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Technical Report TR-2012-10
May 4, 2012

ISO 9000 Impact on Product Quality in a Defense Procurement Environment

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Abstract

Purpose – The purpose of this paper is to provide insights into the relationship between ISO 9001 conformance of suppliers and the quality of products they provide, within a procurement system of a manufacturer operating under contracts with the United States Department of Defense.

Design/methodology/approach – Chi-square tests of independence were performed to compare the receipt acceptance rate of material provided by ISO 9001-conforming suppliers to that of non-ISO 9001-conforming suppliers, for more than 46,000 receipts representing twenty-one material commodity groups provided by almost 800 suppliers. Acceptance of receipts required conformance to both hardware and paperwork requirements. Tests were also performed on data subsets, to determine the impact of ISO 9001 conformance on product quality for each of twenty-one material commodity groups, for manufacturers versus distributors, and for two material control levels.

Findings – For the overall data set, and for the majority of data subsets analyzed, the product quality of non-ISO 9001-conforming suppliers was significantly better than that of ISO 9001-conforming suppliers. When only hardware non-conformances were considered to cause rejections, the results were similar, but effect sizes were generally smaller.

Research limitations/implications – The quantities of receipts and suppliers included in this investigation were very large; however, care should be exercised in generalizing the results, because of the potential influence of the defense industry-related requirements imposed upon the material and the suppliers.

Originality/value – This is believed to be the first paper to investigate the impact of ISO 9001 conformance on product quality using a large quantity of actual product data, for both ISO 9001-conforming and non-ISO 9001-conforming suppliers, in contrast to numerous assessments of quality impact performed using interview and survey data.

Keywords ISO 9000 series, quality management, product quality

Paper type Research paper

1. Introduction & Background

Since the introduction of the ISO 9000 family of standards in 1987, there has been ongoing discussion regarding the impact of the standards on product quality. Two of ISO 9000's foundational predecessors were Mil-I-45208A, *Inspection System Requirements*, and Mil-Q-9858A, *Quality Program Requirements*, both issued in 1963 by the United States Department of Defense (DOD) to govern inspection and quality of military equipment and systems. The third primary predecessor of ISO 9000, and the one that it most closely resembled, was BS 5750, a British standard issued in 1979 that provided guidelines for quality management systems. The ISO 9000 family of standards has been accepted and adopted worldwide. As of the latest published ISO survey (ISO, 2009), more than 1,000,000 companies are registered to ISO 9000, representing 178 countries.

The objective of the ISO 9000 series of standards was to define a set of requirements and practices that could be applied to organizations, regardless of the products or services they produce. Application of these practices, and conformance to the requirements, should enable an organization to deliver products and services that consistently

meet the quality requirements of customers. An organization can obtain formal objective evidence of conformance to one of the ISO 9000 standards via third-party certification. Some organizations have pursued ISO 9001 certification primarily because they believed that failure to achieve it would negatively impact their success in obtaining business contracts (Jones et al., 1997; Sampaio et al., 2009). Motives related to increased business opportunity, along with the desire for improved company image or perception by customers, are categorized as external motives.

Many organizations have pursued ISO 9001 certification because they believed that it would help them to maintain or improve the quality of their products/services, or improve their internal performance (Zaramdini, 2007; Fotopoulos et al., 2010). These motives, similar to those associated with a Total Quality Management (TQM) initiative, are classified as internal motives. A number of researchers have found that ISO 9001 certification was pursued because of a combination of internal and external motives (Beattie and Sohal, 1999; Tsiotras and Gotzamani, 1996; Kim et al., 2011; Yahya and Goh, 2001)

Many researchers have investigated the types and degrees of benefits realized from ISO 9001 certification, and the interactions between motives for pursuing certification and the benefits experienced. Tsiotras and Gotzamani (1996) categorized the benefits as either internal or external. Internal benefits include: operational improvements, increased focus on continuous improvement, improved product/process quality, and reduced quality costs. External benefits include: enhanced competitive position, increased customer satisfaction, and increased ability to enter new international markets. Some investigations have reported that ISO 9001 certification led to more internal than external benefits (Yahya and Goh, 2001; Psomas and Fotopoulos, 2009; Srivastav, 2010). However, many researchers have found that a mixture of internal and external benefits usually results from ISO 9001 certification (Quazi and Padibjo, 1998; Beattie and Sohal, 1999; Rodríguez-Escobar et al., 2006; Piskar and Dolinsek, 2006).

