"THE IMPORTANCE OF FLEXIBILITY IN MANUFACTURING"

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THE IMPORTANCE OF FLEXIBILITY IN MANUFACTURING

ABSTRACT

The goals of our study are to investigate the correlation between manufacturing flexibility and firm performance, and to determine whether manufacturing flexibility holds greater importance in the growth phase of the product life cycle as opposed to the mature phase. The Profit Impact of Marketing Strategy (PIMS) database provides our working data on 1,455 business units. Measures of manufacturing flexibility are extracted from the PIMS database, and a regression analysis conducted with firm performance measures. Flexibility is found to have a significant effect on firm performance and, in general flexibility is found to be more important in the growth phase than in the mature phase of the product life cycle.

(MANUFACTURING FLEXIBILITY; MANUFACTURING STRATEGY; PIMS; PRODUCT LIFE CYCLE)

THE IMPORTANCE OF FLEXIBILITY IN MANUFACTURING

1. Introduction

Flexibility is considered one of the dimensions of manufacturing strategy along with cost, quality, and dependability (see Wheelwright 1984). The profit impact of production costs is direct and clear. Intuitively, flexibility, quality, and dependability should also correlate with profits. The effects of these dimensions, however, is more indirect, depending on extraneous factors to the firm such as buyer behavior, and the costs involved in creating the benefit.

In this paper we will be testing the hypothesis that the economic performance of a firm is correlated with manufacturing flexibility. The hypothesis was generated by Newell and Swamidass (1987) whose study of thirty-five Pacific northwestern machine tool manufacturing firms found a high degree of correlation between firm performance and flexibility. Here, through an analysis of the Profit Impact of Marketing Strategy (PIMS) database, we will show that this relationship holds more generally, for manufacturing firms in a variety of industry groups throughout the U.S.A. Also, it will be shown that manufacturing flexibility is more important in the growth

stage of the product life cycle than it is in the mature phase.

Developments in manufacturing technology and the coining of the term "flexible manufacturing systems" have led to several attempts to define "flexibility" with respect to manufacturing. Taxonomies have been provided by Mandelbaum (1978), Buzacott (1982), Zelenovic (1982), Browne et. al. (1984), and Jaikumar (1984). It should be noted that very little has been done in terms of developing measures for the various types of flexibility (with the exception of the work by Chatterjee, Cohen, Maxwell, and Miller, 1984). As Adler (1985) has stated, no one definition has gained widespread acceptance as each appears to be rather domain specific.

The PIMS database contains data from 7,265 strategic business units on 500 variables. Anderson and Paine (1978) have conducted a critical analysis of the database and found it generally "to be the best current attempt to gather and analyze data on strategic actions of businesses". Of these 7,265 business units 5,878 manufactured at least 70% of their products and these were used for our study of manufacturing firms.

2. The Theoretical Basis For Our Hypotheses

In this section we will review the theoretical basis for our hypotheses that (a) manufacturing flexibility is an important decision variable having a significant impact on firm performance, and (b) manufacturing flexibility is more important in the growth phase of the product life cycle than in the mature phase.

Although more an intuitive understanding than "theory" as such, the idea that flexibility in manufacturing should be significant has been discussed by Wheelwright (1984), Jaikumar (1986), and essentially underlies the whole body of literature on FMS. The logical assertion that "competitive success increasingly depends on management's ability to anticipate and respond quickly to changing market needs" (Jaikumar, 1986, Pg. 76) emphasizes the obvious need for flexibility in a competitive market.

Product life cycle theory suggests that different strategies are appropriate during different stages of the cycle. Wasson (1983) suggests that in the growth stage product design differentiation is a key success factor.

