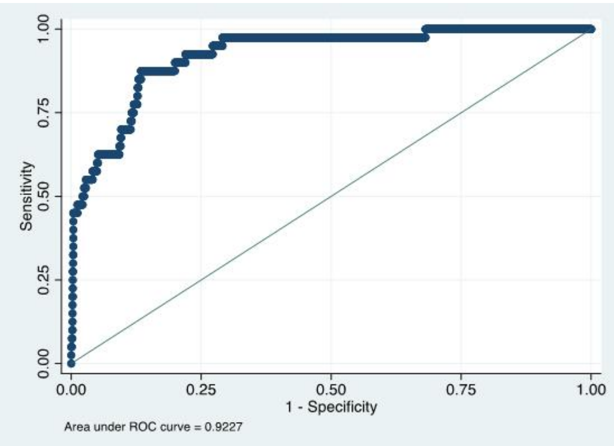

Fig. 1. Area under the ROC Curve for logistic regression (full sample, size = 2,061)

We further test the impact of CMMI on profitability for firms with government customers using OLS with clustered standard errors by firm. As shown in Table 5 model [1], we find that industry moderates the relationship between CMMI and profitability ($\beta = -1,925.26$, $p < 0.05$). CMMI appraisal has different impacts on IT and manufacturing industries. As illustrated in Figure 2, we find that having CMMI appraisal increases the profitability of manufacturing companies, while having CMMI appraisal reduces profitability for IT companies. When we split the sample, we find no significant impact of CMMI on IT

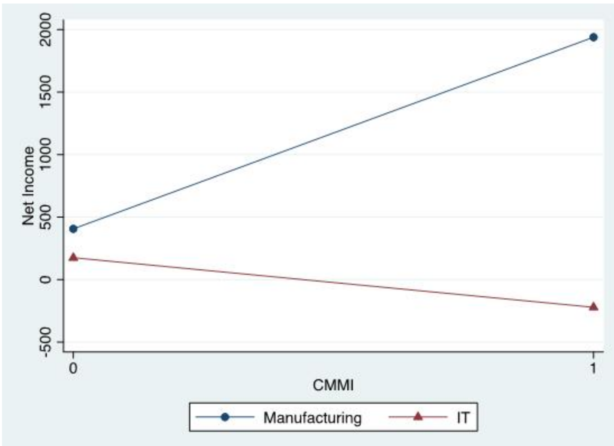

Fig. 2. Relationship between CMMI, Industry and Net Income

Table 5
Main Result: OLS Regression (sample: firms with government sales)

Dependent Variable: Net Income	[1]		[2]		[3]	
	Full Sample		IT		Manufacturing	
	Coef.	t	Coef.	t	Coef.	t
CMMI	1,536.17	1.86*	112.63	1.04	1,338.32	1.67*
ITFirm	–93.77	–0.65				
CMMI*ITFirm	–1,925.26	–2.23**				
GovSales	106.94	0.37	43.52	0.65	81.02	0.17
Size	209.79	2.84***	28.32	2.54**	274.74	2.93***
Constant	–1,152.67	–2.94***	–151.94	–2.61**	–1,583.79	–3.03***
Year Dummy	Yes		Yes		Yes	
Obs.	121		35		86	
F	3.12***		4.09**		3.73***	
Adj. R-squared	36.88%		37.95%		37.78%	
Root MSE	1,204.9		124.92		1,390.6	

***, **, and * denote significance levels at 1%, 5%, and 10% (two-tailed) respectively. Standard errors are clustered by firm.

companies' profitability (model [2]). For manufacturing companies, we find a marginally significant positive impact of having CMMI appraisal on profitability ($\beta = 1,338.32$, $p < 0.10$). Our results suggest that larger firms with better project management capability generate more profits but only in manufacturing industries.

Robustness

We use entropy balancing (Hainmueller, 2012), to balance the covariates of the regression to reduce the bias from misspecification of model form. Entropy balancing is a quasi-matching approach that reweights the distributional properties (e.g., mean, variance, skewness) of each observation to make treatment (e.g., with CMMI) and comparison groups (e.g., without CMMI) as similar as possible on observed confounders (Hainmueller, 2012). Entropy balancing is gaining in popularity because all observations are retained and inferences are not susceptible (as is the case for propensity score matching) to worsened balance when data on important confounders is not available (Zhao & Percival, 2016). As shown in Table 6, in

Table 6
Robustness: entropy weighting (sample: firm with government sales)

