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HOW DO ENTERPRISE RESOURCE PLANNING SYSTEMS AFFECT RISK? POST-IMPLEMENTATION IMPACT

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Appendix A

Key Findings of Illustrative Empirical Studies on ERP Business Value

Study	Measures of ERP Business Value			Data and Sample	Findings
	Process Performance	Profitability	Firm Value		
Anderson et al. (2006)			√ (market value)	Firm filings on IT spending, with a large overlap with ERP system investment (62 firms during 1999-2000)	IT spending is associated with a significant increase in firm value. The association varies across industries: positive in transform industries, insignificant in automate industries, negative/insignificant in informate industries.
Aral et al. (2006)	√ (productivity, inventory, asset utilization, collection efficiency)	√ (ROA, ROE, margin)	√ (Tobin's q)	Vendor (SAP) data on ERP purchases (623 unique firms during 1986-2005)	ERP "purchase" events lead to no improvements in process performance and profitability; ERP "go live" events lead to improvements in process performance, but not in profitability.
Cotteleer and Bendoly (2006)	√ (order lead-time)			Field research (a manufacturing firm that had implemented an ERP system)	There is a significant improvement in order fulfillment improvement after ERP system implementation.
Dehning et al. (2007)	√ (operations, logistics, and support processes)	√ (ROA, ROS)		Event study (123 adoption announcements of IT-based supply chain management systems; during1994-2000)	Comparing pre-implementation and post-implementation periods suggest: (1) improvements in logistics and support processes; (2) an increase in ROS, and (3) no increase in ROA. The overall post-implementation financial performance (ROA/ROS) decreases in the scope of implementation.
Dorantes et al. (2013)	√ (forecasting quality)			Event study (enterprise systems "go-live" announcements, N = 353, during 1995-2008)	Enterprise systems lead to higher management forecast quality.

Study	Measures of ERP Business Value			Data and Sample	Findings
	Process Performance	Profitability	Firm Value		
Gattiker and Goodhue (2005)	√ (coordination improvement and task efficiency)			Survey (111 manufacturing plants where ERP systems had gone live)	Manufacturing plants obtain such benefits as task efficiency and coordination improvements after ERP implementation. The benefits from ERP are moderated by interdependence and differentiation among subunits of an organization.
Hayes et al. (2001)			√ (stock market return)	Event study (347 announcements of ERP adoption; during 1990-1998)	There is a positive market reaction to ERP system adoption. The market reaction is most positive for small/healthy firms. And the reaction to PeopleSoft and SAP systems is positive, while the reaction to other vendors is not significant.
Hendricks et al. (2007)		√ (ROA, ROS)	√ (stock market return)	Event study (186 announcements of ERP adoption; during 1991-1999)	There is moderate evidence for post-implementation improvement in profitability, but no evidence for improvement in stock returns. The post-implementation improvements in profitability are stronger for early adopters (1997 and before).
Hitt et al. (2002)	√ (productivity, inventory, asset utilization, collection efficiency)	√ (ROA, ROE, margin)	√ (Tobin's q)	Vendor (SAP) data on ERP purchases (350 unique firms during 1986-1998)	Firms that invest in ERP systems show an increase in Tobin's q, productivity, ROA, inventory turn, margin, asset utilization, and collection efficiency, but a decrease in ROE.
Karimi et al. (2007)	√ (process efficiency, effectiveness, and flexibility)			Survey of manufacturing firms that have implemented ERP projects (N = 148; 2002-2003)	The extent of ERP implementation is positively related to business process outcomes of ERP implementation. The magnitude of the positive association increases in IS resources.
Ranganathan and Brown (2006)			√ (stock market return)	Event study (116 announcements of ERP adoptions; 1997-2001)	There is a positive abnormal return to ERP system implementation for the overall sample. The abnormal return is most positive for the highest ERP system scope while negative for the lowest ERP system scope.
Sykes et al. (2014)	√ (user work performance)			Survey of ERP system users (N = 255)	Peer advice network improves users' post-implementation job performance.