> "The growth stage is inevitably characterized by a growth in market segmentation ... Sellers must find a niche for themselves ... and design a flexible mix of models to serve the types of segments occupying that niche ... The seller needs to provide quick feedback and a sensitivity to these needs in order to adapt offering designs to the demand pattern ... During this stage, a seller must keep in the forefront of changing design possibilities, in order to preempt any possible opportunities for new competitors"
>
> Wasson (1983), Pg. 339

In the mature phase, however, Catry and Chevalier (1974) recommend increasing the manufacturing process stability, and Patton (1959) advises lower product differentiation. Dean (1950) states that this phase is characterized by greater product standardization and stabilization of production methods. The above literature suggests that manufacturing flexibility is more important in the growth phase than in the mature phase and that manufacturing flexibility is occasionally necessary to carry out the appropriate strategy.

Utterback and Abernathy (1975) describe an evolutionary model of process and product innovation. In this model products and processes undergo a transformation from an early "fluid" period of development to a state that is specific and rigid. During this early stage the process is largely unstandardized and labor intensive.

The process is characterized by loose and unsettled relationships between process elements. As product performance criteria become better known and as the production technology becomes better defined, there is a move towards more efficient, capital intensive, rationalized flow production systems.

It is interesting to note that in 1975 Utterback and Abernathy were aware of some of the impacts of FMS when they stated:

> "It may also be that computer aided manufacturing will ultimately reduce some of the interdependence between product and process change".

An empirical study of thirty five machine tool manufacturing firms in the Pacific northwest of the U.S. by Newell and Swamidass (1987) found that the greater the flexibility the better the economic performance of the firm. In fact, they found that manufacturing flexibility had a greater correlation with economic performance than any of the other variables tested (i.e. environmental uncertainty, and the role of manufacturing managers in strategic decision making). In our study we tested the hypothesis whether the correlation between flexibility and performance holds more generally (i.e. across the U.S., and across industry groups) by using the PIMS database.

3. Description of Performance and Flexibility Measures

From the PIMS data five measures of firm performance were amalgamated to give an overall measure. These five items were averages over the five year period 1980-1984. They were:

(i) return on sales corrected for inflation (ROS) (%)

(ii) return on investment corrected for inflation (ROI) (%)

(iii) real sales growth (%)

(iv) cashflow/revenue (%)

(v) market share growth (%)

The last two measures, cashflow/revenue and market share growth, were used by Thietart and Vivas (1984) in their study using the PIMS data. As they pointed out cashflow/revenue is more of a short-run financial objective while market share growth may entail short-term sacrifices for long-term gain. Other studies using PIMS data have used market share (Buzzell and Wiersema 1981), and ROS (Galbraith and Stiles 1983) as their measures of performance.

As measures of firm performance Newell and Swamidass use the following items: average annual rate of growth in return on total assets, average annual rate of growth of sales, and average annual rate of growth in return on sales. They justify the use of growth as the preferred

measure of performance since in the period of their data collection (1977-1981) the machine tool industry was faced with a severe recession as well as increasing competition from abroad. As a result, growth was considered a rigorous test of firm performance.

In our case growth alone would not have been appropriate since the data was collected for the years 1980-1984 and since we have split the firms into those in the growth phase and those in the mature phase. We have used a linear combination of all the above performance measures (i) to (v) for an overall measure of firm performance (the dependent variable PERFORMANCE in our regression analysis). It does not have the drawbacks of using ROS or ROI alone that Thietart and Vivas reported (i.e. they could not be reasonably approximated by a normal distribution). As one would expect (as a result of the Central Limit Theorem) the multi-item measure provided a distribution that better approximated a normal distribution.

The Cronbach Alpha (Cronbach 1951) was computed for this multi-item measure and found to be between 0.507 and 0.757. This Cronbach Alpha is a measure of reliability in the multi-item construct. The minimum alpha value recommended by Nunnally [1978, Pg. 245] to ensure reliability in a multi-item measure for psychometric

research was in the area of 0.7.[1] Any doubt that this particular combination may have affected our results was eliminated by taking different combinations as well as individual performance measures and repeating the analysis. Such repetitions yielded results that differed little from those reported here.

