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The Effects of Technology Turnover on Workplace Productivity Perceptions

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THE EFFECTS OF TECHNOLOGY TURNOVER ON WORKPLACE PRODUCTIVITY PERCEPTIONS

THESIS

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Abstract

The productivity paradox is a theory that suggests that investments in Information Technology (IT) do not necessarily lead to associated gains in the productivity of the organization (Malakoff, 2000; Hitt and Brynjolfsson, 1996). This perception leads practitioners to question if acquiring new IT systems for the sake of having the latest technology will make their organization any more productive (Liebmann, 1996). Understanding the problem that is facing the practitioners, this research was undertaken to attempt to answer some of the underlying questions relating to the perceptions held about the relationship between IT expenditures and workplace productivity with respect to Air Force communication squadrons.

The research indicates that there may in fact be a perception of an IT productivity paradox. Both commanders and maintainers feel that procurement and administrative changes have been made in IT planning due to the understanding of a potential IT productivity paradox.

Ultimately, the Air Force work centers have the perception that they are getting and adequate return on investment for IT expenditures, indicating that their IT planning procedures have been effective. However, the results also indicate that they have a perceived need for newer technologies to be able to keep their network infrastructures to the necessary level to support their customer's needs. This indicates that IT planning in the Air Force must continually change to strike the appropriate balance between the demands of the customers and the capabilities of the technologies.

THE EFFECTS OF TECHNOLOGY TURNOVER ON WORKPLACE PRODUCTIVITY PERCEPTIONS

I. Introduction

The productivity paradox is a theory that suggests that investments in Information Technology (IT) do not lead to associated gains in the productivity of the organization (Malakoff, 2000; Hitt and Brynjolfsson, 1996). Consequently, since its first postulation by Nobel Prize winning economist Robert Solow, the productivity paradox has been a serious issue that has confounded scholars and practitioners alike (Malakoff, 2000). Academicians debate whether this phenomenon is real or just a perceived anomaly due to the mismeasurement of the constructs of workplace productivity (Brynjolfsson, 1993), while practitioners are just beginning realize that they have yet to find a positive correlation between the considerable sum of money they are investing in information technology (IT) and its effects on workplace productivity (Liebmann, 1996). Compounding this already perplexing problem, recent studies indicate that the academic community's overall perception of the paradox is on the decline (Hitt and Brynjolfsson, 1996), while new findings suggest that product development life cycles are decreasing and thus increasing perceived technology obsolescence rates at the practitioner's level (Liebmann, 1996; Peters, 2000; Sichel, 1999).

Ultimately, the uncertainty brought on by this phenomena indicates that practitioners are starting to question if acquiring new IT systems for the sake of having the latest technology makes their organization any more productive (Liebmann, 1996). Understanding the problem that is facing both communities, this research was undertaken

to attempt to answer some of the underlying questions relating to the relationship between IT expenditures and workplace productivity with respect to Air Force communication squadrons.

It is theorized that an understanding of technology turnover may have increased the practitioners' perception of the paradox and its negative effects on their normal business operations. This epiphany may be responsible for a trend towards a more intelligent IT procurement process and use of information resources to reduce these perceived impacts on IT return on investment (ROI).

The intention of this research is not to look for evidence of the existence of the productivity paradox; rather, it is to investigate the factors that influence IT planning at the workforce component and whether IT expenditures themselves are seen as contributors to workplace productivity. Accordingly, the foundation of this research focuses on the impacts of technology turnover and decreased system life cycles on the perceptions of return on investment (ROI) for IT expenditures of both the senior leadership and network administrators in the Air Force community. It further seeks to identify any new IT acquisition methodologies that have been initiated to realize and measure an acceptable level of ROI from the practitioner's viewpoint.

In order to posit a relationship between IT expenditures, technology turnover, and workplace productivity, this research seeks the answers to five general questions through the use of a 53 question 7-point Likert scale survey:

1. Do the practitioner's have a general perception of a productivity paradox?
2. Have work centers' IT planning initiatives been influenced by the perception of a productivity paradox?

3. What are the current justifications for IT procurements at the work center level?
4. How does the organization view IT in respect to workplace productivity?
5. Is the senior leadership's view of the relationship between IT investments and productivity significantly different from their network administrators?

With sponsorship from the Air Force's Chief Information Office (CIO), these five questions, each of which correspond to a hypothesis to be tested, are addressed in a survey sent to all Air Force Communications Squadron commanders and their respective network administrators.

The following chapters will illustrate specifically how this research was pursued. The next chapter is the literature review of the existing knowledge of the productivity paradox and other foundational studies that enabled the development of the theories tested in this research. The third chapter is the methodology that was implemented to collect, analyze, and report the findings of the research. The fourth chapter depicts the results and analysis used to measure the tests of the research hypotheses. The last chapter provides an assessment of the results and their implications to the Air Force as a result of the research.

There are three appendices at the end of this study that are included to clarify the analysis of the results. Appendix A shows the histograms of each of the factors relating to their associated hypotheses tests. Appendix B illustrates the analysis of variance (ANOVA) tests that were performed to assess Hypothesis 5. Finally, Appendix C depicts the unequal variance tests that were also performed to assess Hypothesis 5.

II. Literature Review

Productivity Paradox

In order to establish the baseline for this research, a formal understanding of the productivity paradox is needed. The productivity paradox is a theory that suggests that investments in Information Technology (IT) do not lead to associated gains in the productivity of the organization (Malakoff, 2000; Hitt and Brynjolfsson, 1996). However, some scholars in the academic community rationalize the perception of the productivity paradox simply as a confounding problem in determining the value, in terms of productivity, or increase in output generated, by IT investments (Brynjolfsson, 1993; Chan, 2000; Due, 1994; Mahmood and Mann, 1993). More specifically, in the context of this research, the perception of the productivity paradox will be described in accordance with the research undertaken by Erik Brynjolfsson (Brynjolfsson, 1993), see **Figure 1** below.

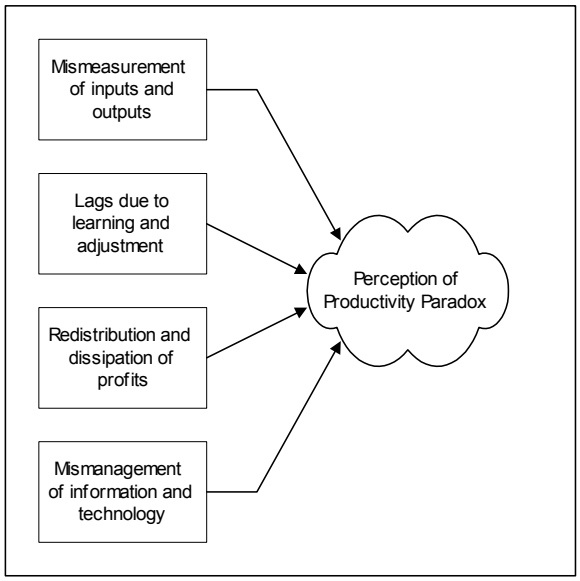

Figure 1: Brynjolfsson's Theory of the Productivity Paradox

Brynjolfsson's study (Brynjolfsson, 1993) ultimately concludes that there are four factors that contribute to this perception of the productivity paradox. They are: mismeasurement of inputs and outputs, lags due to learning and adjustment, redistribution and dissipation of profits, and mismanagement of information and technology (p. 73).

To clarify the meanings of these constructs it is necessary to show how Brynjolfsson justifies them. He starts by justifying his category of mismeasurement of inputs and outputs by explaining that, "traditional measures of the relationship between inputs and outputs fail to account for non-traditional sources of value." (pg 73) Furthermore, he illustrates the meaning of lags due to learning and adjustment by stating that, "if significant lags between cost and benefits exist, the short-term results look poor but ultimately the payoff will be proportionately larger." (pg 73) Next, he classifies the third construct by explaining that the, "redistribution argument suggests that those investing in technology, benefit privately but at the expense of others, so no net benefits show up at the aggregate level." (pg 73) Finally, he explains that mismanagement results from, "something in IT's nature that leads firms or industries to invest in it when they should not, to misallocate it, or to use it to create slack instead of productivity." (pg 73) (Brynjolfsson, 1993)

Brynjolfsson is not alone in his description of the problem. Discussing Brynjolfsson's work, (Chan, 2000) states that the productivity paradox of information technology is defined as "an apparent IT investment paradox with respect to economy-wide productivity, the productivity of IT capital in manufacturing, and the productivity of IT capital in services" (p. 226). Furthermore, according to (Brynjolfsson, 1993),

"computing power in the U.S. economy has increased by more than two orders of magnitude since 1970 yet productivity, especially in the service sector, seems to have stagnated" (p. 67). These issues raise many eyebrows in the business community as managers attempt to establish business plans and budgets for product lines. The obvious question arises in the mind of the business managers as to how much capital should be invested in IT and what are the impacts, if any, to productivity that can be expected from this investment (Liebmann, 1996; Mueller, 1997)? Unfortunately, in today's business climate, the more relevant question seems to be how long can I expect the return on information technology (IT) investment to last before more capital is needed to keep those systems fully operational (Liebmann, 1996)? Subsequently, this enigma of uncertainty in IT investments has been referred to as the productivity paradox of IT investment (Malakoff, 2000).

Importantly, not all researchers agree with Brynjolfsson's analysis. Others have stepped forward to challenge his theory. (Due, 1994) referencing Paul Strasmann, the former CIO at the Department of Defense, states that Brynjolfsson's study was "fundamentally flawed because it fails to take into account the work force component of IT investments that can account for as much as 90% of the total IT spending" (p. 76). This spending at the workforce level brings into question the acquisition practices of the units and the emerging question of technology turnover.

Since the productivity paradox was first postulated (1987), its mere existence has been the subject of many debates (Malakoff, 2000). There are two taxonomies in the academic community that attempt to explain the paradox's existence. One side of the argument contends the paradox exists and IT productivity, whether positively or

negatively affected, can be measured (Brynjolfsson, 1993). The other side dismisses the paradox as perception error due to inadequate measures and constructs used to quantify and define it (Chan, 2000).

Recently, research has indicated that the perception of the paradox is on the decline (Hitt and Brynjolfsson, 1996). Hitt and Brynjolfsson indicated in their 1996 study that " IT has increased productivity and created substantial value for consumers." (pg 121) They conclude by stating that, "there is no inherent contradiction between increased productivity, increased consumer value, and unchanged business profitability." (Hitt and Brynjolfsson, 1996) (pg 121)

However, some new evidence suggests that as product development life cycles decreased and thus increased technology turnover rates, users have become more aware that simply acquiring new technology for its own sake did not necessarily make their organization more productive (Cavill, 2000; Goyal, 2001; Liebmann, 1996; McHale, 1999; Sichell, 1999).

Taken by themselves, these explanations of the paradox are perplexing enough, but the misconception of the paradox is further bolstered by certain sects of the academic community that employ methodologies that fail to incorporate the totality of constructs and measurement devices currently available to assess its impacts (Chan, 2000). Numerous examples of this mismeasurement of productivity can be seen in the research performed by Chan. As an example, (Chan, 2000) reveals that most research on the subject has focused on a single type of data at a single level of an organization to draw conclusions on the causes and perceptions of the paradox (p. 227).

Research Direction

It is the contention of this research that technology turnover is the primary contributing factor to the perception of the paradox from the workforce component. Accordingly, a new theory began to take shape using Brynjolfsson's (1993) study as a baseline and Due's (1994) criticism of that study as an initiator for a further investigation into the explanation of the paradox. Specifically, the criticism that Brynjolfsson's study fails to account for contributions from the work force level (Chan, 2000). This critical omission is the cornerstone of the research undertaken in this thesis effort.

It is necessary to clarify the meaning of Brynjolfsson's constructs to assure that technology turnover is not already incorporated into any one of them. He states that, "the first two explanations point to shortcomings in research, not practice, as the root of the productivity paradox" (p. 73). He continues by justifying his category of mismeasurement of inputs and outputs by explaining that, "traditional measures of the relationship between inputs and outputs fail to account for non-traditional sources of value" (p. 73). Furthermore, he illustrates the meaning of lags due to learning and adjustment by stating that, "if significant lags between cost and benefits exist, the short-term results look poor but ultimately the payoff will be proportionately larger" (p. 73). Next, he classifies the third construct by explaining that the, "redistribution argument suggests that those investing in technology, benefit privately but at the expense of others, so no net benefits show up at the aggregate level" (p. 73). Finally, he explains that mismanagement results from, "something in IT's nature that leads firms or industries to invest in it when they should not, to misallocate it, or to use it to create slack instead of productivity" (Brynjolfsson, 1993) (p. 73). Considering the analysis of these

justifications, it is easily seen that while these categories address both the shortcomings of research methods and the difficulties with quantifying productivity, they do not address technology turnover specifically. Therefore, it is proposed that this research is novel to the community and worthy of further investigation.

The theory being tested here indicates that technology turnover, based on shortened systems development life cycles, has a correlation to the practitioner community's (in this case the Air Force) perception of an IT paradox and could aid in the explanation of the perceived lack of productivity at the work center level. See **Figure 2** below:

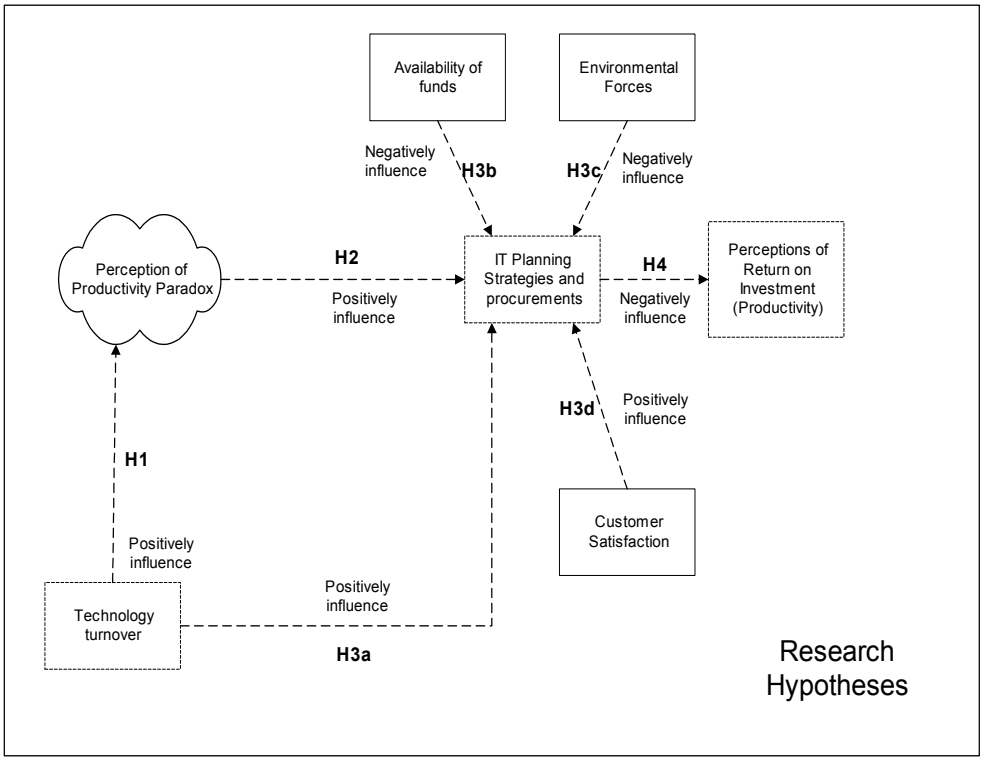

Figure 2: Hypotheses and constructs tested in this research

In addition to suggesting a possible further explanation, this research seeks to determine how this perception impacts work center productivity and return on investment (ROI). In doing so, this research investigates the IT planning strategies of Air Force work centers to see what is driving their IT procurements. The IT planning strategies and procurements element was added with five inputs tested to see what their perceived influences may be. As shown above, the inputs to this planning process are: perceptions of the paradox, technology turnover itself, availability of funds, customer satisfaction, and environmental forces. These are the five factors that were chosen to be tested and should not be viewed as an all inclusive list of contributing factors. They were chosen specifically to seek the answers to the fundamental questions of this research as outline previously. Finally, a series of questions were developed to determine the impacts the current Air Force work center IT strategies have on the perceptions of productivity and ROI.

It is important to understand that the primary focus of this research is not to debate the existence of the paradox, but rather to simply investigate the perceptions held by the Air Force IT community as to the effects that IT investments have had on workplace productivity. More specifically, this research seeks to demonstrate that recent trends yielding reduced systems development life cycles for computer and IT technologies have impacted these perceptions in such a way as to force a shift in IT systems acquisition thinking (Cavill, 2000; Goyal, 2001; Liebmann, 1996; McHale, 1999; Sichell, 1999). These factors may in fact support the purported existence of the paradox and a more rigorous explanation of it, but this is an outcome of the research that should

be studied in greater detail on a larger scale before any causal relationships can be established.

The main objective of this research is to see how technology turnover, through reduced IT system development life cycles, impacts the perception of current network viability at Air Force organizations. Additionally, this study gauges how the Air Force community views the utility of IT technologies and determine the reasons for new purchases and the productivity perceptions they have on these new systems. A final goal of the research was to determine if there is a perceived technology need gap between Air Force senior leaders and network administrators.

The objectives of this research are linked to the five general questions that were outlined previously. These questions have been transformed into hypotheses to be tested by this empirical study and are listed and below:

Hypothesis 1 (H1): The understanding of technology turnover at the work center level of the Air Force has led to a perception of an IT productivity paradox.

Hypothesis 2 (H2): The perception of the paradox has positively influenced the IT planning strategies at the work center level in the Air Force.

Hypothesis 3a (H3a): The understanding of technology turnover has positively impacted Air Force IT procurements process at the work center level.

Hypothesis 3b (H3b): Availability of funding has negatively impacted Air Force IT procurements process at the work center level.

Hypothesis 3c (H3c): Environmental factors, such as customers, mission, and higher headquarter direction, have negatively impacted Air Force IT planning at the work center level.

Hypothesis 3d (H3d): Customer satisfaction positively influences IT planning at the work center level.

Hypothesis 4 (H4): IT procurements are not perceived as contributors to work center productivity.

Hypothesis 5 (H5): The senior leadership at the work center level has a significantly different level of understanding of technology turnover and its effects on IT planning than their network maintainers.

The ideas contained in this research effort were briefed to senior personnel at the Air Force CIO office and they eagerly sponsored this effort. They were active in the construction of the survey instrument and provided a list of all Air Force Communication Squadron commanders as the potential respondents to this survey.

The results of this research could have a great impact to the current IT procurement methodologies employed throughout the Air Force. However, the research is not aimed to assign blame to or applaud any organizations, rather it is to be used as a litmus test for the senior leaders to see where the Air Force is in terms of dealing with the problems of IT expenditures and work center productivity.

III. Methodology

Survey Selection

In order to test the constructs of the research undertaken a 7-point Likert scale format for the questions was chosen. The Likert scale was chosen as the intention of the survey is to measure the perception and tendencies of the respondents to questions about work center productivity and technology turnover. The Likert scale was chosen for its simplicity and ability to obtain inputs on perceptions.

A 7-point scale was chosen to allow for maximum scaling of the respondents perceptions to the questions asked. The scale was constructed as follows: 1 = Strongly Disagree, 2 = Disagree, 3 = Slightly Disagree, 4 = Neutral, 5 = Slightly Agree, 6 = Agree, and 7 = Strongly Agree. It is felt that a Likert scale of a 5-point nature would limit and bunch the responses around the median response of 3. A 7-point scale allows for a response farther away from the median response without having to select one of the extremes unless the respondent feels absolutely compelled to. Additionally, the 6-point Likert scale was eliminated from consideration as it was desired to permit a neutral response to the questions to allow for a possible elimination of questions that may not affect perceptions either positively or negatively. Therefore a search for an existing Likert scale survey instrument was undertaken.

Due to the specific ties to technology turnover and its applicability to return on investment, a detailed search of existing survey instruments was performed by accessing the ISWorld website (http://www.isworld.org). It was found that no specific survey instrument addressed all the factors that were desired to be tested. Certain concepts were

noted for possible use in construction of a new survey at a later date, but no single survey was available for use in this research effort. This necessitated the construction of a unique survey instrument to meet the needs of this research.

Survey Construction

After inspection of the available survey instruments, it was decided that the best way to test the constructs of the research was to develop a new instrument. Two reference books on survey construction were reviewed (Kalton, 1990; Converse and Presser, 1990) and a list of 34 questions was developed to address the five main areas of research. This list of questions was reviewed and approved by the research advisor and sponsor of this research and a set of obverse questions were developed to allow for a reliability check for each of the 34 questions. This list of 68 questions was then randomly sorted in an attempt to remove any ordering bias that might be introduced. This final list of questions was then sent to the Air Force Personnel Center (AFPC) for a formal review of the questions and approval for dissemination.

Survey Approval

The survey was sent to AFPC for approval as it was to appear on the Air Force Institute of Technology (AFIT) hosted website. Initial AFPC response was that the survey was too long and the reliability questions made it seem overly redundant. It was suggested that 15 of the obverse questions be removed bringing the total number of questions to 53. Therefore, the reliability questions were segregated into the five primary focus areas. It was desired that any one of these areas not be left without a form of reliability check to the questions therefore it was decided that a specific percentage from

each section would be removed so as not to leave any one area lacking reliability questions. Each section was considered to be independent of the others and reliability questions were removed at random from each section until the selected removal percentage was achieved. In total 15 reliability questions were removed at random without leaving any one of the main focus areas without a check for reliability. The 53 question survey was then revised and sent to AFPC for their review and the survey was approved and given an official Air Force survey control number, USAF SCN 02-096, that expired on 31 Dec 2002.

Pilot Study

The pilot study was undertaken in two parts. The first part of the study was a functionality check to see that the survey was readable and the collection mechanism was sufficiently gathering and storing the responses. A group of 21 students were chosen from the Information Resource Management program at AFIT. This group was selected for their familiarity of the subject and the assurance of timely and meaningful feedback of survey access and data collection performance. Questions were revised and structural changes were made to the web-based survey for aesthetic reasons based on the responses received from this initial pilot study group.

The second part of the pilot study involved sending the survey to an actual Air Force communication squadron for their response. Information was given as to the anonymity of their responses and the desire for survey feedback. The initial feedback from the commander of this communications squadron led to a reevaluation of the target audience of the survey. The particular communications squadron surveyed had recently

outsourced most of its IT related activities to a contract organization with government civilian oversight. The initial pool of respondents was to be military only, so a revision was made to the survey to allow for the commanders to redistribute the survey to the appropriate management official. The commanders were informed that the survey could only be completed by civilian or contractor personnel on a strictly voluntary basis. It is understood that the Air Force is moving towards outsourcing IT activities and this may have been a limiting factor in the number of respondents that participated in the research. The pilot study was then sent to the designated civilian authority for the chosen communications squadron, but no responses were ever received. In the interest of time, the pilot study was ended at this point. Indications were that this could be a terminal problem with the receipt of responses for the survey, but only if the majority of the communications squadrons to be surveyed had also been outsourced. At this point the decision was made to send out the survey to the masses to see if this was going to limit the respondents to an unacceptable number. If this would have been the case, a major adjustment to the collection of the data would have to be made and this early notice would have left time to make those changes. Ultimately, this was not a terminal factor in the data collection methodology and the research was able to continue.

Survey Dissemination

The population chosen to respond to this survey is of utmost significance to the Air Force. The Air Force has 119 communication squadrons and their commanders are solely responsible for managing and implementing the Air Force's multi-billion dollar communications budget and associated information technology resources. Of these 119

commanders, only 112 email addresses could be found for inclusion in the dissemination of the survey. The survey was sent to these112 Air Force communication squadron commanders, but 4 of the emails were rejected because of outdated email addresses. This meant that the sample size of the population to be survey was 108. Of these 108 commanders two of the respondents sent back justifications as to why this survey was not appropriate for their organizations due to the very specific missions of these organizations. It was agreed that these two organizations were outside the original scope of this research so their responses were not sought. This meant that the final number of respondents intended to be surveyed was 106. These 106 commanders or their representatives were then asked to take the survey themselves and also to disseminate the survey to their associated network maintainers for their response.

Response Retrieval

This survey was hosted on AFIT's computer network and the hyperlink to this web page was sent to each of the respondents to ease their access to the survey. The web page was developed to allow for automatic collection of the survey data in a database, once the respondent submitted the answers. The respondents were asked to provide any further comments they had at the end of the survey and provided a means to request a final version of this research if desired.

Analysis Methods

Once the surveys were completed and the data collected, analysis of the data was performed. The first step was to perform a factor analysis of the individual hypotheses' responses to make sure that the series of questions in fact loaded onto the factor that was

intended. Any additional factors that were found were recorded and the model changed to reflect their inclusion. Additionally, the hypotheses were treated as separate independent events to simplify and remove any cross loading effects between them. The following is a complete list of the original questions for each of the hypotheses. The revised list to include the segregation of questions into distinct factors is included in the next chapter of this report. In the list of questions that follow, the "Neg" in parentheses indicate questions that would have to be negatively scored to allow for proper assessment of an overall score of a factor as these were the obverse questions that were generated for reliability checks as mentioned previously.

Hypothesis 1 Questions

4. Your organization achieves an adequate return-on-investment (ROI) for its IT expenditures before the system has to be upgraded.

5. Recent technological advances are beginning to render your current IT infrastructure obsolete.

8. Recent IT advances have required your organization to procure new systems to maintain the current level of mission readiness and connectivity.

35(Neg). Your organization fails to achieve an adequate return-on-investment (ROI) from previous IT investments prior to seeking upgrades for your current infrastructure.

47. Your organization was able to maximize the potential of your current IT infrastructure before you made your latest major IT purchase.

Hypothesis 2 Questions

1(Neg). Your organization does NOT keep metrics on IT investments or their impacts on the user/customer (such as satisfaction, productivity, or resource savings).

9. The network administrators in your organization keep current with emerging technologies in the IT industry.

10. The network administrators or managers in your organization are empowered to research new IT technologies in advance of any need for network upgrades.

14(Neg). The recent rate of technological advances in the computer industry has NOT affected your organization's IT procurement processes.

19(Neg). Your organization fails to formally review the new technology need against the current systems capabilities prior to initiating the procurement process.

24. Your organization maintains metrics on IT investments and their impacts on the user/customer (such as satisfaction, productivity, or resource savings).

31(Neg). The network administrators or managers in your organization are limited in their ability to research new IT technologies in advance of any need for network upgrades.

33. The recent rate of technological advances in the computer industry has led to a refinement in your organization's IT procurement processes.