Numerous investigations have been performed to understand the relationship between motivation for seeking ISO 9001 certification and the benefits realized. Jones et al. (1997) found that companies who sought certification because of internal motives, either with or without additional external motives, were more likely to perceive benefits from certification. Several others also reported a stronger influence on certification benefits from internal motives than external motives (Sampaio et al., 2009; Terziovski and Power, 2007; Alic and Rusjan, 2010; Jang and Lin, 2008).

Although ISO 9000 is widely accepted as a standard for quality management systems, there has been ongoing discussion regarding the quality-related impact of ISO 9000. Lewis et al. (2006) found that ISO 9001 certification drove implementation of the 'hard' aspects of TQM to a much greater degree than the 'soft' aspects. Poksinska et al. (2003) reported that ISO 9001-certified companies, as compared to non-certified companies, demonstrated improved performance with regard to product quality, delivery reliability, innovation, and customer responsiveness. Similarly, Zaramdini (2007) reported that ISO 9001 certification contributed to improvements in several quality-related measures, including: internal costs, productivity, customer satisfaction, and product quality.

Rao et al. (1997) studied the impact of ISO 9001 certification on quality-related practices and results. They reported that certification is strongly correlated with all eight quality-related factors that they analyzed. Quazi et al. (2002) attempted to validate the findings of Rao et al. (1997), but reached a contradictory conclusion. Although many studies have indicated positive effects from ISO 9001 certification, several have concluded that minimal or no benefits result, with regard to financial and/or operational benefits (Meegan and Taylor, 1997; Quazi et al., 2002; Martínez-Costa et al., 2009; Karapetrovic et al., 2010; Singels et al., 2001; Terziovski et al., 1997).

The ultimate purpose of a quality management system is to provide an infrastructure for managing product/process quality. As indicated above, the literature has reported mixed results with regard to the impact of ISO 9001 certification on product quality. Many studies have investigated the benefits of ISO 9001 certification on the quality-related elements of performance. The clear majority of studies published have used interviews and surveys to measure the perceived quality benefits of ISO 9000 implementation. These studies have captured the perceptions of company leaders/employees regarding the benefits of achieving ISO 9001 conformance. Very few studies have utilized actual product quality data to measure the impact of ISO 9000, and none are known to have studied a large number of material commodities that span a wide range of industries.

The purpose of this study is to evaluate the impact of ISO 9001 conformance on the quality of a wide range of products provided to a manufacturer within the DOD shipbuilding industry. In this study, product quality is measured as the rate of conformance to customer requirements, which include both hardware- and documentation-related requirements.

2. Data Description

The data used for this study represents material receipts for a major shipbuilding defense contractor, received between January, 2008 and May, 2010. The receipts represented only material acquired for incorporation into the final products manufactured, excluding material used for internal purposes, e.g. facilities maintenance. For each receipt, the following information was available:

- Receipt date
- Supplier
- Supplier type (manufacturer or distributor)
- Quality Management System of supplier
- Part number
- Commodity name/number
- Material control level ('standard' or 'Level 1')

'Level 1' material (NAVSEA, 1984) requires documented traceability from the raw material, through all processing steps that impact material behavior, to the point of installation. 'Standard' material does not require this traceability. Suppliers identified as 'ISO 9001-conforming' are those whose quality management system meets the requirements defined in ISO 9001, although certification to those requirements was not necessarily attained. From here forward in this article, the phrase 'ISO 9001 supplier' will be used to mean 'ISO 9001-conforming supplier,' and 'non-ISO 9001 supplier' will mean 'non-ISO 9001-conforming supplier.'

2.1. Data filtering

The starting population of data included 142,566 receipts, of which 28% were provided by ISO 9001 suppliers. Because the receipt inspection process includes some intentional variation in the degree and frequency of inspection, data records were removed for receipts that received inspections more limited than the 'typical' receipt inspection process, and receipts that received no incoming inspection. The receipts removed included:

- dock-to-stock receipts: material from suppliers who performed an outgoing inspection equivalent to the receipt inspection process of the customer
- material procured through the MILSTRIP (Military Standard Requisition and Issue Procedures) process: this material was already accepted into the DOD material supply system

- skip-lot receipts: receipts for which receipt inspection was skipped in accordance with a formal skip-lot management process

By filtering out these receipts, the resultant receipts were subjected to a fairly consistent inspection process for determining the acceptability of each receipt. The resultant set of data represented:

- 46, 541 receipts,
- 19,228 part numbers,
- 214 commodity codes, and
- 791 suppliers.