Before Balancing	Treat (with CMMI)			Control (without CMMI)		
	mean	variance	skewness	mean	Variance	skewness
ITFirm	0.26	0.20	1.09	0.30	0.21	0.89
GovSales	0.68	0.06	–0.59	0.38	0.10	0.80
Size	9.25	2.52	–0.58	6.24	6.58	–0.33
Year	2017	0.26	0.26	2017	0.24	0.42
After Balancing	Treat (with CMMI)			Control (without CMMI)		
	mean	variance	skewness	mean	Variance	skewness
ITFirm	0.26	0.20	1.09	0.27	0.20	1.03
GovSales	0.68	0.06	–0.59	0.68	0.06	–0.58
Size	9.25	2.52	–0.58	9.25	2.52	–0.58
Year	2017	0.26	0.26	2017	0.25	0.24

the subsample of firm-years with government sales, companies with and without CMMI have different characteristics based on mean, variance and skewness before balancing. After balancing, the mean, variance, and skewness are identical. We repeat our main result in Table 5 model [1] using the entropy balanced sample. We find results consistent with the main results (Table 7) that industry moderates the relationship between CMMI appraisal and profitability ($\beta = -1,452.40$, $p < 0.05$). Our results suggest that larger firms ($\beta = 981.64$, $p < 0.01$) and more project management maturity ($\beta = 1,244.19$, $p < 0.05$) are more profitable. Our results are robust before and after entropy balancing.

Table 7
Robustness: OLS after entropy weighting
(sample: firms with government sales)

	Sample with Government Sales	
	Coef.	*t*
CMMI	1,244.19	2.35**
ITFirm	634.50	1.02
CMMI*ITFirm	–1,452.40	–2.10**
GovSales	–234.19	–0.25
Size	981.64	5.10***
Constant	–8,264.70	–4.34***
Year Dummy	Yes	
Obs.	121	
F	10.31	
R-squared	58.39%	

*** and ** denote significance levels at 1% and 5%.

Discussion and conclusions

Prior literature shows inconclusive evidence linking project management maturity to project success in prior studies (Grant and Pennypacker, 2006; Ibbs and Kwak, 2000; Jugdev et al., 2002; Mullaly, 2014; Yazici, 2009). We shed light on one possible explanation: the motivations for applying project management maturity models may differ between studies. Investigating such possible differences presents an opportunity for future research. We also contribute to PMMM research by demonstrating that empirical examination using publicly available data may be used to conduct exploratory investigation of possible confounding variables if a suitable proxy is available.

There are areas that need to be addressed in the follow up research. We included only size and industry in our tests. The literature reviewed to develop our predictions indicates many other variables may affect the relationship between profitability and PMMM. For example, we did not include a variable to measure how departments were governed. Entropy balancing, while balancing the covariates of the regression to reduce the bias from misspecification of model form, does not address omitted correlated variable concerns. We leave investigating these possible omitted correlated variables to future research. Also, in our tests of the relationship between PMMM and profitability, we measured profitability using net income. Other measures (e.g., return on assets, return on investment) may yield different results.

Acknowledgments

This study is partially funded by Social Sciences and Humanities Research Council of Canada (SSHRC) Insight Development Grant (IDG).

References

Albrecht J.C. and Spang, K. (2014), Linking the benefits of project management maturity to project complexity: Insights from a multiple case study, *International Journal of Managing Projects in Business.*

Andersen E.S. and Jessen S.A. (2003). Project maturity in organisations. *International Journal of Project Management*, Vol. 21, No. 6, pp. 457–461.

Aubry M. (2015), Project management office transformations: Direct and moderating effects that enhance performance and maturity, *Project Management Journal*, Vol. 46, No. 5, pp. 19–45.

Backlund F., Chronéer D., and Sundqvist E. (2015), Maturity assessment: towards continuous improvements for project-based organisations? *International Journal of Managing Projects in Business.*

Barney J. (1991), Firm resources and sustained competitive advantage, *Journal of Management*, Vol. 17, No. 1, pp. 99–120.

Brookes N., Butler M., Dey P., and Clark, R. (2014), The use of maturity models in improving project management performance: An empirical investigation, *International Journal of Managing Projects in Business.*

Chrissis M.B.C., Wemyss G., Goldenson D., Konrad M.D., Smith K.L., and Svolou A. (2003), CMMI Interpretive Guidance Project: Preliminary Report.

Görög M. (2016), A broader approach to organisational project management maturity assessment, *International Journal of Project Management*, Vol. 34, No. 8, pp. 1658–1669.

Grant K.P. and Pennypacker J.S. (2006), Project management maturity: An assessment of project management capabilities among and between selected industries, *IEEE Transactions on engineering management*, Vol. 53, No. 1, pp. 59–68.