37. The increasing rates of technological advancement in the IT industry have increased your organization's awareness and planning for network system's procurement.

42(Neg). Your organization's awareness and planning for network system's procurement has NOT been affected by the increasing rates of technological advancement in the IT industry.

49. Your organization formally reviews the new technology need against current system capabilities prior to initiating the procurement process.

51. Before making your latest IT purchase, your organization performed a detailed analysis of your current system's capabilities.

53. The persons responsible for IT procurements in your organization meet with network administrators and managers about emerging technologies on a regular basis.

Hypothesis 3a Questions

18. Your organization must maintain currency in the state-of the-art technological advances to continue to perform its mission.

23. Your organization avoids procuring new computer hardware and/or software technologies simply because they are state-of-the-art and available.

29(Neg). State-of-the-art technological advances are NOT required for your organization to continue to perform its mission.

34(Neg). Your organization's computer hardware and/or software purchases are based availability of new technologies.

45. Your organization's computer hardware and/or software purchases are NOT based strictly on availability of new technologies.

Hypothesis 3b Questions

3(Neg). A primary source for funding innovative computer hardware and/or software technologies in your organization is through end of year funds or "fallout" money.

11. Your organization's computer hardware and/or software purchases are based on available funding.

12. IT funding is a major part of your organization's budget.

16(Neg). IT funding is a relatively small part of your organization's budget.

22. The funding for IT procurements and/or maintenance in your organization is adequate to sustain the mission requirements of the users.

28. The primary source for funding innovative computer hardware and/or software technologies in your organization is through the normal budget process and NOT through the use of "fallout" funds.

50. Your organization assures that there are training funds in the annual budget for user training of new computer system hardware and/or software components.

Hypothesis 3c Questions

20(Neg). Recent upgrades to your IT infrastructure have been based on higher headquarter mandates or regulations.

25. The leadership in your organization feels that IT infrastructure is a critical part of the user's ability to meet mission requirements.

26. The recent upgrades to your IT infrastructure were NOT downward directed.

27(Neg). The leadership in your organization does NOT see IT infrastructure as a critical part of the user's ability to meet mission requirements.

36. Your organization's users/customers drive the requirements for new IT procurements.

38. Your organization's computer hardware and/or software purchases are based on mission need.

46(Neg). Your organization's computer hardware and/or software purchases are NOT based strictly on mission need.

Hypothesis 3d Questions

2. Your organization's users/customers have little influence in the procurement of new IT technologies.

6. Your organization's current infrastructure is capable of meeting the user's requirements in the short term (1-2 yrs).

39. Your organization's current infrastructure is capable of meeting the user's requirements in the long term (2-5 years).

43. Your organization's users/customers are satisfied with the current network infrastructure and capabilities.

Hypothesis 4 Questions

7(Neg). Recent IT purchases have NOT provided your users/customer with new products and services to enhance mission completion.

13(Neg). Your latest major IT purchase was NOT critical to your system users'/customers' ability to continue to perform their mission related tasks.

15(Neg). Recent IT expenditures have NOT permitted your users/customer's to expand their mission capabilities.

17. Recent IT purchases in your organization have been made to increase user/customer productivity.

21. Your latest IT purchases have increased your network personnel's productivity in completing their mission.

30. Your organization has been able to expand the users'/customers' mission capabilities because of recent IT expenditures.

32. Your organization has been able to provide new products and services to the user/customers to enhance mission completion because of recent IT purchases.

40(Neg). Your latest IT purchases have NOT affected the time needed by the customers to complete mission related tasks.

41. New innovations in IT have enabled your organization to reallocate network personnel or resources to enhance mission success.

44(Neg). The new innovations in IT have NOT permitted your organization to redistribute network personnel to enhance mission success.

48. Your latest IT purchases have reduced the time needed by the users/customers to complete mission related tasks.

52. Your latest major IT purchase was critical to the ability of your system's users/customers to continue to perform mission tasks.

After the factor analysis was completed and the model revised, the results of the factors were computed by taking the mean of means of the responses to the individual questions for each factor. The result was a score that could be compared to the Likert scale factors to determine if the respondents agreed with the hypothesis or disagreed.

To test Hypothesis 5, the scores of the distinct factors for each of the seven previous hypotheses of the two groups were compared through an analysis of variance (ANOVA). This was performed to determine if there was a statistically significant difference between the responses received by the commanders and maintainers for each of the factors. Additionally, a test of unequal variances was performed between the two groups for each of the hypothesis factors to determine if the total number of respondents or the difference in number of respondents per group would impact the results and implications.

Summary

This chapter provided the methodology used to gather information on the level of the perception of an IT productivity paradox at the work center level of the Air Force. A web-based survey was used to gather the research data. The subjects for this study were stratified into communication squadron commanders and network maintainers. An email was sent to the all Air Force communication squadron commanders and their respective network maintainers to inform them of the study and the web location for its access. Due to its relatively small size the entire population was selected for this research effort. After the subjects completed the survey, the results were computed to provide a means of analysis. The next chapter provides an analysis of the survey responses.

IV. Results

Demographics

The total number of respondents to the survey was 72. However, to compute the response rate it is necessary to refer to the number of commanders that participated. **Figure 3** illustrates that 21 of the 106 commanders that were contacted responded to the survey or had their designated authority respond yielding a response rate of 19.81%.

Surveys sent	106
Surveys received	21
Response rate	19.81%

0 - 1 yr	14	19.44%
1 - 3 yrs	12	16.67%
3 - 5 yrs	8	11.11%
5 - 7 yrs	7	9.72%
7 - 10 yrs	8	11.11%
10 plus yrs	23	31.94%

33S	34	47.22%
3C0	16	22.22%
3C2	7	9.72%
2E2	3	4.17%
3A0	1	1.39%
Contractor	2	2.78%
Civilian	9	12.50%

Commanders	21	29.17%
Maintainers	51	70.83%

Contractor	2	2.78%
Civilian Employee	9	12.50%
General	0	0%
Colonel	0	0%
Lt Colonel	7	9.72%
Major	8	11.11%
Captain	11	15.28%
1Lt	3	4.17%
2Lt	5	6.94%
CMSgt	1	1.39%
SMSgt	1	1.39%
MSgt	5	6.94%
TSgt	8	11.11%
SSgt	5	6.94%
SrA	3	4.17%
A1C	4	5.56%
Amn	0	0%
AB	0	0%

Figure 3: Survey Results Demographics

Figure 3 also shows that these commanders sent the survey to their maintainers and 51 of them responded. Due to the size of each of the groups, 21 and 51, the Central Limit Theorem can be invoked, thus making an assumption of normality for the statistical distribution of responses possible.

Factor Analysis and Results

The following information is the factor analysis and results for Hypotheses 1 through 4. The factor analysis was performed using both standard and Verimax rotated methodologies to provide the most accurate segregation of the questions. The first two tables illustrate the how the hypothesis questions were segregated into the corresponding components. The questions are then listed under the names of the new factors that were created as a result of this factor analysis. The last table under each hypothesis shows the actual results of the mean of means calculations and corresponding standard deviations. A revised model with the new factors included is shown at the end of this section in **Figure 4**.

Hypothesis 1

Table 1: Component Matrix for test of Hypothesis 1

	Component	
	1	2
Q47	.784	-.039
Q35N	.766	.057
Q4	.742	-.166
Q5	-.186	.800
Q8	.376	.687

Table 2 Rotated Component Matrix for test of Hypothesis 1

	Component	
	1	2
Q47	.784	.026
Q35N	.759	.120
Q4	.753	-.104
Q5	-.252	.782
Q8	.318	.716

Return on Investment

47. Your organization was able to maximize the potential of your current IT infrastructure before you made your latest major IT purchase.

35(Neg). Your organization fails to achieve an adequate return-on-investment (ROI) from previous IT investments prior to seeking upgrades for your current infrastructure.

4. Your organization achieves an adequate return-on-investment (ROI) for its IT expenditures before the system has to be upgraded.

Technology advancement

5. Recent technological advances are beginning to render your current IT infrastructure obsolete.

8. Recent IT advances have required your organization to procure new systems to maintain the current level of mission readiness and connectivity.

Table 3: Results of test of Hypothesis 1

Group	Factor	Cronbach's Alpha	Mean	Standard Deviation
Commanders	Return-on-investment	.6570	5.1587	1.5471
Commanders	Technological advances	.0325	5.0475	1.5452
Maintainers	Return-on-investment	.2499	4.5000	1.6274
Maintainers	Technological advances	.6895	4.8300	1.6009

Hypothesis 2

Table 4: Component Matrix for test of Hypothesis 2

	Component	
	1	2
Q53	.823	-.003
Q49	.798	.022
Q51	.786	.027
Q10	.640	-.465
Q37	.736	-.092
Q31N	.619	-.424
Q19N	.726	.090
Q24	.704	.171
Q9	.461	-.446
Q1N	.611	.218
Q42N	.214	.707
Q14N	.179	.710
Q33	.388	.517

Table 5: Rotated Component Matrix for test of Hypothesis 2

	Component	
	1	2
Q53	.792	.223
Q49	.761	.240
Q51	.749	.242
Q10	.743	-.271
Q37	.732	.114
Q31N	.712	-.238
Q19N	.674	.286
Q24	.630	.358
Q9	.566	-.303
Q1N	.528	.377
Q42N	.011	.738
Q14N	-.023	.732
Q33	.231	.603

Process changes

53. The persons responsible for IT procurements in your organization meet with network administrators and managers about emerging technologies on a regular basis.

49. Your organization formally reviews the new technology need against current system capabilities prior to initiating the procurement process.

51. Before making your latest IT purchase, your organization performed a detailed analysis of your current system's capabilities.

10. The network administrators or managers in your organization are empowered to research new IT technologies in advance of any need for network upgrades.

37. The increasing rates of technological advancement in the IT industry have increased your organization's awareness and planning for network system's procurement.

31(Neg). The network administrators or managers in your organization are limited in their ability to research new IT technologies in advance of any need for network upgrades.

19(Neg). Your organization fails to formally review the new technology need against the current systems capabilities prior to initiating the procurement process.

24. Your organization maintains metrics on IT investments and their impacts on the user/customer (such as satisfaction, productivity, or resource savings).

9. The network administrators in your organization keep current with emerging technologies in the IT industry.

1(Neg). Your organization does NOT keep metrics on IT investments or their impacts on the user/customer (such as satisfaction, productivity, or resource savings).

Administrative changes

42(Neg). Your organization's awareness and planning for network system's procurement has NOT been affected by the increasing rates of technological advancement in the IT industry.

14(Neg). The recent rate of technological advances in the computer industry has NOT affected your organization's IT procurement processes.

33. The recent rate of technological advances in the computer industry has led to a refinement in your organization's IT procurement processes.

Table 6: Results of test of Hypothesis 2

Group	Factor	Cronbach's Alpha	Mean	Standard Deviation
Commanders	Procurement process changes	.8405	4.9571	1.5782
Commanders	Administrative process changes	.5299	4.6507	1.7053
Maintainers	Procurement process changes	.8852	4.2823	1.8443
Maintainers	Administrative process changes	.6593	4.4052	1.5912

Hypothesis 3a

Table 7: Component Matrix for test of Hypothesis 3a

	Component	
	1	2
Q45	**.745**	**-.294**
Q23	**.711**	**-.268**
Q34N	**.159**	**-.547**
Q29N	**.256**	**.775**
Q18	**.524**	**.568**

Table 8: Rotated Component Matrix for test of Hypothesis 3a

	Component	
	1	2
Q45	.801	.020
Q23	.759	.031
Q34N	.359	-.441
Q29N	-.066	.813
Q18	.261	.727

Availability of new technologies

45. Your organization's computer hardware and/or software purchases are NOT based strictly on availability of new technologies.

23. Your organization avoids procuring new computer hardware and/or software technologies simply because they are state-of-the-art and available.

Perceived need of new technologies

29(Neg). State-of-the-art technological advances are NOT required for your organization to continue to perform its mission.

18. Your organization must maintain currency in the state-of the-art technological advances to continue to perform its mission.

Table 9: Results of test of Hypothesis 3a

Group	Factor	Cronbach's Alpha	Mean	Standard Deviation
Commanders	Technology availability	.5585	4.9761	1.6746
Commanders	Perceived need of new technology	.5007	5.5476	1.6260
Maintainers	Technology availability	.4344	4.6862	1.7404
Maintainers	Perceived need of new technology	.4503	5.0588	1.5721

Hypothesis 3b

Table 10: Component Matrix for test of Hypothesis 3b

	Component	
	1	2
Q16N	.822	.420
Q12	.799	.457
Q50	.683	.157
Q22	.618	-.312
Q28	.667	-.520
Q3N	.510	-.502
Q11	-.033	.679

Table 11: Rotated Component Matrix for test of Hypothesis 3b

	Component	
	1	2
Q16N	.917	.110
Q12	.918	.066
Q50	.655	.250
Q22	.339	.604
Q28	.264	.804
Q3N	.143	.701
Q11	.351	-.582

Budgeted funding

16(Neg). IT funding is a relatively small part of your organization's budget.

12. IT funding is a major part of your organization's budget.

50. Your organization assures that there are training funds in the annual budget for user training of new computer system hardware and/or software components.

Fallout funding

28. The primary source for funding innovative computer hardware and/or software technologies in your organization is through the normal budget process and NOT through the use of "fallout" funds.

3(Neg). A primary source for funding innovative computer hardware and/or software technologies in your organization is through end of year funds or "fallout" money.

22. The funding for IT procurements and/or maintenance in your organization is adequate to sustain the mission requirements of the users.

Table 12: Results of test of Hypothesis 3b

Group	Factor	Cronbach's Alpha	Mean	Standard Deviation
Commanders	Availability of Funds	.7515	4.5238	2.1316
Commanders	Fallout Funding	.6779	2.7301	1.7616
Maintainers	Availability of Funds	.8470	3.8169	1.9915
Maintainers	Fallout Funding	.6757	3.0588	1.7999

Hypothesis 3c

Table 13: Component Matrix for test of Hypothesis 3c

	Component	
	1	2
Q38	.800	.131
Q25	.781	.117
Q27N	.750	.109
Q46N	.703	-.334
Q36	.413	-.131
Q20N	-.040	.926
Q26	.053	.901

Table 14: Rotated Component Matrix for test of Hypothesis 3c

	Component	
	1	2
Q38	.800	.131
Q25	.781	.117
Q27N	.750	.108
Q46N	.703	-.334
Q36	.413	-.132
Q20N	-.039	.926
Q26	.053	.901

Internal forces

38. Your organization's computer hardware and/or software purchases are based on mission need.

25. The leadership in your organization feels that IT infrastructure is a critical part of the user's ability to meet mission requirements.

27(Neg). The leadership in your organization does NOT see IT infrastructure as a critical part of the user's ability to meet mission requirements.

46(Neg). Your organization's computer hardware and/or software purchases are NOT based strictly on mission need.

36. Your organization's users/customers drive the requirements for new IT procurements.

External forces

20(Neg). Recent upgrades to your IT infrastructure have been based on higher headquarter mandates or regulations.

26. The recent upgrades to your IT infrastructure were NOT downward directed.

Table 15: Results of test of Hypothesis 3c

Group	Factor	Cronbach's Alpha	Mean	Standard Deviation
Commanders	Internal forces	.7285	5.5238	1.3451
Commanders	External forces	.7735	2.6190	1.5294
Maintainers	Internal forces	.7076	5.0431	1.6583
Maintainers	External forces	.8418	3.4117	1.9106

Hypothesis 3d

Table 16: Component Matrix for test of Hypothesis 3d

	Component	
	1	2
Q2N	-.043	.999
Q43	.800	-.001
Q39	.780	.040
Q6	.780	.016

Table 17: Rotated Component Matrix for test of Hypothesis 3d

	Component	
	1	2
Q2N	-.010	1.000
Q43	.799	-.028
Q39	.781	.014
Q6	.780	-.010

Customer satisfaction

43. Your organization's users/customers are satisfied with the current network infrastructure and capabilities.

39. Your organization's current infrastructure is capable of meeting the user's requirements in the long term (2-5 years).

6. Your organization's current infrastructure is capable of meeting the user's requirements in the short term (1-2 yrs).

Table 18: Results of test of Hypothesis 3d

Group	Factor	Cronbach's Alpha	Mean	Standard Deviation
Commanders	Customer satisfaction	.7919	4.5873	1.8546
Maintainers	Customer satisfaction	.6276	4.4379	1.6890

Hypothesis 4

Table 19: Component Matrix for test of Hypothesis 4

	Component	
	1	2
Q21	.781	-.081
Q30	.773	-.046
Q15N	.761	.036
Q17	.743	-.194
Q48	.724	-.044
Q52	.708	-.239
Q32	.657	-.168
Q13N	.556	-.434
Q7N	.545	.080
Q40N	.538	-.014
Q44N	.482	.752
Q41	.515	.718

Table 20: Rotated Component Matrix for test of Hypothesis 4

	Component	
	1	2
Q21	.744	.253
Q30	.722	.282
Q15N	.677	.351
Q17	.756	.134
Q48	.676	.262
Q52	.743	.079
Q32	.667	.121
Q13N	.686	-.162
Q7N	.462	.301
Q40N	.494	.212
Q44N	.124	.885
Q41	.168	.867

Mission enhancement

21. Your latest IT purchases have increased your network personnel's productivity in completing their mission.

30. Your organization has been able to expand the users'/customers' mission capabilities because of recent IT expenditures.

15(Neg). Recent IT expenditures have NOT permitted your users/customers to expand their mission capabilities.

17. Recent IT purchases in your organization have been made to increase user/customer productivity.

48. Your latest IT purchases have reduced the time needed by the users/customers to complete mission related tasks.

52. Your latest major IT purchase was critical to the ability of your system users'/customers' to continue to perform mission tasks.

32. Your organization has been able to provide new products and services to the users/customers to enhance mission completion because of recent IT purchases.

13(Neg). Your latest major IT purchase was NOT critical to your system users'/customers' ability to continue to perform their mission related tasks.

7(Neg). Recent IT purchases have NOT provided your users/customers with new products and services to enhance mission completion.

40(Neg). Your latest IT purchases have NOT affected the time needed by the customers to complete mission related tasks.

Reallocation of resources

44(Neg). The new innovations in IT have NOT permitted your organization to redistribute network personnel to enhance mission success.

41. New innovations in IT have enabled your organization to reallocate network personnel or resources to enhance mission success.

Table 21: Results of test of Hypothesis 4

Group	Factor	Cronbach's Alpha	Mean	Standard Deviation
Commanders	Mission completion enhancement	.9056	5.2952	1.3478
Commanders	Reallocation of resources	.9256	3.7380	2.0959
Maintainers	Mission completion enhancement	.8513	4.8823	1.4065
Maintainers	Reallocation of resources	.7226	3.5882	1.5244

New Model

Figure 4 illustrates the factors that make up the hypotheses that were tested in this research. It is important to note that each hypothesis was treated as an independent event, so the suggestion of causal relationships between hypotheses is not an intention of this research.

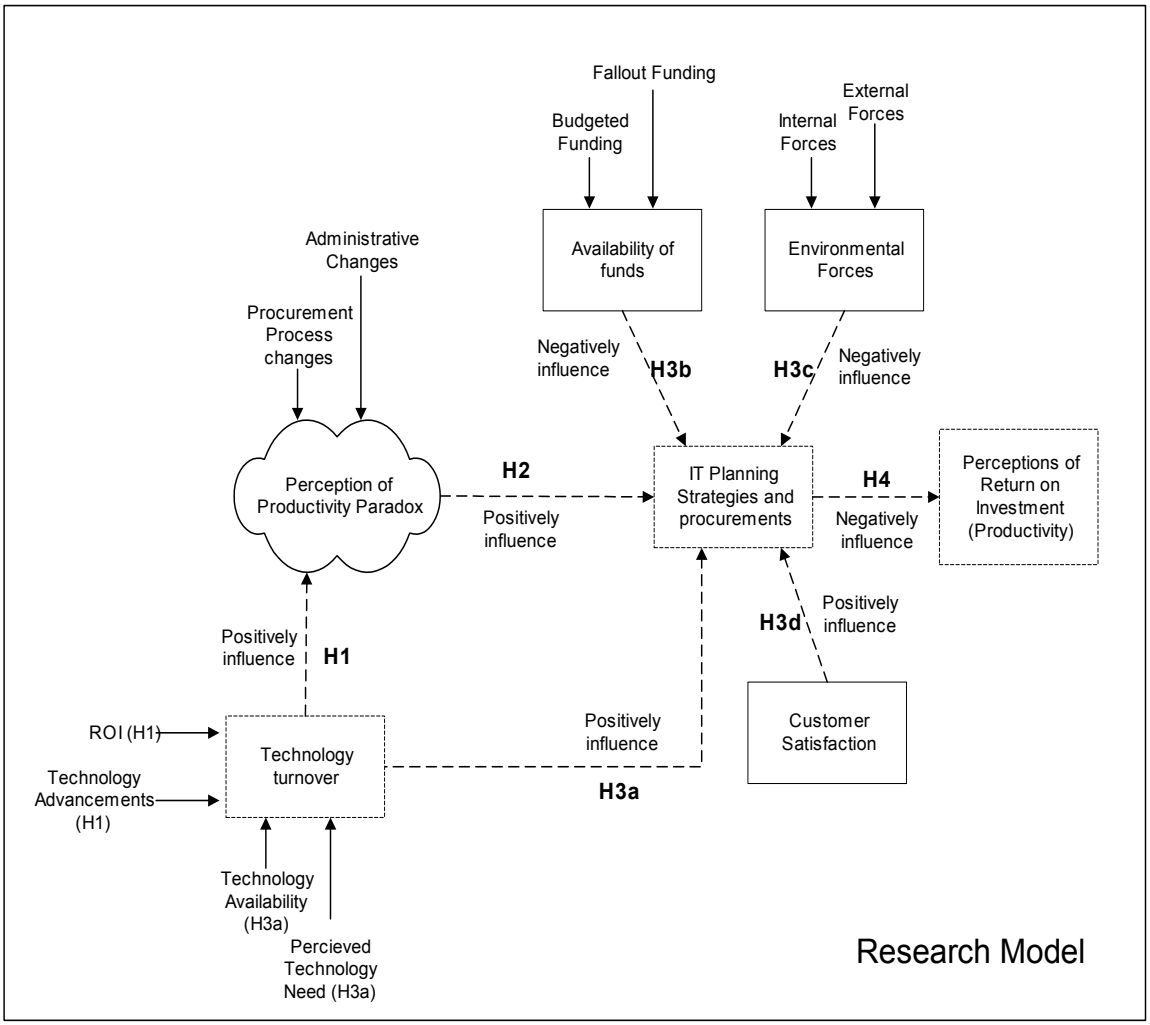

Figure 4: New Thesis Model

Deleted Questions

The following questions were deleted due to reliability issues and insufficient factor loading in the factor analysis.

Question 2 did not load on the intended factor of Hypothesis 3d which was customer satisfaction. Since there was no other factor that was intended to be tested and there was only one question that loaded on this additional factor, this question was eliminated. This was done as reliability on a factor with only one question was difficult to assess.

Question 11 loaded moderately on one factor, but in the data analysis this question had severely negative effects on reliability of the factor it loaded on. Reliability was significantly increased with the omission of this question and therefore was removed.

Question 34 did not load on either the original factor or the new factor that was revealed after the factor analysis. Since there was no other factor that was intended to be tested and there was only one question that loaded on this additional factor, this question was eliminated. This was done as reliability on a factor with only one question was difficult to assess.

Hypothesis 5

Table 22 shows the results of the test of Hypothesis 5. Included in the table are the results of the ANOVA to include the student's t test, the Tukey-Kramer means test, and the Levene test of unequal variance. An alpha of .05 was chosen to give a 95% confidence interval of the ANOVA results.

Table 22: Results of test of Hypothesis 5

Factor tested	Student's t (alpha =.05)	Tukey-Kramer HSD (alpha =.05)	Unequal variances (Levene)	Results
H1 (Return-on-investment)	.1676	-.13918	.4948	No significant difference
H1 (Technological advances)	.0647	-.03377	.2229	No significant difference
H2 (Procurement process changes)	**< .0001**	**.38971**	**<.0001**	Significant difference
H2 (Administrative changes)	.3139	-.23396	.3469	No significant difference
H3a (Technology availability)	.3699	-.33409	.6592	No significant difference
H3a (Perceived need of new technology)	.0954	-.08671	.9477	No significant difference
H3b (Budgeted Funds)	**.0212**	**.10691**	.1799	Significant difference
H3b (Fallout Funding)	.2211	-.19920	.5487	No significant difference
H3c (Internal forces)	**.0088**	**.12179**	**.0006**	Significant difference
H3c (External forces)	**.0181**	**.13714**	**.0129**	Significant difference
H3d (Customer satisfaction)	.5666	-.36364	.2596	No significant difference
H4 (Mission completion enhancement)	**.0003**	**.18918**	.2337	Significant difference
H4 (Reallocation of resources)	.6332	-.46960	**<.0001**	No significant difference

In interpreting the results of **Table 22**, it should be known that a Tukey-Kramer result that is positive yields a result of a significant difference in the means. This can also be verified by the fact that the student t-test is less than the chosen alpha of .05. The Levene unequal variance test indicates possible problems with the difference in the size of the groups when the result is less than the given alpha of .05. This would indicate that

caution should be used when generalizing the results to the entire population. Each of these situations is bolded in the table above to illustrate it when they occurred.

V. Implications to the Air Force

This chapter addresses the results and interpretations of the research as well as the overall implications to the Air Force. Additionally, the chapter identifies the limitations of the research and posits possible future research to be performed to further the knowledge in this area.

Implication to Air Force

Each hypothesis is repeated below followed by an interpretation of the results and an associated implication to the research.

Hypothesis 1

The understanding of technology turnover at the work center level of the Air Force had led to a perception of an IT productivity paradox.

Interpretation

Both groups feel that they get an adequate return on investment for IT related purchases, but they also feel that they need to continually upgrade their systems due to technological advances and user requirements.

Implications

Due to the low alpha of the technology advancement factor of the model for this hypothesis, one cannot generalize this particular construct Air Force-wide. A better survey instrument is needed to test the technological advancement factor to allow for proper measurement. However, the return-on-investment factor has a moderate alpha and can be generalized. Therefore, the research can only indicate that there is not a great perception of a productivity paradox from a return-on-investment standpoint at the Air Force's work center level, thus Hypothesis 1 is thus not supported.

Hypothesis 2

The perception of a paradox has positively influenced the IT planning strategies at the work center level in the Air Force.

