ABSTRACT

This study adopts a complete framework in testing the quality, productivity, and profitability relationship. Different from the existing literature, this study treats the productivity as an intermediate variable for linking the quality and profitability. In addition, the quality behaviors of this study are tested from three different levels: company wide, process, and product l, which is unique in the quality related research. By using the time-series data from a lead-frame manufacturer, our empirical results show the support for the following findings:

1. The increase on the quality level is associated with the decrease on the nonconformance costs and increase on the operation efficiency.
2. The increase on the quality level is associated with the increase of the productivity.
3. The increase on the quality level is associated with the increase on the profitability.
4. The company wide quality behaviors can not be generalized to all the products and all the processes.

Key Words:Quality Cost , Productivity , Profitability, Productivity Driver

I. INTRODUCTION

The classic quality cost model classifies the costs of quality into two major components. These components are costs of conformance, which consist of prevention and appraisal expenditures, and costs of nonconformance, which include both internal and external failure costs. According to the traditional COQ quality cost model (Juran 1950), the optimal quality level is determined based on the trade-off between the conformance and nonconformance costs.

Although the COQ model has been widely promoted in the quality cost literature, some well-known quality experts, including Deming, maintain that company should ignore the COQ model because the nonconformance costs reported by the current quality cost system represent only a fraction of the actual losses from poor quality. Kaplan and Atkinson (1989) also state that:

> "The conventional wisdom that attempts to 'optimize' the number of defects has probably grossly underestimated the costs imposed on the factory by having to inspect, move, store, reschedule, and rework defective items, as well as the loss in reputation caused by shipment delays and delivering defective items to customers. A leading Japanese industrialist estimates that the 'true' losses due to defective are six times the measured losses." (pp. 375-376)

The statement of Kaplan and Atkinson (1989) clearly points out the lack of measurement on the opportunity costs, such as the loss of market shares, and the indirect effects, such as the production disruption and inventory increasing, caused by the quality problem is the drawback of the classic quality model. With the underestimated nonconformance costs, the optimal quality level determined by the COQ model is substantially lower than the true optimal quality level. Therefore, the use of COQ model leads to the wrong managerial decision.

Although nonconformance costs may not capture the true costs of the quality failure, the quality cost measurements may still provide valuable information to managers in allocating resources for quality improvements (Crosby 1984). Several researches have documented the negative relationship between the preventive costs and nonconformance costs and concluded that it is in the best interest of the firm to spend money in doing quality prevention. However, how much a firm shall spend on the preventive costs and how to measure the return on the quality investments are not addressed in the earlier literature.

Ittner (1990) conducts a detailed analysis of a detailed analysis of the quality level and productivity relationship at a consumer durable manufacturing plant. His paper shows that the quality improvement results in productivity increase from nonconforming cost reduction and process efficiency gain. The link between quality and profit levels seems implicitly assumed but not tested. Buzzil and Gale (1987) state that the impact of quality on profits arrives from two areas: (1) reducing the nonconforming costs, (2) increasing the sale price and total market share.

This study intends to expand the framework of Ittner (1990) with including the analysis of quality costs and quality level relationship, quality level and profitability relationship by using the data of a public company in Taiwan. The expanding framework provides a comprehensive analysis of quality cost and its effect on the firm's performance. It can clarify the quality confusion and give managers a better understanding on how the quality affects the bottom line.

II. RESEARCH SITE AND DATA COLLECTION

Research Site

This study uses a lead frame manufacturer as the research site. Lead frame is an essential part for integrated circuit (IC) assembly. Under the current technology, almost all integrated circuits require lead frames. The research site is a public held company with stocks trading in Taiwan Stock Exchange. Although the company is well known in the semiconductor industry for its product and technology know-how, the management is frustrated with the problem of high defective rate. The company is constantly addressing the quality concerns, but the improvements are very limited. The competition and business cycle drive the price low that results in a low profit margin, usually is less than 10%. With the low profit margin, the quality problem becomes more important. The improvement on quality is also providing the opportunity for a dramatic profit margin jump. During the research period, the employees of research site were very cooperative in providing the required data and patiently explained their processes and problems. Under some circumstances, the researchers were allowed to access the accounting books to compile some necessary data. The trust of the research site on the researchers increases the data reliability and uniqueness for this study, which are usually the problems of field studies.