2.2. Commodity groups

The initial 214 commodity codes were grouped into larger categories of similar commodities, to produce a final set of 21 commodity groups. The quantities of receipts assigned to each of the 21 commodity groups, and the splits between ISO 9001 suppliers and non-ISO 9001 suppliers who provided those receipts, are illustrated in Figure 1. The overall split of receipts was 46% from ISO 9001 suppliers, and 54% from non-ISO 9001 suppliers.

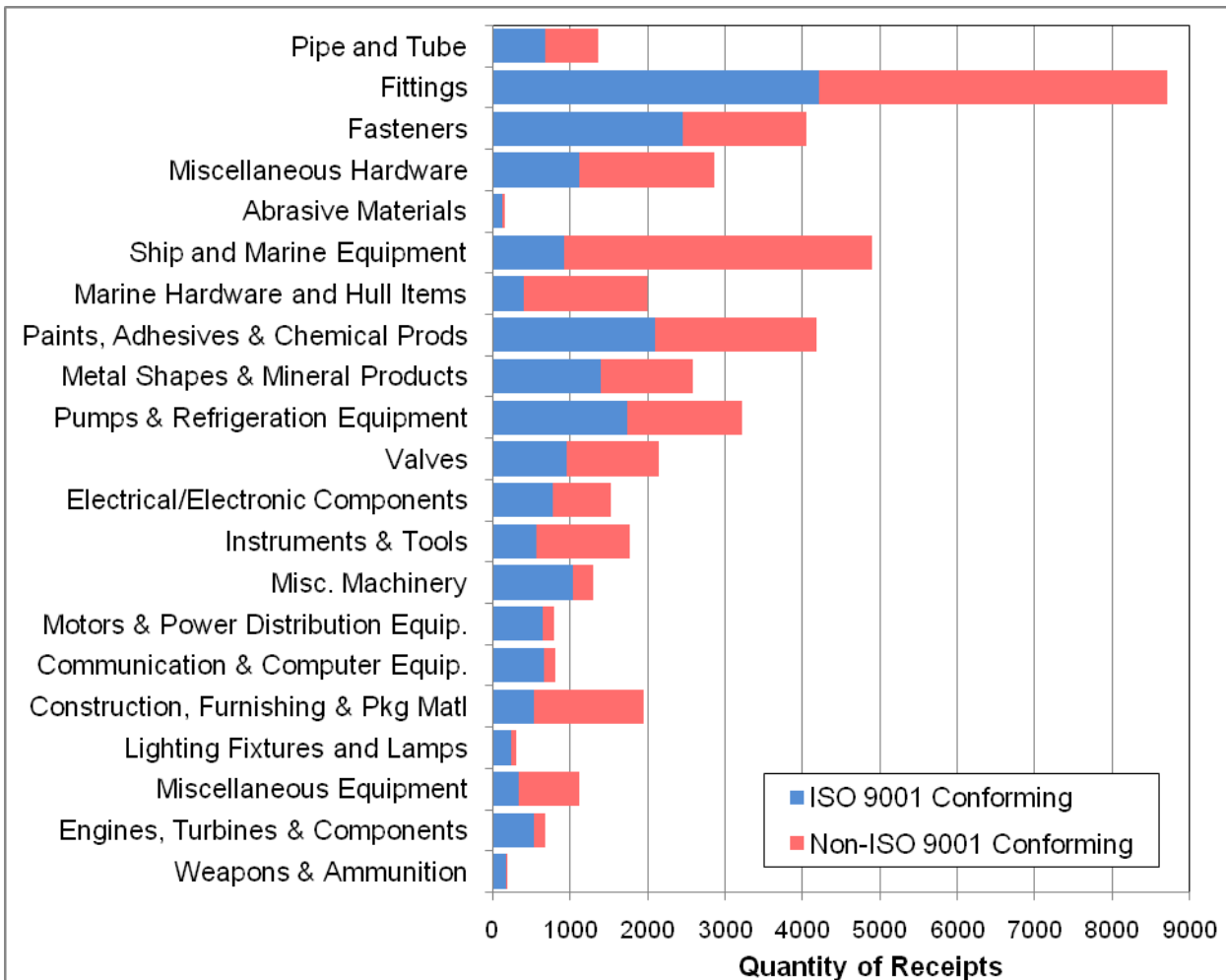


Figure 1. Receipt quantities by supplier ISO 9001 conformance, by commodity group

The quantities of suppliers who provided the receipts for each commodity group, and the splits between ISO 9001 and non-ISO 9001 suppliers, are illustrated in Figure 2.