Interpretation

Even though a perception of a paradox cannot be supported (Hypothesis 1 results), both groups feel that process and administrative changes have been made to account for its foundational symptoms. This apparent disagreement with the perception of the paradox could be resolved if a better instrument was used for the technology advancements factor of Hypothesis 1. This factor may indeed indicate that they do have

a perception of the paradox that has led to the changes indicated by the results of this hypothesis.

Implications

From the results above one can see that both of the groups feel that a positive influence on IT planning has taken place due to a realization of a perceived existence of an IT paradox. This is contrary to the findings of Hypothesis 1, but this could be explained due to the low reliability of the technology advancement factor of the model for Hypothesis 1. The process changes factor has a high alpha and the administrative changes factor has a moderate alpha, but the process changes factor has an indication of a possible bias due to unequal variances. Therefore, caution should be used when making a generalization to the entire population even though the Cronbach's alpha for each factor is moderate to high. Considering the limitations outlined above, Hypothesis 2 is supported.

Hypothesis 3a

The understanding of technology turnover has positively impacted Air Force IT planning at the work center level.

Interpretation

Both groups feel that availability of technologies is not a driving force in IT planning. However, they both have a perceived need for new

technologies to continue to meet mission and customer requirements. These two results indicate that technology turnover is impacting IT planning, but not due to the mere availability of new technologies.

Implications

The commander group alphas are moderate and the maintainer group alphas are low. This would indicate a possible problem with the survey instrument. A misconception or misread of the questions is evident between the two groups. This results in a measurement of this hypothesis that is not very reliable and suspect to generalization. Considering these limitations, Hypothesis 3a is only partially supported. This is due to the low alpha of the maintainer's responses which indicates that full support to the hypothesis cannot be made at this time, even though there is a perceived need of new technologies, and a perception that the mere availability of new technologies does not impact IT planning.

Hypothesis 3b

Availability of funding has negatively impacted Air Force IT planning at the work center level.

Interpretation

The two groups differ on their perception of the appropriate level of funding for IT expenditures. The commanders seem to indicate that the

current level of budgeted funding is adequate, whereas the maintainers feel that the current level is not. This indicates a significant disconnect in the perceptions of funding ideologies for IT. It is understood that the means for this factor are both close to the median of four, indicating that the perceptions are not significantly great in either of the cases, but the difference is significant enough to raise a question for future studies to investigate this potential problem. The disconnect between the two groups' perceptions could lead to the commanders not approving IT initiatives or not budgeting for them even if the maintainers feel that the new initiatives are warranted. However, both groups feel that the majority of IT funding is through end-of-year or fallout money rather than budgeted expenses.

Implications

Both groups have moderate to high alphas for this model, therefore the factors and their results are reliable and generalizable to the Air Force. Due to the disconnect between perceptions of appropriate IT budget funding, it is clear that this factor does indeed negatively impact IT planning at the work center level. The maintainers who are the closest to the operational aspects of the networks do not feel adequate funding is available. These maintainers are relying on commanders to provide budgeted funds for upgrades to these systems, and these commanders already feel that the funding is adequate. This could make procurement of

new IT innovations difficult. Additionally, these results indicate that the organizations are reliant on fallout funds to make IT improvements. Again, the commanders that are in charge of the distribution of these fallout funds already feel adequate coverage for IT funding exists, potentially exacerbating the problem. Lastly, by the nature and availability of fallout funds, this means that certainty on system upgrades is suspect, negatively impacting IT procurements. Therefore Hypothesis 3b is supported.

Hypothesis 3c

Environmental factors, such as customers, mission and higher headquarter direction; have negatively impacted Air Force IT planning at the work center level.

Interpretation

Both groups feel that internal forces such as mission requirements, user needs, and leadership influences have a positive impact on IT procurements. However, both groups also indicate that the recent IT expenditures have been downward directed, resulting in a negative impact on procurements.

Implications

Both groups have high alphas, but there are indications of a possible bias due to unequal variances. Therefore, caution should be used when making a generalization to the entire population even though the Cronbach's alpha for each factor is high. The results indicate that the work centers are required to coordinate higher headquarter demands with user and mission needs for IT expenditure dollars. These results indicate that a negative impact on IT procurements exists due to work center environmental factors, thus Hypothesis 3c is supported. However, it is impossible to gauge the level of conflict between internal and external forces with this model. An additional study into this phenomenon is needed to show the actual relationship of these two factors and the impacts it has to work center productivity. The results here simply indicate that a conflict between internal and external forces exists.

Hypothesis 3d

Customer satisfaction positively influences IT planning at the work center level.

Interpretation

Both groups feel that their users and/or customers are satisfied with the current infrastructure and its ability to meet their short and long term needs. However, this model fails to measure or gauge how this

satisfaction relates to work center IT planning. This results from a question that was included in the survey being improperly constructed. The question was removed as it severely impacted the reliability of the model. A new survey with a form of this question more clearly addressed is needed to test this hypothesis.

Implications

Both groups have to moderate to high alphas indicating that this model is reliable and generalizable to the Air Force for judging customer satisfaction. However, the instrument lacks an adequate measure of how customer satisfaction influences work center IT planning, due to the removal of Question 2 for reliability reasons. Therefore, this instrument is unable to measure the desired response to Hypothesis 3d, and thus cannot be supported. It is important to note that customer satisfaction is an important part of IT planning and should still be investigated with a more robust instrument in the future.

Hypothesis 4

IT procurements are not perceived as contributors to work center productivity.

Interpretation

Both groups feel IT related expenditures have improved or enhanced the way their customers complete their mission, but have not allowed the organizations to reallocate resources to expand or diversify their missions. The first factor indicates that there is a perception that IT procurements do indeed positively impact work center productivity. The second factor indicates that these positive impacts to work center productivity are limited to the scope of their existing mission, thus failing to allow for future mission expansion.

Implications

Both groups have high alphas, but the reallocation of resources factor has an indication that a possible bias exists due to unequal variances between the groups. Therefore, caution should be used when making a generalization to the entire population even though the Cronbach's alpha for each factor is high. The results indicate that the personnel at the work centers do have a perception that IT does positively impact productivity. This impact is limited but the perception is still a positive one, thus Hypothesis 4 is not supported.

Hypothesis 5

The senior leadership at the work center level has a significantly different level of understanding technology turnover and its effects than their network maintainers.

Interpretation

The two groups were statistically equivalent on eight of the 13 factors that are part of this model. The five factors where there was a statistically significant difference are procurement process changes, availability of funds, internal forces, external forces, and mission completion enhancement. However, three of these five factors showed implications that unequal variances could have contributed to the statistical difference between the mean responses. Therefore, it is difficult to make inferences on the reasons for the difference in means of these three factors. As for the remaining two factors, these differences indicate that there are some opposing ideologies between the commanders and their maintainers on some critical issues in the IT arena.

Implications

The results above show a partial support for Hypothesis 5. There are five factors that indicate a statistically significant difference in the two groups' responses. The first of these factors (procurement process changes) indicate that the commanders have a higher understanding of the

procurement process changes that were made to cope with the perception of an IT paradox. This may be due to poor communications within the organizations or specific need to know restrictions, but as mentioned above the unequal variances between the mean responses could be a contributing factor to this statistical difference.

The next factor is the most troubling of the results as it indicates that the commanders feel that IT funding is adequate whereas the maintainers feel that it is not. As explained in the analysis of Hypothesis 3b above, this disconnect indicates potential problems with acquisition of new IT systems. However, due to both the commanders and maintainers mean responses being close to the median of four for this instrument, it is suggested that this potential problem be studied in future research.

The next two factors deal with the environmental influence on IT planning. In both cases, the commanders have a greater perception of the internal and external forces that impact IT spending. This makes logical sense as they in fact are in charge of the organization and must interact with all forces regularly to complete the mission. The difference between these two groups may be explained by the location proximity and the necessarily narrowly focused support requirements of the maintainers but as mentioned previously the unequal variances between the mean responses could be a contributing factor to this statistical difference.

The last factor is also troubling as it indicates that the personnel most closely tied to the operation of IT equipment, the maintainers, have

a lower perception of IT's value towards work center productivity than do the commanders in charge of procuring it. This means that commanders could have a higher expectation of productivity gains for an IT purchase than is feasible, thus potentially supporting a further perception of a paradox.

Overall Assessment

The research indicates that there may be a perception of an IT productivity paradox, even though Hypothesis 1 was not supported. Both commanders and maintainers feel that procurement and administrative changes have been made in IT planning due to the understanding of a potential IT productivity paradox. The apparent disconnect between the results of Hypotheses 1 and 2 should be studied in greater detail, but could possibly be explained by the low reliability of the survey instrument used to test Hypothesis 1. The important thing to note is that IT planning changes have been made to account for the recent technology life cycle reductions prevalent in the information age. Whether it is called the IT productivity paradox or not, the results are still the same, Air Force work centers are adapting their IT procurement strategies to account for this change in the technological marketplace.

Ultimately, the Air Force work centers have the perception that they are getting and adequate return on investment for IT expenditures, indicating that their IT planning procedures have been effective. However, the results also indicate that they have a perceived need for newer technologies to be able to keep their network infrastructures to the necessary level to support their customer's needs. This indicates that IT planning in

the Air Force must continually change to strike the appropriate balance between the demands of the customers and the capabilities of the technologies.

Limitations of Research

This research has many limitations that constrain the certainty of the results. The single most limiting factor was the survey itself. It was constructed using a series of newly fashioned questions that were thought to be representative of how perceptions of each of the phenomena to be tested were formed. This was necessary because a single preexisting survey was not found to address all of the factors and hypotheses needed. Therefore, instead of constructing a new survey, a more thorough search of existing surveys should be done and a piece mill assessment survey should be created from these previously validated surveys to allow for a more rigorous and accurate assessment of the theories being tested. A further limitation of this type of survey is the self reporting of the respondents' perceptions. The survey answers could be skewed by the respondent to make the outcomes appear as they feel they should rather than their actual assessment of the phenomena being tested. Considering these limitations, the results of this research are still valid, but some areas could not be accurately tested. Further research should be done in these areas to allow for a more thorough understanding of the IT productivity phenomena.

Another limitation was identification and access to the population being surveyed. Physical access was eased through the web-based posting of the survey and email notification of location and survey response times. However, the Air Force is moving towards privatization of IT and computer networking functions. This meant that access

to the people in charge of networks could be through civilian or contractor rather than strictly military channels. Since the Air Force has not entirely migrated to this privatization concept, the target population was mixed between military, civilian, and contractor personnel. This revelation was not understood until the pilot study was completed. The original intent was to assess military personnel's perceptions only, as the assumption at the start of the research was that control would still be performed by military personnel even if IT privatization had taken place at particular communication squadrons. As such the survey was only approved for dissemination to military personnel. To cope with the restrictions made evident by the pilot study, the survey was sent to all the communication squadron commanders with the caution that the survey could only be given to civilians or contractors on a voluntary basis only. This could have contributed to the relatively low response rate of the survey. To cope with these restrictions a more detailed survey approval process would have been needed to address the potential civilian and contractor respondents. The decision was made to proceed with the approved survey as this more detailed process would have extended the timeline of research to a point that would have made completion under the current time restrictions infeasible. Results indicated that civilian and contractor personnel still responded to the survey on a voluntary basis, but the commanders were limited in their abilities to encourage these two groups to participate on a larger scale.

With the understanding of a more diverse population of respondents comes a realization that access to the respondents could be difficult. A list of communication squadron commanders was received form AFPC, but a list of all potential respondents to include civilian and contractor personnel could be impossible because of this diversity

and the continual push towards privatization. It is recommended that if this type of research is performed again for this population that this aspect be addressed with AFPC personnel before survey construction takes place to determine if contact of all relevant personnel is feasible.

A further limitation could have been the willingness a commanders to participate in this survey as an organization. Due to the diverse nature of the enlisted network maintenance field, contact to the network maintainers was left entirely up to the commanders who received the survey. This could introduce a bias to the results as commanders could have selected only those maintainers that were ideologically aligned with themselves, or chose not to include any of their maintainers so as not to increase their already overburdened workload.

Another limitation is the assumption of independence between the hypotheses being tested. It is easily seen that one hypothesis could have a correlation to the others. The research undertaken in this study should be divided in to the distinct groups and performed in a more rigorous manner before they are looked at in totality so causal relationships can be made.

Future Research

Each of the hypotheses in this research should be looked at in individual studies. The results indicate that there are phenomena in each of the hypotheses that warrant future investigation. As stated in the limitations above, the instrument used to measure these hypotheses lacked validity in certain areas such as customer satisfaction and technology turnover's direct impact to IT planning.

Additionally, an area was identified in the environmental influences hypothesis that indicated that internal and external forces are conflicting when it comes to workplace IT planning. The degree and interrelation of these forces should be studied in detail to determine what impact they truly have to workplace IT planning.

Another area of future study should be in investigating the perceptions of available and sufficient funding for IT expenditures. The results indicated that the commanders and maintainers have significantly different perceptions of these funding issues and this could be a critical conflict when it comes to planning IT expenditures and assessments of current system viability.

Since this study was a point in time assessment of the phenomena being tested, it is suggested that this research be repeated periodically to produce a time series analysis of the data. It has been postulated that the influence on workplace productivity from IT parallels the productivity impacts realized by the introduction of the electric motor in the Industrial Revolution (David, 1990). An assessment in a time series formatted study could revel that as IT becomes more ingrained in the way we operate, as did the electric motor, we will see productivity gains associated with procurements.

Lastly, the results of this study indicate that a significant difference is evident between the perceptions of commanders and maintainers with respect to IT's influence on workplace productivity. The difference indicates that maintainers have lower perception of IT's influence on productivity than do their commanders. This could lead to a problem in assessing return on investment for IT expenditures and evaluating the need for future system upgrades. A more detailed study should be performed to investigate this

difference and see if it contributes to a greater perception of IT productivity paradox in one group versus the other.

Appendix A

The following are histograms of each of the factors relating to their associated hypotheses tests.

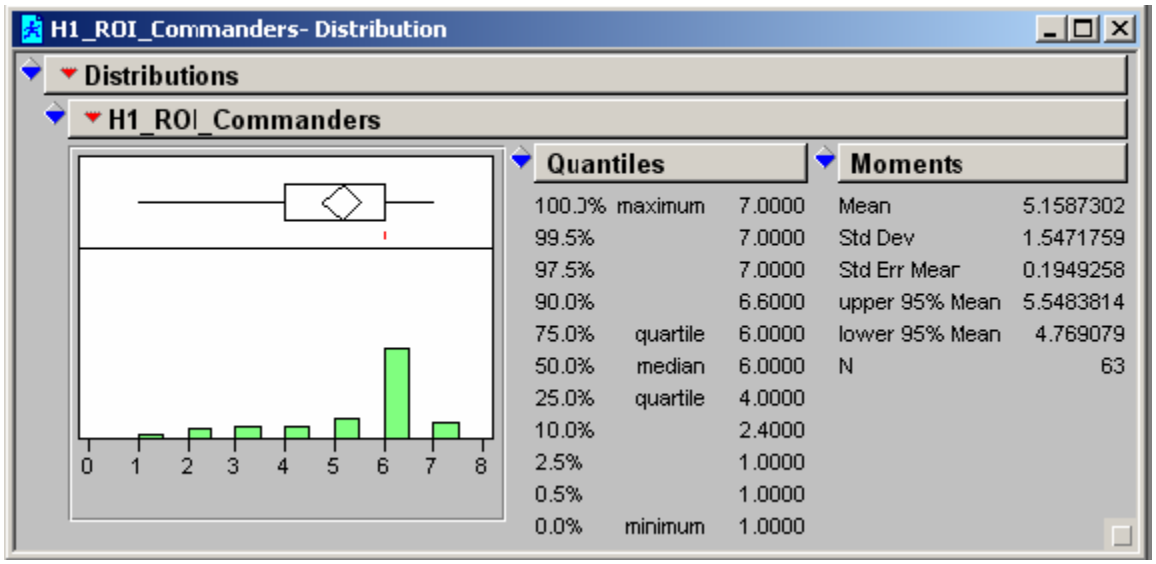

Figure 1: Hypothesis 1 Return on Investment factor histogram (Commanders)

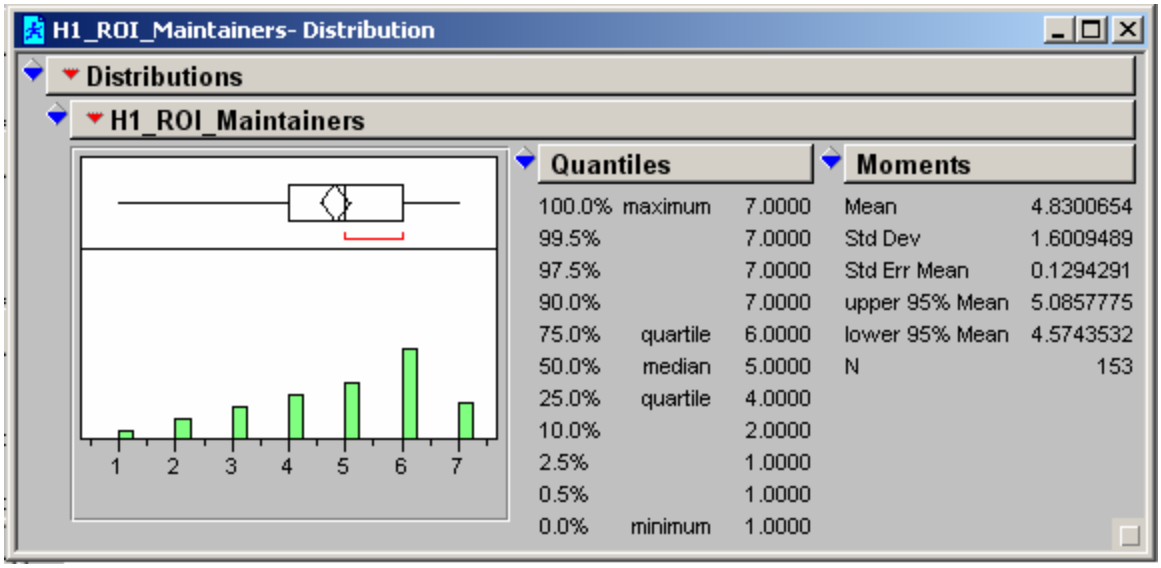

Figure 2: Hypothesis 1 Return on Investment factor histogram (Maintainers)

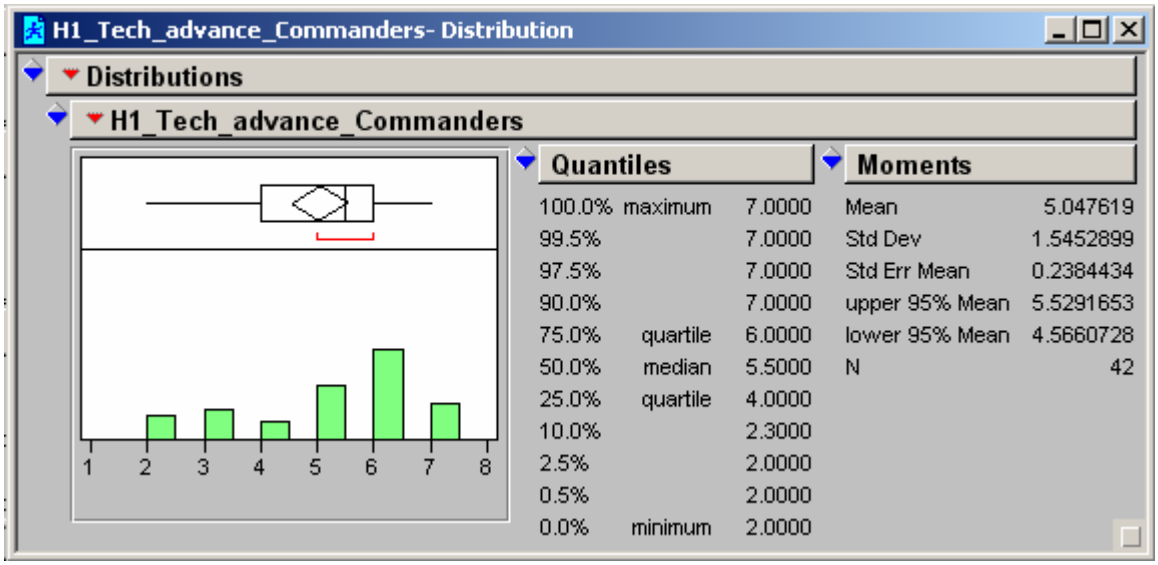

Figure 3: Hypothesis 1 Technology Advancements factor histogram (Commanders)

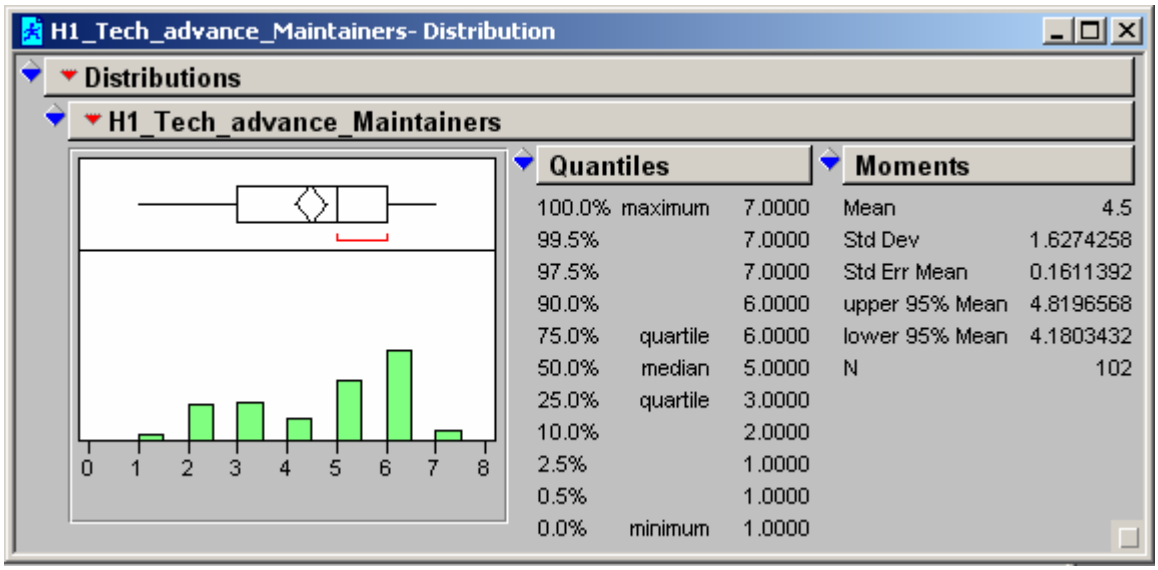

Figure 4: Hypothesis 1 Technology Advancements factor histogram (Maintainers)

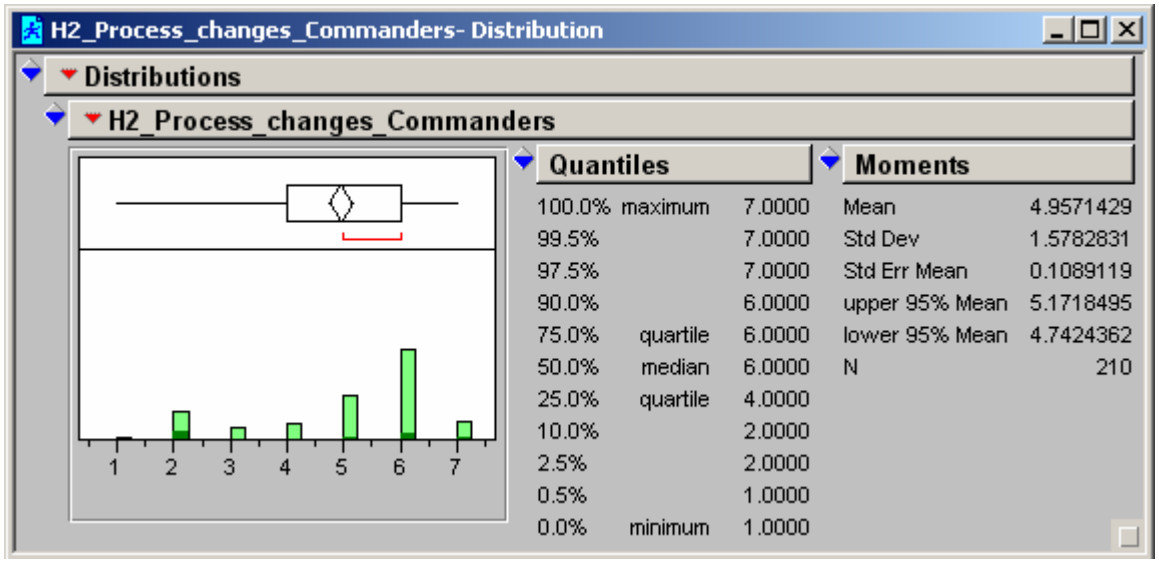

Figure 5: Hypothesis 2 Procurement Process Changes factor histogram (Commanders)

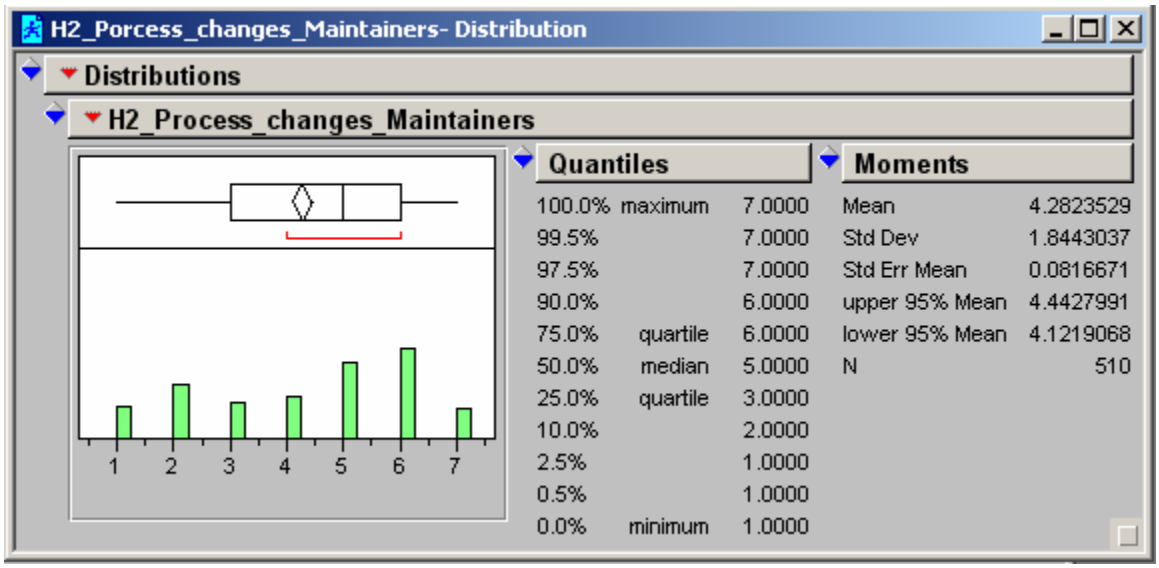

Figure 6: Hypothesis 2 Procurement Process Changes factor histogram (Maintainers)