Appendix B

Robustness Check: Environmental Uncertainty

Panel A: Uncertainty Measured by *EU_PMV*						
	Dependent Variable = Firm Risk					
	(1)		**(2)**		**(3)**	
ERP_PRESENCE	-0.0900***	(0.0223)				
ERP system scope						
Level 1 (L1)			-0.0932***	(0.0223)		
L1 (1 oper.)					-0.0883***	(0.0227)
L1 (1 func.)					-0.0910***	(0.0223)
Level 2 (L2)			-0.0949***	(0.0223)		
L2 (2 oper.)					-0.0783**	(0.0247)
L2 (1 func. & 1 oper.)					-0.0878***	(0.0225)
L2 (2 func.)					-0.0954***	(0.0223)
Level 3 (L3)			-0.0991***	(0.0223)		
L3 (1 func. & 2 oper.)					-0.0947***	(0.0229)
L3 (2 func. & 1 oper.)					-0.0961***	(0.0223)
Level 4 (L4)			-0.0947***	(0.0227)	-0.0914***	(0.0227)
Environmental uncertainty						
EU_PMV	0.0723***	(0.0174)	0.0779***	(0.0173)	0.0827***	(0.0174)
EU_PMV × ERP_DEPLOY	-0.0725***	(0.0174)				
EU_PMV × L1			-0.0452*	(0.0185)		
EU_PMV × L1 (1 oper.)					-0.0233	(0.0461)
EU_PMV × L1 (1 func.)					-0.0500**	(0.0187)
EU_PMV × L2			-0.0782***	(0.0175)		
EU_PMV × L2 (2 oper.)					-0.0782	(0.1948)
EU_PMV × L2 (1 func. & 1 oper.)					-0.0389	(0.0263)
EU_PMV × L2 (2 func.)					-0.0835***	(0.0176)
EU_PMV × L3			-0.0798***	(0.0174)		
EU_PMV × L3 (1 func. & 2 oper.)					0.0666	(0.0640)
EU_PMV × L3 (2 func. & 1 oper.)					-0.0845***	(0.0174)
EU_PMV × L4			0.0692	(0.0442)	0.0704	(0.0441)
Controls	Included		Included		Included	
Panel B: Uncertainty Measured by *EU_ICR*						
	Dependent Variable = Firm Risk					
	(1)		**(2)**		**(3)**	
ERP_PRESENCE	-0.0770***	(0.0221)				
ERP system scope						
Level 1 (L1)			-0.0782***	(0.0223)		
L1 (1 oper.)					-0.0785***	(0.0229)
L1 (1 func.)					-0.0790***	(0.0223)
Level 2 (L2)			-0.0798***	(0.0223)		
L2 (2 oper.)					-0.0759**	(0.0251)
L2 (1 func. & 1 oper.)					-0.0764***	(0.0225)
L2 (2 func.)					-0.0830***	(0.0223)
Level 3 (L3)			-0.0845***	(0.0223)		
L3 (1 func. & 2 oper.)					-0.0856***	(0.0229)
L3 (2 func. & 1 oper.)					-0.0847***	(0.0224)
Level 4 (L4)			-0.0857***	(0.0226)	-0.0849***	(0.0227)

	Dependent Variable = Firm Risk					
	(1)		(2)		(3)	
Environmental uncertainty						
EU_ICR	0.0274	(0.0156)	0.0265	(0.0156)	0.0278	(0.0156)
EU_ICR × ERP_DEPLOY	-0.0496**	(0.0167)				
EU_ICR × L1			-0.0538*	(0.0213)		
EU_ICR × L1 (1 oper.)					-0.0046	(0.0507)
EU_ICR × L1 (1 func.)					-0.0619**	(0.0222)
EU_ICR × L2			-0.0597**	(0.0205)		
EU_ICR × L2 (2 oper.)					0.3272	(0.2135)
EU_ICR × L2 (1 func. & 1 oper.)					-0.0911**	(0.0283)
EU_ICR × L2 (2 func.)					-0.0534*	(0.0227)
EU_ICR × L3			-0.0616**	(0.0198)		
EU_ICR × L3 (1 func. & 2 oper.)					-0.0380	(0.0414)
EU_ICR × L3 (2 func. & 1 oper.)					-0.0656**	(0.0204)
EU_ICR × L4			-0.0302	(0.0196)	-0.0316	(0.0196)
Controls	Included		Included		Included	

Note: Standard errors in parentheses; ***p < 0.001, **p < 0.01, *p < 0.05.
All variables are defined in Tables 2 and 3.