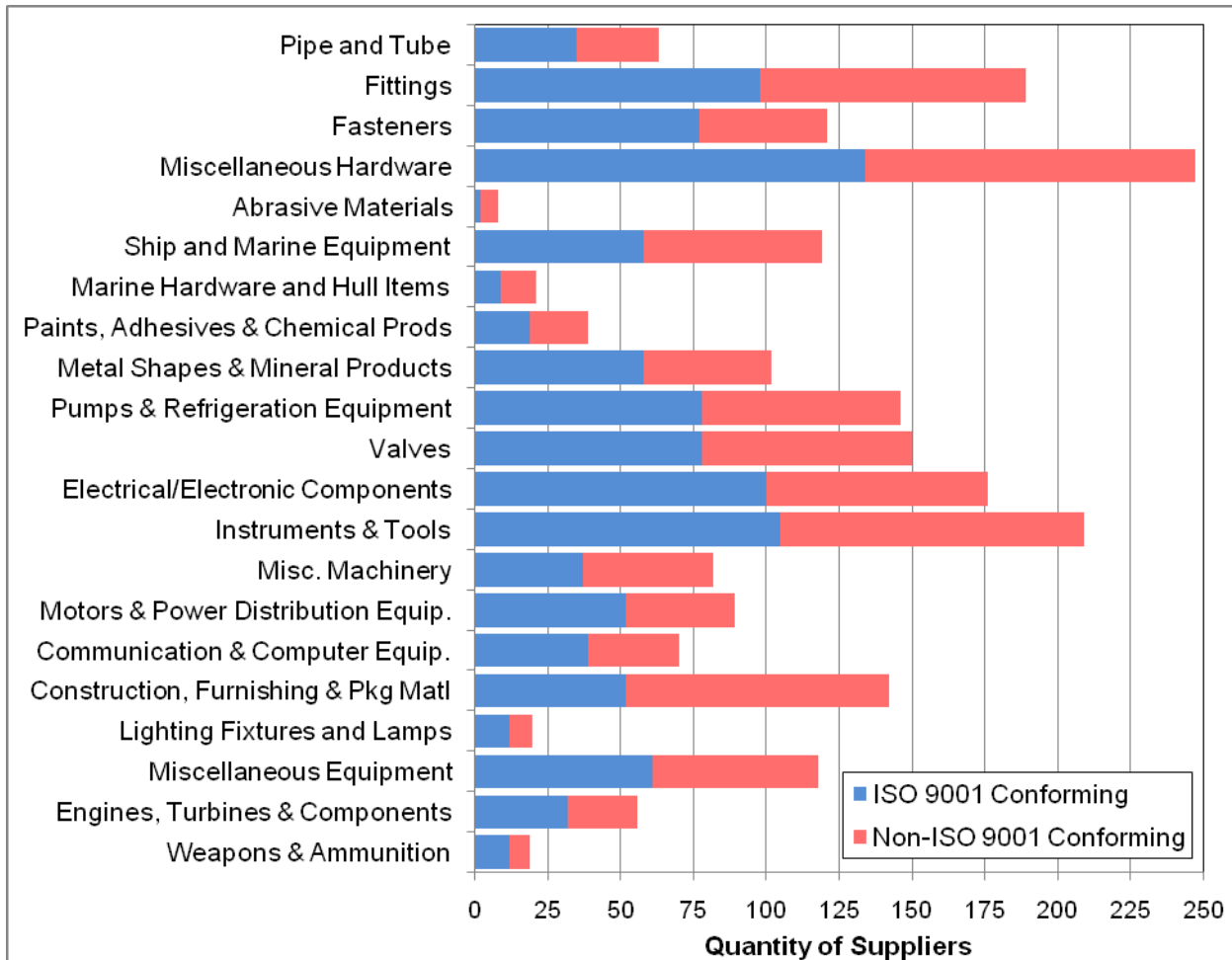


Figure 2. Supplier quantities by ISO 9001 conformance, by commodity group

3. Analysis Method

The basic question that this study is attempting to answer, is: “Is the receipt acceptance rate related to ISO 9001 conformance of the suppliers’ quality management systems?” In order to answer this, the following hypotheses are proposed:

