

**e - c o m p a n i o n**

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Electronic Companion—"Strategic Resource Dynamics of Manufacturing Firms" by Shekhar Jayanthi, Aleda V. Roth, Mehmet M. Kristal, and Lauren Carter-Roth Venu, *Management Science*, doi 10.1287/mnsc.1090.1002.

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## Model Development and Sensitivity Analysis

### EC.1. Development of the Lotka-Volterra System

In order to understand the survival of a firm, in light of its strategic processes, we categorize resources within the manufacturing firm into those that relate to the current demands and future demands of the environment (March 1991). These two types of resources are focused on the short and long-term changes that also reflect the manufacturing firm's strategic position on the resource spectrum. In defining short and long-term decision-making, we borrowed from resource competition models from ecological systems theory to examine the *intra*-space that optimize resource allocation, and in turn, determine implementation of practices and development of competitive capabilities. Analogous to natural ecosystems, the frequencies of oscillations resulting from short- and long-term decision-making are dependent on resource dynamics internal and external to the manufacturing firm.

Building on organizational learning theory, we consider two types of resource allocations within the manufacturing firm. The resources allocated to exploration enhancing the manufacturing firm's resource spectrum in the long run. A firm's resource allocation for exploration could result from decisions related to diversification, adoption of new technologies, and identification of new markets. On the other hand, exploration in manufacturing could consist of resource allocations targeted at experimenting with the design of new product and/or process, and related production equipment. Following May (1974), the growth in long-term resource allocation can be represented as:

$$\Delta x_i(t) = x_i(t + \tau_i) - x_i(t) = \kappa_i x_i(t) \tau_i \quad (\text{EC1})$$

In the above expression,  $\Delta x_i(t)$  represents the change in the amount of resources from  $x_i(t)$  to  $x_i(t + \tau_i)$  over a time  $\tau_i$ .  $x_i(t)$  denotes the long-term resources within the manufacturing firm at time  $t$ . The index  $i=1$  corresponds to the firm's resources allocated to activities other than manufacturing, and  $i=2$  corresponds to the manufacturing resources.  $\kappa_i$  represents the intrinsic growth rate of long-term resources; i.e., the rate at which long-term resource allocation "grows" in the absence of "competition"

from short-term resource allocations.  $\tau_i$  is the interval with respect to time  $t$  (usually a single period) over which strategic resource allocations are carried out.

Short-term strategic decisions are associated with the resources related to current changes in the external environment. Resource allocations for the short term favor delimiting the manufacturing firm's resource spectrum. The manufacturing firm's resource allocation is carried out according to the self-reinforcing mechanisms described earlier. Resource allocation to manufacturing operations in the short-term could be targeted to alter and adjust current products, processes and related equipment for high-volume ramp-up production. Such an allocation is likely to enhance profitability of the firm and its manufacturing operations in the present and can be represented, in absence of influence from each other, using feedback parameters  $\alpha_{ii}$ :

$$\Delta x_i(t) = \kappa_i x_i(t) \tau_i - (\alpha_{ii}) (\kappa_i x_i(t) \tau_i) x_i(t) \quad (\text{EC2})$$

Thus, the extent of focus on the short- and long- term resource allocation can be used as a basis for understanding the interaction between the dynamics of firm and manufacturing strategic decisions. The effectiveness of strategic changes in gaining a competitive advantage is the result of strategic fit; i.e., consistency between the competitive advantage that a firm seeks, and the manufacturing practices and competitive capabilities that it uses to achieve that advantage. This requires the firm and its manufacturing function to both balance each other's strategic resources and to track each other's changes so that they co-evolve dynamically and so-called 'functional silos' are mitigated. For example, if senior executives, who aim to pursue a strategy of wide product variety, are unfamiliar with the process technology and leave the choice to technical managers, then the firm may end up with sophisticated, but inflexible, automated technology. This inconsistency can be included in the model by using a product term  $\alpha_{ij}$  ( $i \neq j; i, j = 1, 2$ ) that represents the interaction between the resource allocations related to the firm and its manufacturing operations:

$$\Delta x_i(t) = \kappa_i x_i(t) \tau_i - (\alpha_{ii}) (\kappa_i x_i(t) \tau_i) x_i(t) - (\alpha_{ij}) (\kappa_j x_j(t) \tau_j) x_j(t) \quad (\text{EC3})$$

For sufficiently large amounts of resources allocated within the firm and its manufacturing operations, the time delays in Equation (EC3) can be ignored so that the deterministic expression in Equation (1) as  $\Delta t \rightarrow 0$  is sufficient to represent the growth dynamics of the overall system. See May (1974: 30-36) for details.

## EC.2. Competition among Strategic Manufacturing Groups

In addition to observing the resource allocation dynamics within the manufacturing firms, we used the LV model to capture the dynamics of competition among groups with respect to financial resources (Carroll 1981; Brittain and Wholey 1988):

$$\frac{dy_i(t)}{dt} = g_i(y_i, y_j) = \kappa_i y_i(t) \left[ 1 - \sum_{j=1}^8 \alpha_{ij} y_j(t) \right]; i = 1, 2, \dots, 8. \quad (\text{EC4})$$

Here, the populations competing for the two types of financial resources – related to the firm and its manufacturing – are the four strategic groups.  $y_i(t)$  denotes the trajectories of the financial resources – SGA and COGS – for each of the four strategic groups. The proxy variables used to capture the competitive dynamics among the four groups were weighted averages of SGA and COGS with respect to TA over time for the four groups. We estimated the parameters of Equation (EC4) in a similar manner as described in Section 5.2.

TABLE EC.4 shows the parameter estimates of the set of differential equations in Equation (EC4). The rate of growth or improvement in cost reduction is statistically different from zero at the 90% confidence level for all the strategic manufacturing groups except for COGS in the case of ESMS IV. Consistent with the complex nature of resource allocation of ESMS IV firms, the trajectory for COGS is concave over time (i.e., it increases and then decreases over time as seen in Figure EC.1). The rate of decrease in COGS that represent manufacturing resources allocated in the firm's *intra*-space is the steepest for ESMS II firms followed by those for ESMS III and ESMS I. The growth rate parameters for SGA for all the firms show a decline with increasing production volume over time illustrating the presence of learning curves. The exception is ESMS II, for which the trajectory of resources allocated is

relatively flat indicating more or less a constant resource allocation within the firm (other than manufacturing).

TABLE EC.1. Costs included in the Cost of Goods Sold (COGS) and Selling, Administrative, and other (SGA) expenses according to manufacturing strategy decisions.

<i>Manufacturing strategy decisions (Hayes and Wheelwright 1984)</i>	<i>Categories of decisions (Hayes and Wheelwright 1984)</i>	<i>Representative items included in COGS by COMPUSTAT (p. 52-53)</i>	<i>Representative items included in SGA by COMPUSTAT (p. 271)</i>
Structural	Capacity	<ul style="list-style-type: none"> <li>• Operating expenses</li> <li>• Direct labor</li> <li>• Heat, light, and power</li> <li>• Direct costs</li> </ul>	-
	Sourcing and vertical integration	<ul style="list-style-type: none"> <li>• Supplies</li> <li>• Transportation</li> <li>• Freight-in</li> <li>• Warehouse expense</li> </ul>	
	Facilities – size, location, specialization	<ul style="list-style-type: none"> <li>• Improvements to leased property</li> <li>• Lease expense</li> <li>• Rent and royalty expense</li> </ul>	
	Information and process technology – degree of automation, interconnectedness, lead vs. follow.	<ul style="list-style-type: none"> <li>• Amortization of tools and dies</li> <li>• Amortization of software cost and amortization of capitalized software costs</li> </ul>	
Infrastructural	Resource allocation and capital budgeting systems	-	<ul style="list-style-type: none"> <li>• Corporate expense</li> <li>• Marketing expense</li> <li>• Advertising expense</li> </ul>
	Human resource systems		<ul style="list-style-type: none"> <li>• Labor and related expenses</li> <li>• Strike expense</li> </ul>
	Work planning and control systems		<ul style="list-style-type: none"> <li>• Accounting expense</li> <li>• Marketing expense</li> </ul>
	Quality systems		-
	Measurement and reward systems – measures, bonuses, promotion policies		<ul style="list-style-type: none"> <li>• Directors' fees and remuneration</li> <li>• Stock-based compensation when reported below a gross profit figure</li> <li>• Severance pay</li> </ul>
	Product and process development systems		<ul style="list-style-type: none"> <li>• Research and development expense</li> <li>• Engineering expense</li> <li>• Amortization of research and development costs</li> </ul>

TABLE EC.2. Variables used in the analysis procedure (the index  $k$  represents the company and  $t$  represents the time period).

Variable Name	Measure	References	Transformation	COMPUSTAT Industrial Quarterly References
<b>Estimation of the Lotka-Volterra model</b>				
Firm resources	$adjsga_{kt} = \frac{sgaa_{kt}}{ta_{kt}}$ ; $sgaa_{kt}$ =selling, general and administrative expenses and $ta_{kt}$ =total assets	Hilton (2004)	None	DATA 1: Selling, General & Administrative Expenses, DATA 40: Total assets
Manufacturing resources	$adjcog_{kt} = \frac{cogs_{kt}}{ta_{kt}}$ ; $cogs_{kt}$ =cost of goods sold, and $ta_{kt}$ =total assets	Hilton (2004)	None	DATA 30: Cost of Goods Sold DATA 40: Total Assets
<b>Firm characteristics</b>				
Firm age	$t - f\_year$ ; $f\_year$ =founding year	Williamson and Verdin (1992)	$\ln(age)$	Based on Hoover's Online and Reuter's company descriptions
Capital Intensity $cap_{kt}$	$cap_{kt} = \frac{ppe_{kt}}{emp_{kt}}$ ; $ppe_{kt}$ =plant, property, and equipment, $emp_{kt}$ =number of employees	Hendricks and Singhal (2003)	$\ln(cap_{kt})$	DATA 42: Plant, Property, & Equipment, DATA 29: Number of employees (from COMPUSTAT Industrial Annual)
Firm diversification $entropy_{kt}$	$entropy_{kt} = \sum_{b=1}^B p_{bkt} \ln\left(\frac{1}{p_{bkt}}\right)$ ; $p_{bkt}$ =share of the $k$ th company at time $t$ in the $b$ th segment	Palepu (1985)	Coded as 0 if entropy measure is less than or equal to median, 1 otherwise	$p_{bkt}$ based on net Sales extracted from COMPUSTAT Segments Database
Firm size $size_{kt}$	$sales_{kt}$ =sales for the $k$ th company at time $t$ .	Dobrev and Carroll (2006)	$\ln(sales_{kt})$	DATA 2: Net Sales
R&D intensity $ri_{kt}$	$\frac{rd_{kt}}{sales_{kt}}$ ; where, $rd_{kt}$ =R&D expenditure for the $k$ th company at time $t$ .	Kor and Mahoney (2001)	$\ln(ri_{kt})$	DATA 4: R&D expenses DATA 2: Net Sales
Four strategic manufacturing groups	$\delta$ based on eigenvalues of the community matrix $\mathbf{A}$	Maynard Smith (1974)	Automatically coded in SAS as 0-1 indicator variable	-

TABLE EC.3A. Descriptive statistics for performance measures and control variables for the raw data

	<i>N</i> *	<i>Mean</i>	<i>Standard deviation</i>	<i>Maximum</i>	<i>Minimum</i>
Firm's age	1775	22.36	11.53	58.00	1.25
Capital intensity	1572	70.14	53.55	269.13	6.33
Firm diversification	1656	.14	.33	1.94	.00
Firm size	1730	361.93	1115	9598	0
R&D intensity	1726	49.47	144.13	1214	-0.85

\**N* is the total number of observations for all the firms and time periods (quarters).

TABLE EC.3B. Correlation matrix for performance measures and control variables for the raw data for the year 2003 and fourth quarter\*.

	1	2	3	4	5
1. Firm's age	1.00				
2. Capital intensity	.07	1.00			
3. Firm diversification	.19	.25	1.00		
4. Firm size	.30	.14	.27	1.00	
5. R&D intensity	.30	.16	.29	.96	1.00
	<.0001	<.0001	<.0001	<.0001	

\* Entries in parentheses indicate the *p*- values of the correlations

TABLE EC4. Parameter estimates for the competitive dynamics among strategic groups.