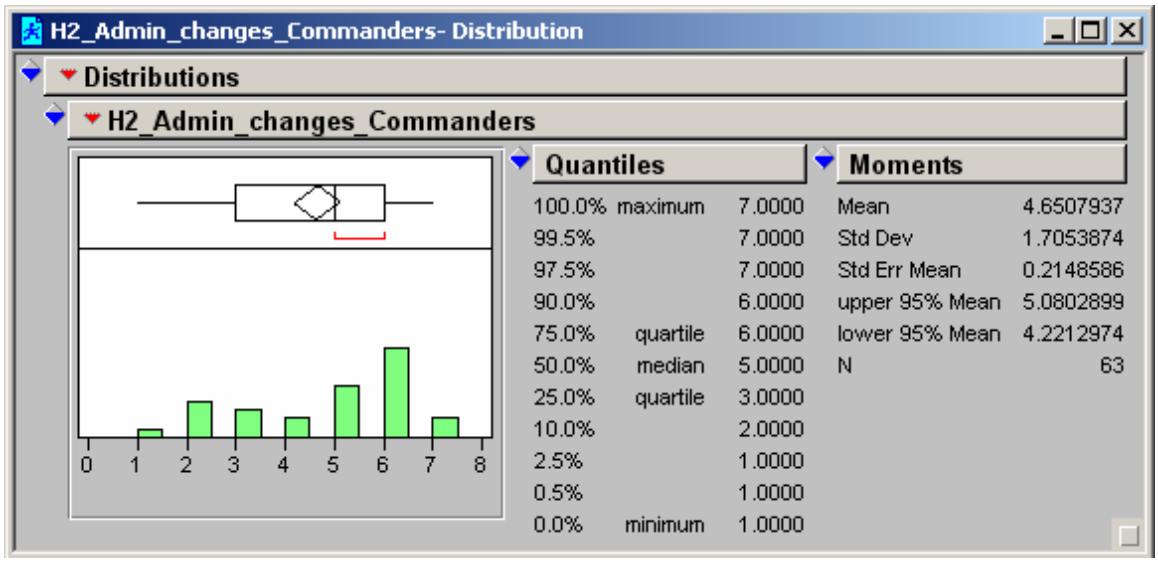

Figure 7: Hypothesis 2 Administrative Changes factor histogram (Commanders)

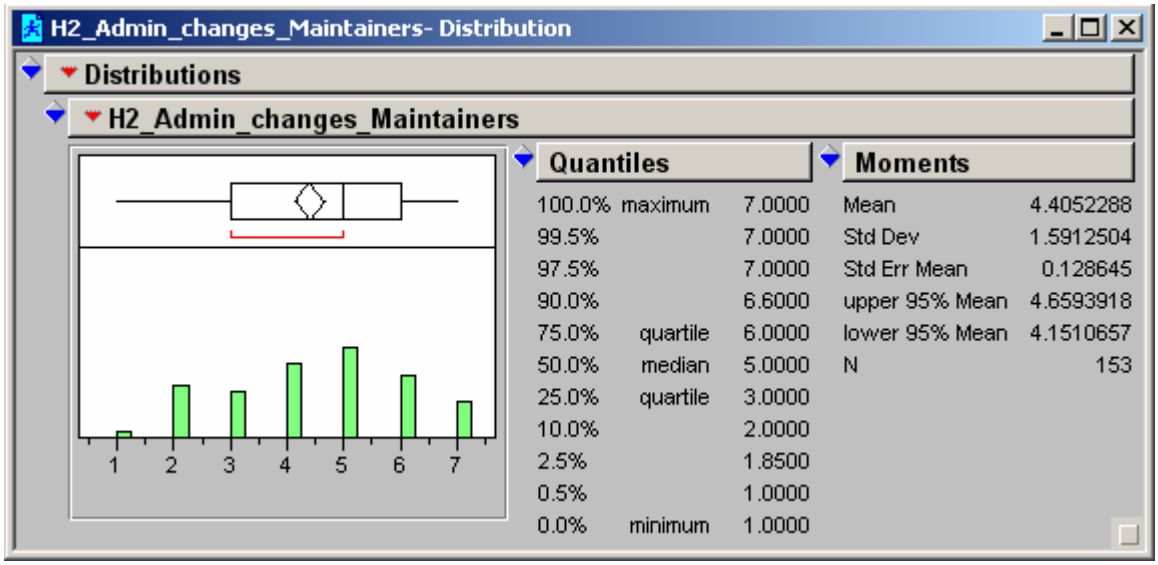

Figure 8: Hypothesis 2 Administrative Changes factor histogram (Maintainers)

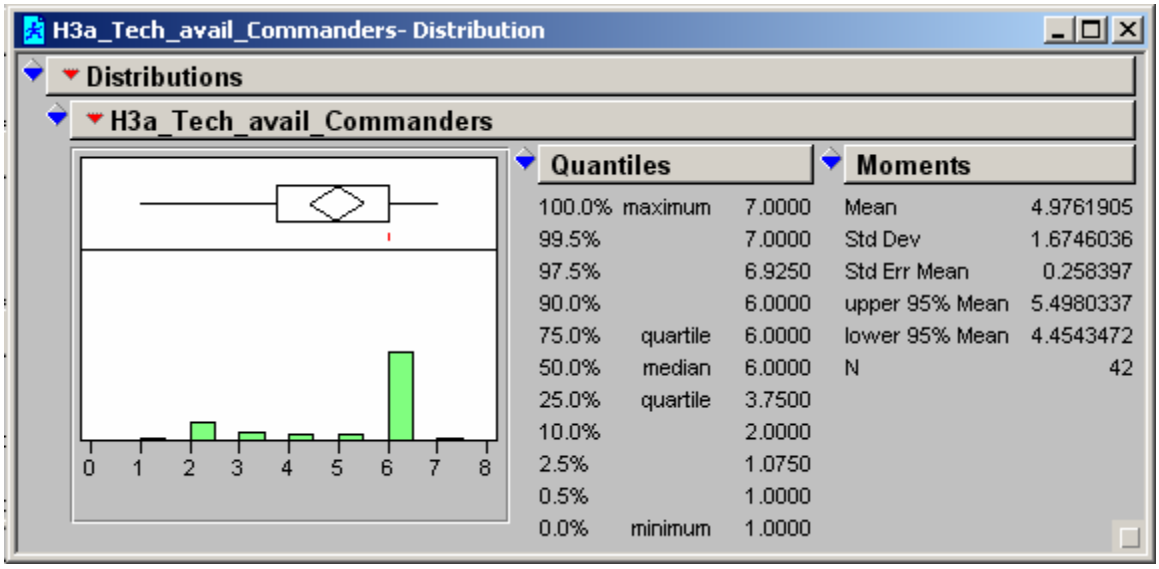

Figure 9: Hypothesis 3a Technology Availability factor histogram (Commanders)

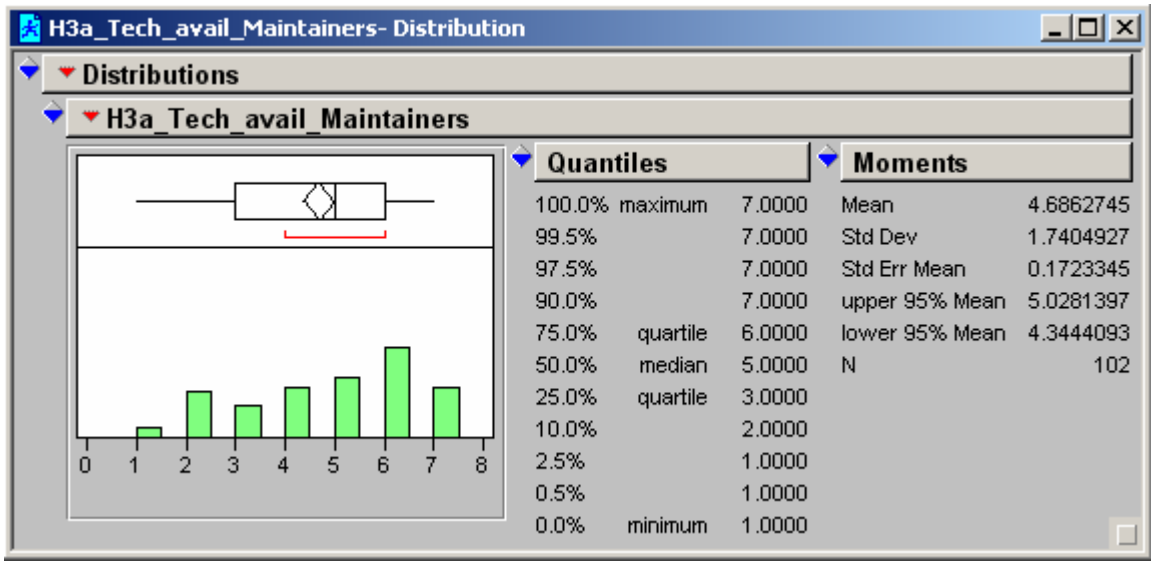

Figure 10: Hypothesis 3a Technology Availability factor histogram (Maintainers)

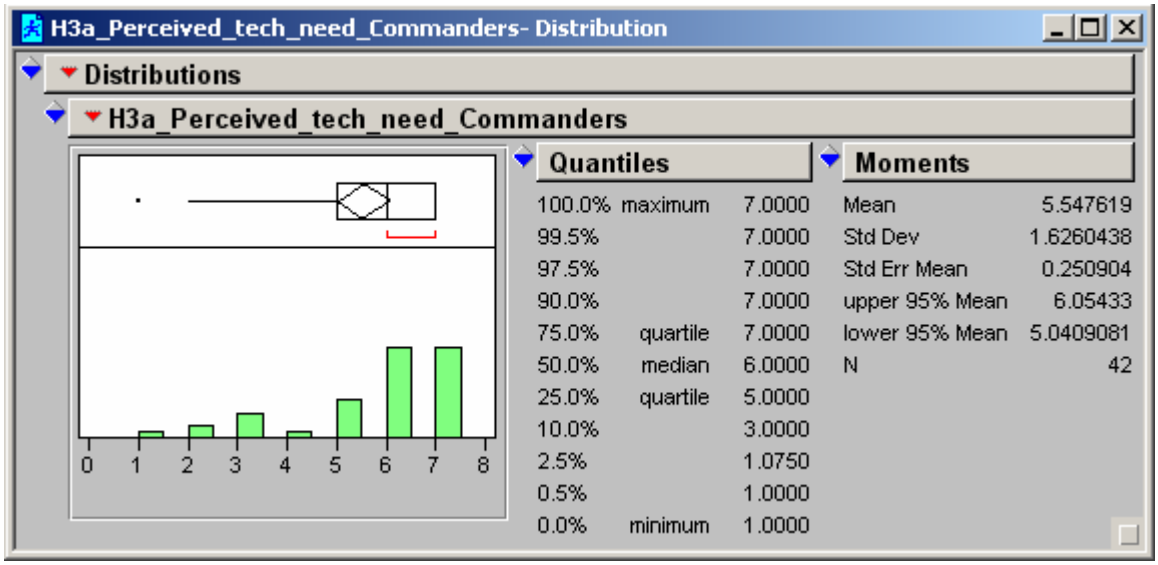

Figure 11: Hypothesis 3a Perceived Technology Need factor histogram (Commanders)

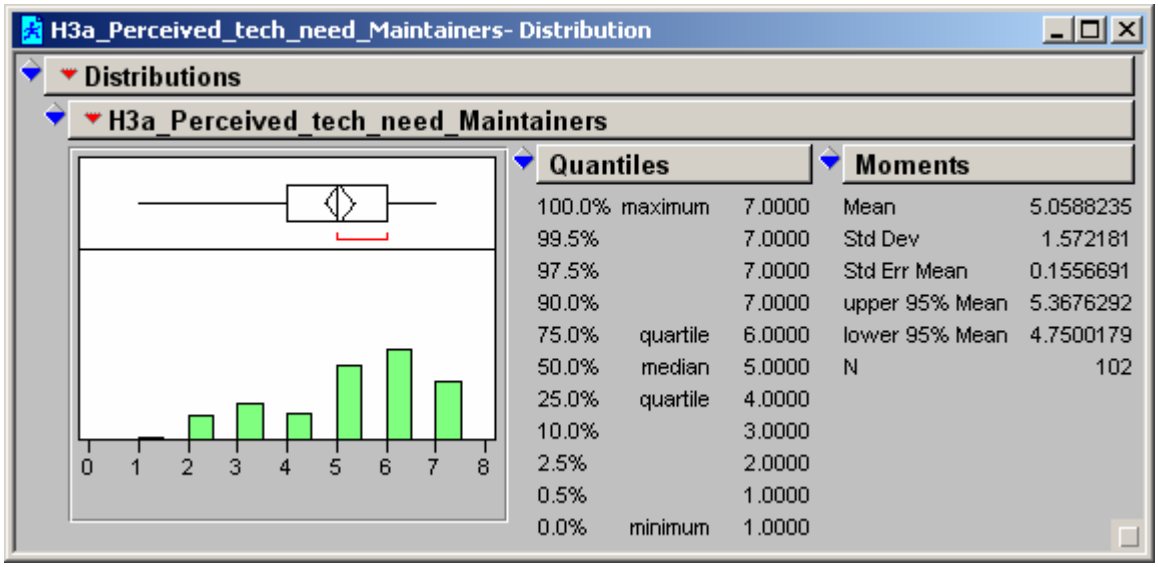

Figure 12: Hypothesis 3a Perceived Technology Need factor histogram (Maintainers)

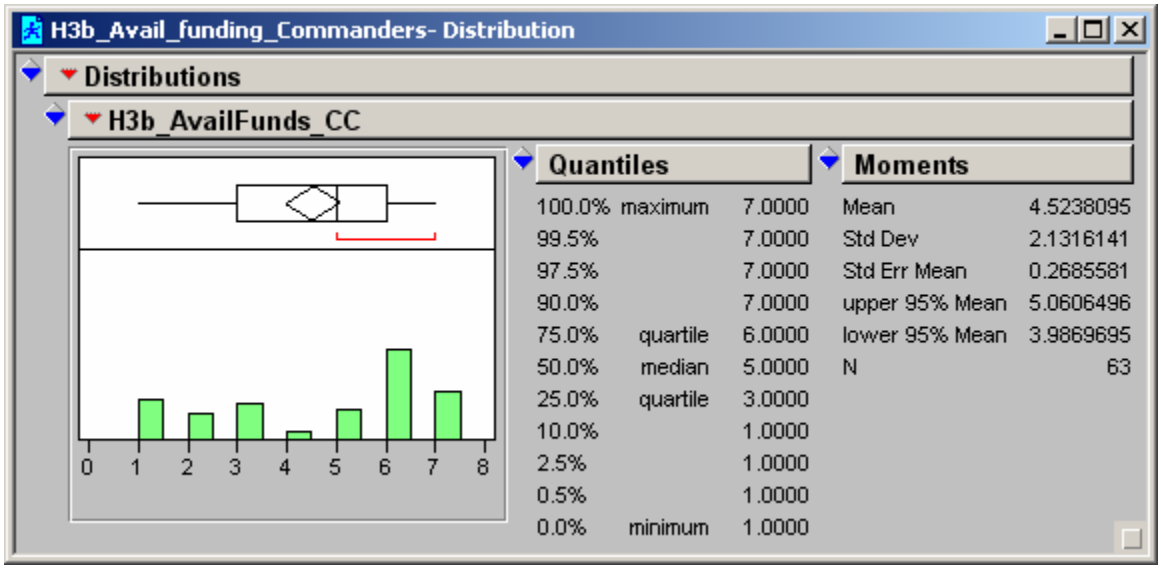

Figure 13: Hypothesis 3b Budgeted Funding factor histogram (Commanders)

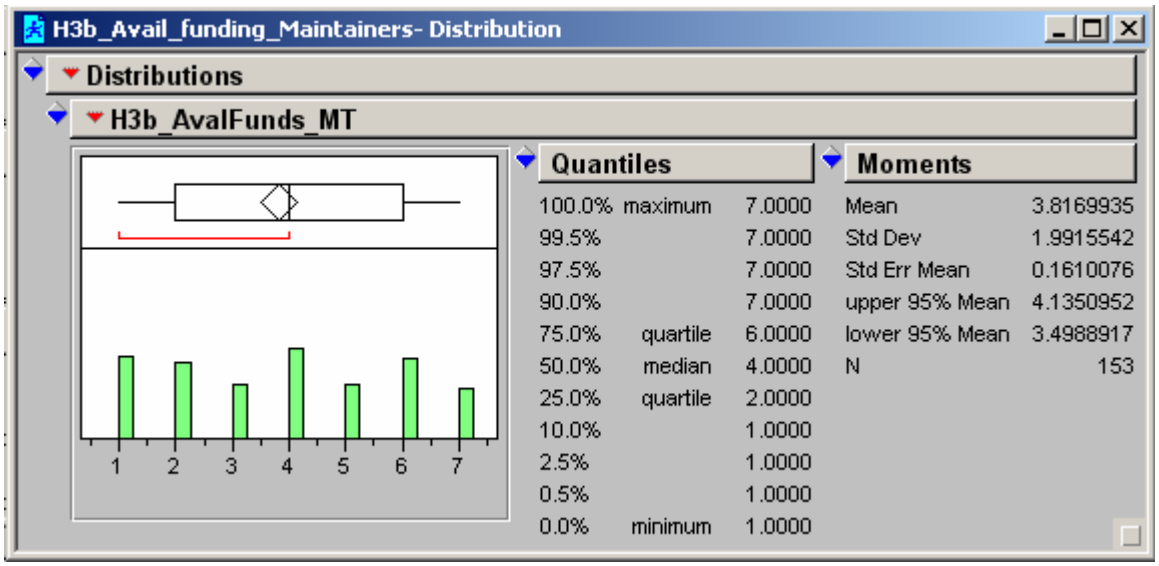

Figure 14: Hypothesis 3b Budgeted Funding factor histogram (Maintainers)

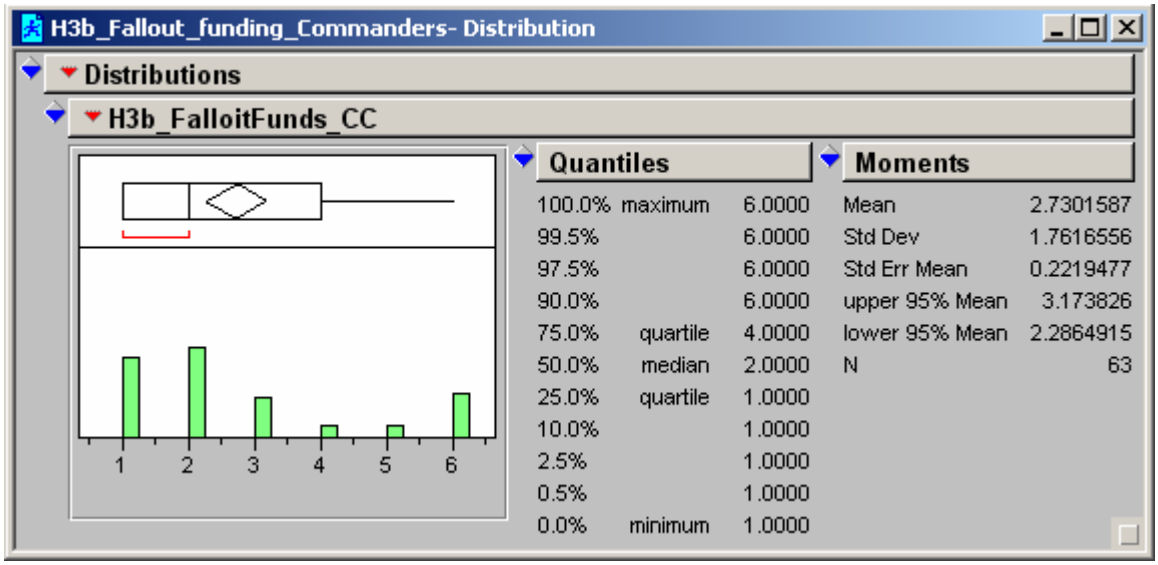

Figure 15: Hypothesis 3b Fallout Funding factor histogram (Commanders)

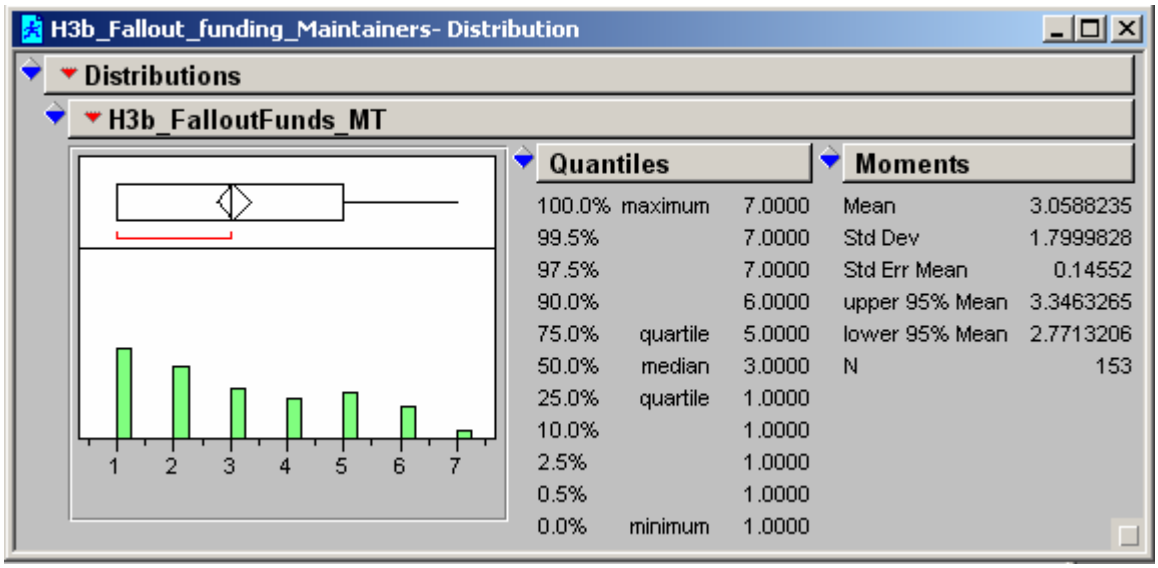

Figure 16: Hypothesis 3b Fallout Funding factor histogram (Maintainers)

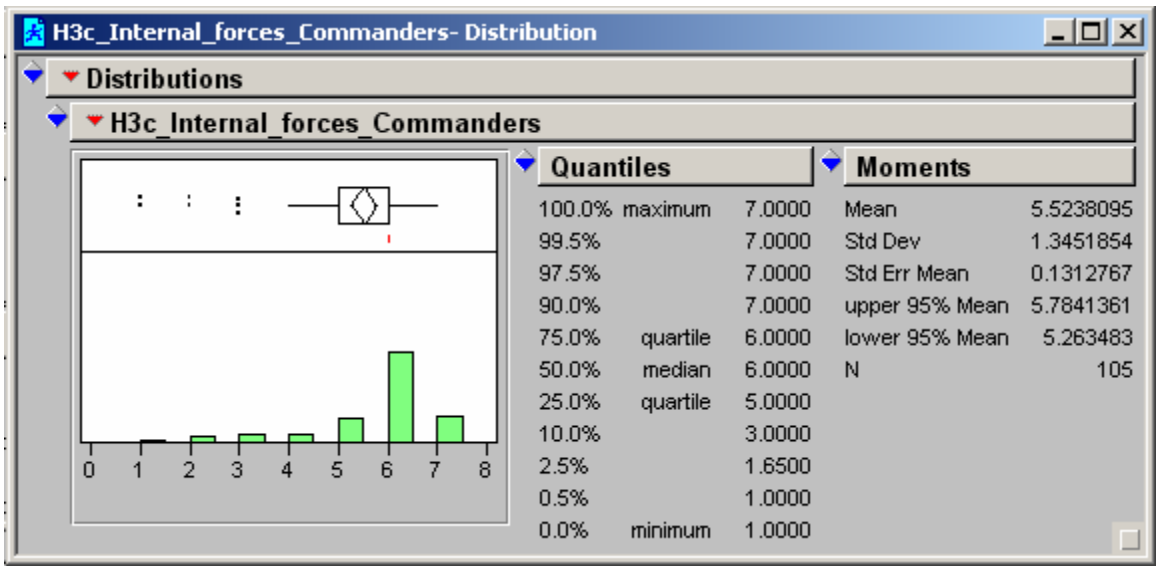

Figure 17: Hypothesis 3c Internal Forces factor histogram (Commanders)

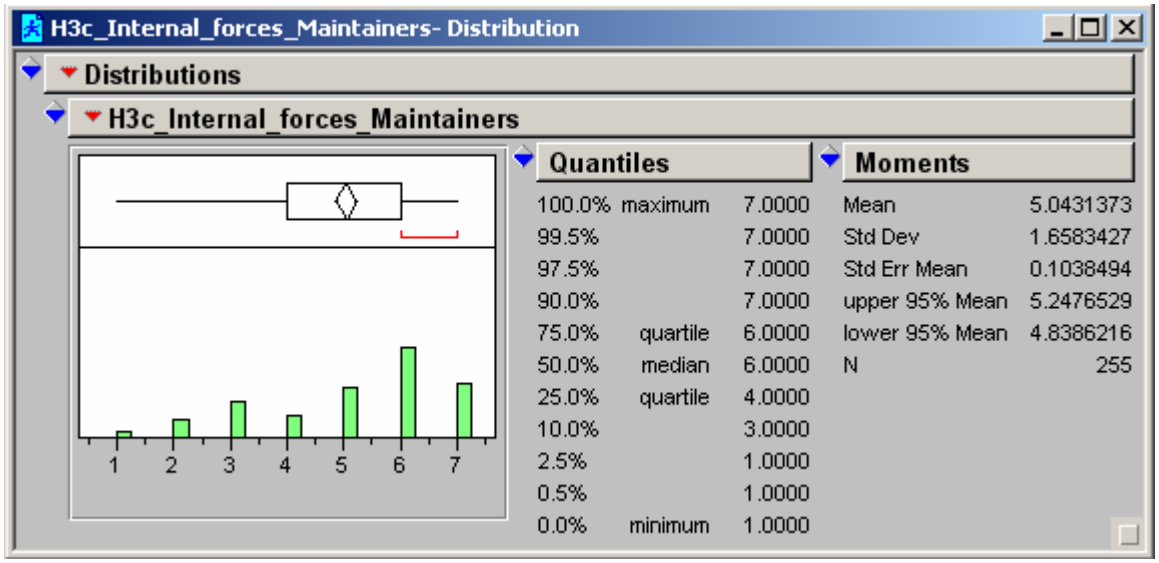

Figure 18: Hypothesis 3c Internal Forces factor histogram (Maintainers)