H₀: The receipt acceptance rate is independent of ISO 9001 conformance of suppliers

H₁: The receipt acceptance rate is not independent of ISO 9001 conformance of suppliers

For various subsets of the data, the same essential question was asked, applied to each sub-category, e.g. “Is the receipt acceptance rate *for suppliers who manufacture* related to ISO 9001 conformance of the suppliers’ quality management systems?”

The subsets of data analyzed:

- Suppliers who manufacture
- Suppliers who distribute
- 'Standard control level' material
- 'Level 1' material
- Commodity groups of material (21 total)

The chi-square test of independence was used to analyze the full set and the subsets of data, to test the hypotheses and answer the questions being asked. SPSS software was used to perform all statistical analysis for this study.

4. Analysis Results & Discussion

4.1. Results of analysis

For the overall set of data, representing 46,541 receipts, the result of the chi-square test comparing the receipt acceptance rate of ISO 9001 suppliers to that of non-ISO 9001 suppliers, was:

$$\chi^2 = 94.044, df = 1, p = 0.000$$

Because the p -value is < 0.05 , the null hypothesis is rejected, and the alternative hypothesis is accepted. The conclusion is that the receipt acceptance rate is not independent of ISO 9001 conformance of suppliers. The receipt acceptance rate for ISO 9001 suppliers was 94.0%, versus 96.0% for non-ISO 9001 suppliers. The statistical measure typically used to measure effect sizes in 2x2 contingency tables is the phi-coefficient. For this test of the overall set of data, the phi-coefficient was 0.045, which would be considered a very small effect size. However, when viewed from the perspective of defective rates for incoming receipts of material, a change from 4.0% rejected (for non-ISO 9001 suppliers) to 6.0% rejected (for ISO 9001 suppliers) represents a 50% increase in the rate of rejection, which is considered a very large increase from a process quality performance perspective.

Table I summarizes the results of the chi-square tests performed on the overall set of data, and on the data subgroups. Table II provides a summary of chi-square tests performed on each of the twenty-one commodity groups of material.

Data Subgroup		Receipt Quantity	Receipt Acceptance Rate			Chi-square Test Result		
Supplier Type	Material Control Level		ISO 9000-conforming suppliers	Non-ISO 9000-conforming suppliers	Difference ¹ (percentage points)	χ^2 value	df	<i>P</i> value
ALL	ALL	46,541	94.0%	96.0%	- 2.0	94.044	1	0.000
ALL	Level 1	12,045	94.0%	95.3%	- 1.3	10.401	1	0.001
ALL	Standard	34,496	94.1%	96.1%	- 2.0	79.886	1	0.000
Manufacturer	ALL	30,429	92.9%	96.1%	- 3.2	148.143	1	0.000
Distributor	ALL	16,112	96.0%	95.8%		0.248	1	0.618
Manufacturer	Standard	23,836	93.5%	96.3%	- 2.8	98.570	1	0.000
Manufacturer	Level 1	6,593	90.7%	94.9%	- 4.2	44.608	1	0.000
Distributor	Standard	10,660	95.5%	95.7%		0.391	1	0.532
Distributor	Level 1	5,452	96.5%	96.3%		0.061	1	0.805

¹ (ISO 9000-Conforming Rate) - (Non-ISO 9000-Conforming Rate)

Color code:

Significantly lower % accepted for ISO 9000-conforming suppliers

No significant difference detected in % accepted

Table I.

Chi-square test results for overall set of data and various subgroups.