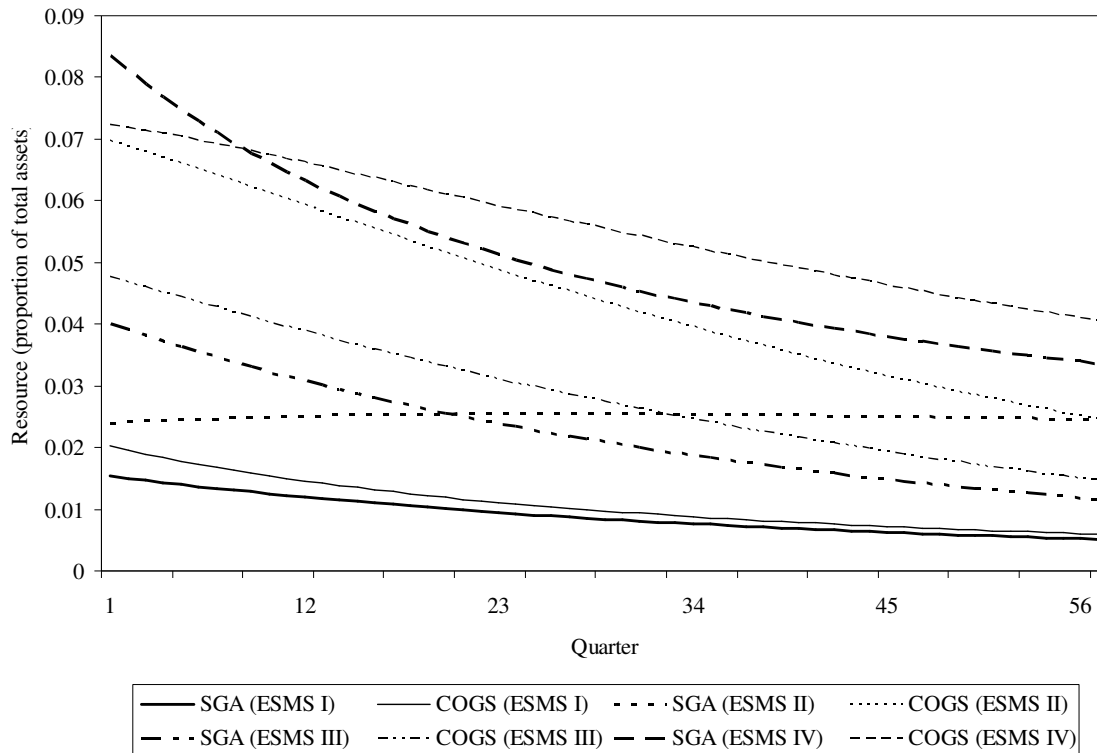
Group →	ESMS I*		ESMS II*		ESMS III*		ESMS IV*	
Series →	SGA**	COGS**	SGA**	COGS**	SGA**	COGS**	SGA**	COGS**
$i, j \rightarrow$	1	2	3	4	5	6	7	8
$\kappa_i$	-.01 (-.015, -.012)	-.008 (-.009, -.006)	-.005 (-.007, -.004)	-.016 (-.018, -.013)	-.022 (-.024, -.020)	-.018 (-.019, -.017)	-.01 (-.012, -.009)	.005 (-.001, .011)
$\alpha_{1j}$	.005 (-.002, .012)	.03 (.007, .048)	.007 (.0001, .014)	.006 (.002, .010)	.001 (-.004, .006)	.06 (.030, .091)	.02 (.001, .040)	.005 (-.001, .011)
$\alpha_{2j}$	.006 (.003, .010)	.23 (.183, .275)	.006 (.001, .010)	.002 (.001, .004)	-.0005 (-.007, .006)	.02 (.003, .044)	.16 (.113, .208)	.05 (.003, .094)
$\alpha_{3j}$	.06 (.016, .101)	.01 (.007, .016)	.006 (.000, .013)	.02 (-.018, .069)	.0004 (-.004, .005)	.0004 (-.001, .002)	-.004 (-.008, .0001)	.01 (-.009, .035)
$\alpha_{4j}$	.04 (.019, .065)	.01 (.005, .019)	.005 (.001, .010)	-.006 (-.012, .001)	-.0007 (-.002, .001)	-.0003 (-.007, .006)	.005 (.00003, .010)	.003 (-.002, .008)
$\alpha_{5j}$	.07 (.026, .107)	.004 (-.001, .008)	.005 (-.028, .037)	-.002 (-.008, .005)	.01 (-.013, .041)	.002 (-.003, .007)	.0001 (-.004, .004)	.01 (.008, .021)
$\alpha_{6j}$	.004 (.0004, .008)	.21 (.181, .245)	-.04 (-.058, -.016)	.004 (-.001, .009)	.003 (-.049, .054)	-.002 (-.011, .006)	.0002 (-.001, .002)	-.0008 (-.011, .009)
$\alpha_{7j}$	.01 (.006, .018)	.08 (.064, .103)	-.12 (-.150, -.101)	-.05 (-.075, -.023)	-.01 (-.017, -.003)	.005 (-.002, .012)	.10 (.080, .119)	.03 (.002, .062)
$\alpha_{8j}$	.006 (.002, .010)	.003 (.002, .004)	.01 (.007, .016)	.03 (.010, .051)	.005 (-.0003, .010)	.001 (-.005, .008)	-.003 (-.007, -.0001)	.02 (-.001, .046)
MAD***	.0004	.001	.001	.002	.001	.002	.003	.004
RMSE***	.0006	.001	.001	.004	.002	.002	.004	.005

\*EMS I companies are hypothesized as single-product specialists, ESMS II companies as single-product generalists, ESMS III companies as multi-product generalists, and ESMS IV companies as multi-product specialists (van Witteloostuijn and Boone 2006).

\*\*The variables used in the analysis are the weighted averages for SGA and COGS for the companies within each of the four strategic groups.

\*\*\*Entries for Root Mean Squared Error (RMSE) and Mean Absolute Deviation (MAD) are for the weighted average values for SGA and COGS for each of the four strategic groups.

As shown in Figure EC.1, in general, the trajectories for all the groups for the two types of resource allocations – SGA and COGS – exhibit convergence indicating that the industry as a whole is pursuing resource strategies to achieve best practices over time (McKendrick 2001). Consistent with previous research, the figure shows convergence of the two types of financial resources within strategic groups (Fiegenbaum and Thomas 1995, Osborne, Stubbart, and Ramprasad 2001). The convergence is not pronounced outside the groups indicating barriers to mobility across groups (Mascarenhas 1989).



**Figure EC.1.** Trajectories of the weighted average resource allocations for the four strategic groups

The general trend in the interaction coefficients is consistent with the resource-partitioning theory. The parameter estimates that are statistically significant with 90% confidence level are the ones that are around the periphery of the community matrix. In particular, a majority of the coefficients exhibit symbiotic behavior (+,+) among financial resources allocated within the EMS I and II firms and those allocated within ESMS III and ESMS IV firms. The interaction coefficients representing competition have a negative sign and are statistically significant for competition at least in one direction across financial resources. For example, there is predatory competition (-,+) between SGA resources of ESMS

II firms and COGS for ESMS III firms, indicating that COGS for ESMS III firms expands at the expense of SGA resources of ESMS II firms. This may be due to the perceived threat to ESMS III firms resulting from investment of resources by ESMS II firms in marketing capability. There is full competition (–,–) between ESMS II and IV firms and predatory competition between EMS III and IV with respect to SGA resources. This is consistent with resource-partitioning theory, which argues the negative influence of the growth of larger generalists in ESMS II and ESMS III on the smaller specialists in EXMS IV.

### **EC.3. Manufacturing Practices and Competitive Capabilities**

TABLE EC.5 shows the least square means for the models developed using capabilities and practices as the dependent binary response variables. To begin with, ESMS I firms exhibit characteristics of Miller and Roth's (M-R) (1994) "innovators" in terms of capabilities such as product performance (Likelihood Ratio ( $LR$ )=10.93;  $p$ =.01), and dependable delivery ( $LR$ =21.63;  $p$  < .0001). The manufacturing practice that ESMS I firms emphasize, which is also characteristic of "innovators" is investment in lead-time reduction programs ( $LR$ =11.08;  $p$ =.01). The competitive capabilities most important to either ESMS II or ESMS III firms are those of "marketeers" – volume flexibility ( $LR$ =17.82;  $p$  =.0005) and broad distribution ( $LR$ =20.19;  $p$ =.0002). The practices, which are significantly important for ESMS II or III firms are labor-management relationships ( $LR$ =29.61;  $p$  < .0001), quality of the fabrication process ( $LR$ =12.21;  $p$ =.01). ESMS IV firms show the greatest emphasis on low prices ( $LR$ =26.55;  $p$  < .0001). These traits are consistent with those of "caretakers" of the M-R taxonomy.

In addition to characteristics of pure M-R taxa there is an overlap among attributes of the taxa emphasized by firms in our strategic manufacturing groups. ESMS I firms also emphasize advertising ( $LR$ =28.15;  $p$  < .0001) that is important for "caretakers." ESMS III firms show a greater emphasis related to characteristics of "innovators," e.g. by investing in new product introduction programs ( $LR$ =35.34;  $p$  < .0001). Similarly, firms in ESMS IV illustrate characteristics of "innovators" and "marketeers." The "marketeer" capabilities emphasized by ESMS IV firms are the shortest time-to-market ( $LR$ =22.50;  $p$  <

TABLE EC.5. Comparison of competitive capabilities and manufacturing practices for the four manufacturing strategy groups based on coding of 10-K reports for the year 2004 for firms in the sample.

Group→ Mean* (Standard error)**	ESMS I (n=14)		ESMS II (n=6)		ESMS III (n=7)		ESMS IV (n=3)		Likelihood ratio (p-value)
<b>COMPETITIVE CAPABILITIES</b>									
<i>Premium price</i>	-.15 (.12)	(3,4)	.24 (.23)	(3,4)	.80 (.23)	(1,2,4)	<b>6.95</b> (.23)	(1,2,3)	26.55 ( $<.0001$ )
<i>Design flexibility</i>	1.36 (.27)	(4)	2.25 (.45)	-	1.63 (.32)	(4)	<b>7.91</b> (.32)	(1,3)	16.25 (.001)
<i>Volume flexibility</i>	-.52 (.12)	(2,3,4)	<b>.42</b> (.24)	(1,4)	.30 (.21)	(1,4)	-6.53 (.21)	(1,2,3)	17.82 (.0005)
<i>Conformance</i>	-.87 (.13)	-	-.20 (.25)	-	-.18 (.21)	-	.90 (.48)	-	0.69 (.88)
<i>Performance</i>	<b>1.78</b> (.21)	(2,3,4)	.73 (.29)	(1)	1.02 (.28)	(1)	1.07 (.58)	(1)	10.93 (.01)
<i>Speed</i>	.25 (.13)	(2,4)	-.32 (.25)	(1,3,4)	.60 (.31)	(2,4)	<b>8.07</b> (.31)	(1,2,3)	22.50 ( $<.0001$ )
<i>Dependability</i>	<b>-2.9</b> (.13)	(2,3,4)	-1.42 (.32)	(1,4)	-1.13 (.28)	(1,4)	-7.46 (.28)	(1,2,3)	21.63 ( $<.0001$ )
<i>After sales service</i>	-.28 (.13)	(2,3,4)	<b>2.44</b> (.44)	(1,3)	1.67 (.30)	(1,2)	1.76 (.51)	(1)	25.94 ( $<.0001$ )
<i>Advertising</i>	<b>.34</b> (.12)	(2,3)	-1.00 (.28)	(1,4)	-1.52 (.27)	(1)	-.05 (.49)	(2)	28.45 ( $<.0001$ )
<i>Broad distribution</i>	-.12 (.12)	(2,3)	<b>1.06</b> (.27)	(1,3)	.39 (.21)	(1,2)	.51 (.47)	-	20.19 (.0002)
<i>Broad product line</i>	-.47 (.12)	(2,3,4)	.09 (.24)	(1,4)	.42 (.22)	(1,4)	<b>6.48</b> (.22)	(1,2,3)	28.09 ( $<.0001$ )
<b>MANUFACTURING PRACTICES</b>									
<i>Labor management relationship</i>	-.66 (.25)	(2,3)	-1.32 (.34)	(1,3,4)	<b>2.50</b> (.53)	(1,2,4)	.27 (.52)	(2,3)	29.61 ( $<.0001$ )
<i>Zero defects</i>	.02 (.12)	(2,4)	.50 (.24)	(1,3)	-.31 (.21)	(2,4)	<b>.81</b> (.46)	(1,3)	16.74 (.0008)
<i>Manufacturing lead-time reduction</i>	<b>-1.00</b> (.18)	(2,3)	-2.76 (.66)	(1)	-2.47 (.37)	(1)	-7.23 (.37)	-	11.08 (.01)
<i>Computer Aided Design</i>	-1.58 (.21)	-	-.85 (.27)	-	-.97 (.30)	-	-.46 (.50)	-	2.47 (.48)
<i>New products or processes</i>	1.42 (.25)	(3,4)	1.61 (.32)	(4)	2.21 (.47)	(1,4)	<b>8.88</b> (.47)	(1,2,3)	13.57 (.004)
<i>Closing plants</i>	-1.34 (.24)	-	-1.59 (.29)	-	-1.67 (.36)	-	-7.72 (.36)	-	5.41 (.14)
<i>SPC (Statistical Process Control)</i>	-.85 (.17)	(2,3)	<b>.45</b> (.25)	(1,4)	.42 (.26)	(1,4)	-.92 (.45)	(1,2,3)	12.21 (.007)
<i>Product quality</i>	-.31 (.12)	(2,4)	.25 (.24)	(1,3,4)	-.33 (.21)	(2,4)	<b>7.10</b> (.21)	(1,2,3)	21.28 ( $<.0001$ )
<i>New product introductions</i>	-.35 (.15)	(2,3,4)	<b>1.83</b> (.37)	(1)	1.52 (.28)	(1)	1.67 (.48)	(1)	35.34 ( $<.0001$ )
<i>Reducing workforce size</i>	-1.04 (.14)	(2,3,4)	-.09 (.25)	(1)	.42 (.21)	(1)	<b>.68</b> (.47)	(1)	17.40 (.0006)
<i>Capacity utilization</i>	-1.46 .23	(2,3)	<b>.82</b> (.33)	(1,4)	.68 (.23)	(1,4)	-5.26 (.23)	(2,3)	35.66 ( $<.0001$ )
<i>Inventory management</i>	-.93 (.15)	(2,3,4)	.21 (.29)	(1,3,4)	1.18 (.25)	(1,2,4)	<b>8.59</b> (.25)	(1,2,3)	29.52 ( $<.0001$ )

