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# Fit and Misfit of Plural Sourcing Strategies and IT-Enabled Process Integration Capabilities: Consequences of Firm Performance in the U.S. Electric Utility Industry

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# Appendix A

## Additional Estimations for the ROA Models and Other Firm Performance Measures

In addition to the pooled OLS estimations with $ROA_{t+1}$ as the measure of firm performance that are reported in the paper, we estimated the models using random effects (RE) and fixed effects (FE) specifications. The RE and FE results, which are reported in Table A1, were consistent with the pooled OLS results and supported H1 and H2.

We also evaluated our hypotheses using two additional firm performance measures: Tobin's Q**,** which is the total dollar amount market value divided by the total dollar amount replacement value of a firm in a given year) and operating revenue/total assets, which is the total dollar amount of revenue divided by total dollar amount of assets of a firm in a given year. We selected these measures because Tobin's Q provides a forward-looking market measure and operating revenue/total assets provides an operating efficiency assessment (Bharadwaj 2000; Bharadwaj et al. 1999). For the Tobin's Q and operating revenue/total assets models, we employed the Breusch and Pagan Lagrangian multiplier test against the null hypothesis that the coefficients estimated by the RE estimator are not systematically different than those of the OLS estimator (Bruesch and Pagan 1980). The test failed to reject the null hypothesis for the operating revenues/total $\text{assets}_{t+1}$ model, supporting pooled OLS estimation over RE, and rejected the null hypothesis for the Tobin's $Q_{t+1}$ model ($\chi^2 = 2.784$, $p < 0.01$), supporting RE estimation over OLS estimation. We then examined if FE or RE estimation is to be favored for the Tobin's $Q_{t+1}$ model. As we use robust standard errors, we conducted the over-identification test using the Sargan-Hansen statistic against the null hypothesis that the coefficients estimated by the efficient RE estimator are not systematically different from the ones estimated by the consistent FE estimator (Wooldridge 2002).[1] We rejected this null hypothesis for the Tobin's $Q_{t+1}$ model ($\chi^2 = 122.14$, $p < 0.001$), supporting FE estimation over RE estimation. The FE results for the Tobin's $Q_{t+1}$ model [2] and the OLS results for the operating revenue/total assets$_{t+1}$ model are provided in Table A1. Consistent with the results using ROA as the measure of firm performance, we find support for H1 (INTER × MSI) using Tobin's Q and operating revenue/total assets as measures of firm performance. However, unlike the results using ROA as the measure of firm performance, we do not find support for H2 (INTRA × MSI) using Tobin's Q and operating revenue/total assets as measures of firm performance.