The research site owns 15% ~ 25% domestic market share of the IC lead frame. The IC lead frame counts 12% ~ 20% of the total assembly cost per IC. The IC technology advancement increases the product diversity and complexity. Currently the company offers nine (9) major product categories as summarized in Table 1.

The manufacturing processes for all product categories are identical, but their costs are different because of complexity and technology requirements. The basic manufacturing process is expressed in Figure 1. Stamping and etching are two different technologies in manufacturing lead frame. Stamping technology requires high initial investments (or fixed costs), but it can reduce the later manufacturing costs. The stamping is usually applied to the mature products with high volumes and low prices. Conversely, etching technology produces high manufacturing costs. The mask technology not only shortens the product development time; it also enables the firm to produce the highly complex products, which are impossible under the stamping technology. Naturally etching is applied to high price low volume products. In order to capture both the low end and high end markets, the research firm maintains both technologies. After stamping or etching, each product need to go through coating. The stamping, etching and coating can be considered the three key manufacturing processes of the research site.

Data Collection

The study firm received ISO 9002 certificate in 1994. The certificate of ISO 9002 proves that the firm has complied with all the ISO guidelines in setting up the quality related documentation system. From research point of view, the data from post-ISO periods will be more reliable and objective because of the comprehensive documentation systems. We have chosen January 1995 to September 1999 as the study period. In the studies of Hayes and Clark (1986) and Ittner (1990), both use the monthly time-series data. In this study we also collect the monthly data. Therefore we have 57 months in total under the chosen study period. In obtaining the data for this research, we use all data collection methods specified by Yin (1986) for field study research. They are direct observation, interviews, documentation, and archival data. Foe the documentation, we have used the company's annual reports and brochures. The archival data are more comprehensive. They include most of the daily and monthly operation reports and cost analyses.

Quality Measures

According to Morse, Roth and Poston (1987), quality can be defined as quality of design and quality of conformance. Quality of design is the difference of customer expectation features and product designed features. Quality of conformance is the difference of product design specifications and actual manufacturing specifications. Quality of conformance can be measured as the defective rate (DEF) or defective loss ratio (LOSS). Quality of design can be measured as the customer complain rate (COM) or customer complain dollar ratio (COMD).

This study collects all the four quality level measures. The followings are the definitions for the quality measures:

Defective Rate (DEF) = Defective Pieces / Manufacturing Pieces;

Defective Loss Ratio (LOSS) = Scrap Dollars /

Manufacturing Costs;

Customer Complain Rate (COM) = Complain Pieces / Manufacturing Pieces;

Customer Complain Dollar Ratio (COMD) = Complain Dollars / Net Sales.

Although four different measures are collected in this study, the quality of conformance definition is more consistent with the research purpose.

Productivity Measures

Traditionally productivity is defined as the output of using the individual scare resource, such as employees, machines hours. Banker and Datar (1987) points out the potential problems of using the individual input index to measure the productivity. Hayes and Clark (1986) also argues that the most suitable measure for productivity will be TFP. Similarly Ittner (1990) has used TFP as the productivity measure for testing the quality and productivity relationship. With all the literature support, we choose TFP as the productivity measure for this study.

The TFP measure is usually defined as:

$$\frac{\text{Output Units *Unit Standard Costs in Base Year Dollars}}{\text{Sum of (Input Units * Unit Input Price in Base Year Dollars)}}$$

Since the research site does not adopt the standard cost system, the TFP in this study is modified as:

$$\frac{\text{Output Units *Unit Average Price in Base Year Dollars}}{\text{Sum of (Input Units * Unit Input Price in Base Year Dollars)}}$$

We use 1999 as the base year for this study. The denominator of the above TFP formula consists of three factors: direct materials, direct labor, and overhead. We use the lead price in 1999 for adjusting the direct materials, so are the wage rate of 1999 for direct labor and consumer price index (CPI) in 1999 for overhead.