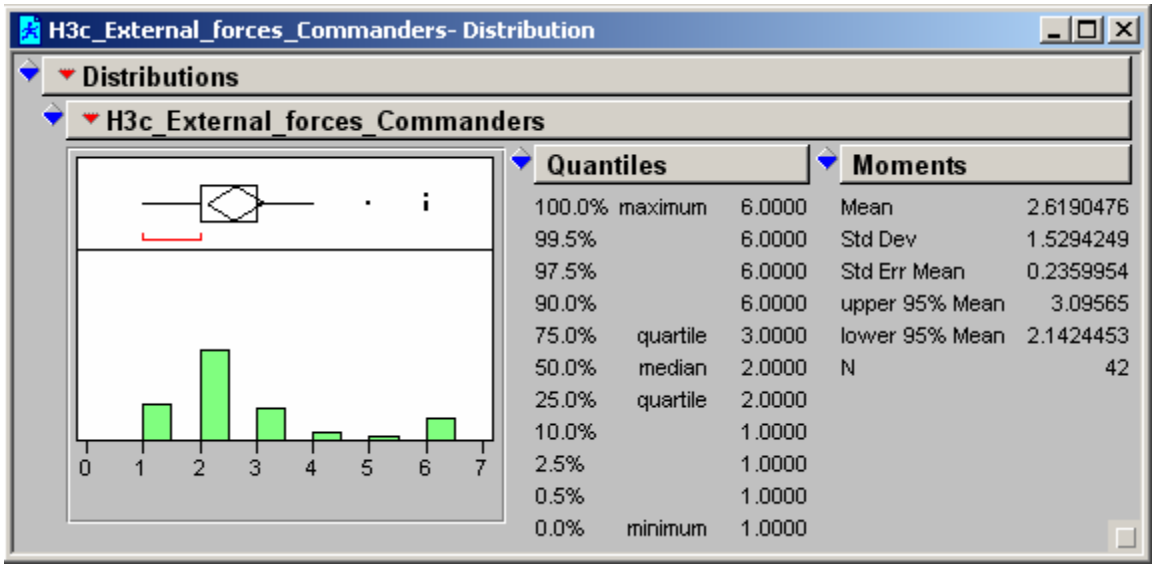

Figure 19: Hypothesis 3c External Forces factor histogram (Commanders)

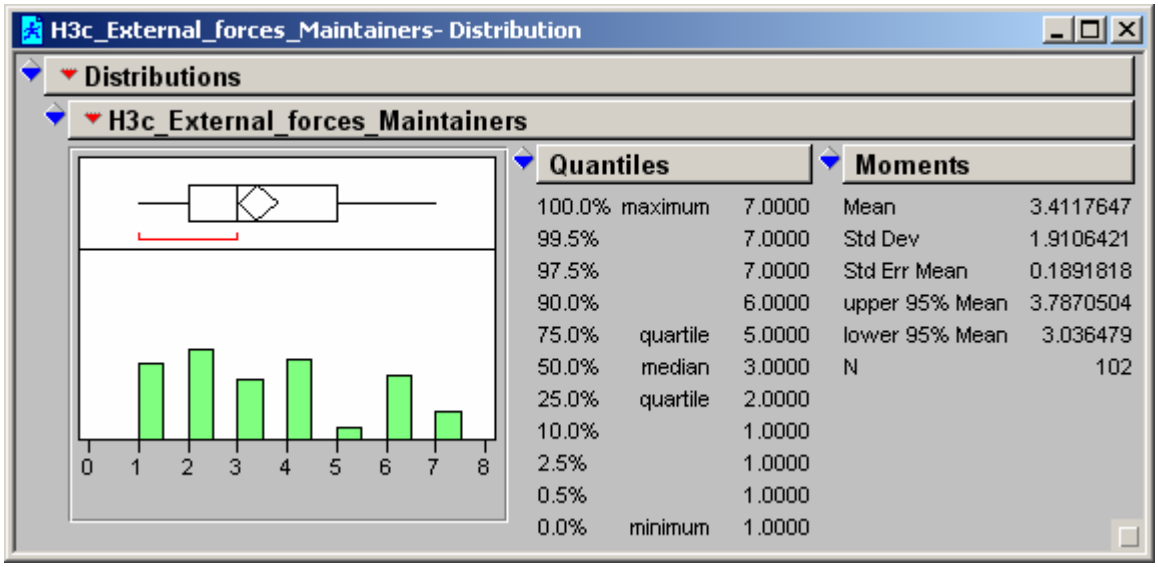

Figure 20: Hypothesis 3c External Forces factor histogram (Maintainers)

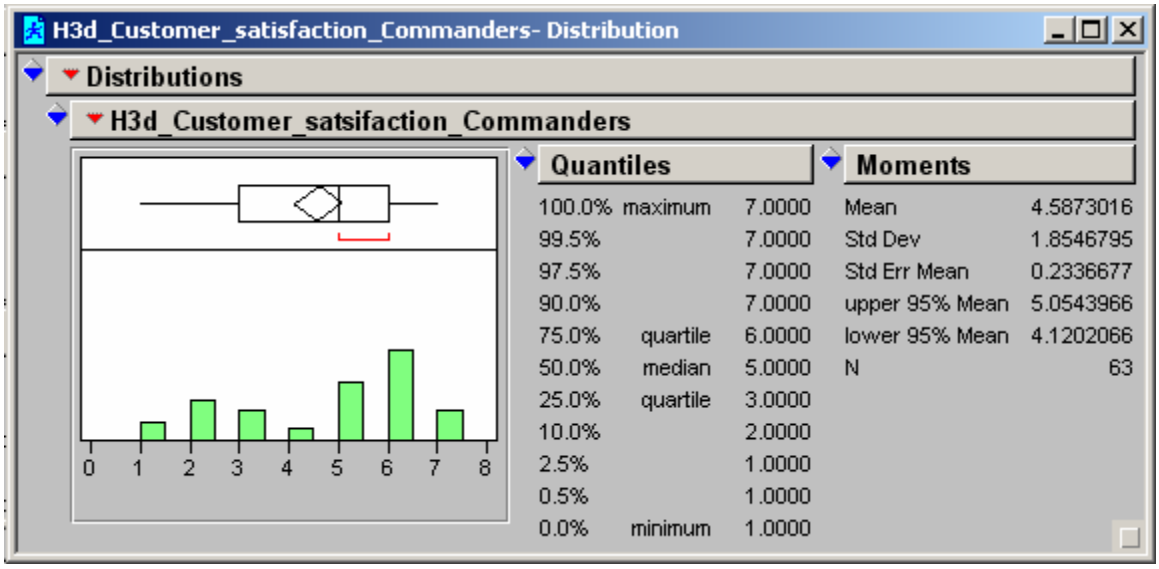

Figure 21: Hypothesis 3d Customer Satisfaction factor histogram (Commanders)

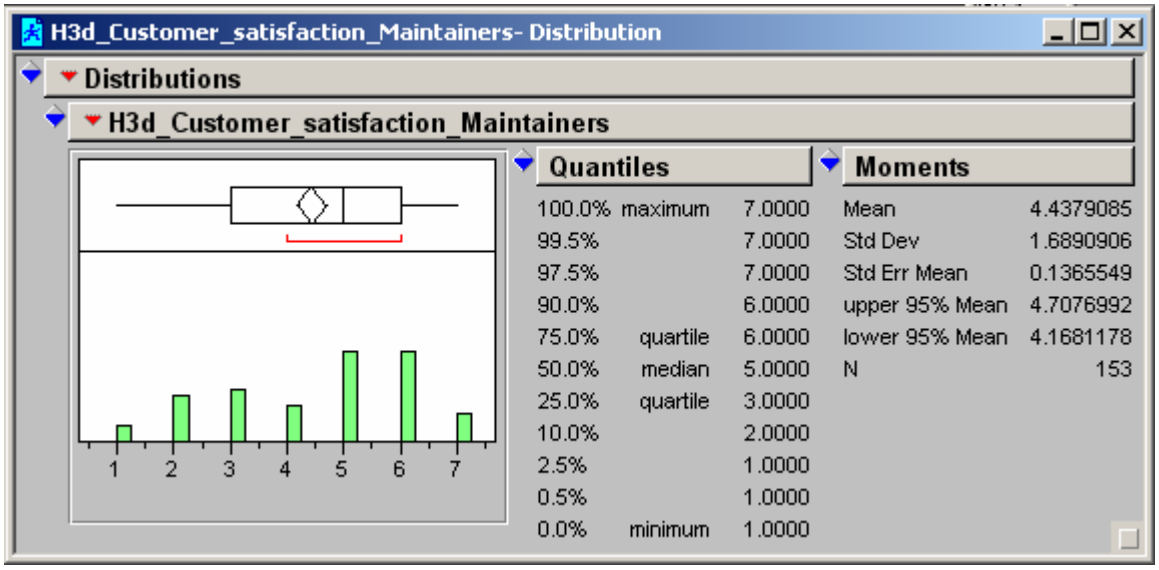

Figure 22: Hypothesis 3d Customer Satisfaction factor histogram (Maintainers)

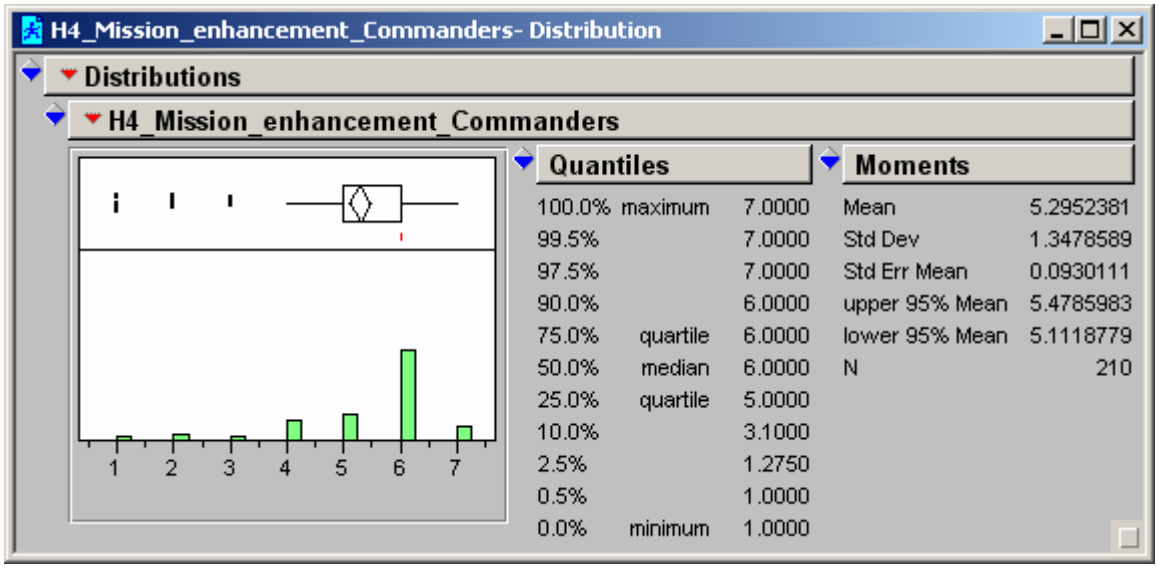

Figure 23: Hypothesis 4 Mission Enhancement factor histogram (Commanders)

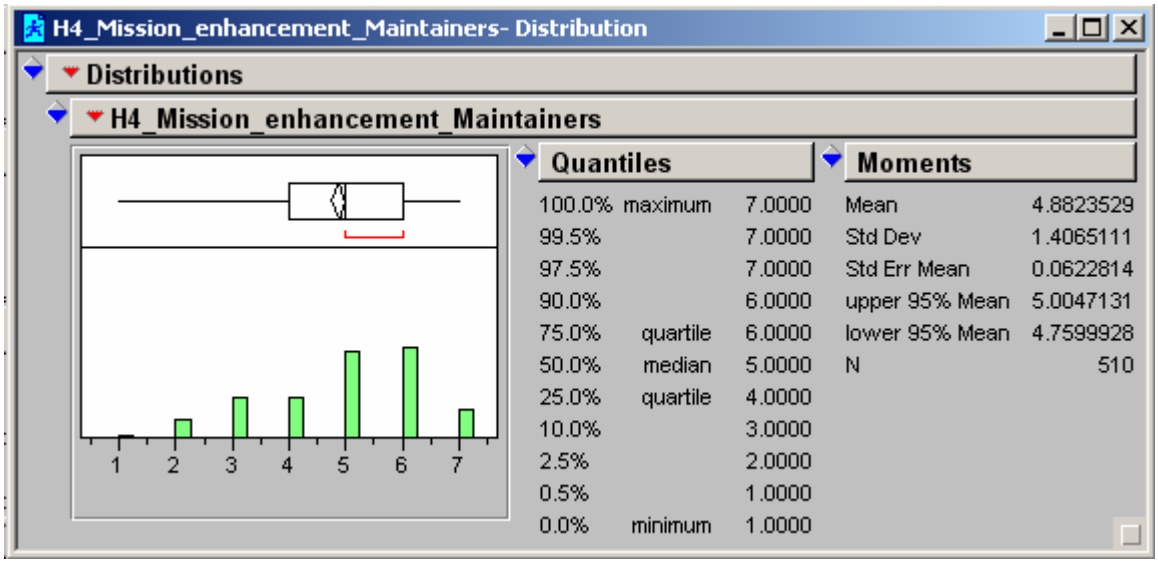

Figure 24: Hypothesis 4 Mission Enhancement factor histogram (Maintainers)

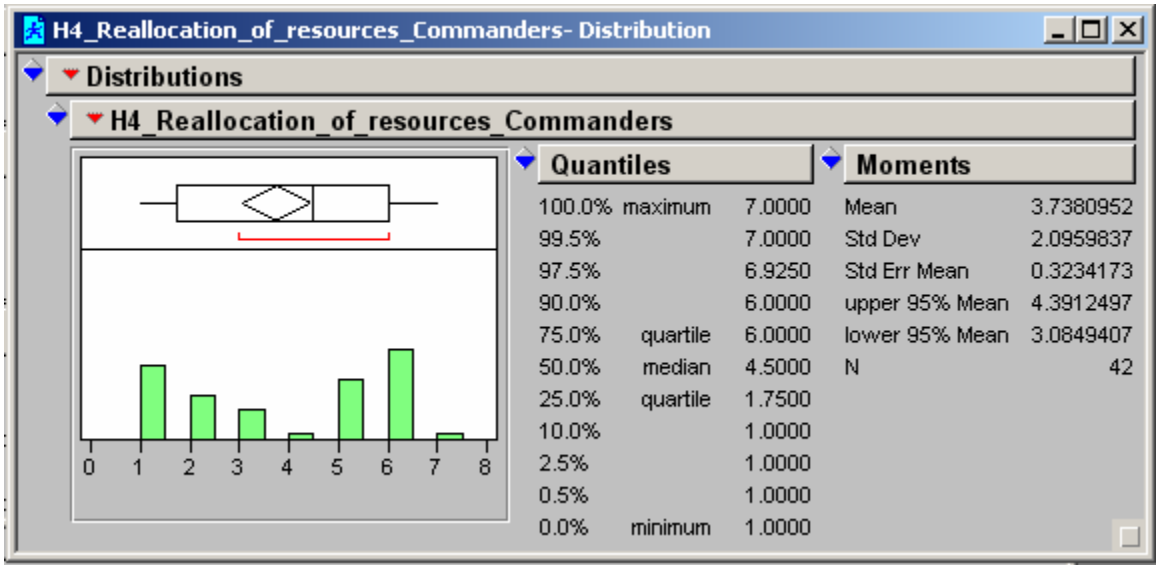

Figure 25: Hypothesis 4 Reallocation of Resources factor histogram (Commanders)

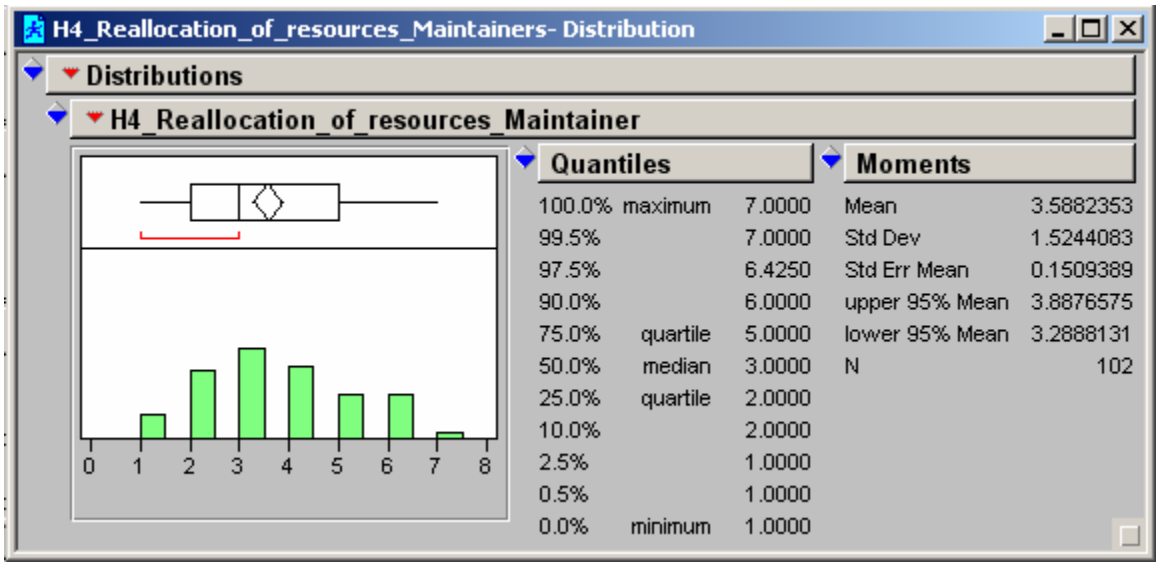

Figure 26: Hypothesis 4 Reallocation of Resources factor histogram (Maintainers)

Appendix B

The following are analyses of variances (ANOVA) for the responses between the two groups for the factors relating to the hypotheses tested. This is the data used in the assessment of Hypothesis 5.