\*Represents least squares means of the effect of the strategic manufacturing group.

\*\*Indicates the standard error of the mean for the strategic manufacturing group.

Note: Competitive capabilities and manufacturing practices are based on Miller and Roth (1994). The numbers in parentheses indicate the groups from which this group was significantly different as indicated by pair-wise comparisons based on the Tukey-Kramer procedure at the .10 level of significance. Numbers in bold indicate the highest mean value for the respective capabilities and practices. The observed Likelihood Ratio (LR) statistic is presented with the associated *p*-value in parentheses below.

TABLE EC.6. Parameter estimates for the generalized linear models to capture the relationship between normalized means for competitive capabilities of the strategic manufacturing groups and those for the Miller and Roth (1994) taxonomy.

<i>Parameter</i>	ESMS I	ESMS II	ESMS III	ESMS IV
Intercept	-48.75† (15.87)	-1.81 (1.04)	-15.99 (1.78)	-458.16‡ (110.87)
Caretakers	5.29‡ (1.33)	-3.25‡ (.84)	-2.61† (.91)	27.53† (9.32)
Marketeers	1.78† (.57)	-.83† (.36)	-.66* (.39)	12.51† (3.96)
Innovators	-1.42† (.530)	2.74‡ (.33)	3.04‡ (.36)	2.33 (3.70)
Caretakers × Marketeers	-.18‡ (.05)	.14‡ (.03)	.13‡ (.03)	-.78† (.33)
Caretakers × Innovators	.08† (.03)	-.12‡ (.02)	-.14‡ (.02)	-.01 (.18)
Marketeers × Innovators	.01 (.01)	-.03‡ (.003)	-.03‡ (.00)	-.11† (.04)
Caretakers × Marketeers × Innovators	.0002 (.0002)	.0004‡ (.0001)	.0005‡ (.0001)	.005‡ (.001)
Likelihood ratio with respect to base model with no interactions	16.47†	23.45‡	25.82‡	13.52†

\**p-value* < .10; †*p-value* < .05; ‡*p-value* < .001

TABLE EC.7. Parameter estimates for the generalized linear models to capture the relationship between normalized means for manufacturing practices of the strategic manufacturing groups and those for the Miller and Roth (1994) taxonomy.

<i>Parameter</i>	ESMS I	ESMS II	ESMS III	ESMS IV
Intercept	-63.06‡ (11.44)	-41.00‡ (7.48)	-56.56‡ (1.23)	-132.62‡ 16.77
Caretakers	3.51† (1.56)	-3.34‡ (.700)	-2.95‡ (.66)	1.24† (4.89)
Marketeers	3.30‡ (.50)	2.50‡ (.38)	3.20‡ (.50)	1.64† (.70)
Innovators	-.18* (.09)	1.93‡ (.42)	2.42‡ (.61)	4.88‡ (.81)
Caretakers × Marketeers	-.22‡ (.05)	-	-	-
Caretakers × innovators	-	-	-	-.54‡ (.08)
Marketeers × Innovators	-	-.06‡ (.02)	-.09‡ (.02)	-
Caretakers × Marketeers × Innovators	-	-	-	-
Likelihood ratio with respect to base model without interactions	7.33†	6.78†	11.74‡	4.65†

\**p-value* < .10; †*p-value* < .05; ‡*p-value* < .001

.0001) and greatest breadth in product lines ( $LR=28.09$ ;  $p < .0001$ ), and the “marketeer” practice emphasized by ESMS IV firms is product quality programs ( $LR=21.28$ ;  $p < .0001$ ). The “innovator” practice that ESMS IV firms emphasize is the development of new products ( $LR=13.57$ ,  $p=.004$ ). Thus, our manufacturing groups represent an inclusive structure as we move from ESMS I to IV – ESMS I firms show “innovator” and “caretaker” traits, ESMS II and III firms exhibit a hybrid of “marketeer” and “innovator,” attributes, and ESMS IV firms emphasize a hybrid of “caretaker” “marketeer,” and “innovators” characteristics. Transitioning from ESMS I to IV, such an inclusive and distributed structure stems from a greater consistency among resources in the *intra*-space, which in turn expands the scope of capabilities and practices pursued by firms.

The parameter estimates are based on standardized ESMS means (mean/standard error) for each of the groups from TABLE EC.5 (e.g.  $-1.25$  for premium price for ESMS I) and standardized means for caretakers (e.g.,  $28.01$ ), marketers (e.g.,  $39.77$ ), and innovators (e.g.,  $30.44$ ) from the Miller and Roth (1994) taxonomy. We created four variables ( $v_1, v_2, v_3, v_4$ ) for the ESMS columns in TABLE EC.5. Similarly, we created three variables ( $w_1, w_2, w_3$ ) representing the caretaker, marketeer, and innovator columns in the MR taxonomy for competitive capabilities. Using PROC GENMOD in SAS, we estimated the following models for each of the four ESMS groups ( $d=1,2,3,4$ ):

$$\begin{aligned} v_d = & \eta_0 + \eta_1 w_{1c} + \eta_2 w_{2c} + \eta_3 w_{3c} + \eta_4 w_{1c} w_{2c} \\ & + \eta_5 w_{1c} w_{3c} + \eta_6 w_{2c} w_{3c} + \eta_7 w_{1c} w_{2c} w_{3c} + \varepsilon_c, c = 1, 2, \dots, C \end{aligned} \quad (\text{EC5})$$

Here,  $C$  total number of competitive capabilities in the MR taxonomy. We developed similar set of models for manufacturing practices to explore the relationship between standardized means for manufacturing practices of our four groups and those of the MR taxonomy. The results of these analyses are presented in TABLE EC.6 and EC.7.

#### EC.4. Sensitivity Analysis

We conducted sensitivity analysis using theoretical concepts from the ecology literature related to two key issues: (1) the role of diversity of asset position in the resilience of manufacturing firms; i.e. the

ability of the manufacturing firm to adapt to endogenous stress and exogenous shocks; and (2) the related phenomenon of path dependence also described as density dependence, field effects and endogenous technical change (Perrings 1998).

#### **EC.4.1. Position**

The first area of sensitivity is related to the diversity of manufacturing firms within an industry with respect to their asset position. The management of practices and capabilities critical to system resilience involves decreasing the probability of transition to pursuing unfavorable strategies or increasing the probability of transition to pursuing favorable strategies. The probability of transition from one strategy to another depends on the system's ability to preserve its function in the presence of endogenous stress and exogenous shocks. Examples of factors that impact system resilience include demand, competitors, technology, and/or regulation. In ecology, more complex systems (e.g., coral reefs, tropical moist forests) have been associated with less resilience due to the high degree of connectance defined as the extent of interdependence among individual processes within the ecosystem (May 1972). Contrarily, the entire spectrum of species that facilitate critical strategic processes, may determine the resilience of an ecosystem under various environmental conditions.

While some species and groups of species are likely to enjoy higher ecological value under the current environmental conditions, it does not mean that rest of the species are unnecessary with little or no value. Diversity is important because species that are less prominent under one set of environmental conditions may play an important role under different conditions. When an ecosystem is perturbed, the extent to which the attrition of some species impacts critical processes is dependent on the number of other species that can assume a particular function (Holling 1992; Perrings et al. 1995).

In managed ecosystems, environmental conditions, such as change in prices, can increase the stress on manufacturing firms. Thus, the resilience of these firms depends on the presence of other strategic attributes supporting key structuring processes over the range of environmental conditions within the industry. In the semiconductor industry, strategic attributes are likely to include diversity of products, suppliers, and customers. The existence of particular technologies and best practices can preclude

development of certain products or implementation of certain technologies and best practices; i.e., it can lock the system into a particular strategic mode. Conversely, the existence of a diverse set of products, suppliers, and customers can enable the manufacturing firm to function effectively over a wide range of environmental conditions (Heywood 1995). Sensitivity analysis under a diversity of manufacturing firms is reflected in (1) determining the role of firms in supporting decision-making processes in industry over the appropriate range of environmental conditions, and (2) evaluating the opportunity cost of such decision-making processes in the industry that enable their conservation.

In order to assess the role of diversity in impacting the resilience of the system – firm and its manufacturing – we used the following variables to represent the position of the manufacturing firm.

**Current Assets:** Using current assets as the available resources lowers the amount of resources in the system over time compared to Total Assets (TA). Current assets are listed on a balance sheet and represent the total of available cash, accounts receivable, inventory value, tradable securities, and any other assets transferable into cash within a one-year time period. These assets have the potential to be easily liquidated when a firm files for bankruptcy, and hence are of importance to a firm's creditors. Clearly, the day-to-day operations of a firm are carried out using its current assets.

Given the short-term orientation of current assets, it is likely that a majority of manufacturing firms in the industry would consider adapting to the environmental conditions through exploiting their function, which would mean greater relative distance between absolute eigenvalues for the firm and its manufacturing operations. Exploitation would, in turn, translate into preference of manufacturing firms to pursue strategies that are relatively more prone to exponential growth. Thus, a majority of firms are likely to exhibit greater probability of transitioning to ESMS I and II strategic groups that concentrate on increasing their efficiency in manufacturing single and multiple products. In other words, the short-term annual focus is more likely to facilitate mobility of firms to ESMS I and II strategic groups.

**Sales:** The net sales of manufacturing firms are smaller in magnitude compared to those of their TA over time. In addition, the sales of a firm capture the uncertainty in external environmental conditions in various forms; e.g., business cycles, density dependence, speculative bubbles, and bandwagon effects.

These components in the sales are likely to contribute to variability over time in both the asset position and path dependence among manufacturing firms in the industry. Thus, under changing environmental conditions, firms with a weak position may choose to move to a strategic group with stronger position (e.g., by adding more products to their portfolio). Similarly, some firms with a strong asset position may choose to allocate resources to their single primary product under more severe environmental conditions (e.g., under increasing competitive pressure from other firms).

Weaker path dependence in sales of some manufacturing firms is likely to shift them to a strategic group with greater path dependence as in the case of a specialist (e.g., by engaging in learning by doing) to adapt to external changes. Contrarily, some manufacturing firms with greater path dependence may choose to behave as a generalist with weaker path dependence, e.g., by exploring new products, markets, and customers. Therefore, under the influence of business cycles, density dependence, speculative bubbles, and bandwagon effects, which are likely to change the position and path dependence continuously over time, manufacturing firms are likely to move in clockwise direction in Figure EC.2: II → III → IV → I → II to adapt to variability in the external environment. In this scheme, firms in a strategic group do not necessarily have to transition to the adjacent strategic group. Firms in a group may “skip” one or more groups as they move in the clockwise direction. For example, firms pursuing ESMS III strategies are likely to transition to pursuing ESMS I strategies. The choice of the cycle insures that the resource allocation paths for all firms in the industry are considered that begin at the trough followed by an early upswing (ESMS II) to reach the peak followed by the downswing to the trough again (Schohl 1999).