**Table A1. Robustness Results for the ROA Models and With Other Firm Performance Measures**

| Dependent Variables → | ROA$_{t+1}$ | | ROA$_{t+1}$ | | Tobin's $Q_{t+1}$ | | Operating Revenue/Assets$_{t+1}$ | |
|---|---|---|---|---|---|---|---|---|
| Estimation → | Random Effects | | Fixed Effects | | Fixed Effects | | Pooled OLS | |
| Models → | Main | Interaction | Main | Interaction | Main | Interaction | Main | Interaction |
| ROA | 0.536*** | 0.540*** | 0.175** | 0.185** | | | | |
| | (0.071) | (0.068) | (0.074) | (0.073) | | | | |
| Tobin's Q | | | | | 0.388*** | 0.385*** | | |
| | | | | | (0.095) | (0.096) | | |
| Oper Rev/ Assets[b] | | | | | | | 0.797*** | 0.797*** |
| | | | | | | | (0.040) | (0.040) |
| MSI[a] | -0.005* | -0.006* | -0.007 | -0.006 | -0.156** | -0.156** | -0.002 | 0.002 |
| | (0.003) | (0.003) | (0.007) | (0.007) | (0.075) | (0.075) | (0.088) | (0.087) |
| INTER[b] | 0.004*** | 0.002*** | 0.003 | 0.000 | -0.004 | -0.004* | -0.008 | -0.017** |
| | (0.001) | (0.000) | (0.002) | (0.001) | (0.005) | (0.003) | (0.008) | (0.007) |
| INTRA[b] | -0.001 | -0.003** | -0.001† | -0.003*** | -0.011* | -0.004 | -0.020** | -0.011 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.006) | (0.010) | (0.009) | (0.023) |
| INTER[b] × MSI[a] | | 0.011*** | | 0.016*** | | 0.017** | | 0.039** |
| | | (0.003) | | (0.003) | | (0.007) | | (0.018) |
| INTRA[b] × MSI[a] | | -0.017** | | -0.016*** | | 0.050 | | 0.056 |
| | | (0.008) | | (0.005) | | (0.053) | | (0.103) |
| INTER_MOD[b] | 0.000 | 0.000 | -0.001** | -0.001** | -0.002 | -0.002 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.008) | (0.008) | (0.007) | (0.007) |
| INTRA_MOD[b] | -0.002*** | -0.002** | -0.003** | -0.002* | -0.006 | -0.005 | -0.003 | -0.002 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.008) | (0.008) | (0.007) | (0.007) |
| IT Customization[b] | 0.002** | 0.001 | 0.001 | 0.001 | 0.013* | 0.009 | 0.028** | 0.027** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.008) | (0.008) | (0.011) | (0.011) |

[1] We used the XTOVERID program (version 2.1.6; 2Nov2011) by Schaffer and Stillman (2006) for the Stata software package. We also conducted the Hausman test with FE and RE specifications without robust standard errors, as the Hausman test is only applicable when the models are not specified with robust standard errors (Hayashi 2000, p. 234, note 18). The Hausman test suggests that the FE estimation should be preferred over RE estimation.

[2] As a FE specification of "Small T and Large N" (few time periods and many firms) that includes lagged dependent variable on the right-hand-side of the equation can produce biased estimates (Roodman 2009), we employed dynamic panel estimation to further examine the Tobin's $Q_{t+1}$ model. We used the XTABOND2 Stata procedure for the Arellano–Bover/Blundell–Bond System Generalized Method of Moments (GMM) estimator (Arellano and Bond 1991; Arellano and Bover 1995; Blundell and Bond 1998). As with the FE results, we observed the System GMM results to support H1 and not H2.

**Table A1. Robustness Results for the ROA Models and With Other Firm Performance Measures (Continued)**

| Dependent Variables → | $ROA_{t+1}$ | | $ROA_{t+1}$ | | Tobin's $Q_{t+1}$ | | Operating Revenue/$Assets_{t+1}$ | |
|---|---|---|---|---|---|---|---|---|
| Estimation → | Random Effects | | Fixed Effects | | Fixed Effects | | Pooled OLS | |
| Models → | Main | Interaction | Main | Interaction | Main | Interaction | Main | Interaction |
| IT Infrastructure[b] | -0.001 | -0.001 | -0.001† | -0.001 | -0.005 | -0.004 | -0.012** | -0.012* |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.006) | (0.006) | (0.006) | (0.006) |
| Supplier Concentration | -0.004 | -0.005 | -0.002 | -0.001 | -0.017 | -0.018 | 0.053 | 0.054 |
| | (0.003) | (0.003) | (0.004) | (0.004) | (0.034) | (0.034) | (0.083) | (0.084) |
| Oil Crisis Shock | 0.003 | 0.002 | 0.005** | 0.005** | -0.028* | -0.025 | 0.058 | 0.059 |
| | (0.002) | (0.002) | (0.003) | (0.002) | (0.017) | (0.017) | (0.036) | (0.036) |
| Depreciation Expenses[b] | 0.000 | 0.000 | -0.001† | -0.001† | -0.001 | -0.003 | 0.011 | 0.010 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.007) | (0.007) | (0.012) | (0.012) |
| Firm Age[b, c] | 0.001 | 0.001 | -0.006 | -0.006 | -0.007 | -0.006 | 0.038 | 0.038 |
| | (0.001) | (0.001) | (0.004) | (0.004) | (0.049) | (0.050) | (0.027) | (0.027) |
| Production Capacity[b, d] | 0.000 | 0.000 | -0.002 | -0.001 | 0.011 | 0.009 | -0.001 | -0.002 |
| | (0.001) | (0.001) | (0.002) | (0.002) | (0.015) | (0.014) | (0.031) | (0.031) |
| CWIP_Other[b] | -0.001 | -0.001 | -0.002* | -0.002* | -0.015 | -0.014 | -0.012 | -0.011 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.009) | (0.009) | (0.013) | (0.014) |
| Constant | 0.025*** | 0.025*** | 0.045*** | 0.044*** | 0.603*** | 0.607*** | 0.070*** | 0.070*** |
| | (0.004) | (0.004) | (0.004) | (0.004) | (0.083) | (0.084) | (0.025) | (0.024) |
| F-statistic | 13.010** | 14.920*** | 3.601*** | 10.824*** | 8.155*** | 74.724*** | 46.242*** | 66.724*** |
| Firms | 121 | 121 | 133 | 133 | 109 | 109 | 113 | 113 |
| Firm-Year Observations | 805 | 805 | 886 | 886 | 687 | 687 | 762 | 762 |