Appendix C

Robustness Check: Sample-Split Analysis

Panel A: Four Levels of ERP System Scope								
	Dependent Variable = Firm Risk							
	(1)		(2)		(3)		(4)	
	No ERP (N = 356) & Level 1 (N = 382)		No ERP (N = 356) & Level 2 (N = 464)		No ERP (N = 356) & Level 3 (N = 490)		No ERP (N = 356) & Level 4 (N = 435)	
L1	-0.0805*	(0.0374)						
L2			-0.0879*	(0.0346)				
L3					-0.1019**	(0.0328)		
L4							-0.0674*	(0.0308)
EU_PMV	0.0650**	(0.0220)	0.0730***	(0.0217)	0.0642**	(0.0203)	0.0802***	(0.0215)
EU_PMV × L1	-0.0359	(0.0231)						
EU_PMV × L2			-0.0739***	(0.0219)				
EU_PMV × L3					-0.0664**	(0.0203)		
EU_PMV × L4							0.0927	(0.0511)
EU_ICR	0.0166	(0.0193)	0.0151	(0.0190)	0.0138	(0.0179)	0.0227	(0.0186)
EU_ICR × L1	-0.0415	(0.0259)						
EU_ICR × L2			-0.0397	(0.0245)				
EU_ICR × L3					-0.0451*	(0.0222)		
EU_ICR × L4							-0.0356	(0.0229)
Controls	Included		Included		Included		Included	

Panel B: Combinations of ERP Modules						
	Dependent Variable = Firm Risk					
	(1)		(2)		(3)	
	No ERP (N = 356) & Level 1 (N = 382)		No ERP (N = 356) & Level 2 (N = 464)		No ERP (N = 356) & Level 3 (N = 490)	
L1 (1 oper.)	-0.0823*	(0.0386)				
L1 (1 func.)	-0.0825*	(0.0376)				
L2 (2 oper.)			-0.0763*	(0.0382)		
L2 (1 func. & 1 oper.)			-0.0793*	(0.0354)		
L2 (2 func.)			-0.0850*	(0.0347)		
L3 (1 func. & 2 oper.)					-0.1015**	(0.0333)
L3 (2 func. & 1 oper.)					-0.1037**	(0.0327)
EU_PMV	0.0671**	(0.0223)	0.0772***	(0.0218)	0.0676***	(0.0204)
EU_PMV × L1 (1 oper.)	-0.0246	(0.0556)				
EU_PMV × L1 (1 func.)	-0.0379	(0.0235)				
EU_PMV × L2 (2 oper.)			0.0775	(0.2443)		
EU_PMV × L2 (1 func. & 1 oper.)			-0.0357	(0.0314)		
EU_PMV × L2 (2 func.)			-0.0787***	(0.0219)		
EU_PMV × L3 (1 func. & 2 oper.)					0.0986	(0.0721)
EU_PMV × L3 (2 func. & 1 oper.)					-0.0697***	(0.0203)
EU_ICR	0.0176	(0.0194)	0.0181	(0.0190)	0.0152	(0.0179)
EU_ICR × L1 (1 oper.)	0.0141	(0.0604)				
EU_ICR × L1 (1 func.)	-0.0497	(0.0271)				
EU_ICR × L2 (2 oper.)			0.3862	(0.2643)		
EU_ICR × L2 (1 func. & 1 oper.)			-0.0798*	(0.0338)		
EU_ICR × L2 (2 func.)			-0.0307	(0.0273)		
EU_ICR × L3 (1 func. & 2 oper.)					-0.0428	(0.0458)
EU_ICR × L3 (2 func. & 1 oper.)					-0.0480*	(0.0229)
Controls	Included		Included		Included	

Note: Standard errors in parentheses; ***p < 0.001, **p < 0.01, *p < 0.05.
All variables are defined in Tables 2 and 3.