For the study here we found several variables in the PIMS database which describe some aspect of manufacturing flexibility. The items in the PIMS data used were:

- frequency of product changes
- technological change (0= no change, 1= change)
- customization (0=standard product, 1=customized)
- development time for new products
- % small batches in production
- total R&D/revenue

Some of the above items were then rescaled such that lower numbers indicated less flexibility and higher numbers more flexibility. Newell and Swamidass (1987) incorporated in

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[1] Cronbach Alpha = $k/(k - 1) * (1 - \sum_{i=1}^{k} \sigma_i^2 / \sigma_m^2)$

where,

k = the number of items included in the measure

σ^2_i = the variance of item i

σ^2_m = variance of the measure

Peter (1979) has pointed out that Nunnally's guidelines were primarily concerned with the development of finely tuned measures of individual traits to be used for decisions about individuals. Peter suggests that for marketing research, since it is not of the same nature, can accept lower levels of reliability. This is also true of the research here.

flexibility. Newell and Swamidass (1987) incorporated in their measure of manufacturing flexibility five items (which were scored on ten point scales from most flexible in the industry to least flexible in the industry): new products introduction, introducing new production processes, product varieties, product features, and R&D effort. Unlike Newell and Swamidass' study we could not combine all of the above aspects of flexibility into one measure as the Cronbach Alpha was too low. Consequently, each aspect was treated as a separate independent variable.

4. Testing Procedure

A sample of 5,879 business units was drawn from the PIMS database which manufactured 70% of their products. This group was then further subdivided into six different types of businesses, and into two stages of the product life cycle. Those observations which included extreme values in any of the performance variables or in R&D/revenue were eliminated. The correlation matrix was computed, and multivariate linear regressions were performed. Initially, those independent variables which had coefficients below the 90% confidence level were excluded in subsequent computations of the regression analysis. Afterwards, variables which exhibited colinearity with other independent variables were eliminated.

The firms were split by 6 types of businesses: Consumer Durables, Consumer Non-durables, Capital Goods, Raw Materials and Semi-finished Goods, Components for Finished Goods, and Supplies manufacturers. There were eight possible types of businesses within the database. However, the two remaining businesses, Services and Retailers/Wholesale Distributors were, quite naturally, lacking in manufacturers. This division was performed on the basis of how the businesses classified themselves in

response to a question on the survey.

The business units were then further divided into two groups according to where they were in the product life cycle. These two groups consisted of those who were in the growth phase and those who were in the mature phase. This distinction was made, as Thietart and Vivas had made it, by both qualitative and quantitative criteria. The quantitative criterion was the reported market growth. The qualitative criterion was where the respondents perceived themselves to be on the product life cycle. If both market growth was greater then 4.5% p.a., and the respondent reported that the business was in the growth stage then the business was classified in the growth stage. Similarly, the respondents had to report that they were in the mature phase, and the market growth rate had to be between -1% and 4.5% for the business to be considered in the mature stage. All other businesses were excluded. The introductory stage and decline stage included too few observations to be analyzed.

Thietart and Vivas noted that the PIMS database, like any other, was likely to contain miscoded variables. They followed the PIMS recommendation of excluding 5% of the observations with the largest absolute residuals. We went somewhat further excluding a larger proportion of the observations, the reason being that large increases in market share or ROI and ROSs in excess of an average of

30% p.a. over the five year period indicate some extraordinary change not likely to be attributable to normal operations of a firm. Also, an examination of the frequency distribution over the ROI and ROS revealed (in some industry groups) two separate mound shapes indicating the possibility of two distinct populations. The cutoff points used were: for R&D/revenue (%) 0, 10; for ROI (%)-20, 30; for ROS (%) -20, 30; for real sales growth (%)-20, 40; for cashflow/revenue (%) -20,20; and for market share growth (%) -15,20 (lower bound, upper bound, respectively). Thus the sample size was pruned down to 1,455 business units.