#### **EC.4.2. Path Dependence**

The second area for sensitivity analysis is related to path dependence, which is closely associated with the phenomenon of density dependence in ecology and field effects and speculative bubbles in economics and physics. The LV model in Equation (1) assumes density dependence given by the rate of growth of the resource allocations over time depends on its size (Clark 1990). The density dependent growth drops to zero at maximum carrying capacity, which is a stable equilibrium in the LV model. In the case of

manufacturing firms, allocating resources beyond the carrying capacity increases the likelihood of a system collapse or transition to a strategy resulting in lower levels of productivity (Arrow et al. 1995). Similar to terrestrial ecosystems that become more “brittle” (Holling 1986) when they approach the climax state (e.g., carrying capacity) manufacturing firm may pursue strategies that favor exponential growth and allow for less variation in the firm’s behavior. However, the capacity of that system to absorb exogenous shocks is also likely to be reduced.

	Functional products	Innovative products
Efficiency	ESMS I	ESMS II
Responsiveness	ESMS IV	ESMS III

**Figure EC.2.** Classification of the four strategic manufacturing groups (Fisher 1997).

In economics, an example of field effects is the result of dependence of a given customer’s demand for certain products on the extent of preference of the same products by other customers. Other cases of field effects can be readily seen in speculative bubbles or bandwagons (Aoki 1995, 1996). Density dependence, field effects, and speculative bubbles are all likely to influence the transition probabilities among various evolutionary stable strategies. Analogous to the reorganization of ecological systems that occurs when critical variables cross threshold values, density dependence, field effects, and speculative bubbles are likely to result in a concentration of activities that may lock manufacturing firms into a particular technology or best practice. This, in turn, may weight the transition probabilities from one strategic group to another.

In order to assess the impact of path dependence on the resilience of the system – firm and its manufacturing – we used the following variables:

**Lagged Total Assets:** The Total Assets of a firm represent the sum of total current assets, long-term receivables, other investments, net property plant and equipment, and other assets. Given the long-term orientation of TA, the use of lagged Total Assets as resources available in the system provided an opportunity to examine the impact of path dependence on system resilience. Decision-makers at lagged time ( $t - \xi$ ) are likely to undergo greater uncertainty in allocating resources compared to time  $t$ . This, greater the time delay ( $\xi$ ) the more likely is it that the combined system in Equation (1) exhibits oscillations (May 1974). Depending on the extent of path dependence, firms in the initial strategic groups are likely to consider adapting to the environmental conditions by locking into a particular technology or best practice. This lock-in mode may lead firms to behave more like specialists by expanding relative distance between absolute eigenvalues for the firm and its manufacturing operations over time. Thus firms would prefer pursuing strategies that are relatively more consistent with exponential growth by attempting to approach the climax state; and it is likely that they will transition to ESMS I, II, and III strategic groups.

**Lagged Sales:** When lagged Sales are considered as the amount of resources available over time, there is opportunity to examine the impact of both position and path dependence on system resilience. Decision-makers at lagged time ( $t - \xi$ ) are likely to recognize greater uncertainty in allocating resources compared to those at time  $t$ . At the same time, firms may choose to allocate smaller amount of resources to cope with the uncertainty in available resources. Thus, generalists found when TA was the available resources may choose to behave like specialists. Also, single product firms may choose to explore other product offerings, while multiple product manufacturers may focus on a single product to enhance their revenues. These decisions are likely to be based on cyclical changes, field effects, and speculative bubbles embodied in the sales of products of the manufacturing firms. Therefore, behavior of the firms under business cycles, density dependence, field effects, and speculative bubbles is likely to show movement in the anti-clockwise direction (Figure EC.2) to begin with an early downswing (ESMS IV) after a cyclical peak: IV  $\rightarrow$  III  $\rightarrow$  II  $\rightarrow$  I  $\rightarrow$  IV (Schohl 1999). This transition scheme is similar to that described for the

Sales variable above. In addition, increased uncertainty at lagged time in the presence of business cycles may swing resource allocations in overly exploitative or exploratory mode so that firms are likely to transition to ESMS I, and ESMS IV in greater numbers.

We used a multinomial probit model to understand the relationship between the strategic manufacturing groups from those based on time-series data on TA and those related to asset position and path dependence variables. The model specification is as follows:

$$z_{sk} = \theta_0 + \theta_1 \ln r_k + \omega_1 stg_{1k} + \omega_2 stg_{2k} + \omega_3 stg_{3k} + \varepsilon'_{sk}; s = 1, 2, 3, 4. \quad (EC5)$$

Here,  $z_{sk}$  represents probability that the  $k$ th firm is transitioned to pursuing a strategy  $s$  ( $s=1,2,3,4$ ) based on a multinomial distribution.  $r_k$  denotes the observed values for the control variables – the ratio of TA to variables used for sensitivity analysis, e.g., the ratio of TA to Current Assets. The values for the control variables were based on end of the study period to be consistent across all firms in the sample.  $\omega_1$ ,  $\omega_2$ , and  $\omega_3$  denote the effects of the manufacturing groups and  $stg_{1k}$ ,  $stg_{2k}$ , and  $stg_{3k}$  represent 0-1 dummies corresponding to the four groups based upon the analysis using TA.  $\theta_0$  denotes the intercept and  $\theta_1$  is the coefficient associated with the respective control variables.  $\varepsilon'_{sk}$  are independent and identically distributed  $N(0, \sigma^2)$  error terms. We performed this analysis using the GENMOD procedure in SAS 9.1 (2004) with a cumulative probit link function. The procedure also allowed us to compute odds ratios for pair-wise comparisons among the strategic groups. We used the absolute values of the square root of TA as the weights associated with the firms in our sample because of the systematic megaphone pattern of the variance in residuals, from the model in Equation (EC5), with respect to TA. Diagnostic checks (plots of residual deviances, leverage values, Cook's distance, and influence on single fitted value) on all the estimated models after making this modification did not reveal any influential observations. Normal probability plots of the residuals from these models did not show departure from model assumptions (Kutner et al. 2005).

TABLE EC.8 through EC.11 show the estimated coefficients of Equation (1) along with their respective 95% confidence intervals resulting from the bootstrapping procedure explained in Section 5.2. Each of the variables used in the analysis altered the computational characteristics of the model in Equation (1). As such, each MATLAB run for various variables took several hours (sometimes more than 24 hours) on a Dell desktop computer with an Intel Pentium 4 processor. The quality of the parameter estimates was insured through the use of two criteria: Root Mean Square Error (RMSE) and Mean Absolute Deviation (MAD). These values for adjusted SGA and adjusted COGS based on all the variables used – Current Assets, Sales, lagged Total Assets, and lagged Sales – for all the firms are relatively low within  $\pm 5\%$  of the time-series data. TABLE EC.8 through EC.11 also list the values of the estimated relative difference between eigenvalues ( $\hat{\delta}$ ) for firms in the sample.

The results from our analysis for *Current Assets* in TABLE EC.8 show that a majority of the firms in our sample are in ESMS I ( $n=10$ ) and ESMS II ( $n=17$ ). There are only three firms in ESMS III ( $n=3$ ) and no firms in ESMS IV. The multinomial probit analysis presented in TABLE EC.12 shows that all the parameter estimates are negative showing a movement from the previous classification based on TA. The strongest association is for ESMS II firms ( $p < .05$ ), which is consistent with the relatively large shift of the manufacturing firms to ESMS II when Current Assets are the available resources for the firms. The odds ratios (TABLE EC.13) reveal that the odds of moving away from ESMS II (.37;  $p < .001$ ) and IV (.24;  $p < .001$ ) to ESMS I are higher compared to ESMS II and IV firms moving into ESMS I. The odds of transitioning from ESMS I to ESMS III (1.23;  $p < .05$ ) are relatively higher compared to moving from ESMS III to ESMS I. The likelihood of firms transitioning from ESMS II to ESMS III is higher than that from ESMS III to ESMS II (3.32;  $p < .001$ ). Further, the movement from ESMS IV is more likely to ESMS II (.65;  $p < .05$ ) and III (.20;  $p < .001$ ) strategic groups. These observations are consistent with the expected behavior of the system when Current Assets are used as the available resources in the LV model for normalizing SGA and COGS.

In the case of *Sales* (TABLE EC.9), a large proportion of firms are under EMSM I ( $n=10$ ) and ESMS II ( $n=14$ ). There are fewer firms in ESMS III ( $n=1$ ) and ESMS IV ( $n=5$ ). The multinomial probit analysis presented in TABLE EC.12 shows that there is a negative and statistically significant ( $p < .001$ ) association for ESMS II group, while the relationship between ESMS III for the initial groups and the groups based on Sales is positive and statistically different from zero ( $p < .001$ ). This means that the movement to ESMS II in the new strategic groups is favored compared to the groups based on TA. The odds ratio indicates that the transition from ESMS III to ESMS I is statistically significant (.56;  $p < .001$ ). The odds are favorable for transitioning from ESMS I to ESMS II (2.07;  $p < .001$ ) rather than from ESMS II to ESMS I. The odds of transitioning from ESMS IV to ESMS I are not statistically significant as we may be picking up a downswing in the business cycle during which firms may be exploring new markets and customers to enhance their sales position. The movement away from ESMS III (.27;  $p < .001$ ) and IV (.47;  $p < .001$ ) to ESMS II is also statistically significant. Further transition from ESMS III (based on TA) to ESMS IV (1.73;  $p < .001$ ) is more favorable than from ESMS IV to ESMS III. These findings are as expected. When Sales alone are used as the resources for normalizing SGA and COGS, the firms move towards pursuing strategies that reflect the business cycles in the industry.

Based on TABLE EC.10, there are a large number of firms in ESMS I ( $n=12$ ) and ESMS II ( $n=15$ ). There is only one firm each in ESMS III ( $n=2$ ) and IV ( $n=1$ ), due to availability of lower amount of resources at time  $t-4$ . Under *lagged Total Assets* with a lag of four quarters (one year), all parameter estimates for the strategic manufacturing groups are positive and statistically different from zero ( $p < .001$ ). This result means that there is resistance to transition from the existing group membership based on TA for ESMS I, II, III. The odds ratios for ESMS I with respect to ESMS II (1.61;  $p < .001$ ), III (1.34;  $p < .001$ ) and IV (3.15;  $p < .001$ ) are highly favorable indicating that there is more resistance for ESMS I firms to move than that for ESMS II, III and IV firms to move. The odds of a firm transitioning from ESMS III to II are higher (.83;  $p < .05$ ) compared to firms moving from ESMS II to ESMS III. However, there is greater resistance to move from current ESMS II compared to ESMS IV (1.95;  $p < .001$ ). Further, ESMS III strategic group is favored over ESMS IV in not moving from respective groups (2.35;  $p < .001$ ).

.001). These results are consistent with the fact that normalizing the SGA and COGS time-series data with lagged Total Assets renders the firms relatively less vulnerable to transition to other strategic groups.

Based on TABLE EC.11, there are a large number of firms in ESMS I ( $n=14$ ) followed by equal number of firms in ESMS II ( $n=8$ ) and ESMS IV ( $n=8$ ). Under *lagged Sales* with a lag of four quarters (one year), estimates of the strategic groups are statistically different from zero for ESMS I ( $p < .001$ ), ESMS II ( $p < .05$ ), and ESMS III ( $p < .001$ ). The negative sign for ESMS I and ESMS II shows migration to ESMS I and ESMS II based on lagged sales, while the positive sign for ESMS III indicates resistance to move from the existing ESMS III. The odds ratios in TABLE EC.13 indicate that movement away from ESMS II (.48;  $p < .001$ ), ESMS III (.19;  $p < .001$ ), and ESMS IV (.37;  $p < .001$ ) is more likely to EMS I (based on lagged sales) than the other way around. Similarly, movement away from ESMS III (.40;  $p < .001$ ) and ESMS IV (.77;  $p < .05$ ) is more likely compared to movement from ESMS II to ESMS III and IV. ESMS III firms are more likely to be favored to prevail in the classification based on TA compared to those in ESMS IV (1.91;  $p < .001$ ). These observations are consistent with the description for the relationship between classification based on TA and those based on lagged Sales that is predominantly determined by business cycles.