Productivity Drivers

Why does the productivity increase if there is a quality improvement. According to Ittner (1990), the productivity gain arrives from both the direct cost reduction and indirect cost reduction. The contemporary view on quality believes in the indirect effect of quality on productivity is substantially higher than the direct effect so that the zero defect can be the quality goal. However, the indirect cost reduction is difficult to estimate.

1. Direct Productivity Driver

The direct effect of quality on productivity will be through the reduction of internal and external failure costs, that is, nonconformance costs. To measure the nonconformance costs we compile the following costs:

Internal Failure Costs = Scrap Costs + Internal Rework Costs;

External Failure Costs = Customer Complain Costs + Costs of Returned Product + Profit Loss of Returned Product + Sale Allowance +Rework Costs of Returned Product;

Total Failure Costs (FAIL) = Internal Failure Costs + External Failure Costs.

The above failure costs are not provided by the research company. We need to arbitrarily allocate the costs to the most appropriate item. The rework costs in the external failure costs only include the rework costs on the returned products, which shall be distinguished from the internal rework costs. If the returned products can not be reworked, it will be classified in the items of costs of returned product and profit loss of returned product.

2. Indirect Productivity Driver

Hay and Clark (1986) point out several productivity drivers according to their field study. Their productivity drivers include inventory level, capital investment and learning, reducing waste, and production confusion. They have tested each driver individually. But the correlation among drivers is not addressed in their study. In our view, some of drivers may have significant correlations. In practice, we observe that the firm with low quality (high defective rate) incurs more production interruptions and shows high volume of WIP inventory. In this study, we propose the following two possible indirect productivity drivers:

WIP Inventory Turnover (WIP) = Costs of Finished Goods Manufactured /[(Beginning WIP + Ending WIP) /2];

Effective Machine Operation Ratio (EMO) = Actual Manufacturing Hours / Machine Operation Hours.

Although we consider only two indirect productivity drivers, this shall not be interpreted as the two are the only drivers will affect productivity out from the quality improvement. In deed the indirect effect of the quality shall be more extensive and dynamic than what we describe. It is possible that we may only capture a small portion of the indirect effect.

Profitability Measures

Through an increase of the productivity, the quality improvement will have a impact on the firm's profitability. However, the firm's profits are affected by many factors. Some of them may not relate to quality at all. Given the sale price is constant, the improvement of productivity will result in a decrease of cost of goods sold, which leads to an increase of gross profit. The gross profit (GP) seems to be the best surrogate of the profitability measure for this study.

Measures among Company, Process and Product

Most of the quality related studies focus on the firm wide data. The firm wide data can only be used to explain the quality pattern of the entire firm. The generalization of the results to each individual process and product is limited. In the research site, each major process has its unique technology and has a different quality concern. By the same token, each product has different technology complexity. Therefore, the quality patterns or behaviors among products or processes may not be the same. To address this issue, we extend our data set to three processes and nine products. Some of firm wide data may not be applicable to the process or product.

For example, TFP is applicable to the process, but not the product; gross profit is applicable to the product, but not the process. Table 2 is the summary of the data items being collected for the entire company, process and product.

III. RESEARCH DESIGN AND TESTS

Most of the current quality literature emphasizes either on the study of the behaviors of the quality cost (Ittner 1990, Carr 1992, Carr and Ponemon 1994) or the relationship between quality and productivity (Ittner 1990). Although the relationship between productivity and quality is important, it is more important for the firm to know the relationship between the quality and profit. Without knowing the impact of the quality on profit, the firm can not exercise the right decision on the quality related investments. Unfortunately the linkage of quality to profit is missing in the current literature. Different from the existing literature on quality costs, this study will take a more comprehensive approach in exploring the effect of quality on business operations. We will replicate some of the prior research, but our main objective is to use a complete framework to show the effect of the quality on the bottom line step by step. The research design can be expressed as the Figure 2:

Quality and Profitability

1. Company Wide

The main purpose of this paper is to study the relationship between the quality level and firm's profit. Buzzill and Gale (1987) argue that the impact of quality on profit has two: (1) the quality of design will affect the price and market share and eventually affect the profits; (2) the quality of conformance will affect the quality costs, which can change the overall manufacturing costs and profits. Morse, Roth and Poston (1987) take a more dynamic view in describing the quality and profit relationship. In their opinion, the quality improvement will enable the firm to take different pricing strategies, such as increasing, decreasing, or constant. Different pricing strategies will have different profit implications. If the strategy choice is correct, the quality improvement will increase the firm's overall profitability.