5. Summary of Test Results

The following tables summarize the results of the regression analyses. Only coefficients which are significant at the 90% confidence level or greater are reported. For further detail (correlation matrices, etc.) refer to the Appendix.

TABLE 1. EFFECTS OF FLEXIBILITY ON PERFORMANCE

Business	CONSUMER DURABLES		CONSUMER NON-DURABLES	
Variable	GROWTH	MATURE	GROWTH*	MATURE
Customization				
Freq. Prod. Ch.	-20.92 (0.000)			
Technol. Change	32.06 (0.001)			
Develop. Time				
%Small Batches				
Tot. R&D/Rev.		-7.11 (0.000)		6.19 (0.000)
R^2 (%)	55.22	12.64		6.26
F (D.F.)	14.2 (2,23)	21.0 (1,145)		17.8 (1,267)
Prob(error)	0.000	0.000		0.000
Sample Size	26	147	73	269
Cronbach Alpha	0.507	0.716		0.651

* there were no significant effects for this group

TABLE 1 (CONTINUED)

Business MATL	CAPITAL GOODS		RAW AND SEMI-FINISHED	
Variable	GROWTH	MATURE	GROWTH	MATURE
Customization				
Freq. Prod. Ch.	11.63 (0.031)			
Technol. Change	-14.96 (0.006)			
Develop. Time		6.22 (0.004)		
%Small Batches	0.196 (0.002)			
Tot. R&D/Rev.			4.55 (0.015)	-2.63 (0.010)
R^2 (%)	22.62	4.76	9.13	4.59
F (D.F.)	6.43 (3,66)	7.25 (1,145)	5.03 (1,50)	5.53 (1,115)
Prob(error)	0.001	0.008	0.029	0.020
Sample Size	70	147	52	117
Cronbach Alpha	0.647	0.712	0.720	0.686

TABLE 1 (CONTINUED)

Business Variable	COMPONENT MFGRS GROWTH	COMPONENT MFGRS MATURE	SUPPLIES MFGRS GROWTH	SUPPLIES MFGRS MATURE
Customization				
Freq. Prod. Ch.				
Technol. Change			19.34 (0.015)	
Develop. Time		-4.45 (0.001)		
%Small Batches	-0.20 (0.024)			-0.15 (0.002)
Tot. R&D/Rev.		2.47 (0.003)		
R^2 (%)	3.98	7.16	9.47	4.46
F (D.F.)	4.02 (1,97)	8.64 (2,224)	5.02 (1,48)	8.21 (1,176)
Prob(error)	0.048	0.000	0.030	0.005
Sample Size	99	227	50	178
Cronbach Alpha	0.661	0.702	0.672	0.757

NB: (i) The figures in the brackets beneath the regression coefficients are the probabilities that the effect is zero.

(ii) The Prob(error) is the P-level for the entire regression taken together based on the computed F-statistic with degrees of freedom (D.F.) for the numerator and denominator, respectively.

6. Conclusions

There are two major findings from this study. The first is that manufacturing flexibility is an important decision variable for firms. The obtaining of, or the decision of not acquiring, manufacturing flexibility has a statistically significant effect on firm performance. The second is that, generally, (with the exception of the component manufacturers) we have found that manufacturing flexibility is more significant among growth firms than mature firms where significance is measured in terms of R^2 (the proportion of variance in performance explained by manufacturing flexibility).