In summary, our sensitivity analysis of the LV model using variables to represent available resources provided results that are as expected and consistent with existing literature on system resilience. Specifically, using Sales at time  $t$  ( $LR=202.52$ ;  $p < .0001$ ) and  $t-4$  (to represent last year's sales) ( $LR=275.40$ ;  $p < .0001$ ) exhibit predictable transitions to other strategic groups in the industry. Using Current Assets ( $LR=228.95$ ;  $p < .0001$ ), as expected, shows a predictable movement of the firms to more strategies that favor exponential growth. The most consistent behavior among the variables representing position and path dependence with respect to probabilities of transition among strategic groups is related to lagged Total Assets ( $t-4$ ) ( $LR=66.09$ ;  $p < .0001$ ). Thus, the results from sensitivity analysis confirm robustness of the LV system behavior when TA is used for normalizing SGA and COGS in the model in Equation (1).

TABLE EC.8. Parameter estimates of the Lotka-Volterra system of equations representing the resource allocation dynamics for the firm and its manufacturing operations using ratios of SGA to COGS with respect to *Current Assets (CA)*.

<i>Company</i>	$\kappa_1^*$	$\alpha_{11}^*$	$\alpha_{12}^*$	$\kappa_2^*$	$\alpha_{21}^*$	$\alpha_{22}^*$	RMSE**	MAD**	Eigenvalues***	$\hat{\delta}$
Actel <b>ESMS I</b>	-.0157 (-.0168, -.0146)	.0457 (.0399, .0515)	.0136 (.0088, .0182)	-.0273 (-.0289, -.0257)	-.0686 (-.1105, -.0268)	.1166 (.0714, .1618)	.0179 .0205	.0091 .0109	{.06, .01}	.83
AMD <b>ESMS I</b>	-.0008 (-.0010, -.0006)	.0047 (.0030, .0065)	.0049 (.0042, .0056)	.0094 (.0077, .0112)	.0132 (.0034, .0231)	.0383 (.0247, .0519)	.0205 .0349	.0156 .0263	{.027, .00069}	.97
Anadigics <b>ESMS I</b>	.1176 (.0911, .1441)	.7112 (.4289, .9934)	.3326 (.0954, .5698)	.0899 (.0618, .1180)	.1836 (-.3745, .7416)	.5117 (.1182, .9053)	.0241 .0351	.0173 .0280	{-.09, -.03}	.67
Analog Devices <b>ESMS I</b>	.0059 (.0046, .0073)	.1023 (.0935, .1112)	.0680 (.0627, .0733)	-.0884 (-.0902, -.0866)	-.3854 (-.4097, -.3611)	-.1328 (-.1625, -.1032)	.0110 .0141	.0073 .0103	{-.43, -.009}	.98
Catalyst <b>ESMS I</b>	.0009 (-.0010, .0028)	.0276 (.0141, .0412)	.0249 (.0177, .0321)	-.1288 (-.1341, -.1235)	.1562 (.1091, .2034)	-.3442 (-.3634, -.3249)	.0359 .0733	.0229 .0464	{-.42, -.001}	.99
Cypress Semiconductor <b>ESMS I</b>	-.0259 (-.0311, -.0207)	-.0784 (-.1264, -.0304)	-.1550 (-.1971, -.1130)	.2141 (.2027, .2254)	.5939 (.4659, .7218)	.9006 (.7962, 1.0051)	.0245 .0402	.0178 .0265	{5.91, .03}	.99
Intel <b>ESMS I</b>	.0011 (.0002, .0019)	.0240 (.0171, .0309)	.0083 (.0033, .0132)	-.0361 (-.0428, -.0294)	.0182 (-.0291, .0655)	-.1984 (-.2393, -.1574)	.0077 .0195	.0060 .0138	{-.03, -.001}	.97
Linear Technology <b>ESMS I</b>	-.0201 (-.0204, -.0198)	.0502 (.0408, .0596)	-.0225 (-.0297, -.0152)	-.0609 (-.0613, -.0605)	-.0583 (-.0788, -.0379)	-.4044 (-.4180, -.3908)	.0024 .0027	.0017 .0020	{.12, .02}	.83
Microsemi <b>ESMS I</b>	.0117 (.0037, .0197)	-.0030 (-.0672, .0612)	-.0030 (-.0389, .0329)	.0873 (.0815, .0932)	.5575 (.4810, .6341)	.1270 (.0890, .1650)	.0077 .0249	.0054 .0196	{4.83, -.01}	.99
Texas Instruments <b>ESMS I</b>	.0061 (.0051, .0071)	.0041 (-.0002, .0085)	.0175 (.0151, .0199)	-.0619 (-.0639, -.0598)	.0161 (-.0023, .0346)	-.1149 (-.1175, -.1124)	.0167 .0319	.0110 .0242	{-.11, -.007}	.94
Trident Microsystems <b>ESMS I</b>	.0101 (.0072, .0131)	.0076 (-.0015, .0168)	.0291 (.0201, .0380)	-.1319 (-.1397, -.1240)	.1467 (.0784, .2149)	-.5414 (-.5593, -.5236)	.0259 .0538	.0164 .0390	{-1.18, -.01}	.99
Xicor <b>ESMS I</b>	.0070 (.0050, .0089)	.0168 (.0077, .0258)	-.00484 (-.0099, .0002)	-.07038 (-.07946, -.06130)	.2265 (.1939, .25903)	-.3947 (-.4221, -.3672)	.0407 .0703	.0273 .0482	{-1.05, -.0069}	.99
Altera <b>ESMS II</b>	-.0089 (-.0095, -.0084)	.0166 (.0109, .0224)	.0086 (.0016, .0156)	-.0433 (-.0461, -.0405)	.0683 (.0378, .0988)	-.3413 (-.3791, -.3035)	.0084 .0105	.0046 .0065	{-.12, .009}	.99
Atmel <b>ESMS II</b>	.0823 (.0648, .0999)	.0243 (-.0977, .1464)	.3929 (.2928, .4930)	.0165 (-.0142, .0472)	-.5878 (-.9579, -.2178)	.3778 (.3109, .4447)	.0118 .0237	.0091 .0189	{-.018, .0028}	.84
Diodes <b>ESMS II</b>	-.0013 (-.0102, .0075)	-.0370 (-.0679, -.0060)	.0412 (.0170, .0654)	.0748 (.0179, .1317)	-.5142 (-.5625, -.4659)	.3284 (.1787, .4782)	.0114 .0420	.0089 .0300	{-1.30, .001}	.99
Dpac <b>ESMS II</b>	-.0072 (-.0265, .0121)	-.1189 (-.1860, -.0519)	.0191 (-.0165, .0548)	.1407 (-.0695, .3510)	-.0418 (-.1478, .0641)	.3882 (-.1592, .9356)	.0348 .1273	.0243 .0942	{-.09, .007}	.92

Exar <b>ESMS II</b>	-.0101 (-.0107, -.0096)	.0042 (.0005, .0078)	.0222 (.0190, .0254)	-.0827 (-.0838, -.0816)	.1121 (.0972, .1269)	-.2932 (-.2990, -.2874)	.0095 .0145	.0056 .0102	{.005, -.00016}	.97
Hei <b>ESMS II</b>	-.0068 (-.0088, -.0047)	.0236 (.0167, .0304)	.0124 (.0068, .0179)	-.0719 (-.0822, -.0617)	.0561 (.0448, .0674)	-.1892 (-.2098, -.1685)	.0255 .0915	.0167 .0691	{-.087, .007}	.92
Integrated Device Tech <b>ESMS II</b>	.0045 (.0032, .0059)	.1125 (.0967, .1285)	.02349 (.0128, .0342)	-.1447 (-.1476, -.1418)	-.0676 (-.1049, -.0303)	-.8596 (-.9027, -.8165)	.0182 .0200	.0125 .0147	{.235, -.005}	.98
International Rectifiers <b>ESMS II</b>	-.0008 (-.0011, -.0005)	.0129 (.0107, .0151)	.0215 (.0202, .0228)	-.0436 (-.0446, -.0425)	.0292 (.0216, .0368)	-.1024 (-.1059, -.0989)	.0105 .0324	.0069 .0240	{-.0376, .00096}	.97
Lattice Semiconductor <b>ESMS II</b>	.0417 (.0313, .0522)	.3980 (.0859, .7102)	.2803 (.0684, .4922)	.0753 (.0606, .0899)	.4223 (-.0468, .8914)	.6639 (.3633, .9643)	.0155 .0184	.0101 .0127	{-.04, .005}	.88
LSI Logic <b>ESMS II</b>	.0168 (.012, .0221)	.0775 (.0389, .1162)	.0020 (-.0064, .0103)	-.0013 (-.0182, .0155)	.0516 (.0017, .1016)	-.0244 (-.0869, .0381)	.0134 .0235	.0095 .0164	{-.017, .0004}	.98
Standard Microsystems <b>ESMS II</b>	.0386 (.0256, .0515)	-.0576 (-.1091, -.0061)	.2119 (.1647, .2592)	-.0011 (-.0420, .0399)	-.9305 (-1.1505, -.7104)	.44378 (.3608, .5267)	.0270 .0558	.0156 .0328	{.01, -.005}	.52
Sigma Designs <b>ESMS II</b>	.0134 (.0076, .0192)	.1520 (.0555, .2484)	-.1441 (-.2078, -.0803)	.1116 (.0818, .1414)	.1116 (.0818, .1414)	.9107 (.8264, .9951)	.0669 .0524	.0370 .0350	{.0988, -.022}	.78
Xilinx <b>ESMS II</b>	.0211 (.0019, .0402)	.0989 (-.1816, .3795)	.0523 (-.1860, .2907)	.1417 (.0734, .2100)	.3430 (-.3608, 1.0468)	.8908 (.5556, 1.2262)	.0152 .0219	.0089 .0138	{.43, -.02}	.95
Zarlink <b>ESMS II</b>	.0059 (.0046, .0072)	.0213 (.0144, .0282)	.0176 (.0128, .0224)	-.0595 (-.0712, -.0477)	-.0669 (-.0898, -.0440)	-.2195 (-.2653, -.1737)	.0247 .0374	.0166 .0251	{.33, -.006}	.98
Zilog <b>ESMS II</b>	.00562 (-.00002, .01125)	.0638 (.0355, .0922)	-.0264 (-.0381, -.0147)	.1749 (.1504, .1995)	.8362 (.7219, .9505)	.0465 (.0057, .0873)	.0294 .0344	.0218 .0268	{.26, -.008}	.97
Microchip <b>ESMS III</b>	-.0120 (-.0129, -.0112)	.0197 (.0161, .0233)	-.0058 (-.0091, -.0025)	-.0048 (-.0063, -.0032)	.0675 (.0567, .0783)	.0742 (.0662, .0822)	.0155 .0245	.0121 .0190	{.011, -.01}	.09
Silicon storage <b>ESMS III</b>	.1761 (.1062, .2461)	.5683 (.3132, .8234)	.6594 (.3905, .9283)	.0675 (-.0184, .1534)	-.1629 (-.9907, .6649)	.3866 (-.0985, .8716)	.0230 .0780	.0174 .0534	{.0986, -.07}	.29
Supertex <b>ESMS III</b>	-.0085 (-.0089, -.0081)	.0092 (.0074, .0111)	.0042 (.0022, .0062)	-.0028 (-.0036, -.0020)	-.0049 (-.0104, .0006)	.0912 (.0856, .0968)	.0063 .0130	.0051 .0093	{.0077, .0044}	.43

\*Entries represent parameter estimates. The 95% confidence intervals for each of the parameters are specified in parentheses.

\*\*Entries for Root Mean Square Error (RMSE) and Mean Absolute Deviation (MAD) in the top row are for *adjsga* (representing the firm's resources) and those in the row below are for *adjcog* (representing manufacturing resources).

\*\*\*Eigenvalues were used to classify the four strategic manufacturing groups. A relatively large difference in the eigenvalues corresponds to ESMS I firms. ESMS II firms have opposite and unequal eigenvalues. Eigenvalues for ESMS III firms are relatively equal, while eigenvalues for ESMS IV firms are complex.

TABLE EC.9. Parameter estimates of the Lotka-Volterra system of equations representing the resource allocation dynamics for the firm and its manufacturing operations after normalizing by the respective quarter's *Sales*.