Hainmueller J. (2012), Entropy balancing for causal effects: A multivariate reweighting method to produce balanced samples in observational studies, *Political Analysis*, pp. 25–46.

Hardie N. (1998), The effects of quality on business performance, *Quality Management Journal*, Vol. 5, No. 3, pp. 65–83.

Ibbs C.W. and Kwak Y.H. (2000), Assessing project management maturity, *Project Management Journal*, Vol. 31, No. 1, pp. 32–43.

Jugdev K. (2004), Through the Looking Glass: Examining Theory Development in Project Management with the Resource-Based View Lens, *Project Management Journal*, Vol. 35, No. 3, pp. 15–26.

Jugdev K., Mathur G., and Fung T.S. (2007), Project management assets and their relationship with the project management capability of the firm, *International Journal of Project Management*, Vol. 25, No. 6, pp. 560–568.

Jugdev K. and Thomas J. (2002), Project management maturity models: The silver bullets of competitive advantage, *Project Management Journal*, Vol. 33, No. 4, pp. 4–14.

Kosieradzka A. and Ciechańska O. (2018), Impact of enterprise maturity on the implementation of six sigma concept, *Management and Production Engineering Review*, No. 9.

Langley M.A. (2018), *Success in Disruptive Times: Expanding the Value Delivery Landscape to Address the High Cost of Low Performance.* Project Management Institute, Newtown, USA.

Laursen M. and Svejvig P. (2016), Taking stock of project value creation: A structured literature review with future directions for research and practice, *International Journal of Project Management*, Vol. 34, No. 4, pp. 736–747.

Liu J.Y.-C., Chen V.J., Chan C.-L., and Lie T. (2008), The impact of software process standardization on software flexibility and project management performance: Control theory perspective, *Information and Software Technology*, Vol. 50, No. 9–10, pp. 889–896.

Milosevic D. and Patanakul P. (2005), Standardized project management may increase development projects success, *International Journal of Project Management*, Vol. 23, No. 3, pp. 181–192.

Mir F.A. and Pinnington A.H. (2014), Exploring the value of project management: linking project management performance and project success, *International Journal of Project Management*, Vol. 32, No. 2, pp. 202–217.

Mullaly M. (2014), If maturity is the answer, then exactly what was the question? *International Journal of Managing Projects in Business.*

PMBOK (2008), A guide to the Project management body of knowledge (Pmbok guide), fourth edition. In (Vol. 4th), Newtown Square, Pa.: Project Management Institute.

Rezania D. and Ouedraogo N. (2014), Organization development through ad hoc problem solving, *International Journal of Managing Projects in Business*, Vol. 7, No. 1, pp. 23–42.

Sampaio, P., Saraiva, P., and Rodrigues, A.G. (2009), ISO 9001 certification research: questions, answers and approaches, *International Journal of Quality & Reliability Management.*

Sanchez F., Micaelli J.-P., Bonjour E., and Monticolo D. (2019), A Step for Improving the Transition Between Traditional Project Management to Agile Project Management Using a Project Management Maturity Model, *The Journal of Modern Project Management*, Vol. 7, No. 1.

Sandor A. and Guban A. (2021), A Measuring Tool for the Digital Maturity of Small and Medium-Sized Enterprises, *Management and Production Engineering Review*, Vol. 12, No. 4, pp. 133–143.

Santos B.P., Enrique D.V., Maciel V.B., Lima T.M., Charrua-Santos F., and Walczak R. (2021), The Synergic Relationship Between Industry 4.0 and Lean Management: Best Practices from the Literature, *Management and Production Engineering Review*, 94-107-194-107.

Sztorc M. and Savenkovs K. (2020), The use of lean management instruments to shape business models of service companies, *Management and Production Engineering Review.*

Thibodeau P. (2013), The firm behind healthcare. gov had topnotch credentials–and it didn't help, *ComputerWorld (Oct. 2013).*

Van der Wiele T., Brown A., Millen R., and Whelan D. (2000), Improvement in organizational performance and self-assessment practices by selected American firms, *Quality Management Journal*, Vol. 7, No. 4, pp. 8–22.

White S.K. (2018), What is CMMI? A model for optimizing development processes.

Winter M. and Szczepanek T. (2008), Projects and programmes as value creation processes: A new perspective and some practical implications, *International Journal of Project Management*, Vol. 26, No. 1, pp. 95–103.

Yazici H.J. (2009), The role of project management maturity and organizational culture in perceived performance, *Project Management Journal*, Vol. 40, No. 3, pp. 14–33.

Zhao Q. and Percival D. (2016), Entropy balancing is doubly robust, *Journal of Causal Inference*, Vol. 5, No. 1.