Although Buzzill and Gale (1987) and Morse, Roth and Poston (1987) show the conceptual relationship between profit and quality, no empirical works are conducted in both studies. In this study, we empirically test the profit and quality relationship. Especially we are interested in short-term impact of the quality on profit, that is the cost effect, not the long-term impact, that is market share (or sale volume effect). In order to look at the cost effect, we introduce three control variables:

Unit Price (PRICE) = Average Unit Sale Price in That Month;

Sale Quantity (QUAT) = Total Sale Quantity;

Business Cycle (BC): a dummy variable.

When the demand growth rate on IC is positive, the dummy variable will be 1; conversely it will be zero. According to WSTS, for our study period, only years 1996 a 1998 show negative growth, the growth rate for the rest of years are positive.

Therefore, we specify the following regression:

GPt = b0 + b1 Xit + b2 PRICEt + b3 QUATt + b4 BCt + Et(REG1)

where: Xi (i = 1, 2, 3, 4); X1 = DEF, X2 = LOSS, X3 = COM, X4 = COMD.

(REG1) can be used the test the relationship between quality and profitability. If we empirically show the significant association between the quality and profitability, it is not sufficient to conclude the association arriving from the productivity improvement out from quality enhancement. To complete our intended argument, two additional tests are required according two Figure 2. We therefore specify the following regressions:

GPt = b0 + b1 TFPt + b2 PRICEt + b3 QUATt +

b4 BCt + Et(REG2)

TFPt = b0 + b1 Xit + Et(REG3)

where: Xi (i = 1, 2, 3, 4); X1 = DEF, X2 = LOSS, X3 = COM, X4 = COMD.

2. Product Level Relationship

The association test of (REG1) can be extended to the product level to check if the relationship holds across over nine (9) different product categories. Since the nine products show different product complexity and the defective probability are very different, the extension of the tests is meaningful and can provide different insights for the quality research. Because some data are not available for the product level for the chosen study period, we can only obtain 33 months data for these tests. PRICE and QUAT definitions are slightly modified to individual product, instead of using the average price and total sale quantities of total products.

Quality and Productivity

1. Company Wide

After understand the quality and profitability relationship, our second researcg purpose to study how the quality leads to the productivity improvements. Ittner (1990) empirically tests the relationship and shows the association between quality and productivity. According to Figure 2, the quality level will affect the failure costs and operation efficiency, which leads to the overall changes of productivity. In addition to Ittner (1990), the direct effect of quality on productivity has also documented in other papers (Kaplan (1983), Roth and Morse (1983)). The indirect effect of the quality is also referred to hidden costs of quality. The estimation of hidden costs of quality can be seen in Albright and Roth (1992) and Kim and Liao (1994). To understand the quality and productivity relationship, in addition to (REG3), we need more tests. To test the quality impacts, we speified:

FAIRt = b0 + b1 Xit + Et(REG4)

WIPt = b0 + b1 Xit + b2 BCt + Et(REG5)

where: Xi (i = 1, 2, 3, 4); X1 = DEF, X2 = LOSS, X3 = COM, X4 = COMD. In (REG5), we add the business cycle dummy variable to control the effect of busineess environment on the inventory status. (REG4), (REG5) and (REG5) together can explain the impacts of the quality on the direct costs and hidden costs. By assuming that other things are not changed, the costs reduction shall lead to the productivity gain. We further test the following regressions:

TFPt = b0 + b1 FAIRt + Et (REG6)

TFPt = b0 + b1 WIPt + Et(REG7)

2. Process Level Relationship

To better understand the quality and productivity relationship, we extend the (REG3), (REG4), (REG5), (REG6) and (REG7) tests to the three major processes. Since the data for LOSS, COM and COMD do not exist for process level, for the quality level measured in the process level, we can only use the defective rate (DEF).