The initial reaction may be that the R^2's are rather small. However, it must be kept in mind that we are examining very broadly defined groups in this cross-sectional data. Also, it should be remembered that manufacturing flexibility is just one aspect of manufacturing strategy and just one of a myriad of decision variables for a firm which impact on the performance of the firm. If we examine other published reports using PIMS data we see that the R^2's we obtain are within the same general area as those obtained by other researchers. From Table 1 we see that the R^2 ranges anywhere from 3.98% to 55.22%. Buzzell and Wiersema

(1981) obtained R^2s of 27.9%, 29.9%, and 39.3% in their models of variables affecting changes in market share. Galbraith and Stiles' (1983) study of relative firm power[2] and its association with firm profitability achieve R^2s ranging from 6.0% to 23.5%. Thietart and Vivas (1984) attain R^2s ranging from 42% to 92%. They, however, allow a much higher correlation between independent variables (0.42) than we do in our models (generally below 0.2, depending on the number of observations).

Newell and Swamidass' study (1987) of machine tool manufacturers can be thought of as a special case of the capital goods producers in the mature phase. Their study had a 11% R^2 as compared to our 4.76% R^2 for the more broadly defined group.

In many of the regression models one can see significant negative coefficients. This implies that it is possible to try to have too much manufacturing flexibility for the given situation. This is contrary to a finding of Newell and Swamidass which was that increased flexibility meant improved firm performance. This is likely due to the fact that associated with each aspect of flexibility there is a cost (i.e. higher set up costs for a higher percentage of small batches, higher development

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[2] Galbraith and Stiles (1983) defined relative firm power between producing firms, their suppliers, and their customers by concentration levels in their factor and output markets as well as barriers to entry.

costs for a greater number of new product introductions, etc.). These costs may be greater than the resulting return, ergo the negative effect. Whether the effect has a positive coefficient or a negative coefficient depends on whether the majority of the firms in the group are in the area of positive or negative marginal returns, respectively, for the investment in the particular aspect of manufacturing flexibility.

It must also be kept in mind that these results are a function of the given technology (at the time when this data was gathered very few American firms had FMS). The new flexible technologies can reduce the costs of frequent product changes and small batches, and reduce product development time. The advent of these technologies provides us with an incentive for further work in clarifying the characterization of manufacturing flexibility.

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APPENDIX

THE IMPORTANCE OF MANUFACTURING FLEXIBILITY TO FIRM PERFORMANCE: AN ANALYSIS OF PIMS DATA

CONSUMER DURABLE MANUFACTURERS IN THE GROWTH PHASE

VBLS NUMBERED AS FOLLOWS:
1 CUSTOMIZATIONC
2 RE FREQ PRD CH
3 TECHNOL CHANGC
4 RE DEV TIME
5 %SMALL BATCHS
6 TOTAL R&D/REV A
7 PERFORMANCE

DATA ARE IN WFL 2: 26 OBSS ON 7 VBLS.

THE CORRELATION MATRIX

	1	2	3	4	5	6	7
1	1.0000						
2	.3003	1.0000					
3	-.2081	.0919	1.0000				
4	.2654	.2219	-.0135	1.0000			
5	.4850	.0148	-.2440	.5969	1.0000		
6	-.1945	-.1003	-.1003	-.6707	-.6278	1.0000	
7	-.3621	-.5364	.4629	-.2693	-.1340	.1087	1.0000

RESULTS OF REGRESSION ANALYSIS

DEP.VBL: PERFORMANCE

NAT:		EST	SE	P
0	CONSTANT	59.13	8.68	.000
2	RE FREQ PRD CH	-20.92	5.02	.000
3	TECHNOL CHANGC	32.06	8.70	.001

EST.RES.SD 15.93
AV.FCST SD 17.61
SAM.RES.SD 14.99
SAM. R SQR .5522
F - 14.2 (2,23 DF): P - .000

CONSUMER DURABLE MANUFACTURERS IN THE MATURE PHASE

VBLS NUMBERED AS FOLLOWS:

1 CUSTOMIZATIONC
2 RE FREQ PRD CH
3 TECHNOL CHANGC
4 RE DEV TIME
5 %SMALL BATCHS
6 TOTAL R&D/REV A
7 PERFORMANCE

DATA ARE IN WFL 2: 147 OBSS ON 7 VBLS.