<i>Company</i>	$\kappa_1^*$	$\alpha_{11}^*$	$\alpha_{12}^*$	$\kappa_2^*$	$\alpha_{21}^*$	$\alpha_{22}^*$	RMSE**	MAD**	Eigenvalues***	$\hat{\delta}$
Actel ESMS I	.0165 (.0034, .0297)	-.0656 (-.0876, -.0436)	.1246 (.1000, .1492)	-.0192 (-.0520, .0136)	-.0728 (-.1181, -.0275)	.0515 (.0162, .0868)	.0315 .0291	.0236 .0199	{-.0096, -.0031}	.68
Altera ESMS I	.0632 (.0519, .0746)	.0128 (-.0091, .0346)	.1633 (.1470, .1796)	-.2492 (-.3039, -.1945)	-.2492 (-.3039, -.1945)	-.3453 (-.4122, -.2784)	.0246 .0142	.0172 .0090	{-.49, -.12}	.76
AMD ESMS I	.0025 (.0001, .0050)	.0215 (.0046, .0384)	-.0068 (-.0176, .0041)	.0170 (.0071, .0269)	.0546 (.0264, .0828)	-.0074 (-.0373, .0226)	.0556 .0529	.0381 .0402	{-.02, -.0002}	.99
Anadigics ESMS I	-.0143 (-.0206, -.0080)	-.0153 (-.0486, .0181)	-.0329 (-.0560, -.0097)	-.0520 (-.0605, -.0436)	.0122 (-.0439, .0682)	-.1376 (-.1752, -.1000)	.0850 .0932	.0600 .0641	{.08, .01}	.88
International Rectifiers ESMS I	.0014 (-.0053, .0082)	.0386 (.0207, .0565)	-.0175 (-.0254, -.0096)	-.0094 (-.0320, .0132)	-.0679 (-.1211, -.0146)	.0152 (-.0014, .0317)	.0183 .0342	.0118 .0220	{-.018, -.004}	.78
Lattice Semiconductor ESMS I	-.0221 (-.0314, -.0129)	-.1533 (-.1723, -.1343)	.0667 (.0461, .0873)	.1660 (.1024, .2297)	-.2274 (-.2837, -.1711)	.6716 (.4930, .8501)	.0394 .0778	.0255 .0342	{.098, .019}	.81
LSI Logic ESMS I	.0170 (.0127, .0212)	.0177 (.0081, .0274)	.0100 (.0040, .0160)	-.0619 (-.0763, -.0476)	-.1897 (-.2085, -.1710)	.0064 (-.0113, .0241)	.0363 .0345	.0234 .0240	{.03, .01}	.67
Silicon storage ESMS I	-.0229 (-.0276, -.0183)	.1341 (.1265, .1418)	-.0147 (-.0222, -.0072)	-.0901 (-.1324, -.0479)	.0335 (.0254, .0415)	-.1323 (-.1938, -.0708)	.0929 .1591	.0604 .1030	{.07, .02}	.71
Supertex ESMS I	.0155 (.0055, .0255)	-.2068 (-.2284, -.1853)	.1371 (.1197, .1544)	.2180 (.1664, .2696)	-.0084 (-.0382, .0214)	.4382 (.3465, .5298)	.0389 .0254	.0257 .0189	{-.21, -.01}	.95
Zilog ESMS I	.0141 (.0087, .0195)	-.0202 (-.0462, .0057)	.0363 (.0187, .0538)	-.0938 (-.1133, -.0742)	-.1022 (-.1152, -.0893)	-.1194 (-.1650, -.0738)	.0418 .0307	.0297 .0224	{-.14, -.02}	.86
Analog Devices ESMS II	.0226 (.0183, .0270)	.0707 (.0655, .0760)	.0061 (-.0036, .0159)	-.0515 (-.0542, -.0489)	-.2857 (-.2903, -.2811)	.1288 (.1211, .1365)	.0150 .0106	.0093 .0075	{.22, -.02}	.91
Atmel ESMS II	.0205 (.0108, .0303)	-.1561 (-.1783, -.1339)	.1234 (.1055, .1413)	.1455 (.1174, .1737)	-.1849 (-.2285, -.1414)	.4069 (.3551, .4587)	.0224 .0362	.0163 .0264	{.036, -.016}	.56
Diodes ESMS II	.0024 (-.0012, .0060)	.0327 (.0203, .0451)	.0140 (.0083, .0197)	-.0991 (-.1070, -.0911)	-.0914 (-.0942, -.0886)	-.1155 (-.1264, -.1046)	.0169 .0262	.0140 .0174	{.5674, -.0027}	.99
Dpac ESMS II	.0312 (-.0082, .0705)	.0656 (.0013, .1299)	.0095 (-.0608, .0797)	.1673 (.0922, .2424)	.1577 (-.0559, .3712)	.1832 (.1280, .2384)	.0650 .0869	.0516 .0605	{.26, -.03}	.88
Exar ESMS II	.0217 (.0208, .0226)	-.0076 (-.0087, -.0065)	.0096 (.0079, .0114)	-.0341 (-.0406, -.0277)	.0105 (.0036, .0175)	-.0474 (-.0551, -.0396)	.0430 .0351	.0283 .0222	{.10, -.03}	.70

Hei <b>ESMS II</b>	.0068 (-.0355, .0491)	.2161 (.1733, .2589)	-.0388 (-.0901, .0125)	-.0595 (-.1254, .0065)	-.1280 (-.1934, -.0626)	-.0480 (-.1219, .0258)	.0424 .0539	.0324 .0407	{.06, -.001}	.98
Integrated Device Tech <b>ESMS II</b>	.0210 (.0189, .0232)	.0392 (.0321, .0462)	.0171 (.0115, .0226)	-.1950 (-.2066, -.1835)	-.0233 (-.0525, .0058)	-.4603 (-.4762, -.4445)	.0453 .0481	.0328 .0342	{.32, -.02}	.94
Microchip <b>ESMS II</b>	.0055 (.0037, .0074)	-.0093 (-.0186, .0001)	.0312 (.0290, .0334)	-.0066 (-.0129, -.0003)	-.1034 (-.1337, -.0730)	.0958 (.0906, .1011)	.0091 .0139	.0065 .0106	{.03, -.003}	.90
Sigma Designs <b>ESMS II</b>	.0109 (.0078, .0141)	.0117 (.0071, .0164)	-.0214 (-.0257, -.0170)	-.0142 (-.0244, -.0040)	.1010 (.0967, .1052)	-.0802 (-.0940, -.0663)	.2502 .1673	.1416 .0970	{.10, -.007}	.93
Texas Instruments <b>ESMS II</b>	.0157 (.0140, .0175)	.0129 (.0080, .0177)	.0039 (.0022, .0056)	-.0299 (-.0372, -.0225)	-.0142 (-.0294, .0011)	-.0273 (-.0336, -.0210)	.0242 .0326	.0181 .0231	{.07, -.02}	.71
Trident Microsystems <b>ESMS II</b>	-.0012 (-.0117, .0093)	.1134 (.1033, .1236)	-.1048 (-.1235, -.0861)	.0480 (.0091, .0870)	.0468 (.0400, .0536)	.0498 (-.0119, .1116)	.0796 .0722	.0560 .0501	{-.016, .003}	.81
Xicor <b>ESMS II</b>	.0210 (.0183, .0237)	.0375 (.0302, .0448)	.0165 (.0114, .0216)	-.1611 (-.1659, -.1564)	-.0438 (-.0619, -.0257)	-.2374 (-.2492, -.2257)	.0301 .0535	.0218 .0338	{.38, -.02}	.75
Xilinx <b>ESMS II</b>	.0010 (-.0003, .0023)	.0048 (.0028, .0068)	.0030 (-.0007, .0066)	.0126 (.0071, .0181)	.0297 (.0138, .0456)	.0054 (-.0153, .0260)	.0191 .0629	.0131 .0237	{.06, -.001}	.98
Zarlink <b>ESMS II</b>	-.0050 (-.0142, .0041)	-.0961 (-.1146, -.0777)	.0661 (.0519, .0804)	-.0322 (-.0793, .0149)	-.1188 (-.1546, -.0830)	.0435 (-.0222, .1092)	.0587 .0506	.0430 .0319	{.01, -.0017}	.83
Microsemi <b>ESMS III</b>	.0361 (.0287, .0435)	-.1688 (-.1923, -.1454)	.0948 (.0863, .1032)	.0456 (.0174, .0738)	.1482 (.0877, .2087)	.0285 (.0052, .0517)	.0141 .0284	.0108 .0179	{-.043, .0426}	.01
Catalyst <b>ESMS IV</b>	.0269 (.0192, .0347)	-.0168 (-.0530, .0195)	.0613 (.0403, .0824)	-.1066 (-.1214, -.0917)	-.2546 (-.3156, -.1935)	-.0180 (-.0515, .0155)	.0955 .2030	.0642 .0943	{-.015+.056 <i>i</i> , -.015-.056 <i>i</i> }	-
Cypress Semiconductor <b>ESMS IV</b>	-.0753 (-.0928, -.0577)	-.0139 (-.0571, .0292)	-.1857 (-.2073, -.1642)	.2617 (.1972, .3262)	.5404 (.3867, .6940)	.1503 (.1119, .1887)	.0489 .0963	.0324 .0601	{.11 +.16 <i>i</i> , .11 -.16 <i>i</i> }	-
Intel <b>ESMS IV</b>	.0753 (.0645, .0861)	.0048 (-.0283, .0378)	.2140 (.1995, .2285)	-.0075 (-.0212, .0062)	-.0803 (-.1359, -.0246)	.0550 (.0468, .0632)	.0161 .0326	.0129 .0264	{.003 +.02 <i>i</i> , .003 -.02 <i>i</i> }	-
Linear Technology <b>ESMS IV</b>	.0130 (.0100, .0161)	-.0031 (-.0260, .0197)	.0746 (.0641, .0850)	-.0272 (-.0360, -.0184)	-.0796 (-.1546, -.0046)	.0314 (-.0043, .0671)	.0122 .0107	.0083 .0069	{.005 +.013 <i>i</i> , .005 -.013 <i>i</i> }	-
Standard Microsystems <b>ESMS IV</b>	.0555 (.0386, .0725)	.1880 (.1491, .2269)	-.0200 (-.0381, -.0018)	-.3232 (-.3734, -.2729)	-.8639 (-.9713, -.7565)	-.0001 (-.0339, .0338)	.0592 .0616	.0425 .0352	{.007 +.15 <i>i</i> , .007 -.15 <i>i</i> }	-

\*Entries represent parameter estimates. The 95% confidence intervals for each of the parameters are specified in parentheses.

\*\*Entries for Root Mean Square Error (RMSE) and Mean Absolute Deviation (MAD) in the top row are for *adjsga* (representing the firm's resources) and those in the row below are for *adjcog* (representing manufacturing resources).

\*\*\*Eigenvalues were used to classify the four strategic manufacturing groups. A relatively large difference in the eigenvalues corresponds to ESMS I firms. ESMS II firms have opposite and unequal eigenvalues. Eigenvalues for ESMS III firms are relatively equal, while eigenvalues for ESMS IV firms are complex.

TABLE EC.10. Parameter estimates of the Lotka-Volterra system of equations representing the resource allocation dynamics for the firm and its manufacturing operations using ratios of SGA and COGS with respect to *lagged Total Assets* (TA).