Commodity Group	Supplier Quantities		Receipt Qty	Receipt Acceptance Rate			Chi-square Test Result		
	ISO 9000-conforming Qty (%)	Non-ISO 9000-conforming Qty		ISO 9000-conforming suppliers	Non-ISO 9000-conforming suppliers	Difference ¹ (percentage points)	χ^2 value	df	p value
Pipe and Tube	35 (56%)	28	1,364	88.3%	94.3%	- 6.0	15.362	1	0.000
Fittings	98 (52%)	91	8,712	96.6%	96.0%		2.095	1	0.148
Fasteners	77 (64%)	44	4,046	95.1%	97.1%	- 2.0	10.061	1	0.002
Miscellaneous Hardware	134 (54%)	113	2,854	93.3%	97.2%	- 3.9	24.380	1	0.000
Abrasive Materials	2 (25%)	6	159	98.4%	93.8%		*	1	*
Ship & Marine Equipment	58 (49%)	61	4,892	91.6%	98.3%	- 6.7	117.166	1	0.000
Marine Hardware & Hull Items	9 (43%)	12	1,997	90.2%	99.6%	- 9.4	128.925	1	0.000
Paints, Adhesives & Chemical Products	19 (49%)	20	4,175	98.1%	97.8%		0.458	1	0.498
Metal Shapes & Mineral Products	58 (57%)	44	2,576	95.4%	95.7%		0.103	1	0.748
Pumps & Refrigeration Equipment	78 (53%)	68	3,217	93.5%	95.6%	- 2.1	6.786	1	0.009
Valves	78 (52%)	72	2,135	84.6%	93.3%	- 8.7	42.799	1	0.000
Electrical/Electronic Components	100 (57%)	76	1,525	93.3%	95.3%		2.745	1	0.098
Instruments & Tools	105 (50%)	104	1,773	91.6%	94.4%	- 2.8	4.971	1	0.026
Miscellaneous Machinery	37 (45%)	45	1,292	95.6%	97.0%		1.020	1	0.312
Motors & Power Distribution Equip.	52 (58%)	37	781	90.4%	83.0%	+ 7.4	6.372	1	0.012
Communication & Computer Equip.	39 (56%)	31	810	95.9%	90.4%	+ 5.5	7.596	1	0.006
Construction, Furnishing & Pkg, Mat'l	52 (37%)	90	1,950	90.9%	92.8%		1.951	1	0.162
Lighting Fixtures & Lamps	12 (60%)	8	298	97.1%	86.2%	+ 10.9	11.560	1	0.001
Miscellaneous Equipment	61 (52%)	57	1,119	86.0%	88.6%		1.521	1	0.217
Engines, Turbines & Components	32 (57%)	24	675	90.5%	86.0%		2.484	1	0.115
Weapons & Ammunition	12 (63%)	7	191	98.2%	73.9%	+ 24.3	26.608	1	0.000

* criteria for valid chi-square test were not met

¹ (ISO 9000-Conforming Rate) - (Non-ISO 9000-Conforming Rate)

Color code:

Significantly lower % accepted for ISO 9000-conforming suppliers
Significantly higher % accepted for ISO 9000-conforming suppliers
No significant difference detected in % accepted
Failed to meet criteria for valid chi-square test

Table II.

Chi-square test results by commodity group

4.2. Discussion of Results

These results indicate that for the overall set of data, and for the majority of data subsets, the ISO 9001 suppliers did not perform as well as the non-ISO 9001 suppliers, as measured by the receipt acceptance rate of their material shipments. Factors that were not isolated in the analysis, that potentially could have influenced this investigation, include: differing material complexity and requirements across commodity groups; documentation requirements included in the overall material requirements; impact of other quality management systems to which suppliers conformed; ISO 9001 certification versus ISO 9001 conformance.

4.2.1 Impact of material requirements across parts/commodities

In order to reduce the potential confounding effects from variations in material characteristics across commodity groups, additional analysis was performed on a subset of the data. This subset included only part numbers which had been received from both ISO 9001 suppliers and non-ISO 9001 suppliers. As Table III shows, this subset represented almost 6,000 receipts from almost 200 suppliers, with both receipts and suppliers almost evenly split between ISO 9001 and non-ISO 9001. A chi-square test of independence was performed on this data to test the same hypotheses tested on the overall set of data. The results, shown in Table IV, were that no significant difference in acceptance rate of receipts, for ISO 9001 versus non-ISO 9001 suppliers, was detected at a 0.05 significance level.

	ISO 9000 conforming	Non-ISO 9000 conforming	Total
Supplier Quantity	95	83	178
Receipt Quantity	2,931	2,863	5,794

Table III.