In the company wide test, we do not have the measure for the machine operation efficiency, but this measure exists in the process level. Therefore, we specify the following additional tests:

EMOt = b0 + b1DEFt + Et(REG8)

TFPt = b0 + b1 EMOt + Et(REG9)

IV. EMPIRICAL RESULTS

Although we have tested the intended quality issues from the aspects of company wide, process level and product level respectively, we will only report the company wide results here. However, we need to make a note. We have observed that the quality pattern observed by using the company wide data can not be generalized to all processes and all products. However, the data items used in company wide tests are not directly comparable. For example, the quality measures in the company wide data include defective rate, loss ratio, complaining rate and complain dollars ratio; but in the process data, we can only obtain the defective rate. This may cause some problems. In the company wide data, we find a very strong support by using the loss ratio as the quality measure. However, we can not use the same variable for the process tests. Therefore, even we find no support in the process tests, this is not sufficient to conclude that the quality and productivity relationship is not there. If we can use the same set of data items, the conclusion will be more powerful and persuasive.

Quality and Profitability Tests Results

Table 3 is the tested results for the relationship of quality level and profitability.

If we choose the loss ratio as the quality measure ,the regression results strongly support our hypothesis that the higher quality will lead to a higher profit margin.

The signs for the control variables are all consistent with our expectation. From the regression in Table 3, we also learn that our testing results are sensitive to the choice of the quality measure. In our opinion, the loss ratio is the most suitable measure for the purpose of this study. Although we have shown the strong association between quality and profitability, in our analysis this relationship shall be the result of the productivity improvement. We further conduct two additional tests to verify our belief. The test results are reported in Table 4 and Table 5.

Table 4 shows that the productivity gain leads to the increase of the profit margin. However, some of the signs of the control variables are not consistent with our expectations. To complete our argument, we need to check if the quality does affect the productivity. Table 5 is the result for testing quality and productivity relationship. Out of four quality measures, three of the signs are consistent with our expectation, but none of them are significant. In order to show the linkage between quality and productivity, we may need to control other variables having simultaneous effects on productivity. Because of the data limitation, we are not able to achieve this.

Quality and Productivity Tests Results

Although we have not been able to establish the relationship between quality and productivity, our analysis is not sufficient to conclude that the quality has no effect on productivity. We suspect that the positive effects of the quality on productivity has been offset by other negative effects which we fail to control in the previous test. In order to see if the quality has any effects on productivity. We will test the relationship between the quality and productivity drives. Particularly, we will test one direct driver, nonconformance cost, and one indirect driver, work in process inventory.

We first test the association between the quality and productivity drivers. The results are shown in Tables 6 and 7 respectively. Table 6 shows that the quality is strongly associated with nonconformance cost if we choose the defective loss as the quality measure. Similarly we see the same relationship between the quality and work in process inventory. Again the results are only constrained to use the defective loss to be the quality measure. We further test if both productivity drivers in this study do affect the productivity under our testing. The results are reported in Table 8 and 9. We find the anticipated results for the indirect driver, but not the direct driver. The results of Table 8 and 9 reinforce the importance of controlling the other variables in order the explain the productivity behaviors.

V. CONCLUSION

This study adopts a complete framework in testing the quality, productivity, and profitability relationship. Our research design has treated the productivity as the intermediate variable for linking the quality and profitability, which is a major difference with the existing literature. In addition, we have studied the quality behaviors from the aspects of company wide, process level, and product level, which is unique in the quality related research. By using the time-series data from a lead-frame manufacturer, our empirical results show the support for the following findings:

1. The increase on the quality level is associated with the decrease on the nonconformance costs and increase on the operation efficiency.
2. The increase on the quality level is associated with the increase of the productivity.
3. The increase on the quality level is associated with the increase on the profitability.
4. The company wide quality behaviors can not be generalized to all the products and all the processes.

The above three findings together completely describe the short-term quality impact on the profit through the cost reduction and operation efficiency increase. Although the support of the second finding is not statistically significant, the direction is consistent with our expectation. The reason for the weak association between productivity and failure costs or operation efficiency may be explained the dynamic behaviors of productivity. The variables we use in this study may not be sufficient to capture the true productivity behaviors.