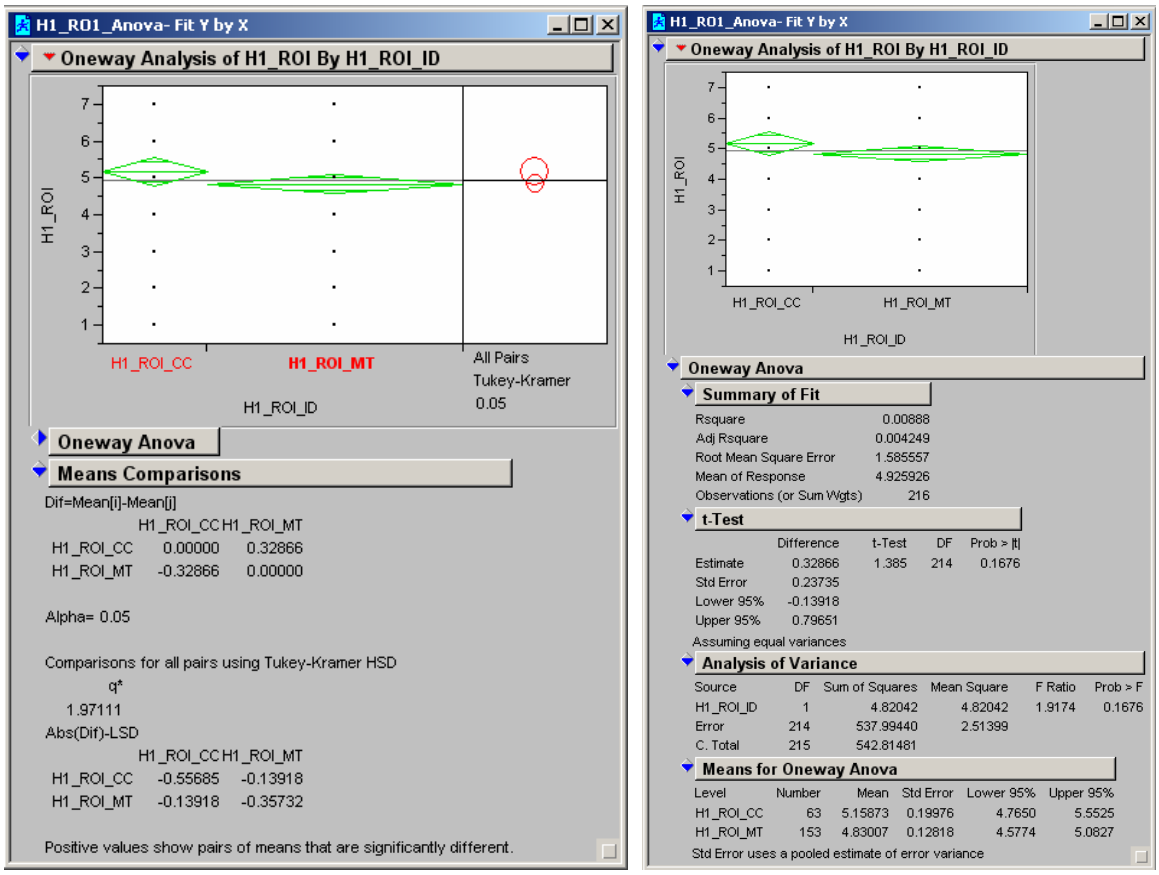

Figure 1: ANOVA for Return on Investment factor of Hypothesis 1

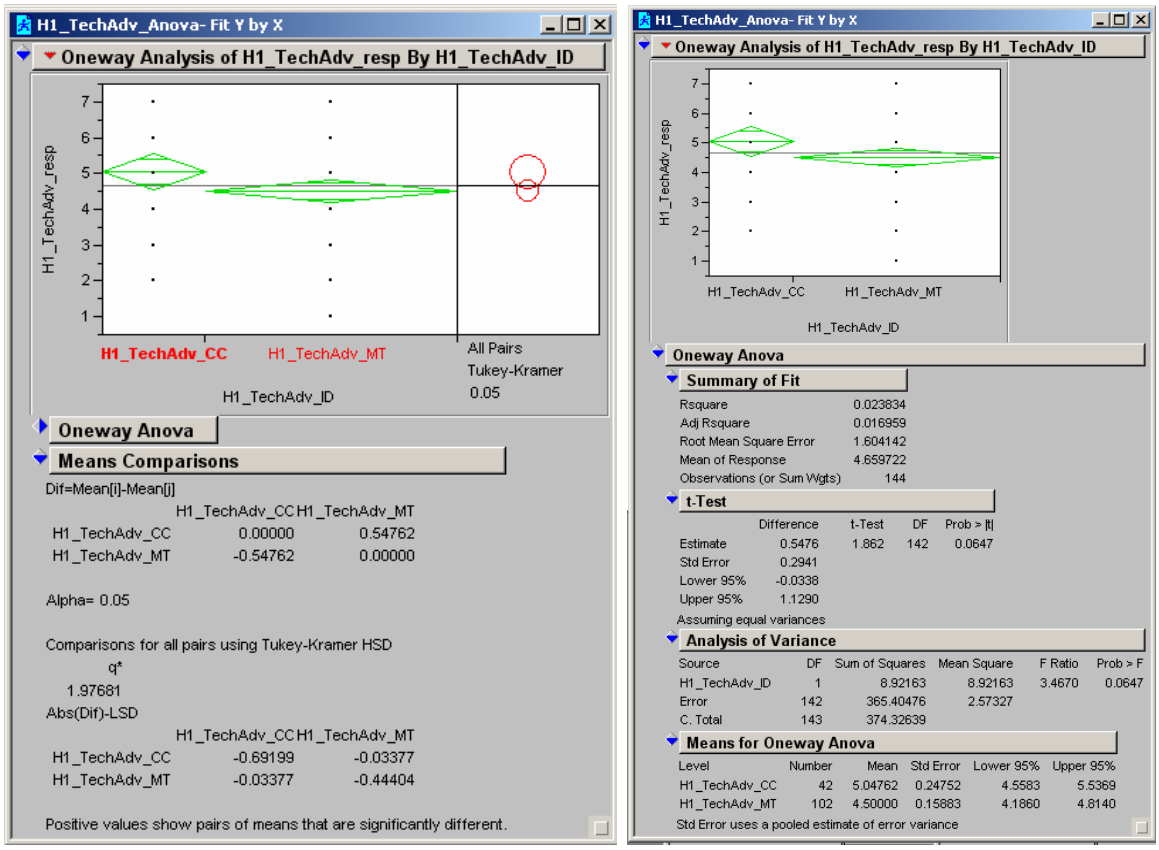

Figure 2: ANOVA for Technology Advancements factor of Hypothesis 1

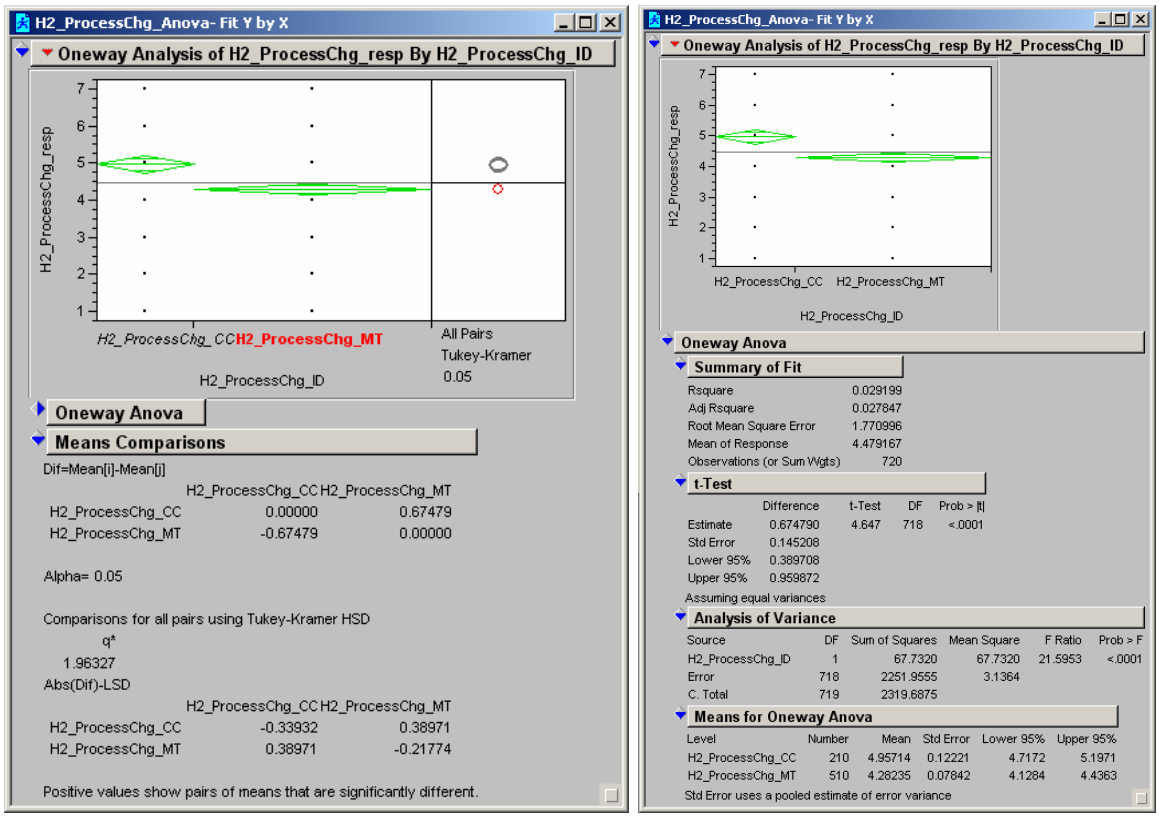

Figure 3: ANOVA for Procurement Process Changes factor of Hypothesis 2

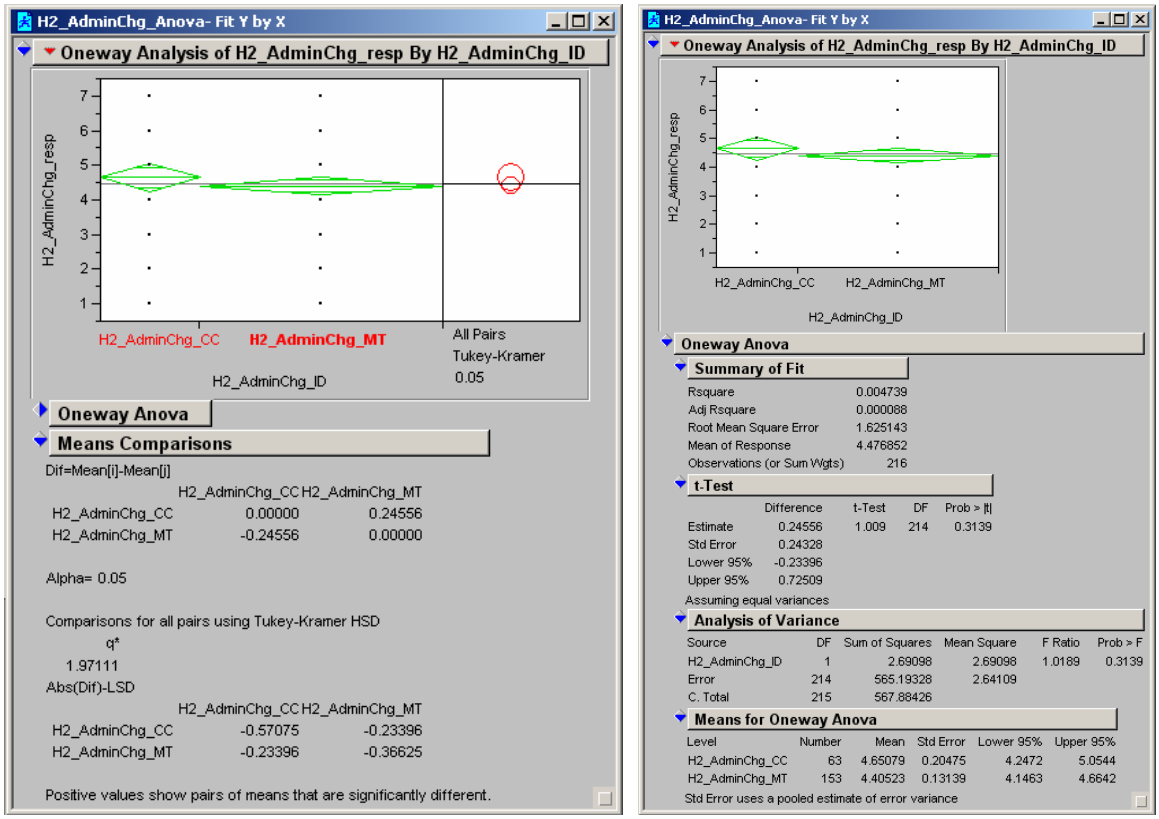

Figure 4: ANOVA for Administrative Changes factor of Hypothesis 2

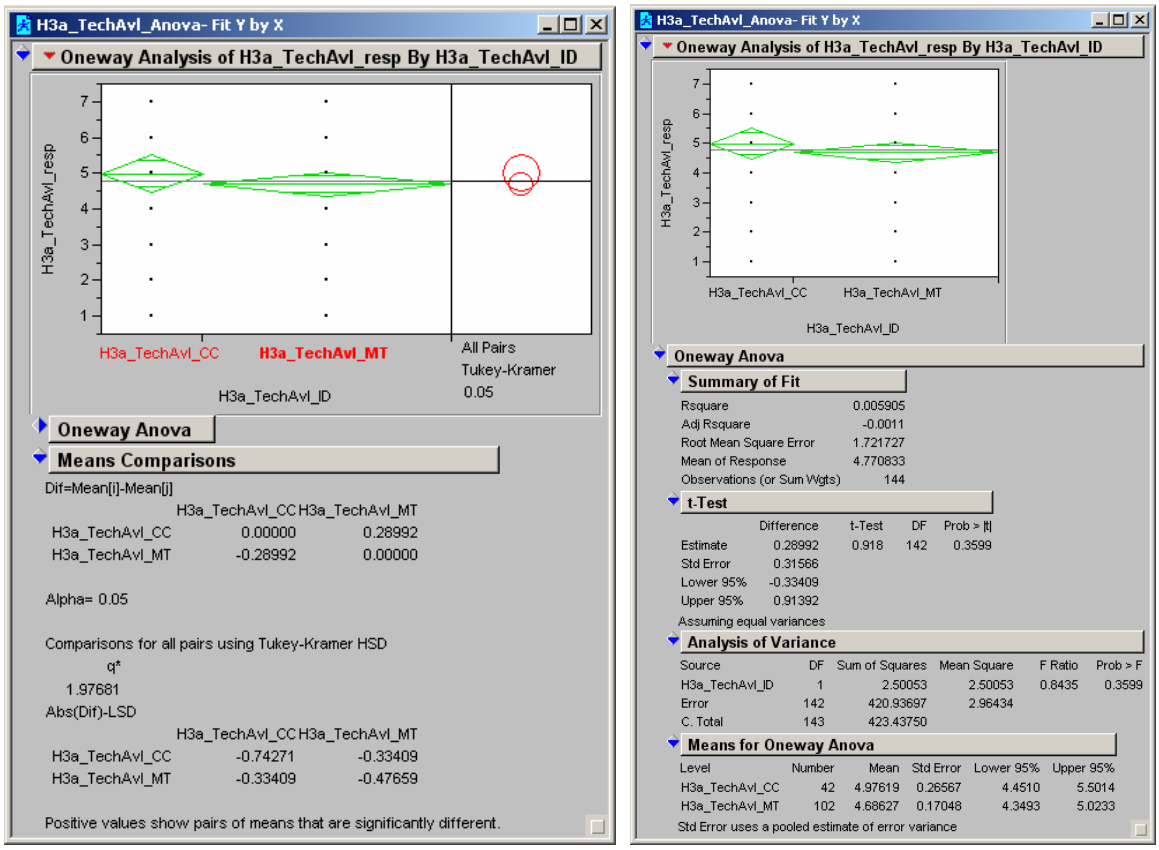

Figure 5: ANOVA for Technology Availability factor of Hypothesis 3a

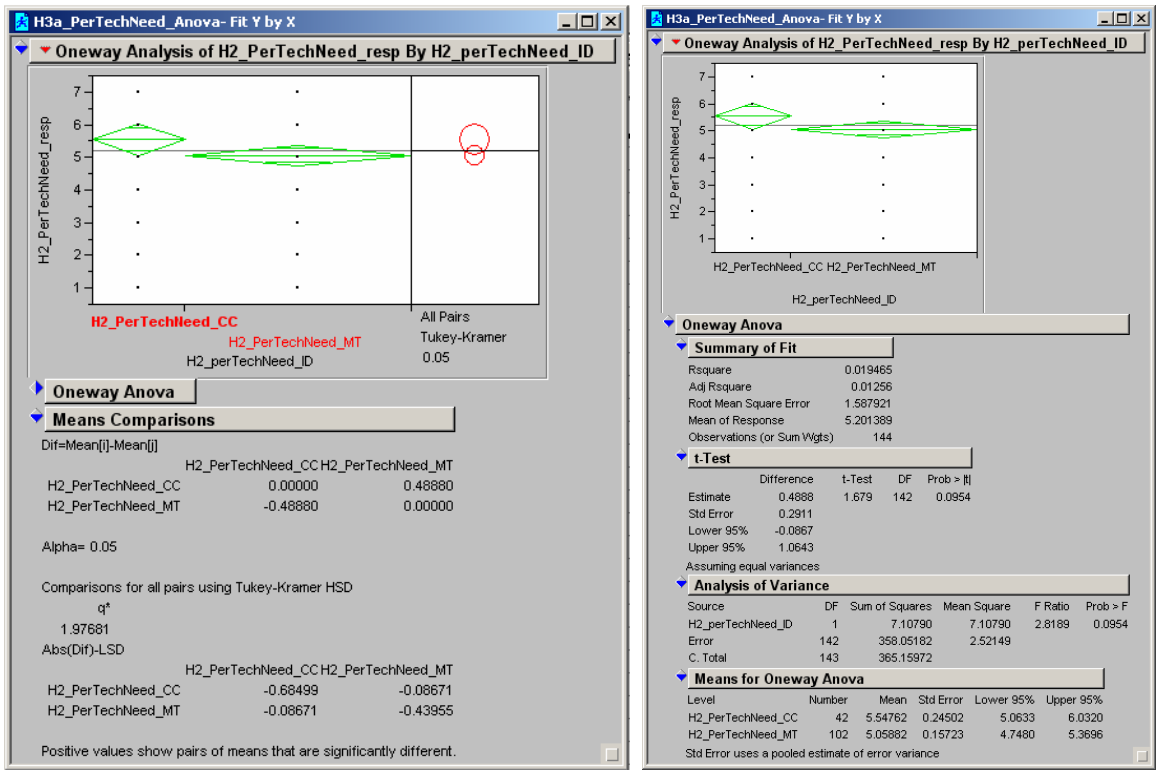

Figure 6: ANOVA for Perceived Technology Need factor of Hypothesis 3a

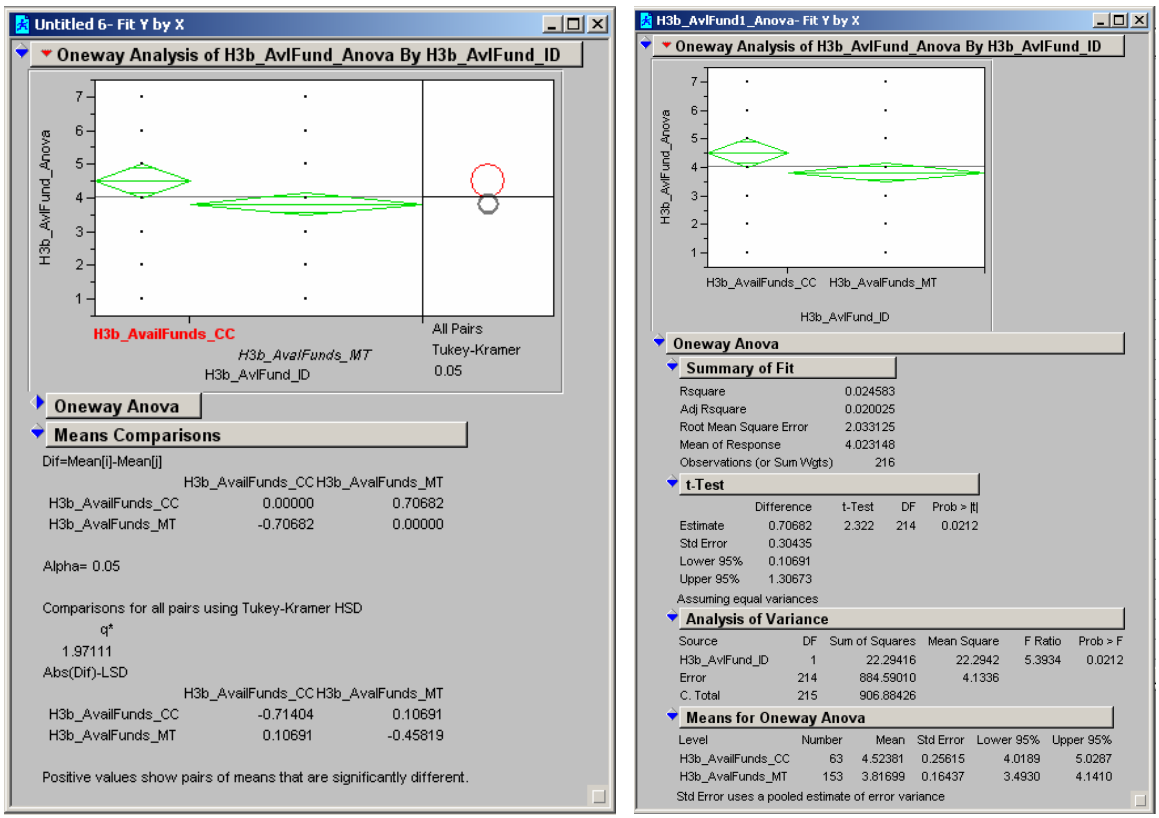

Figure 7: ANOVA for Budgeted Funding factor of Hypothesis 3b

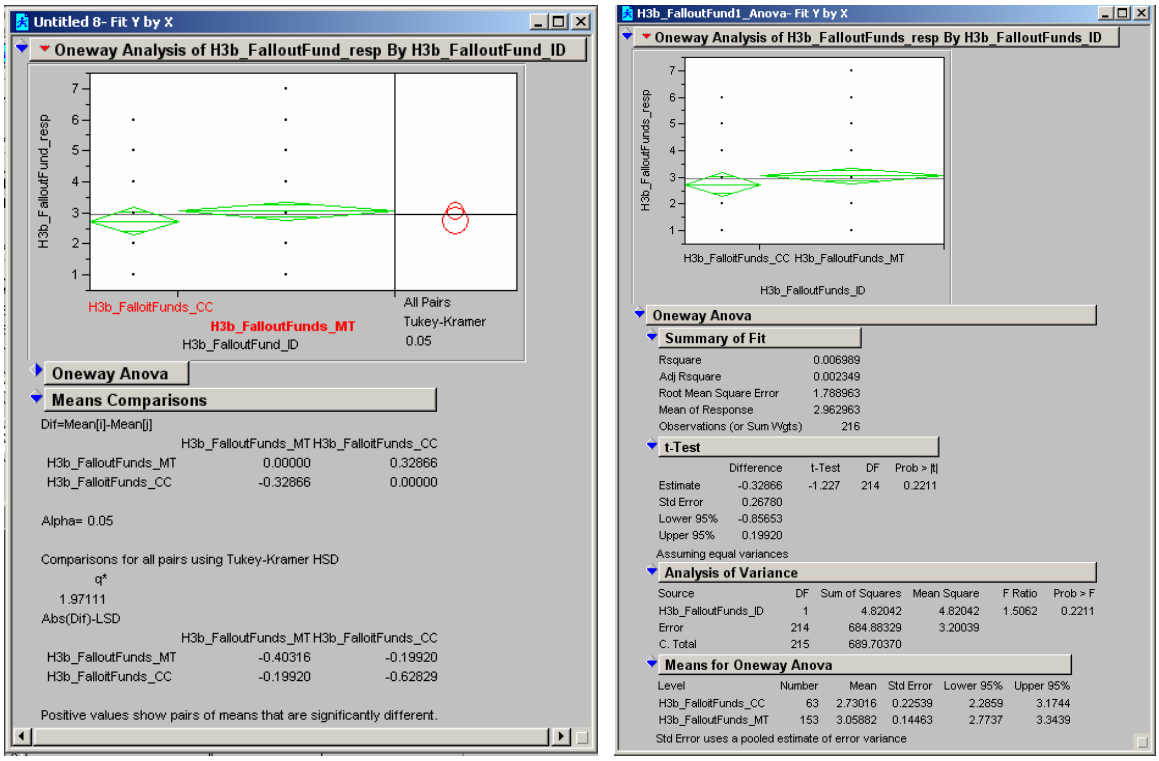

Figure 8: ANOVA for Fallout Funding factor of Hypothesis 3b

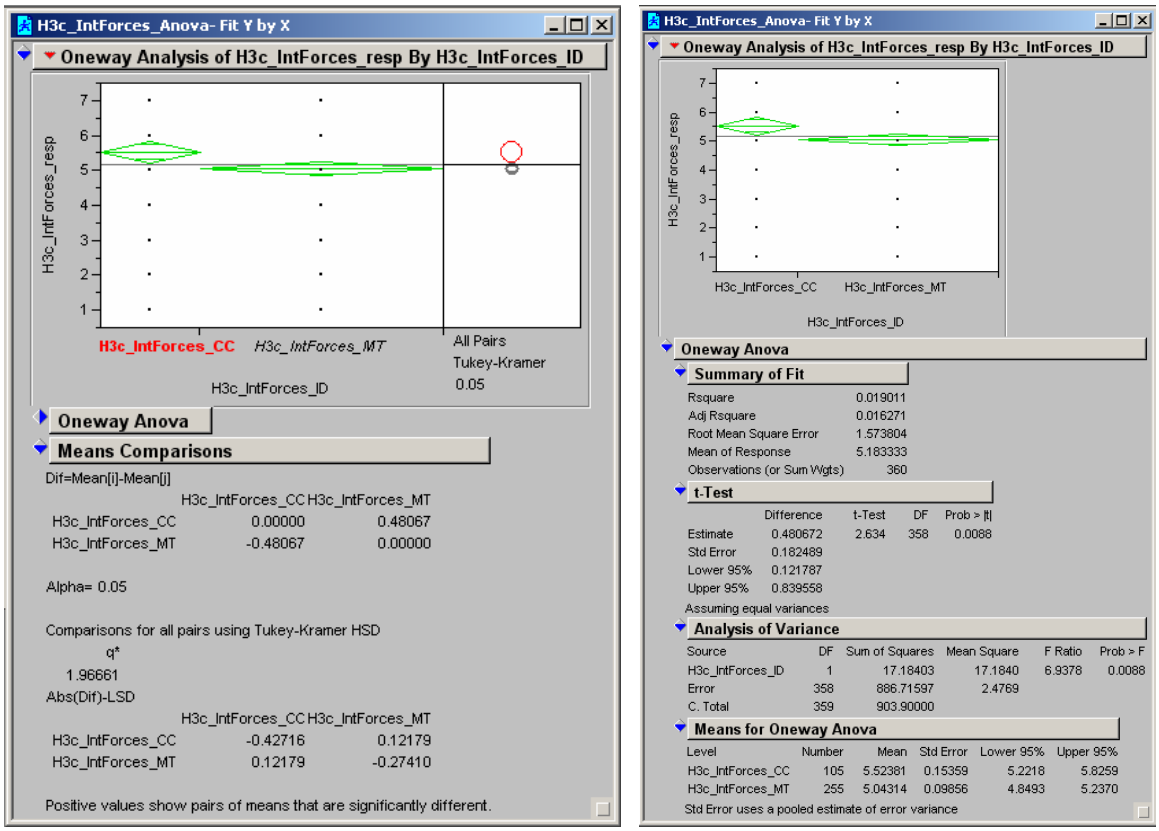

Figure 9: ANOVA for Internal Forces factor of Hypothesis 3c

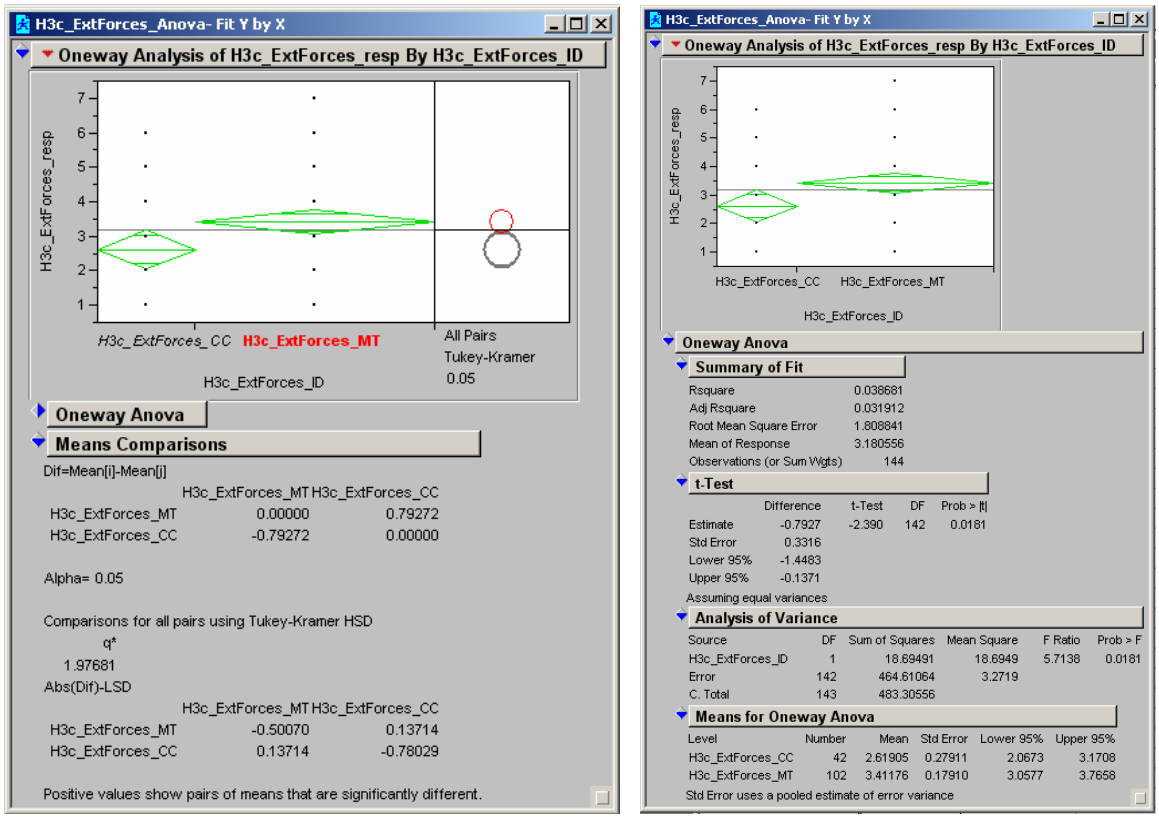

Figure 10: ANOVA for External Forces factor of Hypothesis 3c