THE CORRELATION MATRIX

	1	2	3	4	5	6	7
1	1.0000						
2	-.2275	1.0000					
3	-.0675	.0487	1.0000				
4	-.4860	.2605	.1086	1.0000			
5	.2861	.0497	.0628	.0083	1.0000		
6	-.4068	.1282	-.0570	.2274	.0525	1.0000	
7	.1290	-.0666	.1011	-.0423	-.0009	-.3555	1.0000

RESULTS OF REGRESSION ANALYSIS

DEP.VBL: PERFORMANCE

NAT:		EST	SE	P
0	CONSTANT	21.21	2.78	.000
6	TOTAL R&D/REV A	-7.106	1.552	.000

EST.RES.SD 24.27
AV.FCST SD 24.61
SAM.RES.SD 24.11
SAM. R SQR .1264
F - 21.0 (1,145 DF): P - .000

CONSUMER NON-DURABLE MANUFACTURERS IN THE MATURE PHASE

VBLS NUMBERED AS FOLLOWS:

1 CUSTOMIZATIONC
2 RE FREQ PRD CH
3 TECHNOL CHANGC
4 RE DEV TIME
5 %SMALL BATCHS
6 TOTAL R&D/REV A
7 PERFORMANCE

DATA ARE IN WFL 2: 269 OBSS ON 7 VBLS.

THE CORRELATION MATRIX

	1	2	3	4	5	6	7
1	1.0000						
2	-.0669	1.0000					
3	-.0385	-.1125	1.0000				
4	.0870	.3334	.1336	1.0000			
5	.5401	.0054	-.0750	.1929	1.0000		
6	.0190	-.1503	.1368	.0648	-.0370	1.0000	
7	-.0084	.0745	.0323	.0998	-.0830	.2503	1.0000

RESULTS OF REGRESSION ANALYSIS

DEP.VBL: PERFORMANCE

NAT:	EST	SE	P
0 CONSTANT	9.062	1.763	.000
6 TOTAL R&D/REV A	6.194	1.466	.000

EST.RES.SD 21.32
AV.FCST SD 21.48
SAM.RES.SD 21.24
SAM. R SQR .0626
F - 17.8 (1,267 DF): P - .000

CAPITAL GOODS MANUFACTURERS IN THE MATURE PHASE

VBLS NUMBERED AS FOLLOWS:
1 CUSTOMIZATIONC
2 RE FREQ PRD CH
3 TECHNOL CHANGC
4 RE DEV TIME
5 %SMALL BATCHS
6 TOTAL R&D/REV A
7 PERFORMANCE

DATA ARE IN WFL 2: 147 OBSS ON 7 VBLS.

THE CORRELATION MATRIX

	1	2	3	4	5	6	7
1	1.0000						
2	-.1346	1.0000					
3	-.1887	.2333	1.0000				
4	-.0676	.0173	.1267	1.0000			
5	.4501	-.1025	-.2069	.1865	1.0000		
6	-.1087	.3117	.0274	.1050	.1447	1.0000	
7	-.0565	.0619	.0675	.2183	-.0104	-.0530	1.0000

RESULTS OF THE REGRESSION ANALYSIS

DEP.VBL: PERFORMANCE

NAT:		EST	SE	P
0	CONSTANT	3.317	7.229	.324
4	RE DEV TIME	6.223	2.311	.004

EST.RES.SD 27.33
AV.FCST SD 27.71
SAM.RES.SD 27.14
SAM. R SQR .0476
F - 7.25 (1,145 DF): P - .008

RAW MATL'S OR SEMI-FINISHED GOODS MANUFACTURERS IN THE GROWTH PHASE

VBLS NUMBERED AS FOLLOWS:

1 CUSTOMIZATIONC
2 RE FREQ PRD CH
3 TECHNOL CHANGC
4 RE DEV TIME
5 %SMALL BATCHS
6 TOTAL R&D/REV A
7 PERFORMANCE

DATA ARE IN WFL 2: 52 OBSS ON 7 VBLS.