In this study, we have only showed the short term impacts of the quality on profits. The short-term impact is just portion of the quality effect on profits. In order to learn the total impact of quality on profit, the future research can be extended to study the long-term impacts of the quality on profit. The quality driver study is another interesting extension. After the firm understands the quality and profit relationship, the next question is to ask how to improve the quality. The question can not be answered without a thorough quality driver analysis.

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Figure 1: Manufacturing Process

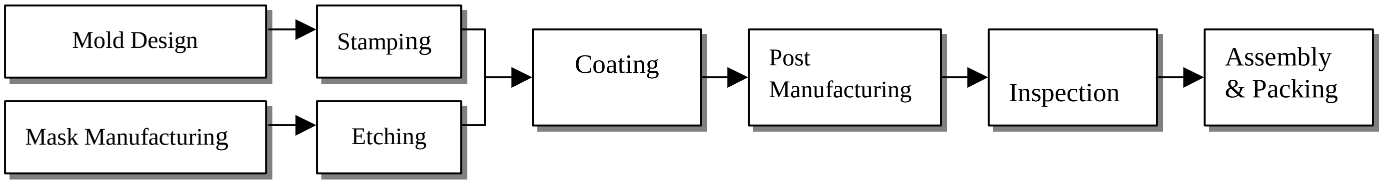

Figure 2: Complete Framework of Quality, Productivity and Profitability

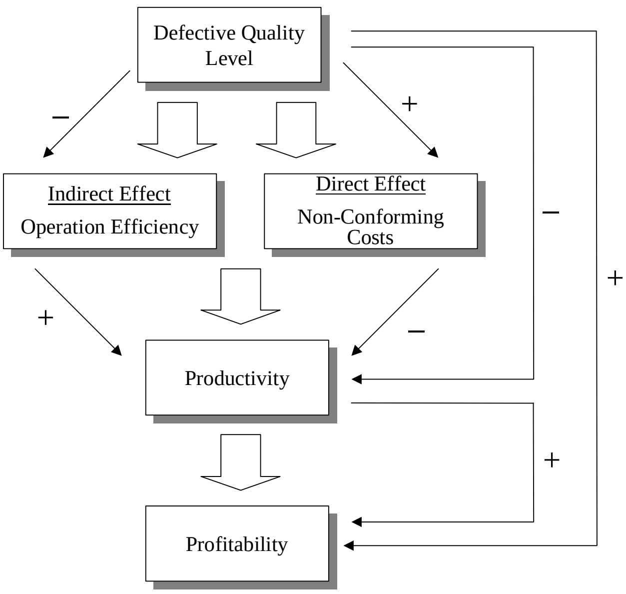

Table 1: Product Categories

	Style
Category 1	P-DIP lead frame
Category 2	DUAL lead frame
Category 3	IDF lead frame
Category 4	SO lead frame
Category 5	PLCC lead frame
Category 6	SKINNY lead frame
Category 7	QFP lead frame
Category 8	LOC lead frame
Category 9	other lead frame

Table 2: Measures among Company, Process and Product

	Quality Level	Performance	Quality Costs	Productivity	Profitability
Company Wide Variables	Í Defective Rate Í Defective Loss Rate Í Customer Complain Rate Í Complain Dollars Rate	Í Inventory Turnover	Í Non Conforming Costs	Í TFP	Í Gross Margin Rate
Process Variable	Í Defective Rate	Í Inventory Turnover Í Machine Operation Ratio		Í TFP	
Product Variables	Í Defective Rate Í Defective Loss Rate				Í Gross Margin Rate