<i>Company</i>	$\kappa_1^*$	$\alpha_{11}^*$	$\alpha_{12}^*$	$\kappa_2^*$	$\alpha_{21}^*$	$\alpha_{22}^*$	RMSE**	MAD**	Eigenvalues***	$\hat{\delta}$
Catalyst <b>ESMS I</b>	.0109 (.0062, .0156)	.0183 (-.0018, .0384)	.1173 (.0989, .1357)	-.2487 (-.2771, -.2202)	-.3328 (-.3853, -.2803)	-.5730 (-.6678, -.4783)	.0374 .0911	.0227 .0622	{-1.74, -.01}	.99
Cypress Semiconductor <b>ESMS I</b>	.0008 (-.0025, .0041)	.0640 (.0267, .1014)	.0865 (.0532, .1198)	-.0943 (-.1130, -.0756)	-.6955 (-.8508, -.5401)	-.5506 (-.7079, -.3933)	.0100 .0173	.0061 .0115	{-1.58, -.0009}	.99
Diodes <b>ESMS I</b>	-.0031 (-.0144, .0081)	-.2492 (-.4015, -.0969)	.1082 (.0564, .1600)	.1628 (.0916, .2340)	-.3476 (-.4638, -.2315)	.5233 (.3245, .7221)	.0100 .0539	.0093 .0352	{.09, .002}	.98
Dpac <b>ESMS I</b>	.0018 (-.0045, .0082)	-.0921 (-.1414, -.0428)	-.0386 (-.0711, -.0061)	.0724 (.0425, .1024)	.9983 (.8733, 1.1234)	-.1449 (-.2924, .0026)	.0245 .0964	.0178 .0732	{-.22, -.001}	.99
Exar <b>ESMS I</b>	-.0198 (-.0224, -.0171)	-.0026 (-.0224, .0172)	-.0667 (-.0867, -.0468)	-.0753 (-.0809, -.0697)	.5695 (.4712, .6679)	-.5064 (-.5207, -.4922)	.0081 .0132	.0052 .0093	{.54, .02}	.96
Linear Technology <b>ESMS I</b>	-.0154 (-.0160, -.0149)	.0916 (.0770, .1062)	-.0343 (-.0425, -.0261)	-.0781 (-.0790, -.0772)	-.1586 (-.1983, -.1190)	-.5606 (-.5822, -.5390)	.0031 .0033	.0022 .0026	{.19, .01}	.95
Microsemi <b>ESMS I</b>	.0303 (.0229, .0376)	-.2198 (-.3001, -.1395)	.0924 (.0452, .1397)	.1982 (.1874, .2091)	.8847 (.7942, .9752)	.7405 (.6736, .8073)	.0063 .0219	.0045 .0164	{-.65, -.03}	.95
Sigma Designs <b>ESMS I</b>	-.0066 (-.0160, .0028)	-.0348 (-.0922, .0225)	-.1433 (-.2214, -.0652)	.1924 (.1725, .2123)	.9613 (.8342, 1.0885)	.5717 (.4105, .7330)	.0423 .0679	.0278 .04611	{.92, .008}	.99
Texas Instruments <b>ESMS I</b>	-.0291 (-.0354, -.0228)	-.0492 (-.0984, -.00004)	-.1179 (-.1433, -.0925)	-.0549 (-.0628, -.0470)	.6262 (.5119, .7404)	-.3568 (-.3661, -.3475)	.0093 .0196	.0065 .0141	{.13, .02}	.85
Trident Microsystems <b>ESMS I</b>	.0085 (.0048, .0122)	.0007 (-.0113, .0127)	.0254 (.0144, .0364)	-.1264 (-.1359, -.1168)	.1817 (.1061, .2572)	-.5344 (-.5524, -.5164)	.0258 .0538	.0164 .0390	{-2.44, -.009}	.99
Xicor <b>ESMS I</b>	.0028 (-.0003, .0059)	-.0495 (-.0855, -.0135)	-.0194 (-.0436, .0049)	.1760 (.1644, .1877)	.0580 (-.0393, .1554)	.8983 (.8243, .9723)	.0227 .0410	.0164 .0320	{-.39, -.0028}	.99
Xilinx <b>ESMS I</b>	-.0102 (-.0113, -.0092)	.0267 (.0138, .0396)	.0239 (.0138, .0340)	-.0617 (-.0651, -.0582)	-.0382 (-.1003, .0239)	-.3896 (-.4525, -.3267)	.0109 .0138	.0074 .0095	{.16, .01}	.94
Actel <b>ESMS II</b>	-.0219 (-.0232, -.0206)	.0463 (.0309, .0617)	.0382 (.0233, .0531)	-.0574 (-.0597, -.0551)	-.0816 (-.1287, -.0346)	-.0560 (-.1052, -.0068)	.0141 .0141	.0091 .0103	{-.99, .03}	.97
Altera <b>ESMS II</b>	-.0151 (-.0159, -.0143)	.0219 (.0152, .0286)	.0086 (.00004, .0171)	-.0674 (-.0704, -.0645)	.1567 (.1058, .2077)	-.5889 (-.6439, -.5339)	.0100 .0173	.0062 .0101	{-.38, .02}	.95
AMD <b>ESMS II</b>	-.0015 (-.0028, -.0002)	.0230 (-.0012, .0471)	.0501 (.0276, .0726)	-.0745 (-.0830, -.0661)	-.2629 (-.3153, -.2105)	-.4682 (-.5425, -.3939)	.0057 .0112	.0044 .0091	{-4.15, .002}	.99
Anadigics <b>ESMS II</b>	.0295 (.0225, .0364)	.3472 (.2697, .4247)	.3730 (.3244, .4217)	-.0148 (-.0220, -.0076)	-.6768 (-.9545, -.3991)	.7925 (.6392, .9457)	.0138 .0232	.0103 .0177	{.03, -.01}	.67

Analog Devices <b>ESMS II</b>	-.0157 (-.0172, -.0142)	-.0130 (-.0314, .0053)	.0435 (.0286, .0583)	-.0981 (-.1012, -.0949)	-.3601 (-.4368, -.2834)	-.4756 (-.5671, -.3840)	.0055 .0077	.0036 .0056	{-.75, .02}	.97
Atmel <b>ESMS II</b>	-.0033 (-.0034, -.0032)	.0113 (.0093, .0133)	.0046 (.004, .0052)	.0058 (.0044, .0071)	-.0206 (-.0304, -.0108)	.0742 (.0652, .0832)	.0061 .0128	.0051 .0101	{-.01, .003}	.70
Integrated Device Tech <b>ESMS II</b>	-.0055 (-.0065, -.0044)	-.0184 (-.0351, -.0016)	.0538 (.0343, .0733)	-.0648 (-.0789, -.0506)	-.1510 (-.2353, -.0667)	-.6741 (-.8530, -.4951)	.0092 .0118	.0064 .0090	{-.28, .006}	.98
International Rectifiers <b>ESMS II</b>	.0082 (.0069, .0096)	.0535 (.0484, .0587)	.0581 (.0512, .0650)	-.0856 (-.0887, -.0824)	.0030 (-.0314, .0374)	-.4777 (-.4977, -.4578)	.0051 .0171	.0032 .0120	{.08, -.009}	.89
Intel <b>ESMS II</b>	-.0063 (-.0067, -.0058)	.0585 (.0484, .0686)	-.0128 (-.0219, -.0037)	-.0627 (-.0675, -.0580)	.0891 (.0425, .1356)	-.5893 (-.6466, -.5319)	.0041 .0088	.0032 .0064	{-.03, .006}	.97
Lattice Semiconductor <b>ESMS II</b>	-.0247 (-.0256, -.0238)	.0438 (.0301, .0574)	.0122 (.0034, .0209)	-.0384 (-.0404, -.0364)	-.0505 (-.1676, .0667)	-.0111 (-.0995, .0772)	.0100 .0100	.0050 .0072	{-.55, .03}	.94
Microchip <b>ESMS II</b>	-.0275 (-.0293, -.0258)	.0222 (.0103, .0342)	.0097 (.0006, .0188)	-.0348 (-.0374, -.0322)	.1823 (.1116, .2529)	-.0481 (-.0877, -.0086)	.0100 .0141	.0052 .0089	{-.11, .03}	.73
Silicon storage <b>ESMS II</b>	.0085 (.0065, .0105)	.0553 (.0480, .0626)	.0728 (.0640, .0817)	-.1269 (-.1318, -.1220)	-.0479 (-.0780, -.0177)	-.5791 (-.6047, -.5535)	.0423 .0679	.0278 .0461	{.26, -.01}	.96
Standard Microsystems <b>ESMS II</b>	-.00005 (-.00571, .00560)	.0548 (-.0349, .1445)	.0502 (.0332, .0671)	-.0561 (-.0632, -.0490)	-.1801 (-.3027, -.0576)	-.0412 (-.0669, -.0156)	.0145 .0255	.0082 .0184	{-.08, .0002}	.99
Supertex <b>ESMS II</b>	-.0037 (-.0047, -.0026)	.0342 (.0193, .0491)	.0403 (.0277, .0529)	-.0910 (-.0933, -.0886)	.0599 (.0274, .0925)	-.6460 (-.6724, -.6196)	.0200 .0100	.0051 .0085	{-.06, .004}	.93
Zarlink <b>ESMS II</b>	.0060 (.0048, .0073)	.0127 (-.0029, .0283)	.0399 (.0249, .0549)	-.0737 (-.0824, -.0650)	-.0084 (-.0682, .0515)	-.5464 (-.5985, -.4942)	.0200 .0283	.0150 .0205	{.13, -.006}	.95
LSI Logic <b>ESMS III</b>	-.0064 (-.0067, -.0061)	.0260 (.0220, .0301)	-.0084 (-.0122, -.0045)	-.0278 (-.0304, -.0252)	.0195 (-.0215, .0605)	-.1238 (-.1466, -.1010)	.0044 .0103	.0031 .0077	{.008, .005}	.38
Zilog <b>ESMS III</b>	.0564 (.0428, .0700)	.5838 (.3084, .8591)	.2409 (.0334, .4484)	-.0152 (-.0296, -.0008)	-.8487 (-1.5702, -.1272)	.6799 (.2087, 1.1512)	.0100 .0141	.0080 .0117	{.0302, -.0296}	.02
Hei <b>ESMS IV</b>	.1133 (.0937, .1330)	.0172 (-.1578, .1924)	.3543 (.2716, .4371)	-.0444 (-.0555, -.0333)	-.7896 (-.9986, -.5805)	.0794 (.0229, .1359)	.0142 .0707	.0102 .0543	{.006+.063 i, .0060-.063 i}	-

\*Entries represent parameter estimates. The 95% confidence intervals for each of the parameters are specified in parentheses.

\*\*Entries for Root Mean Square Error (RMSE) and Mean Absolute Deviation (MAD) in the top row are for *adjsga* (representing the firm's resources) and those in the row below are for *adjcog* (representing manufacturing resources).

\*\*\*Eigenvalues were used to classify the four strategic manufacturing groups. A relatively large difference in the eigenvalues corresponds to ESMS I firms. ESMS II firms have opposite and unequal eigenvalues. Eigenvalues for ESMS III firms are relatively equal, while eigenvalues for ESMS IV firms are complex.

TABLE EC.11. Parameter estimates of the Lotka-Volterra system of equations representing the resource allocation dynamics for the firm and its manufacturing operations using ratios of SGA and COGS with respect to *lagged Sales*.