Appendix D

Robustness Check: ERP System Scope Breakdown

	Dependent Variable = Firm Risk	
ERP system scope breakdown		
L1	-0.0882***	(0.0223)
L2A	-0.0937***	(0.0222)
L2B	-0.0859***	(0.0226)
L2C	-0.0904***	(0.0263)
L2OTHER	-0.0909***	(0.0235)
L3A	-0.0908***	(0.0224)
L3B	-0.0963***	(0.0226)
L3OTHER	-0.0927***	(0.0229)
L4	-0.0901***	(0.0227)
Environmental uncertainty		
EU_PMV	0.0746***	(0.0175)
EU_PMV × L1	-0.0409*	(0.0187)
EU_PMV × L2A	-0.0752***	(0.0177)
EU_PMV × L2B	-0.0251	(0.0266)
EU_PMV × L2C	-0.4982	(0.2653)
EU_PMV × L2OTHER	0.0081	(0.1441)
EU_PMV × L3A	0.0259	(0.0396)
EU_PMV × L3B	-0.0765***	(0.0175)
EU_PMV × L3OTHER	0.0766	(0.0647)
EU_PMV × L4	0.0805	(0.0444)
EU_ICR	0.0228	(0.0156)
EU_ICR × L1	-0.0484*	(0.0212)
EU_ICR × L2A	-0.0433	(0.0226)
EU_ICR × L2B	-0.0765*	(0.0384)
EU_ICR × L2C	-0.0769	(0.0455)
EU_ICR × L2OTHER	-0.0214	(0.0515)
EU_ICR × L3A	-0.0531*	(0.0213)
EU_ICR × L3B	-0.0646*	(0.0336)
EU_ICR × L3OTHER	-0.0438	(0.0415)
EU_ICR × L4	-0.0316	(0.0196)
Controls	Included	

Note: Standard errors in parentheses; ***p < 0.001, **p < 0.01, *p < 0.05.
All variables are defined in Tables 2 and 3.
L2OTHER = L2D + L2E + L2F; L3OTHER = L3C + L3D.
We combine Levels 2D, 2E, and 2F and use the combined group (labeled as *L2OTHER*) in the regression. The reason is that the number of firms in each of the three groups (Levels 2D, 2E, and 2F) is small; in order to carry out the regression, we need to combine them. For the same reason, we combine Levels 3C and 3D to form a combined group (*L3OTHER*) in our regression. We have conducted a further robustness check by excluding *L2OTHER* and *L3OTHER*, which yields highly consistent results.

Appendix E

Robustness Check: Controlling for IT Capital

	Dependent Variable = Firm Risk					
	(1)		(2)		(3)	
ERP_PRESENCE	-0.0854***	(0.0223)				
ERP system scope						
Level 1 (L1)			-0.0892***	(0.0223)		
L1 (1 oper.)					-0.0873***	(0.0228)
L1 (1 func.)					-0.0891***	(0.0223)
Level 2 (L2)			-0.0913***	(0.0223)		
L2 (2 oper.)					-0.0872***	(0.0250)
L2 (1 func. & 1 oper.)					-0.0854***	(0.0225)
L2 (2 func.)					-0.0934***	(0.0223)
Level 3 (L3)			-0.0966***	(0.0223)		
L3 (1 func. & 2 oper.)					-0.0928***	(0.0229)
L3 (2 func. & 1 oper.)					-0.0956***	(0.0223)
Level 4 (L4)			-0.0932***	(0.0227)	-0.0910***	(0.0227)
Environmental uncertainty						
EU_PMV	0.0747***	(0.0180)	0.0809***	(0.0181)	0.0877***	(0.0182)
EU_PMV × ERP_DEPLOY	-0.0670***	(0.0176)				
EU_PMV × L1			-0.0387*	(0.0187)		
EU_PMV × L1 (1 oper.)					-0.0198	(0.0460)
EU_PMV × L1 (1 func.)					-0.0434*	(0.0188)
EU_PMV × L2			-0.0757***	(0.0178)		
EU_PMV × L2 (2 oper.)					-0.0274	(0.2077)
EU_PMV × L2 (1 func. & 1 oper.)					-0.0301	(0.0263)
EU_PMV × L2 (2 func.)					-0.0822***	(0.0179)
EU_PMV × L3			-0.0722***	(0.0176)		
EU_PMV × L3 (1 func. & 2 oper.)					0.0865	(0.0647)
EU_PMV × L3 (2 func. & 1 oper.)					-0.0769***	(0.0176)
EU_PMV × L4			0.0703	(0.0446)	0.0707	(0.0445)
EU_ICR	0.0178	(0.0158)	0.019	(0.0157)	0.0219	(0.0157)
EU_ICR × ERP_DEPLOY	-0.0386*	(0.0170)				
EU_ICR × L1			-0.0449*	(0.0213)		
EU_ICR × L1 (1 oper.)					0.0127	(0.0503)
EU_ICR × L1 (1 func.)					-0.0553*	(0.0220)
EU_ICR × L2			-0.0485*	(0.0204)		
EU_ICR × L2 (2 oper.)					0.3815	(0.2246)
EU_ICR × L2 (1 func. & 1 oper.)					-0.0813**	(0.0281)
EU_ICR × L2 (2 func.)					-0.0431*	(0.0226)
EU_ICR × L3			-0.0509*	(0.0199)		
EU_ICR × L3 (1 func. & 2 oper.)					-0.0408	(0.0419)
EU_ICR × L3 (2 func. & 1 oper.)					-0.0561**	(0.0203)
EU_ICR × L4			-0.0287	(0.0198)	-0.0312	(0.0197)
IT_CAP	0.3550**	(0.1353)	0.4454**	(0.1369)	0.4667***	(0.1353)
IT_CAP × EU_PMV	1.7951	(0.9300)	2.1237	(1.2862)	2.5665*	(1.3017)
IT_CAP × EU_ICR	-0.0692	(0.9221)	0.0099	(0.9231)	-0.0300	(0.9261)
Controls	Included		Included		Included	