*Notes*: Unstandardized coefficients reported. Standard errors are in parentheses. Robust standard errors used, clustered at the firm level for OLS and RE estimations.
Dummies included for NERC region of a firm in models that were not FE estimations.
*p < 0.10, **p < 0.05, *** < 0.01.
†Effects are significant at p < 0.10; coefficients and standard errors shown have been rounded.
[a]These variables are mean centered.
[b]These variables are standardized to z-scores.
[c]0 replaced by 0.1 to be able to take the log.
[d]Winsorized at 5% tails; results stable without winsorizing.

# Appendix B

## Endogeneity Assessment of MSI Using Two-Step Generalized Method of Moments

We used the XTIVREG2 two-step generalized method of moments (GMM) procedure in Stata (Schaffer 2005) to evaluate if MSI was endogenous in the ROA model. The results are summarized in Table B1. We briefly describe the two-stage process that we employed.

**Stage 1**: We estimated MSI using the following three instrumental variables (Deregulation Shock, Log Total $\text{Plants}_{t-1}$, $\text{INTER\_MOD}_{t-1}$). We also included the following variables in estimating MSI: INTER, INTRA, IT customization, IT Infrastructure, Supplier Concentration, Oil Crisis Shock, Depreciation Expenses, Firm Age, Production Capacity, and CWIP_Other.

**Stage 2**: We included the MSI estimates in Stage 2, with ROA as the dependent variable. However, we did not include the interactions (MSI × INTRA/INTER) for the following reasons: There are two ways to go about including interaction terms with the endogenous variable in our specification. First, if Y is the endogenous variable, X1 is the exogenous variable, and Y × X1 is to be included in the second stage, then in the first stage the excluded instrument (Z) needs to be interacted as Z × X1. We have three excluded instruments, requiring the addition of six interaction terms in Stage 1 (the three excluded instruments interacted with INTER and INTRA, respectively). When we included these six interaction terms in Stage 1, the models suffered from excessive multicollinearity and did not converge. Second, one can include instrumental variables in Stage 1 that correlate only with the interaction term but not with the variables that comprise the interaction terms. We are not aware of any instrumental variables to make this inclusion feasible. Furthermore, the results suggest that MSI is not endogenously determined, which makes us more confident about our approach.