<i>Company</i>	$\kappa_1$ *	$\alpha_{11}$ *	$\alpha_{12}$ *	$\kappa_2$ *	$\alpha_{21}$ *	$\alpha_{22}$ *	RMSE**	MAD**	Eigenvalues***	$\hat{\delta}$
Anadigics <b>ESMS I</b>	-.0042 (-.0295, .0211)	.0390 (-.0529, .1308)	-.0323 (-.1045, .0399)	.3210 (.2435, .3986)	.4369 (.3037, .5701)	.1459 (.0280, .2639)	.0990 .1396	.0749 .1017	{.9377, .0051}	.99
Atmel <b>ESMS I</b>	.0140 (.0087, .0194)	.0330 (.0098, .0562)	.0184 (.0072, .0296)	.0764 (.0679, .0849)	-.0145 (-.1805, .1515)	.1449 (.0615, .2284)	.0316 .0794	.0264 .0634	{-.1034, -.0123}	.88
Catalyst <b>ESMS I</b>	.1534 (.1219, .1850)	.5067 (.1964, .8170)	.0043 (-.1342, .1428)	.0183 (-.0425, .0791)	-.5172 (-.9398, -.0945)	.2621 (.1390, .3852)	.0849 .1559	.0613 .1255	{-.1476, -.0372}	.75
Dpac <b>ESMS I</b>	.1162 (.0742, .1583)	-.0173 (-.1310, .0965)	.1447 (.0641, .2252)	.2638 (.1954, .3322)	.4169 (.1577, .6761)	.2092 (.1447, .2736)	.0843 .3046	.0677 .2455	{-.3369, -.0399}	.88
Exar <b>ESMS I</b>	.0018 (-.0027, .0064)	-.0383 (-.0453, -.0313)	.0053 (.0013, .0094)	.0461 (.0309, .0613)	.0782 (.0551, .1014)	.0728 (.0604, .0853)	.0608 .0742	.0414 .0573	{-.1218, -.0017}	.99
Hei <b>ESMS I</b>	-.1008 (-.1458, -.0559)	.5629 (.4051, .7206)	-.2648 (-.3309, -.1986)	.0139 (-.0455, .0734)	-.1503 (-.2963, -.0042)	.0469 (-.0145, .1084)	.0557 .2054	.0385 .1479	{-1.27, -.0184}	.98
International Rectifiers <b>ESMS I</b>	.0076 (-.0039, .0190)	-.0076 (-.0232, .0080)	.0103 (-.0022, .0227)	.0350 (.0019, .0681)	.0368 (-.0197, .0932)	.0409 (.0125, .0694)	.0224 .0557	.0168 .0443	{-.0891, -.0059}	.93
LSI Logic <b>ESMS I</b>	.0176 (-.0183, .0534)	-.3087 (-.3674, -.2499)	.2426 (.2018, .2835)	.3903 (.3103, .4703)	.1201 (-.0654, .3055)	.6701 (.6157, .7245)	.0316 .0592	.0230 .0471	{-.4737, -.0112}	.98
Sigma Designs <b>ESMS I</b>	-.0296 (-.0395, -.0196)	-.0429 (-.0523, -.0335)	-.0359 (-.0455, -.0263)	.3329 (.2841, .3817)	.3506 (.3166, .3845)	.2210 (.1737, .2684)	.2443 .2496	.1564 .1883	{9.2141, .0349}	.99
Supertex <b>ESMS I</b>	-.0316 (-.0837, .0206)	-.4161 (-.5075, -.3246)	.1931 (.0837, .3025)	.0531 (-.0445, .1508)	-.0929 (-.1261, -.0598)	.1456 (-.0492, .3403)	.0436 .0608	.0318 .0487	{-.0638, -.0095}	.85
Texas Instruments <b>ESMS I</b>	.0407 (.0352, .0462)	.0183 (.0056, .0311)	.0412 (.0359, .0464)	-.1368 (-.1596, -.1140)	-.3051 (-.3572, -.2529)	-.0838 (-.1002, -.0674)	.0316 .0574	.0251 .0449	{-.2444, -.0835}	.66
Trident Microsystems <b>ESMS I</b>	.0058 (-.0015, .0131)	.0689 (.0555, .0823)	-.0467 (-.0558, -.0376)	-.0065 (-.0577, .0448)	.1147 (.0326, .1968)	-.0453 (-.0826, -.0080)	.0755 .1926	.0575 .1422	{.0056, .0002}	.96
Xilinx <b>ESMS I</b>	.0733 (.0599, .0868)	.3177 (.2570, .3783)	-.1360 (-.2173, -.0547)	.1868 (.1662, .2075)	-.1275 (-.2401, -.0148)	.5722 (.4236, .7208)	.0346 .0600	.0273 .0406	{-.3030, -.0866}	.71
Zilog <b>ESMS I</b>	.0299 (.0165, .0433)	.1301 (.0752, .1849)	-.0270 (-.0718, .0178)	.0752 (.0271, .1232)	-.5754 (-.7029, -.4479)	.6053 (.4715, .7392)	.0469 .0500	.0361 .0397	{-.5161, -.0307}	.94
AMD <b>ESMS II</b>	-.0455 (-.0606, -.0304)	-.1396 (-.1856, -.0935)	.0221 (-.0273, .0715)	.3945 (.3370, .4520)	.3465 (.2428, .4503)	.4833 (.3493, .6172)	.0624 .0843	.0475 .06095	{-1.2384, .0432}	.96
Analog Devices <b>ESMS II</b>	.0194 (.0143, .0244)	.1311 (.1172, .1451)	-.0561 (-.0731, -.0391)	-.1494 (-.1822, -.1165)	.0623 (.0429, .0818)	-.3707 (-.45173, -.2896)	.0226 .0338	.01675 .02313	{.0834, -.0166}	.80

Integrated Device Tech <b>ESMS II</b>	.0434 (.0307, .0561)	.1025 (.0678, .1372)	.0062 (-.0181, .0305)	-.1527 (-.1921, -.1133)	-.5625 (-.6684, -.4565)	.2077 (.1372, .2782)	.0458 .0592	.0348 .0471	{.8563, -.0418}	.95
Lattice Semiconductor <b>ESMS II</b>	.0031 (-.0027, .0088)	-.0061 (-.0144, .0022)	-.0064 (-.0145, .0017)	.0907 (.0542, .1271)	.1520 (.1221, .1819)	.1111 (.0382, .1839)	.0775 .0975	.0499 .0617	{5.5825, -.0032}	.99
Microsemi <b>ESMS II</b>	.0015 (-.0079, .0109)	-.0116 (-.0261, .0029)	-.0088 (-.0189, .0013)	.0864 (.0609, .1119 0)	.2635 (.2319, .2951)	.0451 (.0188, .0713)	.0224 .1100	.0168 .0759	{.5998, -.0018}	.99
Silicon storage <b>ESMS II</b>	.0593 (.0540, .0645)	.0125 (-.0003, .0254)	.0530 (.0488, .0571)	-.1050 (-.1118, -.0982)	-.2425 (-.2535, -.2315)	.0587 (.0544, .0631)	.2518 .2833	.1464 .5052	{.1210, -.0056}	.95
Standard Microsystems <b>ESMS II</b>	.1416 (.1061, .1772)	.4913 (.2234, .7592)	-.0556 (-.1679, .0567)	-.0298 (-.1275, .0679)	-.2987 (-.8186, .2212)	.1773 (-.0037, .3584)	.0819 .0943	.0570 .0741	{-.2206, .0499}	.77
Xicor <b>ESMS II</b>	.0233 (.0202, .0264)	.0154 (.0064, .0245)	.0376 (.0315, .0438)	-.1770 (-.1848, -.1691)	-.0404 (-.0703, -.0105)	-.2640 (-.2799, -.2481)	.0424 .0837	.0331 .0614	{1.0050, -.0270}	.97
Actel <b>ESMS IV</b>	.0721 (.0621, .0820)	.0256 (-.0086, .0598)	.1421 (.1177, .1665)	-.0753 (-.0919, -.0588)	-.2011 (-.2643, -.1379)	.1051 (.0612, .1490)	.0458 .0539	.0340 .0390	{.0298 +.0238 <i>i</i> , 0298 -.0238 <i>i</i> }	-
Altera <b>ESMS IV</b>	.0406 (.0338, .0473)	-.0017 (-.0188, .0153)	.0933 (.0829, .1037)	-.1953 (-.2142, -.1764)	-.2949 (-.3489, -.2409)	-.1321 (-.1483, -.1160)	.0100 .0361	.0063 .0251	{-.1366+.0143 <i>i</i> , - .1366-.0143 <i>i</i> }	-
Cypress Semiconductor <b>ESMS Iv</b>	.0835 (.0686, .0984)	.0833 (.0469, .1196)	.1211 (.0855, .1566)	-.1993 (-.2272, -.1715)	-.5265 (-.6018, -.4511)	.0414 (-.0482, .1310)	.0566 .1025	.0407 .0758	{.0416 +.1016 <i>i</i> , .04156 -.1016 <i>i</i> }	-
Diodes <b>ESMS IV</b>	.0666 (.047, .0862)	.1546 (.1310, .1781)	.0481 (.0247, .0716)	.0196 (.0056, .0336)	-.4382 (-.4612, -.4151)	.1337 (.1189, .1485)	.0265 .0985	.0203 .0749	{-.0291+.0271 <i>i</i> , - .0291-.0271 <i>i</i> }	-
Intel <b>ESMS IV</b>	.0410 (.0366, .0454)	.0012 (-.0197, .0222)	.1048 (.0973, .1124)	-.0689 (-.0779, -.0599)	-.1774 (-.2274, -.1274)	-.0155 (-.0308, -.0002)	.0224 .0424	.0175 .0291	{-.0050+.0569 <i>i</i> , - .00504-.0569 <i>i</i> }	-
Linear Technology <b>ESMS IV</b>	.0064 (.0022, .0106)	-.0418 (-.0660, -.0176)	.0715 (.0622, .0808)	-.0663 (-.0729, -.0597)	-.1977 (-.2378, -.1576)	.0242 (.0095, .0389)	.0245 .0224	.0177 .0173	{.0090 +.0125 <i>i</i> , .0090 -.0125 <i>i</i> }	-
Microchip <b>ESMS IV</b>	-.0201 (-.0223, -.0180)	.0368 (.0273, .0463)	-.0564 (-.0600, -.0528)	.0025 (-.0056, .0106)	.0840 (.0485, .1196)	-.0216 (-.0303, -.0129)	.0245 .0412	.0172 .0292	{.0030 +.0035 <i>i</i> , .0030 -.0035 <i>i</i> }	-
Zarlink <b>ESMS IV</b>	-.0061 (-.0141, .0018)	-.0954 (-.1137, -.0771)	.0556 (.0396, .0715)	.0492 (.0084, .1067)	.1230 (.0819, .1641)	-.0076 (-.0948, .0797)	.0866 .1095	.0690 .0827	{.0036 +.0258 <i>i</i> , 0036 -.0258 <i>i</i> }	-

\*Entries represent parameter estimates. The 95% confidence intervals for each of the parameters are specified in parentheses.

\*\*Entries for Root Mean Square Error (RMSE) and Mean Absolute Deviation (MAD) in the top row are for *adjsga* (representing the firm's resources) and those in the row below are for *adjcog* (representing manufacturing resources).

\*\*\*Eigenvalues were used to classify the four strategic manufacturing groups. A relatively large difference in the eigenvalues corresponds to ESMS I firms. ESMS II firms have opposite and unequal eigenvalues. Eigenvalues for ESMS III firms are relatively equal, while eigenvalues for ESMS IV firms are complex.

Table EC.12. Association between strategic manufacturing groups based on normalizing with respect to Total Assets and Current Assets, Sales, lagged Total Assets, and lagged Sales.

Variable used for normalizing SGA and COGS time-series data →	<i>Current assets</i>	<i>Sales</i>	<i>Lagged Total Assets</i>	<i>Lagged Sales</i>
Intercept	.68‡ (.16)	-1.05‡ (.22)	-1.46‡ (.14)	-.62† (.24)
Intercept	2.20‡ (.17)	.19 (.21)	.83‡ (.14)	.13 (.24)
Intercept	-	.24 (.21)	2.13‡ (.20)	-
Ln(Total Assets/Current Assets)	1.88‡ (.19)	-	-	-
Ln(Total Assets/Sales)	-	.31‡ (.09)	-	-
Ln(Total Assets/lagged Total Assets)	-	-	2.85‡ (.34)	-
Ln(Total Assets/lagged Sales)	-	-	-	.23† (.11)
ESMS I	-1.42‡ (.17)	-.03 (.13)	1.15‡ (.15)	-1.00‡ (.13)
ESMS II	-.43† (.17)	-.76‡ (.13)	.67‡ (.15)	-.26† (.13)
ESMS III	-1.63‡ (.18)	.55‡ (.14)	.85‡ (.15)	.65‡ (.14)
Likelihood Ratio with respect to model with only control variables	228.95‡	202.52‡	66.09‡	275.40‡

\**p*-value < .10; †*p*-value<.05; ‡*p*-value<.001

TABLE EC.13. Odds ratios for the likelihood of the firms in different groups for the analysis using various variables for normalizing SGA and COGS – Current Assets, Sales, and Lagged Total Assets, and lagged Sales.

Estimate (Standard error)	<i>Current Assets</i>		<i>Sales</i>		<i>Lagged Total Assets</i>		<i>Lagged Sales</i>	
	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval
ESMS I vs. ESMS II	.37‡ (.04)	(.31, .45)	2.07‡ (.18)	(1.74, 2.47)	1.61‡ (.15)	(1.35, 1.93)	.48‡ (.05)	(.40, .58)
ESMS I vs. ESMS III	1.23† (.13)	(1.01, 1.50)	.56‡ (.05)	(.47, .68)	1.34† (.13)	(1.10, 1.63)	.19‡ (.02)	(.16, .24)
ESMS I vs. ESMS IV	.24‡ (.04)	(.17, .34)	.97 (.13)	(.75, 1.26)	3.15‡ (.48)	(2.33, 4.25)	.37‡ (.05)	(.28, .48)
ESMS II vs. ESMS III	3.32‡ (.34)	(2.73,4.05)	.27‡ (.03)	(.22, .33)	.83† (.08)	(.69, 1.00)	.40‡ (.04)	(.33, .48)
ESMS II vs. ESMS IV	.65† (.11)	(.46, .92)	.47‡ (.06)	(.36, .61)	1.95‡ (.29)	(1.46, 2.60)	.77† (.10)	(.60, .99)
ESMS III vs. ESMS IV	.20‡ (.04)	(.14, .28)	1.73‡ (.24)	(1.32, 2.25)	2.35‡ (.36)	(1.74, 3.17)	1.91‡ (.26)	(1.46, 2.49)
Likelihood Ratio ( <i>p</i> -value)	228.95 (<.0001)		202.52 (<.0001)		66.09 (<.0001)		275.40 (<.0001)	

\**p*-value < .10; †*p*-value<.05; ‡*p*-value<.001

Note: Confidence intervals for the odds ratios and the corresponding *p*-values are based on a  $\chi^2$  distribution reported by the PROC GENMOD procedure in SAS Version 9.1.

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