Data for parts received from both ISO 9001-conforming and non-ISO 9001-conforming suppliers

Receipt Quantity	Receipt Acceptance Rate		Chi-square Test Result		
	ISO 9000-conforming suppliers	Non-ISO 9000-conforming suppliers	χ^2 value	df	<i>p</i> value
5,794	95.8%	95.8%	0.003	1	0.956

Table IV.

Chi-square test results for parts received from both ISO 9001-conforming and non-ISO 9001-conforming suppliers

4.2.2 Impact of material documentation requirements

Acceptance of receipts required that both the hardware and any required paperwork must conform to requirements. The ISO 9001 suppliers might have provided higher quality hardware, but possibly did not perform as well at providing documentation/paperwork. In order to test this hypothesis, a chi-square test of independence was

performed on the overall set of data, comparing acceptance rates when only hardware requirements were inspected, i.e. non-conformances in paperwork were ignored. The results, shown in Table V, indicate that the hardware acceptance rate for ISO 9001 suppliers was still significantly lower than that of non-ISO 9001 suppliers. In this case, the ISO 9001 suppliers' receipt acceptance rate was only 0.7 percentage points lower than the rate for non-ISO 9001 suppliers. A difference of 0.7 percentage points seems very small; however, this represents a 46% increase in rejection rate, when viewed as the change from a 1.5% rejection rate for non-ISO 9001 suppliers to a 2.2% rate for ISO 9001 suppliers

Receipt Quantity	Receipt Acceptance Rate		Chi-square Test Result		
	ISO 9000-conforming suppliers	Non-ISO 9000-conforming suppliers	χ^2 value	df	<i>P</i> value
46,541	97.8%	98.5%	31.786	1	0.000

Table V.
Chi-square test results considering only hardware defects

Additionally, chi-square tests were performed on all 21 commodity subgroups, considering only hardware non-conformances. The results are presented in Table VI. The differences in rejection rates between ISO 9001 and non-ISO 9001 suppliers were generally smaller than they were when both hardware and documentation defects were considered.

Commodity Group	Receipt Quantity	Receipt Acceptance Rate			Chi-square Test Result		
		ISO 9000-conforming suppliers	Non-ISO 9000-conforming suppliers	Difference ¹ (percentage points)	χ^2 value	df	<i>P</i> value
Pipe and Tube	1,364	97.9%	98.7%		1.166	1	0.280
Fittings	8,712	99.0%	98.0%	+ 1.0	16.139	1	0.000
Fasteners	4,046	97.8%	99.2%	- 1.4	11.006	1	0.001
Miscellaneous Hardware	2,854	97.5%	98.8%	- 1.3	6.958	1	0.008
Abrasive Materials	159	100.0%	100.0%		*	1	*
Ship & Marine Equipment	4,892	94.0%	99.0%	- 5.0	100.258	1	0.000
Marine Hardware & Hull Items	1,997	97.5%	99.2%		*	1	*
Paints, Adhesives & Chemical Products	4,175	99.6%	99.5%		0.208	1	0.649
Metal Shapes & Mineral Products	2,576	98.1%	98.1%		0.026	1	0.873
Pumps & Refrigeration Equipment	3,217	96.8%	98.3%	-1.5	7.161	1	0.007
Valves	2,135	94.4%	97.0%	- 2.6	8.413	1	0.004
Electrical/Electronic Components	1,525	96.7%	99.2%	- 2.5	11.854	1	0.001
Instruments & Tools	1,773	97.9%	97.8%		0.011	1	0.918
Miscellaneous Machinery	1,292	98.1%	99.2%		*	1	*
Motors & Power Distribution Equipment	781	96.3%	97.0%		*	1	*
Communication & Computer Equipment	810	98.8%	99.3%		*	1	*
Construction, Furnishing & Pkg. Mat'l.	1,950	98.7%	98.2%		0.454	1	0.500
Lighting Fixtures & Lamps	298	99.6%	100.0%		*	1	*
Miscellaneous Equipment	1,119	93.3%	95.3%		1.912	1	0.167
Engines, Turbines & Components	675	97.0%	96.0%		*	1	*
Weapons & Ammunition	191	99.4%	82.6%		*	1	*

* criteria for valid chi-square test were not met

¹ (ISO 9000-Conforming Rate) - (Non-ISO 9000-Conforming Rate)

Color code:	Significantly lower % accepted for ISO 9000-conforming suppliers
	Significantly higher % accepted for ISO 9000-conforming suppliers
	No significant difference detected in % accepted
	Failed to meet criteria for valid chi-square test

Table VI.