THE CORRELATION MATRIX

	1	2	3	4	5	6	7
1	1.0000						
2	-.0722	1.0000					
3	.2270	-.0077	1.0000				
4	.2532	.1923	.7285	1.0000			
5	.3488	.3346	-.0173	.2403	1.0000		
6	-.0919	.3857	-.1990	.0188	.1282	1.0000	
7	-.0394	-.1312	-.0156	-.0917	.0551	.3022	1.0000

RESULTS OF THE REGRESSION ANALYSIS

DEP.VBL: PERFORMANCE

NAT:		EST	SE	P
0	CONSTANT	15.17	5.66	.005
6	TOTAL R&D/REV A	4.548	2.029	.015

EST.RES.SD 29.26
AV.FCST SD 30.44
SAM.RES.SD 28.70
SAM. R SQR .0913
F - 5.03 (1,50 DF): P - .029

RAW MATERIALS AND SEMI-FINISHED GOODS MANUFACTURERS IN MATURE PHASE

VBLS NUMBERED AS FOLLOWS:

1 CUSTOMIZATIONC
2 RE FREQ PRD CH
3 TECHNOL CHANGC
4 RE DEV TIME
5 %SMALL BATCHS
6 TOTAL R&D/REV A
7 PERFORMANCE

DATA ARE IN WFL 2: 117 OBSS ON 7 VBLS.

THE CORRELATION MATRIX

	1	2	3	4	5	6	7
1	1.0000						
2	.2740	1.0000					
3	-.0559	.1631	1.0000				
4	.3072	.4434	.2967	1.0000			
5	.4176	.2043	-.3370	.0746	1.0000		
6	.1732	.2041	.2174	.2508	-.0180	1.0000	
7	.0486	.1336	-.0089	.1575	.0542	-.2142	1.0000

RESULTS OF THE REGRESSION ANALYSIS

DEP.VBL: PERFORMANCE

NAT:		EST	SE	P
0	CONSTANT	14.62	2.57	.000
6	TOTAL R&D/REV A	-2.627	1.117	.010

EST.RES.SD 23.51
AV.FCST SD 23.92
SAM.RES.SD 23.31
SAM. R SQR .0459
F - 5.53 (1,115 DF): P - 020

COMPONENT MANUFACTURERS IN THE GROWTH PHASE

VBLS NUMBERED AS FOLLOWS:
1 CUSTOMIZATIONC
2 RE FREQ PRD CH
3 TECHNOL CHANGC
4 RE DEV TIME
5 %SMALL BATCHS
6 TOTAL R&D/REV A
7 PERFORMANCE

DATA ARE IN WFL 2: 99 OBSS ON 7 VBLS.

THE CORRELATION MATRIX

	1	2	3	4	5	6	7
1	1.0000						
2	.3483	1.0000					
3	.3535	.2627	1.0000				
4	.0877	-.0414	-.0060	1.0000			
5	-.0149	.1351	-.0282	-.4059	1.0000		
6	.1207	.3153	.4875	-.1954	.2807	1.0000	
7	-.0332	-.0208	.0186	-.0151	-.1995	.0889	1.0000

RESULTS OF THE REGRESSION ANALYSIS

DEP.VBL: PERFORMANCE

NAT:		EST	SE	P
0	CONSTANT	31.98	3.95	.000
5	%SMALL BATCHS	-.2044	1019	.024

EST.RES.SD 30.86
AV.FCST SD 31.50
SAM.RES.SD 30.55
SAM. R SQR .0398
F - 4.02 (1,97 DF): P - .048

COMPONENT MANUFACTURERS IN THE MATURE PHASE

VBLS NUMBERED AS FOLLOWS:
1 CUSTOMIZATIONC
2 RE FREQ PRD CH
3 TECHNOL CHANGC
4 RE DEV TIME
5 %SMALL BATCHS
6 TOTAL R&D/REV A
7 PERFORMANCE

DATA ARE IN WFL 2: 227 OBSS ON 7 VBLS.