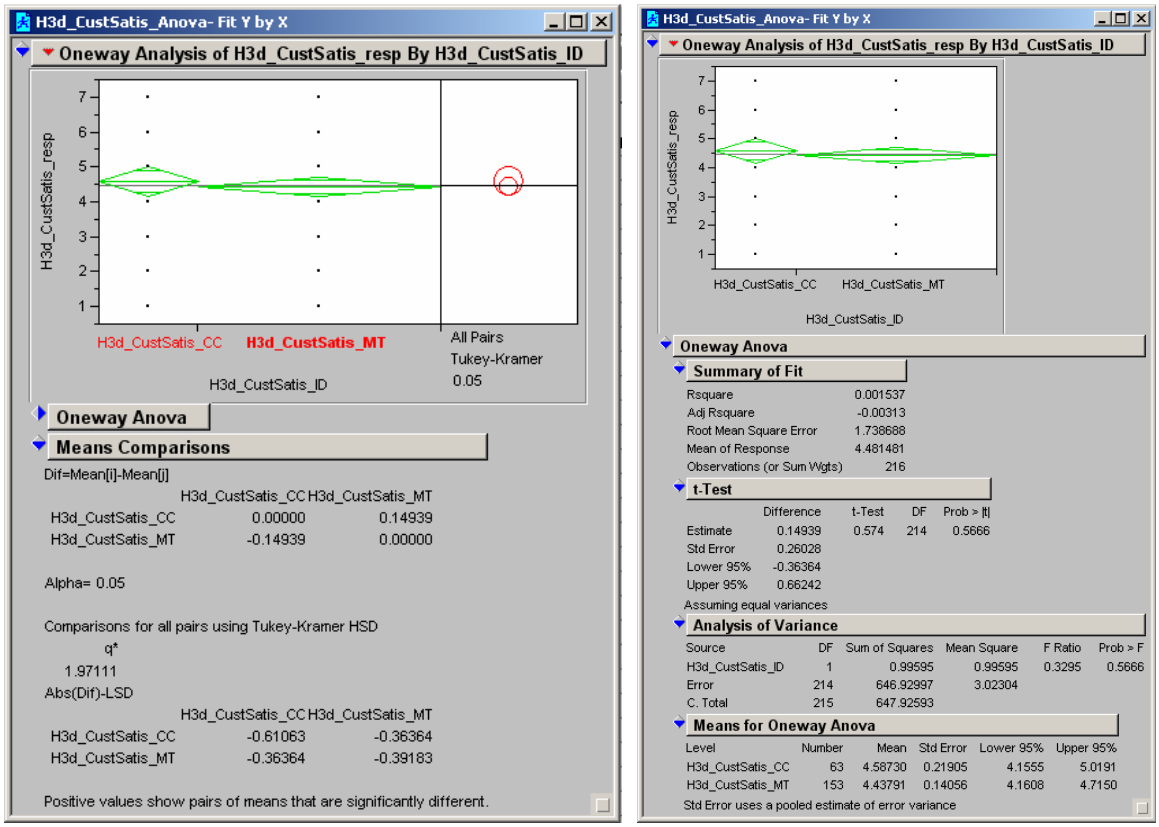

Figure 11: ANOVA for Customer Satisfaction factor of Hypothesis 3d

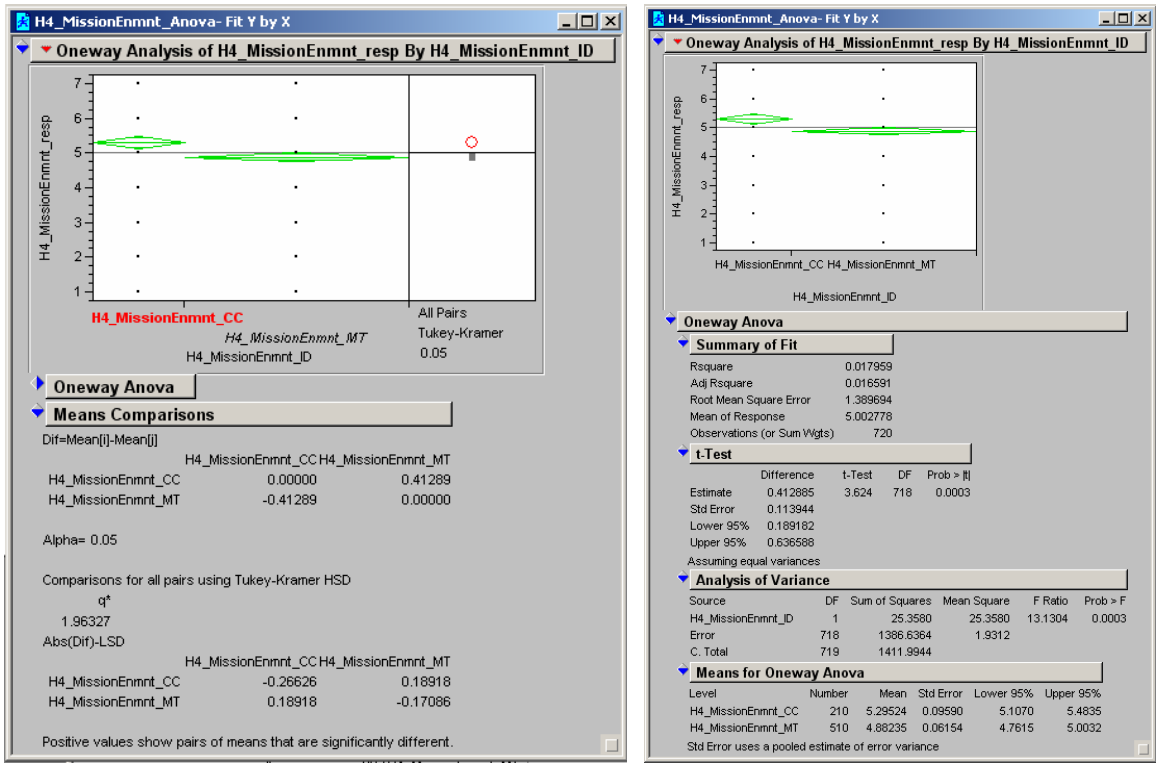

Figure 12: ANOVA for Mission Enhancement factor of Hypothesis 4

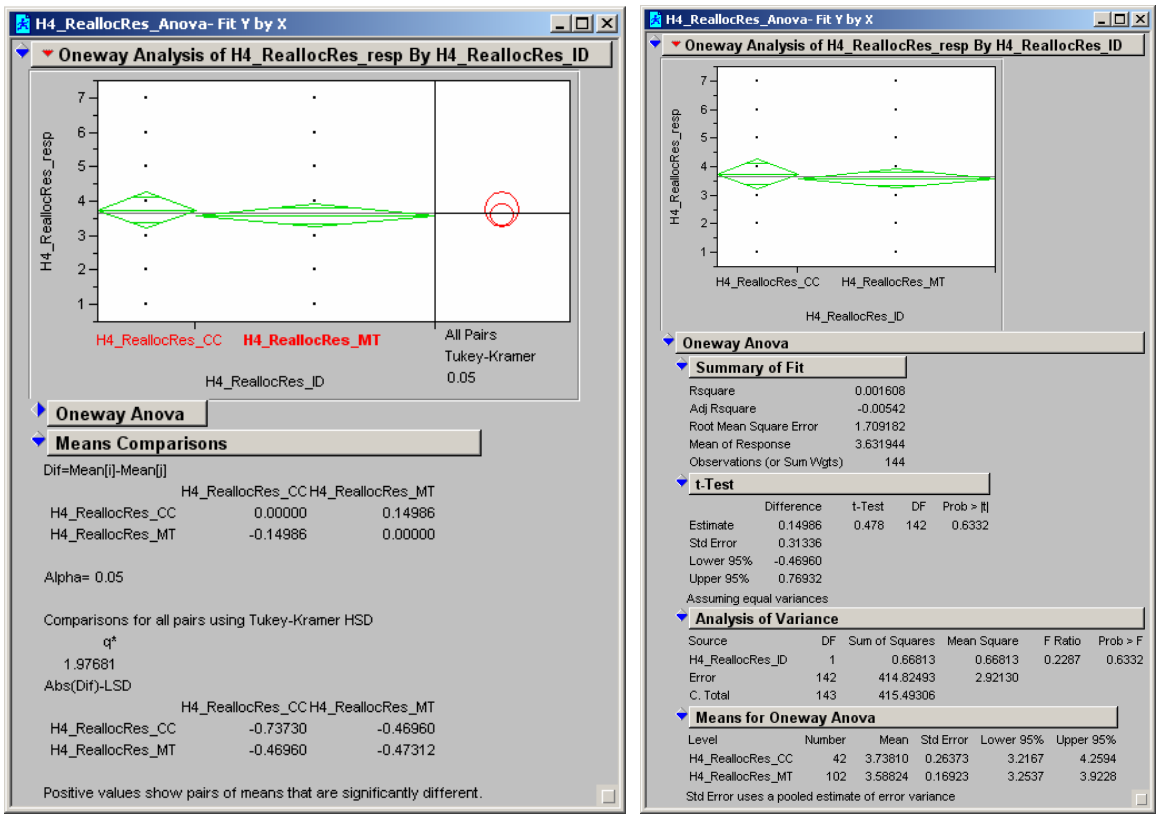

Figure 13: ANOVA for reallocation of Resources factor of Hypothesis 4

Appendix C

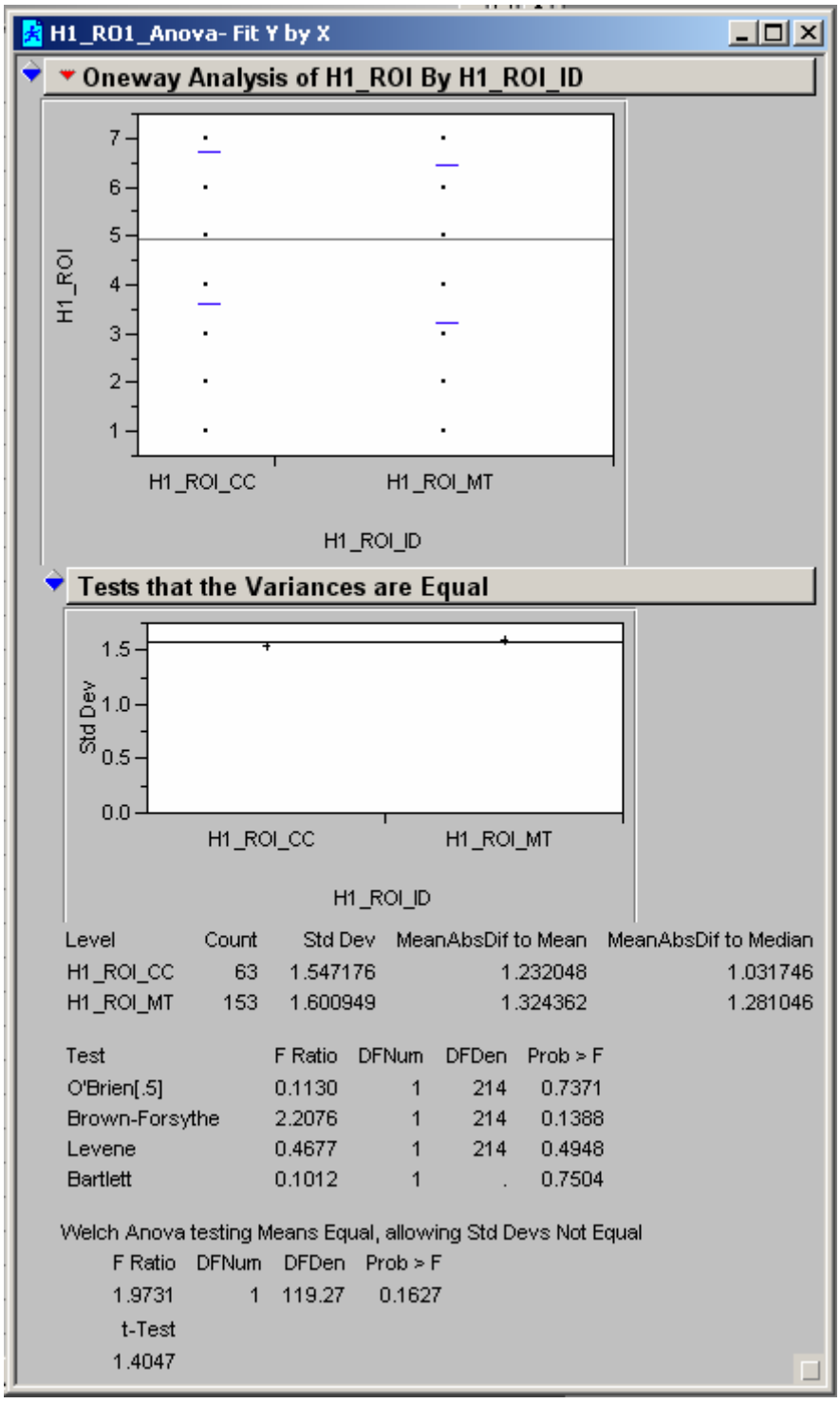

Figure 1: Test of unequal variances Return on Investment factor Hypothesis 1

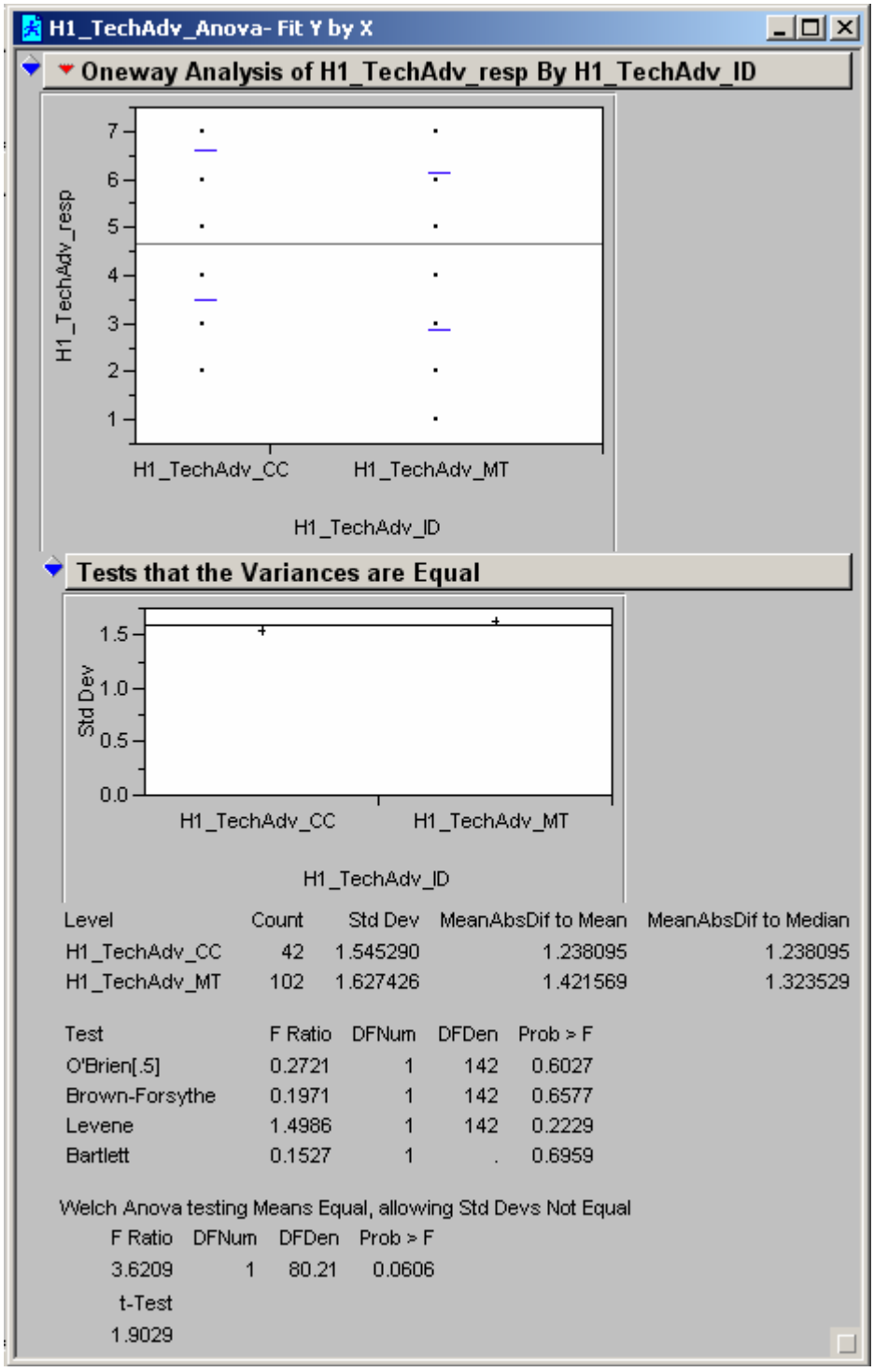

Figure 2: Test of unequal variances Technology Advancements factor Hypothesis 1

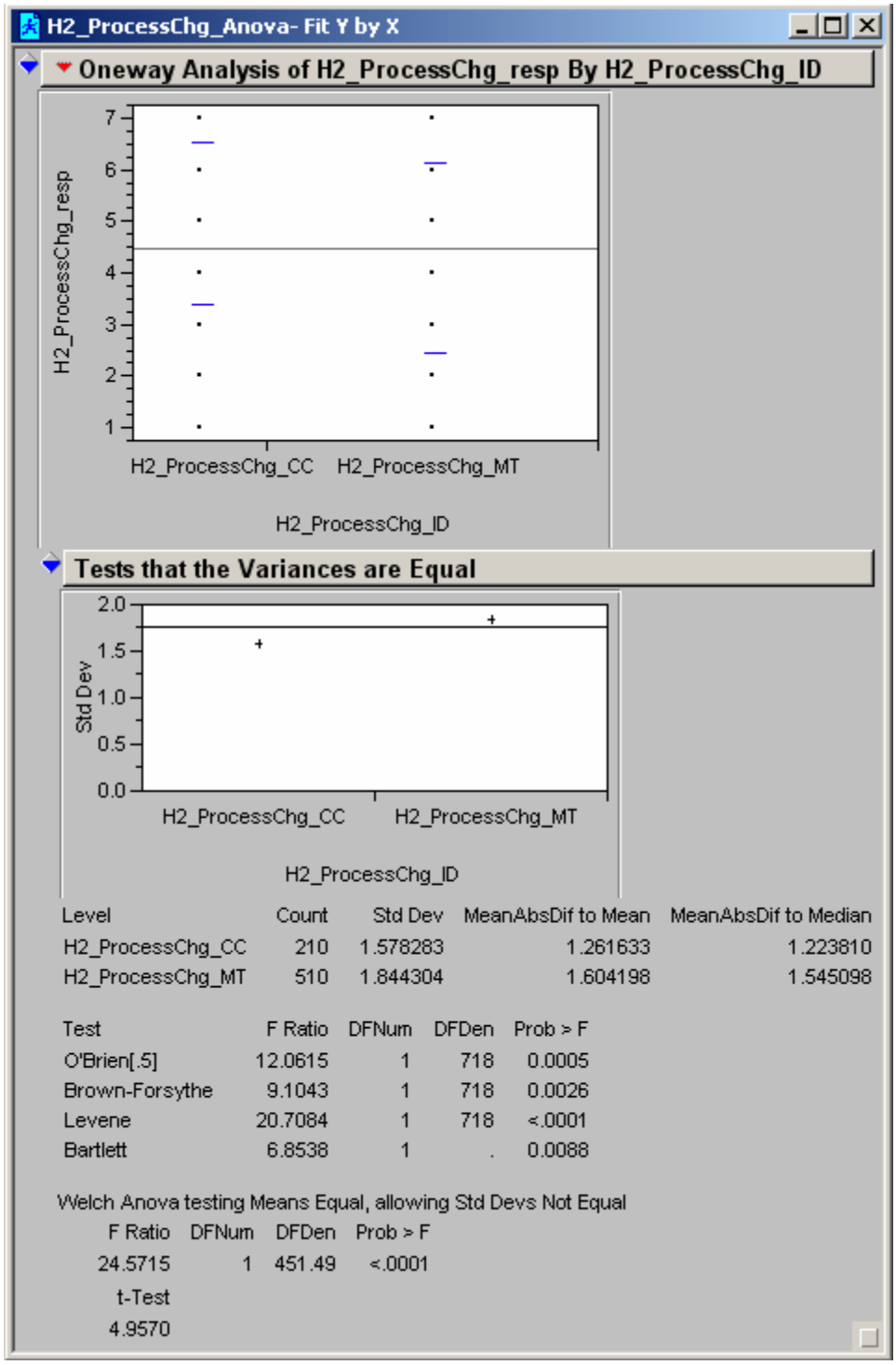

Figure 3: Test of unequal variances Procurement Process Changes factor Hypothesis 2

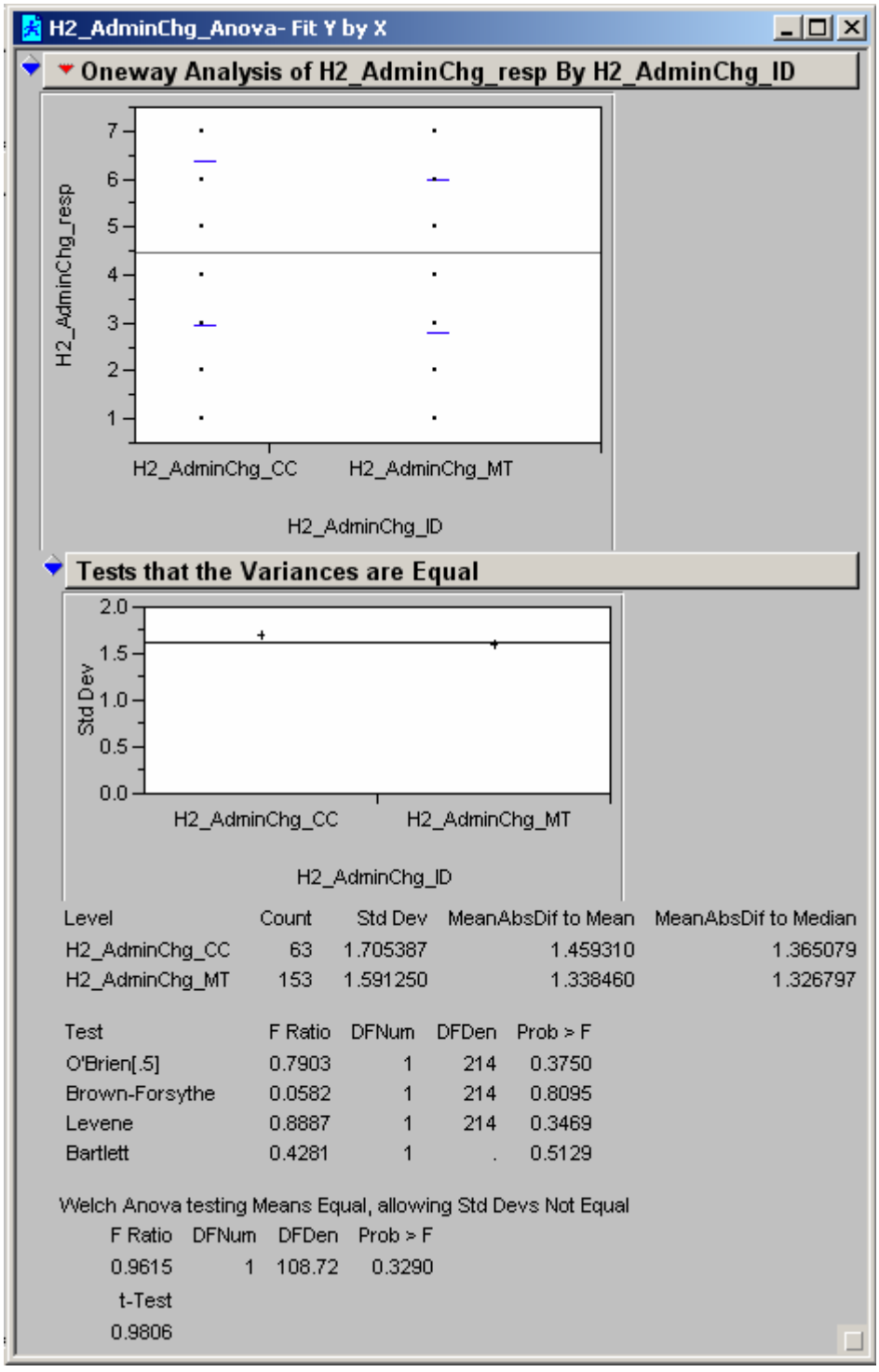

Figure 4: Test of unequal variances Administrative Changes factor Hypothesis 2

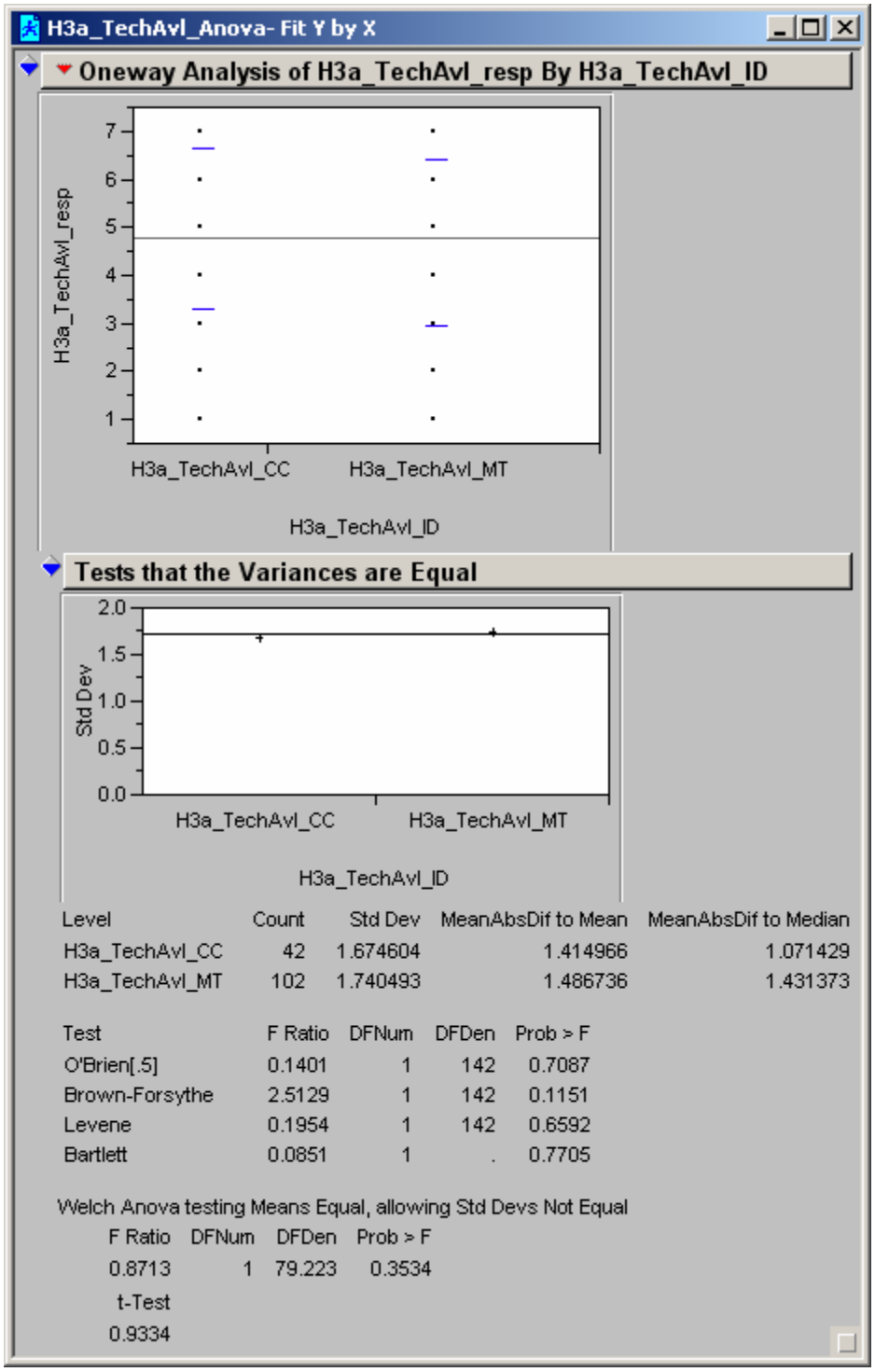

Figure 5: Test of unequal variances Technology Availability factor Hypothesis 3a

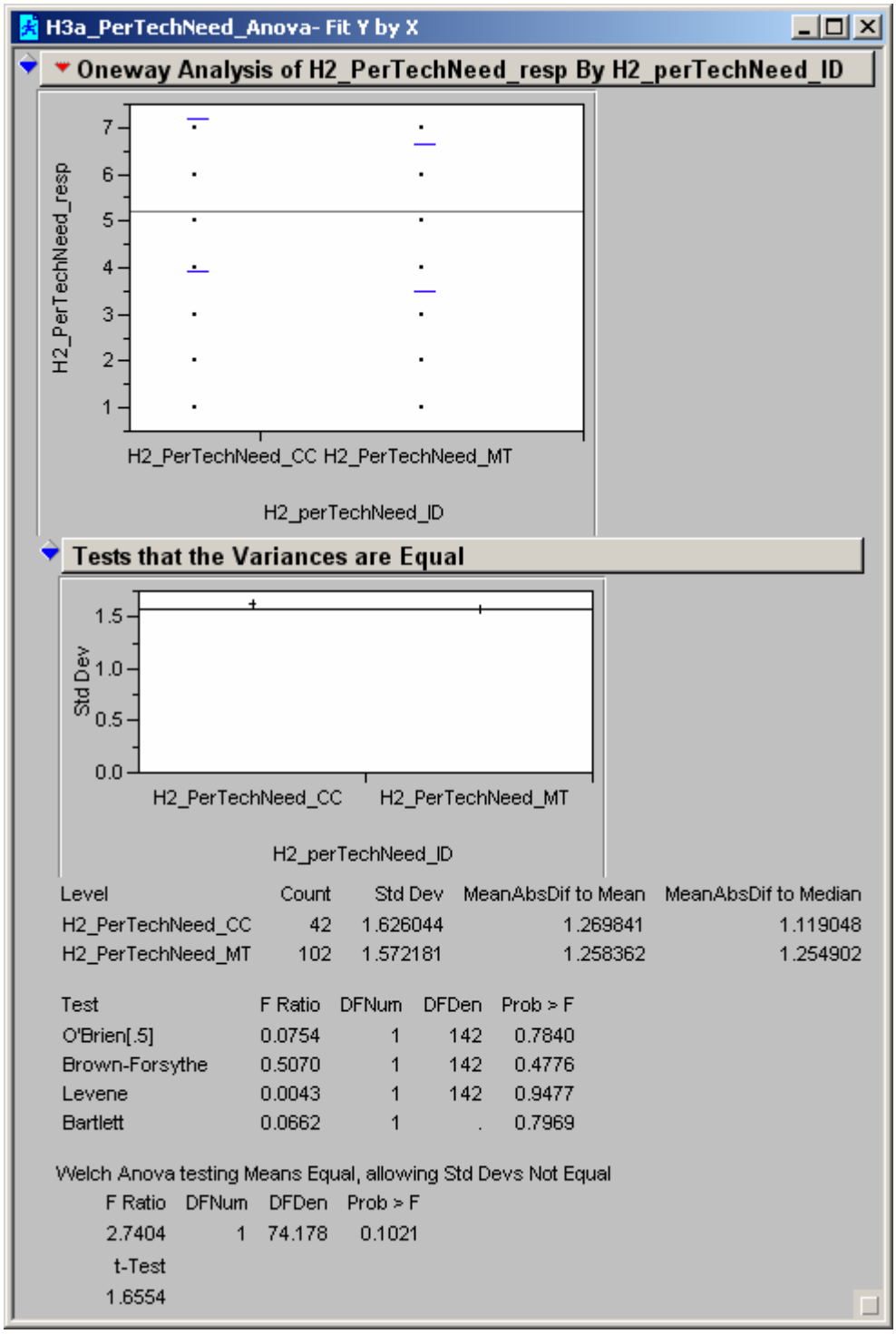

Figure 6: Test of unequal variances Perceived Technology Need factor Hypothesis 3a