| Table B1. Endogeneity Assessment of MSI for $ROA_{t+1}$ (Two-Step GMM) | | |
|---|---|---|
| **Variables** | **First Stage** | **Second Stage** |
| ROA | 0.754* | 0.099 |
| | (0.440) | (0.076) |
| MSI[a] | | 0.004 |
| | | (0.022) |
| INTER[b] | 0.005 | 0.003** |
| | (0.004) | (0.002) |
| INTRA[b] | 0.003 | -0.002** |
| | (0.006) | (0.001) |
| INTER_MOD[b] | -0.002 | -0.001† |
| | (0.003) | (0.001) |
| INTRA_MOD[b] | -0.002 | -0.002 |
| | (0.006) | (0.002) |
| IT Customization[b] | -0.009 | 0.001 |
| | (0.007) | (0.001) |
| IT Infrastructure[b] | -0.005 | -0.001 |
| | (0.004) | (0.001) |
| Supplier Concentration | 0.039 | -0.002 |
| | (0.059) | (0.005) |
| Oil Crisis Shock | -0.009 | 0.005 |
| | (0.106) | (0.005) |
| Depreciation Expenses[b] | -0.003 | -0.001 |
| | (0.009) | (0.001) |
| Firm Age[b, c] | 0.007 | -0.007 |
| | (0.008) | (0.007) |
| Production Capacity[b, d] | -0.082*** | -0.001 |
| | (0.030) | (0.004) |
| CWIP_Other[b] | 0.003 | -0.005** |
| | (0.006) | (0.002) |
| $INTER\_MOD_{t-1}$[b] | 0.020*** | |
| | (0.003) | |
| Deregulation Shock | 0.004 | |
| | (0.005) | |
| Log Total $Plants_{t-1}$ | -0.064** | |
| | (0.031) | |
| F-statistic | 5.839*** | 6.921*** |
| Log-likelihood | 750.878 | 2127.639 |
| Firms | 130 | 130 |
| Firm-Year Observations | 758 | 758 |
| Partial $R^2$ of excluded instruments | 0.121 | |
| Test of excluded instruments (F-statistic) | 12.39*** | |

**Table B1. Endogeneity Assessment of MSI for $ROA_{t+1}$ (Two-Step GMM) (Continued)**

| | |
|---|---|
| *Underidentification tests* | |
| Ho: matrix of reduced form coefficients has rank = K1-1 (underidentified) | |
| Ha: matrix has rank = K1 (identified) | |
| Kleibergen-Paap rk LM statistic ($\chi^2$) | 21.28*** |
| Kleibergen-Paap rk Wald statistic ($\chi^2$) | 38.22*** |
| *Weak identification test* | |
| Ho: equation is weakly identified | |
| Kleibergen-Paap Wald rk F statistic | 12.39*** |
| *Weak-instrument-robust inference* | |
| Tests of joint significance of endogenous regressors B1 in main equation | |
| Ho: B1 = 0 and overidentifying restrictions are valid | |
| Anderson-Rubin Wald test F-statistic | 0.06 (p-value >0.90) |
| Anderson-Rubin Wald test $\chi^2$ | 0.17 (p-value > 0.90) |
| Stock-Wright LM S statistic $\chi^2$ | 0.15 (p-value > 0.90) |
| Hansen J statistic ($\chi^2$) (overidentification test of all instruments) | 0.12 (p-value > 0.90) |
| Endogeneity test of endogenous regressor (MSI) | 0.15 (p-value > 0.70) |
| Number of regressors | 14 |
| Number of instruments | 16 |
| Number of excluded instruments | 3 |
| Instrumented | MSI |
| Excluded instruments | Dereg. Shock, $INTER\_MOD_{t-1}$[b], $lnTotalPlants_{t-1}$ |

*Notes*: Unstandardized coefficients reported.
*p < 0.10, **p < 0.05, ***p < 0.01, ****p < 0.001;
[†]Effects are significant at p < 0.10; coefficients and standard errors shown are rounded.
Standard errors are in parentheses.
[a]These variables are mean centered.
[b]These variables are standardized to z-scores.
[c]0 replaced by 0.1 to be able to take the log.
[d]Winsorized at 5% tails; results stable without winsorizing.

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