THE CORRELATION MATRIX

	1	2	3	4	5	6	7
1	1.0000						
2	.1357	1.0000					
3	.0171	.2528	1.0000				
4	-.0083	-.0175	.1112	1.0000			
5	-.0038	-.1759	-.1707	.0427	1.0000		
6	-.1505	-.0262	.0756	.0811	.2080	1.0000	
7	-.0704	-.0636	.0586	-.2001	.1133	.1609	1.0000

RESULTS OF THE REGRESSION ANALYSIS

DEP.VBL: PERFORMANCE

NAT:		EST	SE	P
0	CONSTANT	27.03	4.63	.000
4	RE DEV TIME	-4.450	1.340	.001
6	TOTAL R&D/REV A	2.467	0.894	.003

EST.RES.SD 25.26
AV.FCST SD 25.54
SAM.RES.SD 25.09
SAM. R SQR .0716
F - 8.64 (2,224 DF): P - .000

MANUFACTURERS OF SUPPLIES IN THE GROWTH PHASE

VBLS NUMBERED AS FOLLOWS:

1 CUSTOMIZATIONC
2 RE FREQ PRD CH
3 TECHNOL CHANGC
4 RE DEV TIME
5 %SMALL BATCHS
6 TOTAL R&D/REV A
7 PERFORMANCE

DATA ARE IN WFL 2: 50 OBSS ON 7 VBLS.

THE CORRELATION MATRIX

	1	2	3	4	5	6	7
1	1.0000						
2	-.0128	1.0000					
3	-.1247	.0066	1.0000				
4	.2073	.2054	.0337	1.0000			
5	.4186	.1311	-.2260	.1453	1.0000		
6	-.0256	.1089	-.1845	-.0454	.1369	1.0000	
7	-.1408	-.1057	.3077	.0952	-.0510	-.2138	1.0000

RESULTS OF THE REGRESSION ANALYSIS

DEP.VBL: PERFORMANCE

NAT:	EST	SE	P
0 CONSTANT	19.60	7.01	.004
3 TECHNOL CHANGC	19.34	8.63	.015

EST.RES.SD 28.91
AV.FCST SD 30.11
SAM.RES.SD 28.32
SAM. R SQR .0947
F - 5.02 (1,48 DF): P - .030

SUPPLIES MANUFACTURERS IN THE MATURE PHASE

VBLS NUMBERED AS FOLLOWS:

1 CUSTOMIZATIONC
2 RE FREQ PRD CH
3 TECHNOL CHANGC
4 RE DEV TIME
5 %SMALL BATCHS
6 TOTAL R&D/REV A
7 PERFORMANCE

DATA ARE IN WFL 2: 178 OBSS ON 7 VBLS.

THE CORRELATION MATRIX

	1	2	3	4	5	6	7
1	1.0000						
2	-.0484	1.0000					
3	.0587	-.0085	1.0000				
4	.0371	.0742	.1927	1.0000			
5	.0748	-.0966	.0205	-.1573	1.0000		
6	-.1004	-.0490	.2725	.1494	.0006	1.0000	
7	.0003	-.0013	.0073	.1334	-.2112	-.0705	1.0000

RESULTS OF THE REGRESSION ANALYSIS

DEP.VBL: PERFORMANCE

NAT:		EST	SE	P
0	CONSTANT	19.05	2.45	.000
5	%SMALL BATCHS	-.1486	.0519	.002

EST.RES.SD 25.75
AV.FCST SD 26.04
SAM.RES.SD 25.61
SAM. R SQR .0446
F - 8.21 (1,176 DF): P - .005

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