【Table 3】：Quality and Profitability Regression

$GP = á + â_1 X_i + â_2 PRICE + â_3 QUAT + â_4 BC + å$

X_1 ：DEF; X_2 ：LOSS; X_3 ：COM; X_4 ：COMD

REG		COEFFICIENT	T VALUE	F VALUE	ADJ. R^2
GP	DEF	0.8692	0.6519!!	1.7277	0.0494
	PRICE	0.3404	1.4373		
	QUAT	0.0000	0.2142		
	BC	0.0442	1.5834		
GP	LOSS	-0.7084	-6.4006***	13.1172***	0.4640
	PRICE	0.5182	3.0006***		
	QUAT	0.0000	1.9875*		
	BC	0.0646	3.1416***		
GP	COM	0.0557	0.1804!!	1.6175	0.0422
	PRICE	0.3569	1.3347		
	QUAT	0.0000	0.1122		
	BC	0.0479	1.7503*		
GP	COMD	0.0459	0.4619!!	1.6683	0.0456
	PRICE	0.3349	1.3383		
	QUAT	0.0000	0.0874		
	BC	0.0497	1.8152*		

Significance Level:* = 0.1；** = 0.05；*** = 0.01；!! = Opposite Direction

N= 57

【Table 4】：Productivity and Profitability Regression

$GP = á + â_1 TFP + â_2 PRICE + â_3 QUAT + â_4 BC + å$

REG		COEFFICIENT	T-VALUE	F VALUE	ADJ. R^2
GP	TFP	0.3969	6.0955***	12.0462***	0.4410
	PRICE	0.3763	2.1503**		
	QUAT	-0.0000	-1.8615*!!		
	BC	-0.0014	-0.0612!!		

Significance Level: * = 0.1；** = 0.05；*** = 0.01；!! = Opposite Direction

N= 57

【Table 5】：Quality and Productivity Regression

$TFP = á + â X_i + å$

X_1：DEF; X_2：LOSS; X_3：COM; X_4：COMD

REG		COEFFICIENT	T-VALUE	ADJ.R^2
TFP	DEF	1.7680	0.7520!!	0.0102
TFP	LOSS	-0.1272	-0.4774	0.0041
TFP	COM	-0.2927	-0.5971	0.0064
TFP	COMD	-0.1412	-0.8245	0.0122

Significance Level:* = 0.1；** = 0.05；*** = 0.01；!! = Opposite Direction

N= 57

【Table 6】：Quality and Nonconformance Costs Regression

$FAIL = á + â X_i + å$

X_1：DEF; X_2：LOSS; X_3：COM; X_4：COMD

REG		COEFFICIENT	T-VALUE	ADJ. R^2
FAIL	DEF	-46.6688	-0.4355!!	0.0034
FAIL	LOSS	86.7918	27.3015***	0.9313
FAIL	COM	8.4156	0.3771	0.0026
FAIL	COMD	8.4533	1.0915	0.0212

Significance Level:* = 0.1；** = 0.05；*** = 0.01；!! = Opposite Direction

N= 57

【Table 7】：Quality and WIP Inventory Regression

WIP = á + â$_1$ X_i +â$_2$ BC + å

X_1 ：DEF; X_2 ：LOSS; X_3 ：COM; X_4 ：COMD

REG		COEFFICIENT	T-VALUE	F VALUE	ADJ. R^2
WIP	DEF	12.0201	4.0940***!!	12.8517***	0.2974
	BC	0.1498	2.4806**		
WIP	LOSS	-0.6626	-1.7512*	5.1394***	0.1288
	BC	0.2090	3.0341***		
WIP	COM	3.4163	6.6202***!!	28.0948***	0.4918
	BC	0.1817	3.5635***		
WIP	COMD	0.7656	3.4343***!!	10.0546***	0.2444
	BC	0.2112	3.3607***		

Significance Level:* = 0.1；** = 0.05；*** = 0.01；!! = Opposite Direction

N= 57

【Table 8】：Nonconformance Costs and Productivity Regression

TFP = á + â FAIL + å

REG		COEFFICIENT	T-VALUE	ADJ.R^2
TFP	FAIL	-0.0004	-0.1315	0.0003

Significance Level:* = 0.1；** = 0.05；*** = 0.01；!! = Opposite Direction

N= 57

【Table 9】：WIP Inventory and Productivity Regression

TFP = á + â WIP + å

REG		COEFFICIENT	T-VALUE	ADJ. R^2
TFP	WIP	0.2937	3.5945***	0.1755

Significance Level: * = 0.1；** = 0.05；*** = 0.01；!! = Opposite Direction

N= 57