Chi-square test results by material commodity group, considering only hardware defects

4.2.3 Potential impact of Mil-I-45208A and Mil-Q-9858A conformance

Many suppliers included in this study had quality management systems that conformed to Mil-I-45208A or Mil-Q-9858A, in addition to or instead of, conformance to ISO 9001. Conformance to either of these standards would suggest that the supplier had been providing material to the defense industry for quite some time, and these suppliers might have been more familiar with the types of material specifications, standards, and drawings associated with some of the material involved in this study. (Many receipts were products that were 'commercial

off-the-shelf items, for which no additional defense-related requirements had been imposed.) Also, suppliers who have been conforming to Mil-I-45208A or Mil-Q-9858A for many years, and who have been steady suppliers to defense industry manufacturers, might be less likely to pursue conformance to ISO 9001, since it might not be considered as necessary as it might be for a supplier who provides primarily commercially-used products. Further analysis of the quality of receipts from suppliers having various combinations of conformance to Mil-I-45208A, Mil-Q-9858A, and ISO 9001 might provide additional insights into the results of this study.

4.2.4 Potential difference between ISO 9001-certified and ISO 9001-conforming suppliers

Suppliers included in this study were identified as having quality management systems that were either conforming to, or not conforming to, ISO 9001. Labeling a quality management system as conforming to ISO 9001 would only require a self assessment, whereas “certification” would require a rigorous assessment of conformance to ISO 9001 requirements by an independent certification body. Therefore, a question triggered by this study is: How does the quality of products provided by ISO 9001-certified suppliers compare to the quality provided by non-ISO 9001-certified suppliers? The answer to that question will be left to a follow-up investigation.

5. Conclusions & Implications

The overall conclusion of this investigation is that, within the environment of this study, product quality is not independent of the ISO 9001 conformance of its suppliers. The results are best interpreted in the context of the 'procurement system' of this manufacturer. The inputs to this procurement system include:

- products/material being procured,
- requirements associated with these products/material,
- complexity of the requirements,
- clarity and completeness of the requirements,
- method of communicating requirements to suppliers,
- suppliers that provide the products/material,
- quality management systems of the suppliers, and
- receipt inspection process used to accept the products/material received.

Within this procurement system, the impact of an ISO 9001-conforming quality management system on delivered product quality varies, and apparently interacts with other material and supplier characteristics. For the overall set of data, the receipt acceptance rate of ISO 9001-conforming suppliers was lower than that of non-ISO 9001-conforming suppliers. Acceptance of a receipt required that both the hardware and documentation conform to all requirements. For some subsets of the data, ISO 9001-conforming suppliers performed significantly better, for some subsets there was no difference detected, and for other subsets the ISO 9001-conforming suppliers performed worse than non-ISO 9001-conforming suppliers. The quality performance of ISO 9001-conforming suppliers appeared to be slightly better when only hardware requirements were measured. Some uncontrolled factors that might have influenced these results have been identified as opportunities for future research.

These results suggest that caution should be exercised when a procurement organization requires suppliers to be ISO 9001-conforming, especially in defense-related procurements, with the expectation that product quality will be better than the quality from non-ISO 9001-conforming suppliers. That result might not be realized, while product costs might increase due to the cost of achieving and maintaining conformance to ISO 9001 requirements.

6. Future Research

Suggested investigations to explore the results of this study:

- 1) Analyze product quality from ISO 9001-certified suppliers vs. suppliers conforming to, but not certified to ISO 9001.
- 2) Investigate conformance to Mil-I-45208A and/or Mil-Q-9858A, and how these interact with ISO 9001 conformance with regard to delivered product quality.
- 3) Analyze the quantity of parts per receipt to determine if ISO 9001 product quality impact is greater for parts shipped in higher volumes.
- 4) Analyze the number and frequency of recurring shipments to determine if the impact of ISO 9001 conformance on product quality is greater for parts shipped more frequently, especially for parts that are not standard off-the-shelf parts for a supplier.

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