Note: Standard errors in parentheses; ***p < 0.001, **p < 0.01, *p < 0.05.
All variables are defined in Tables 2 and 3.
IT_CAP = IT capital (scaled by total assets).

Appendix F

Robustness Check: Controlling for SIC Two-Digit Industry Fixed Effects

	Dependent Variable = Firm Risk					
	(1)		(2)		(3)	
ERP_PRESENCE	-0.0423	(0.0244)				
ERP system scope						
Level 1 (L1)			-0.0448	(0.0247)		
L1 (1 oper.)					-0.0460	(0.0251)
L1 (1 func.)					-0.0450	(0.0247)
Level 2 (L2)			-0.0465	(0.0247)		
L2 (2 oper.)					-0.0405	(0.0271)
L2 (1 func. & 1 oper.)					-0.0415	(0.0249)
L2 (2 func.)					-0.0498*	(0.0247)
Level 3 (L3)			-0.0511*	(0.0248)		
L3 (1 func. & 2 oper.)					-0.0489	(0.0251)
L3 (2 func. & 1 oper.)					-0.0508*	(0.0247)
Level 4 (L4)			-0.0457	(0.0252)	-0.0448	(0.0251)
Environmental uncertainty						
EU_PMV	0.0576***	(0.0174)	0.0617***	(0.0173)	0.0660***	(0.0173)
EU_PMV × ERP_DEPLOY	-0.0577***	(0.0174)				
EU_PMV × L1			-0.0303	(0.0185)		
EU_PMV × L1 (1 oper.)					-0.0236	(0.0455)
EU_PMV × L1 (1 func.)					-0.0340	(0.0186)
EU_PMV × L2			-0.0620***	(0.0175)		
EU_PMV × L2 (2 oper.)					0.0502	(0.2037)
EU_PMV × L2 (1 func. & 1 oper.)					-0.0272	(0.0260)
EU_PMV × L2 (2 func.)					-0.0667***	(0.0176)
EU_PMV × L3			-0.0634***	(0.0173)		
EU_PMV × L3 (1 func. & 2 oper.)					0.0862	(0.0636)
EU_PMV × L3 (2 func. & 1 oper.)					-0.0676***	(0.0174)
EU_PMV × L4			0.0408	(0.0449)	0.0438	(0.0448)
EU_ICR	0.0059	(0.0206)	0.0083	(0.0205)	0.0094	(0.0205)
EU_ICR × ERP_DEPLOY	-0.0416*	(0.0174)				
EU_ICR × L1			-0.0471*	(0.0219)		
EU_ICR × L1 (1 oper.)					0.0168	(0.0503)
EU_ICR × L1 (1 func.)					-0.0562*	(0.0227)
EU_ICR × L2			-0.0442*	(0.0209)		
EU_ICR × L2 (2 oper.)					0.3719	(0.2210)
EU_ICR × L2 (1 func. & 1 oper.)					-0.0786**	(0.0284)
EU_ICR × L2 (2 func.)					-0.0364	(0.0232)
EU_ICR × L3			-0.0458*	(0.0203)		
EU_ICR × L3 (1 func. & 2 oper.)					-0.0469	(0.0421)
EU_ICR × L3 (2 func. & 1 oper.)					-0.0484*	(0.0208)
EU_ICR × L4			-0.0424*	(0.0208)	-0.0440*	(0.0208)
Controls	Included		Included		Included	

Note: Standard errors in parentheses; ***p < 0.001, **p < 0.01, *p < 0.05.
All variables are defined in Tables 2 and 3.

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