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ONLINE APPENDIX

The Impact of Product Architecture and Organization Structure on Quality in Complex Product Development

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1 Robustness of Inverted-U Relationship between Product Architecture Centrality and Warranty Claims

We performed additional analysis to check the validity of our proposed inverted-U relationship between the centrality of a subsystem in the product architecture network and warranty claims.

First, we considered the location of the inflection point (i.e., the level of subsystem centrality where the warranty claims reach its maximum). Technically, this point is where the first partial derivative of the regression equation with respect to subsystem centrality is equal to zero. To identify the inflection point, we set the partial derivative (with respect to the subsystem centrality) of the regression equation of Model 2 equal to zero. Solving $3.78 - 2(6.07)x = 0$ for x, we found that the inflection point is located at a level of subsystem centrality equal to 0.311.

We also divided the sample into deciles and for each sub-sample we conducted separate regressions and examined the coefficient of subsystem centrality.

Table A.1. Coefficients of Subsystem Centrality for Each Decile

	Decile 1	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Decile 10
β:	1.09	3.65	4.29	3.86	1.61	1.53	0.41	-0.68	-1.33	-1.82

Table A.1 shows the coefficients of these separate regressions. Note that the coefficients are positive for the deciles below decile 7 where the inflection occurs, and negative for the deciles above it. These robustness checks verify and confirm the inverted U relationship between subsystem centrality and warranty claims.

2 Replicating the Analysis for 2006 Model Year

We have duplicated our empirical analysis (which was originally for the 2005 model year) for the 2006 model year. Comparing two data sets from the same group representing two different time

Table A.2. Descriptive Statistics for 2006 Model Year

	Variable description	Mean	S.D.	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1)	Warranty incidents for 2006	4.542	2.528	0.139	17.540	1										
(2)	Warranty incidents for 2005	4.115	2.398	0.086	11.830	0.685	1									
(3)	Number of parts	248.5	10.436	183	299	-0.082	0.038	1								
(4)	Number of design engineers	129.4	22.654	24	202	-0.114	0.045	0.167	1							
(5)	Number of ECO's	264.4	12.011	154	368	0.108	-0.029	0.285	0.309	1						
(6)	Fraction of new parts	0.272	0.175	0.049	0.634	0.142	0.166	0.074	0.133	0.105	1					
(7)	Fraction of problematic ECO's	0.341	0.106	0.092	0.593	0.112	0.185	0.041	-0.021	0.065	0.347	1				
(8)	Average ECO tardiness	27.99	5.677	0.000	113.000	-0.185	-0.028	-0.046	-0.259	0.133	0.087	-0.126	1			
(9)	Centrality of a subsystem*	0.263	0.204	0.064	0.498	0.294	0.304	0.229	0.092	0.118	0.021	0.044	-0.066	1		
(10)	Centrality squared of a subsystem*	0.095	0.161	0.001	0.739	-0.362	-0.159	-0.126	0.005	-0.137	0.013	-0.051	0.088	-0.206	1	
(11)	Coordination deficit	0.115	0.068	0.001	0.291	0.225	0.207	0.028	-0.051	0.019	0.128	0.095	-0.139	0.518	-0.325	1

*Normalized scores

periods has been likened to a quasi experiment in a natural setting (Lee 1987), and was applied successfully in examining individual performance and centrality in virtual R&D groups (Ahuja et al. 2003). Clark and Fujimoto (1991) also used two different years to verify the stability of their regression results in an automotive product development environment.

Table A.2 presents the descriptive statistics and bivariate correlations between the variables for the 2006 model year. Note that, the general pattern of the bivariate correlations is quite similar to that for the 2005 model year. One significant difference is the increase in correlation between subsystem centrality and coordination deficit from 0.461 to 0.518 for the 2006 model year.

Table A.3. Random-effects Model of Warranty Incidents For Product Subsystems

Variable	**Model 1** (Controls)		**Model 2** (Architecture)		**Model 3** (Deficit)	
Warranty incidents for 2004	0.661***	(0.071)	0.653***	(0.069)	0.687***	(0.074)
Number of parts	0.0052	(0.011)	0.044	(0.012)	0.0033	(0.014)
Number of design engineers	-0.0071*	(0.004)	-0.0063*	(0.004)	-0.0070*	(0.004)
Number of ECO's	0.0047	(0.003)	0.0052	(0.003)	0.0042	(0.003)
Fraction of new parts	2.649**	(1.215)	2.887**	(1.237)	2.963**	(1.314)
Fraction of problematic ECO's	6.345**	(3.112)	6.773**	(3.006)	6.555**	(3.104)
Average ECO tardiness	-0.234**	(0.109)	-0.217**	(0.0098)	-0.211**	(0.0094)
Centrality of a subsystem			2.96***	(0.913)		
Centrality squared of a subsystem			-4.13***	(1.880)		
Coordination deficit					2.4412***	(0.895)
R-squared	64.28%		67.13%		69.71%	
Adjusted R-squared	64.19%		66.92%		69.51%	
N	3159		3159		3159	

$*p < 0.1$, $**p < 0.05$, $***p < 0.01$

We provide the results of the random-effects model in Table A.3. We observe that almost all of the proposed associations for the 2005 model year holds for the 2006 model year. We note that our main variables of interest, which are: (a) centrality in the product architecture network, (b) the quadratic term for centrality in the product architecture network, and (c) coordination deficit, are all significant at the 0.01 level. The variation in 2006 warranty claims explained by the models (as indicated by R-squared values of 64.19%, 66.92% and 69.51%) is also slightly lower than in the original study, but nevertheless the explanatory power of the models is still quite large. Similar to the 2005 model year, we examined the robustness of the inverted-U relationship (following the steps outlined in Section A of the Appendix) as well as the potential endogeneity issues (as outlined in Section 5.3 of the paper) for this model. We found that the inverted-U relationship is robust and that endogeneity is not a problem.

References

Ahuja M. K., A., D. E. Galletta, K. M. Carley. 2003. Individual Centrality and Performance in Virtual R&D Groups: An Empirical Study. *Management Science* **49** 21-38.

Clark, K. B., T. Fujimoto. 1991. *Product Development Performance: Strategy, Organization, and Management in the World Auto Industry.* Harvard Business School Press, Boston, MA.

Hausman, J. A. 1978. Specification tests in econometrics. *Econometrica* **46** 12511271.

Davidson, R., J. Mackinnon. 1993. *Estimation and Interference in Economics.* Oxford University Press, New York.

Lee, A. 1987. Natural experiments. *Human Relations* **42** (2) 117-137.

White, H. 1980. A heteroscedasticity-consistent covariance matrix estimator and a direct test for heteroscedasticity. *Econometrica* **48** 817838.

Wooldridge, J. M. 2002. *Econometric Analysis of Cross Section and Panel Data.* The MIT Press, Cambridge, MA.