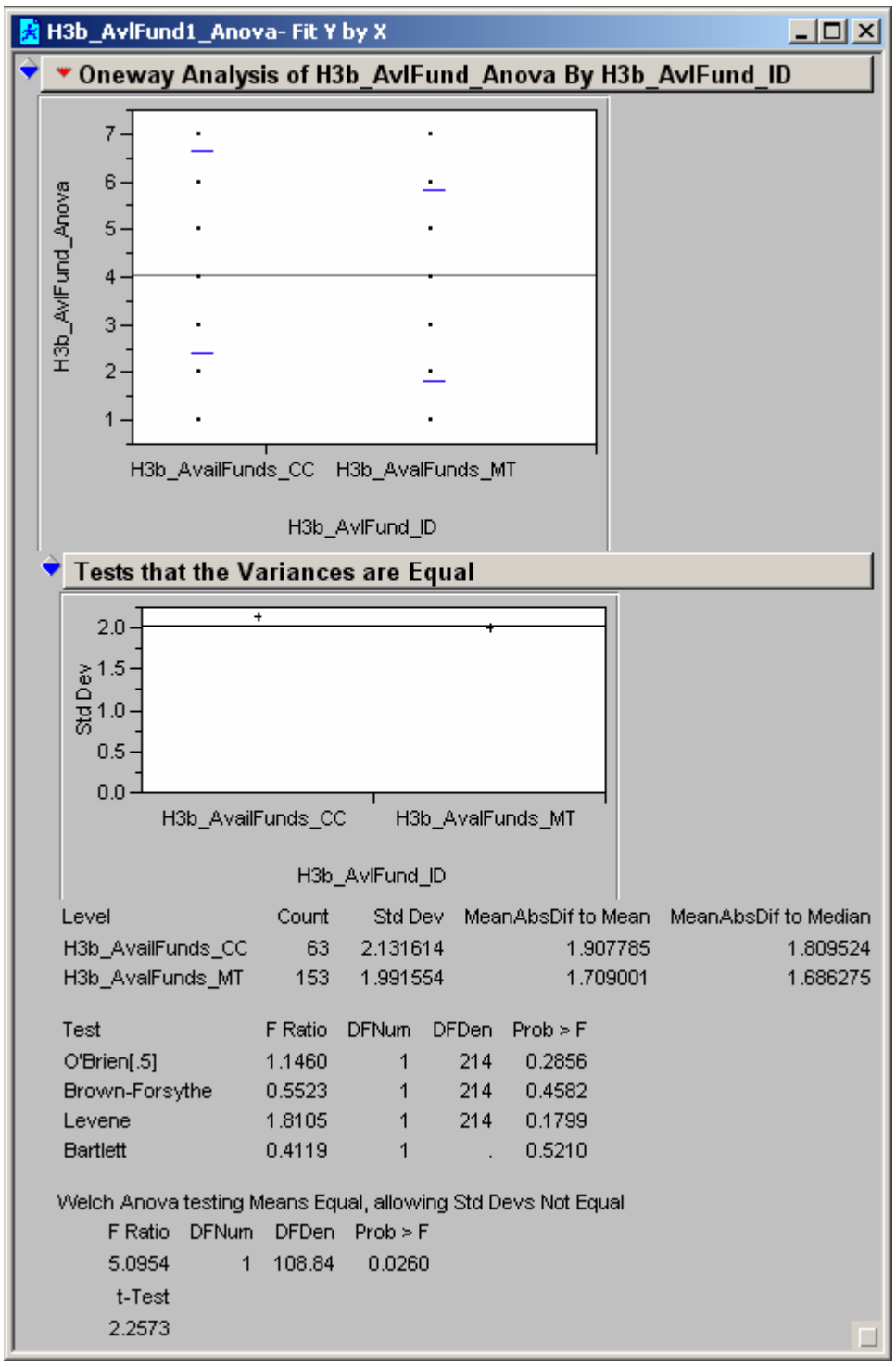

Figure 7: Test of unequal variances Budgeted Funding factor Hypothesis 3b

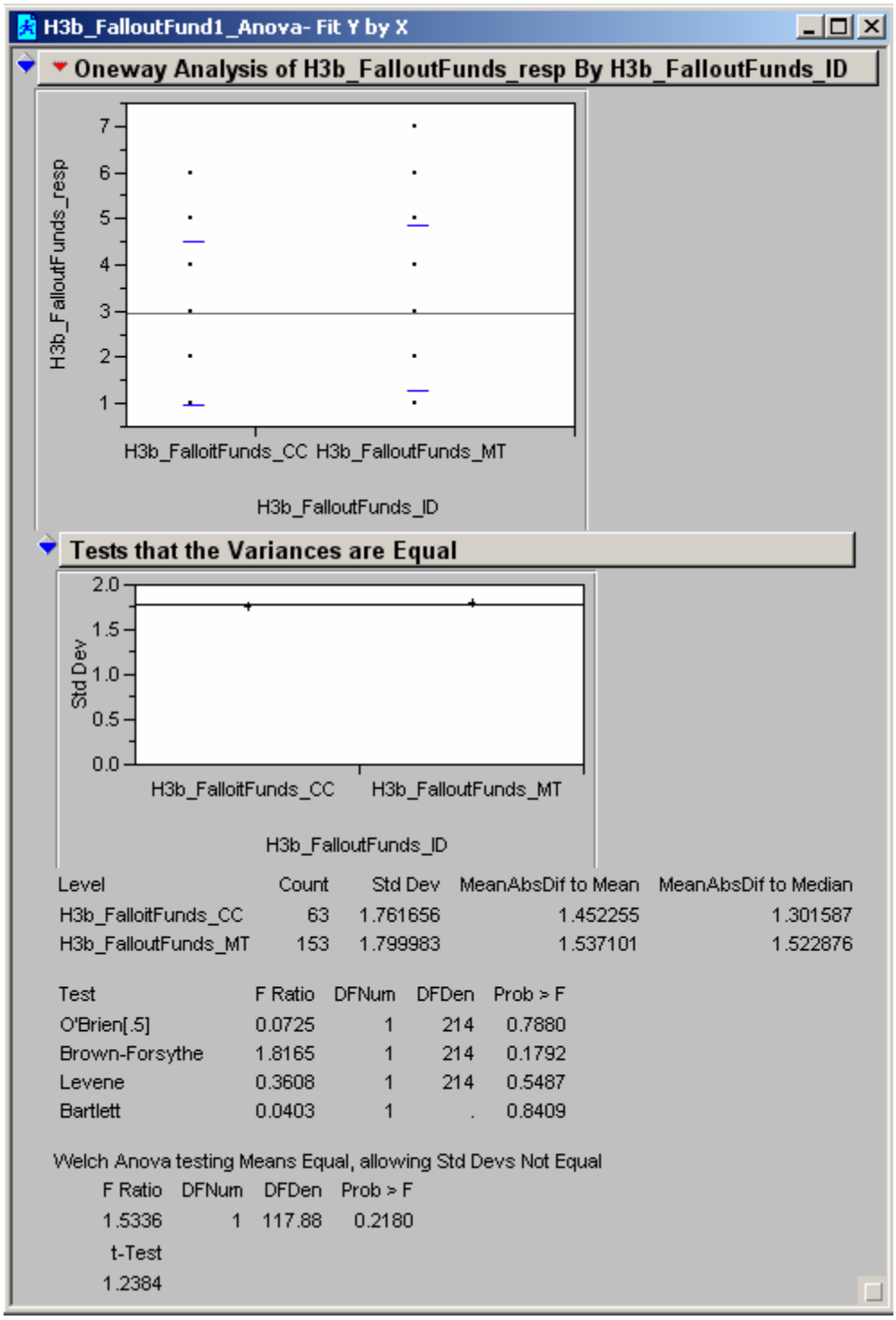

Figure 8: Test of unequal variances Fallout Funding factor Hypothesis 3b

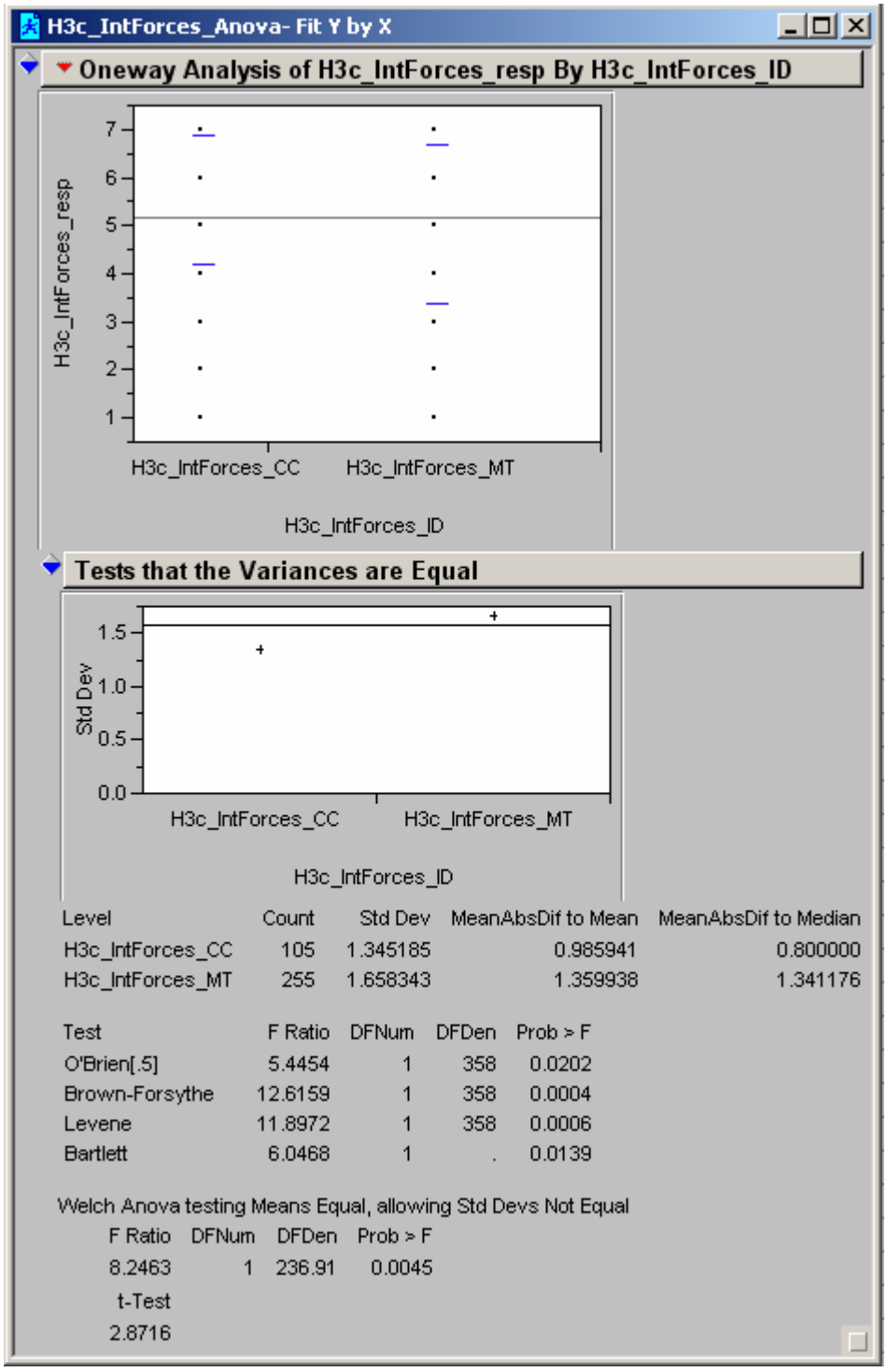

Figure 9: Test of unequal variances Internal Forces factor Hypothesis 3c

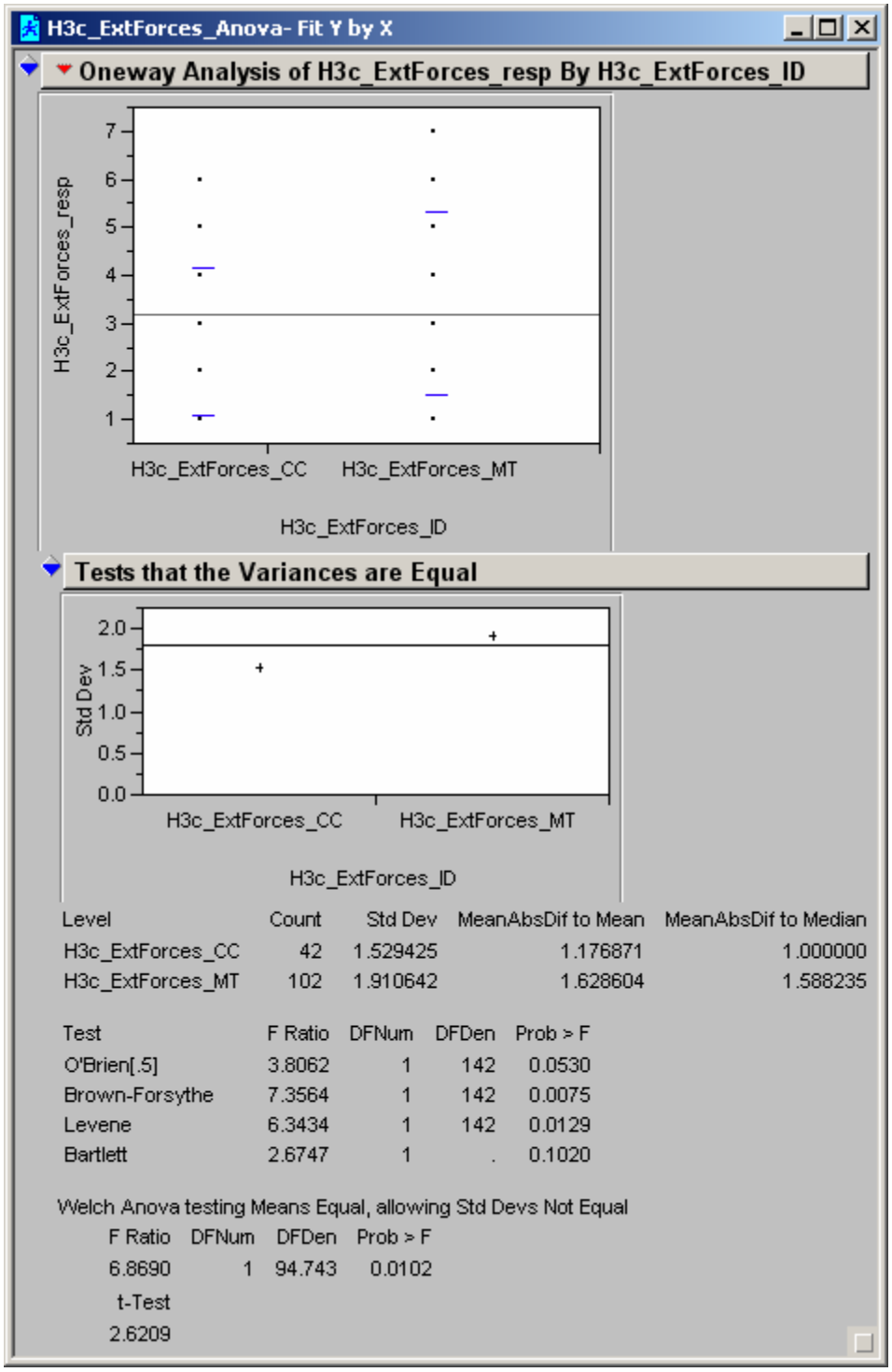

Figure 10: Test of unequal variances External Forces factor Hypothesis 3c

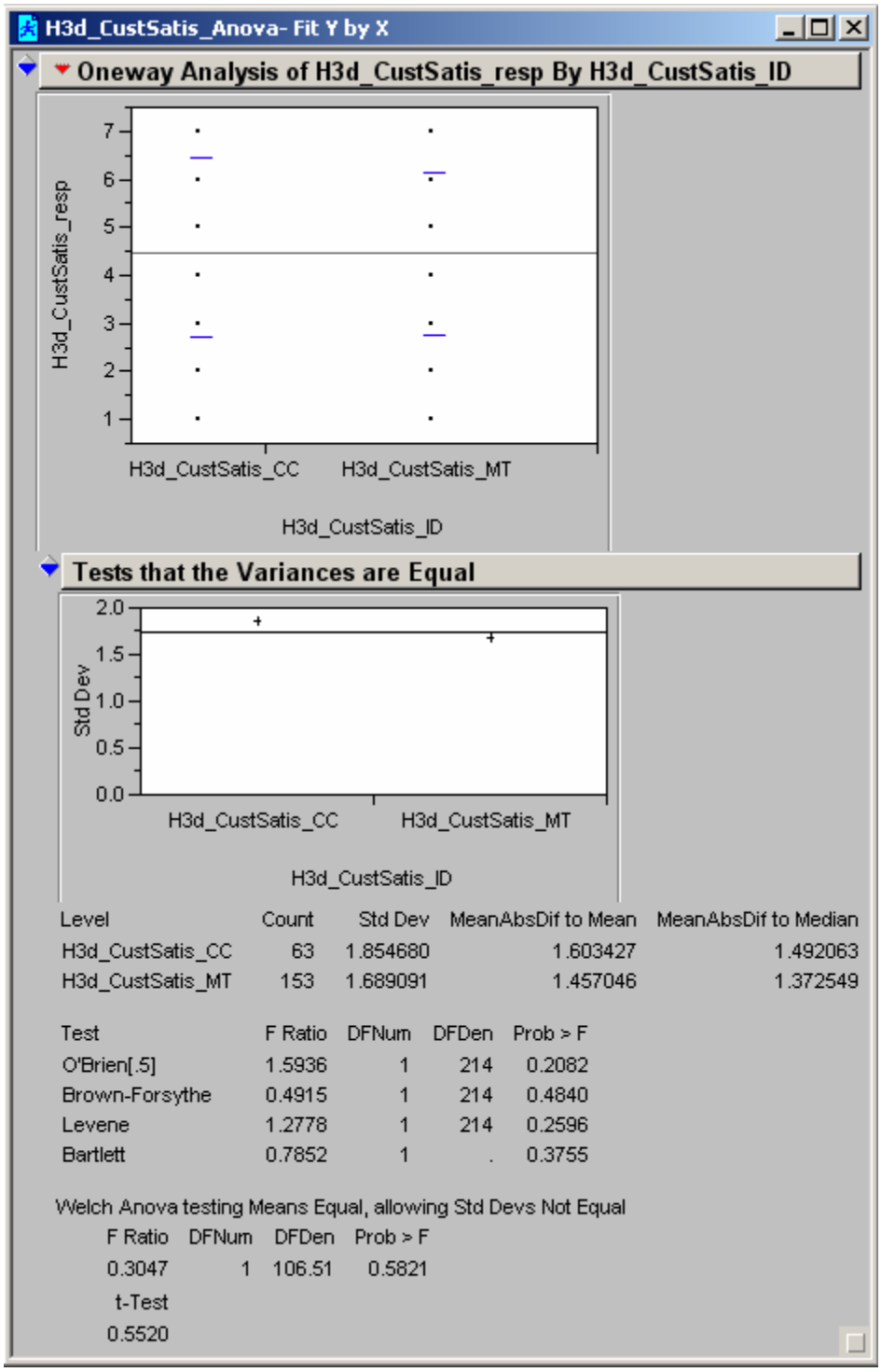

Figure 11: Test of unequal variances Customer Satisfaction factor Hypothesis 3d

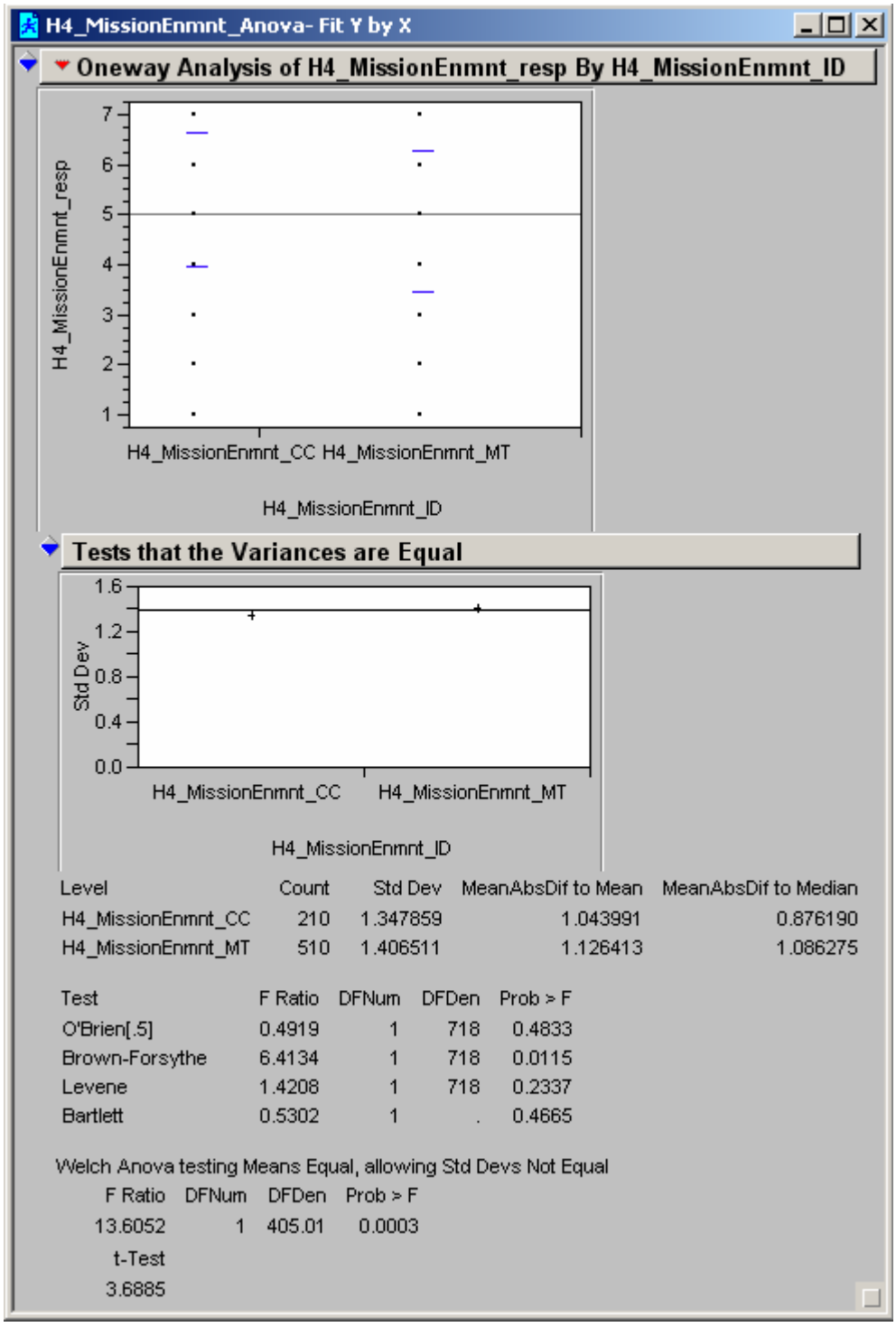

Figure 12: Test of unequal variances Mission Enhancement factor Hypothesis 4

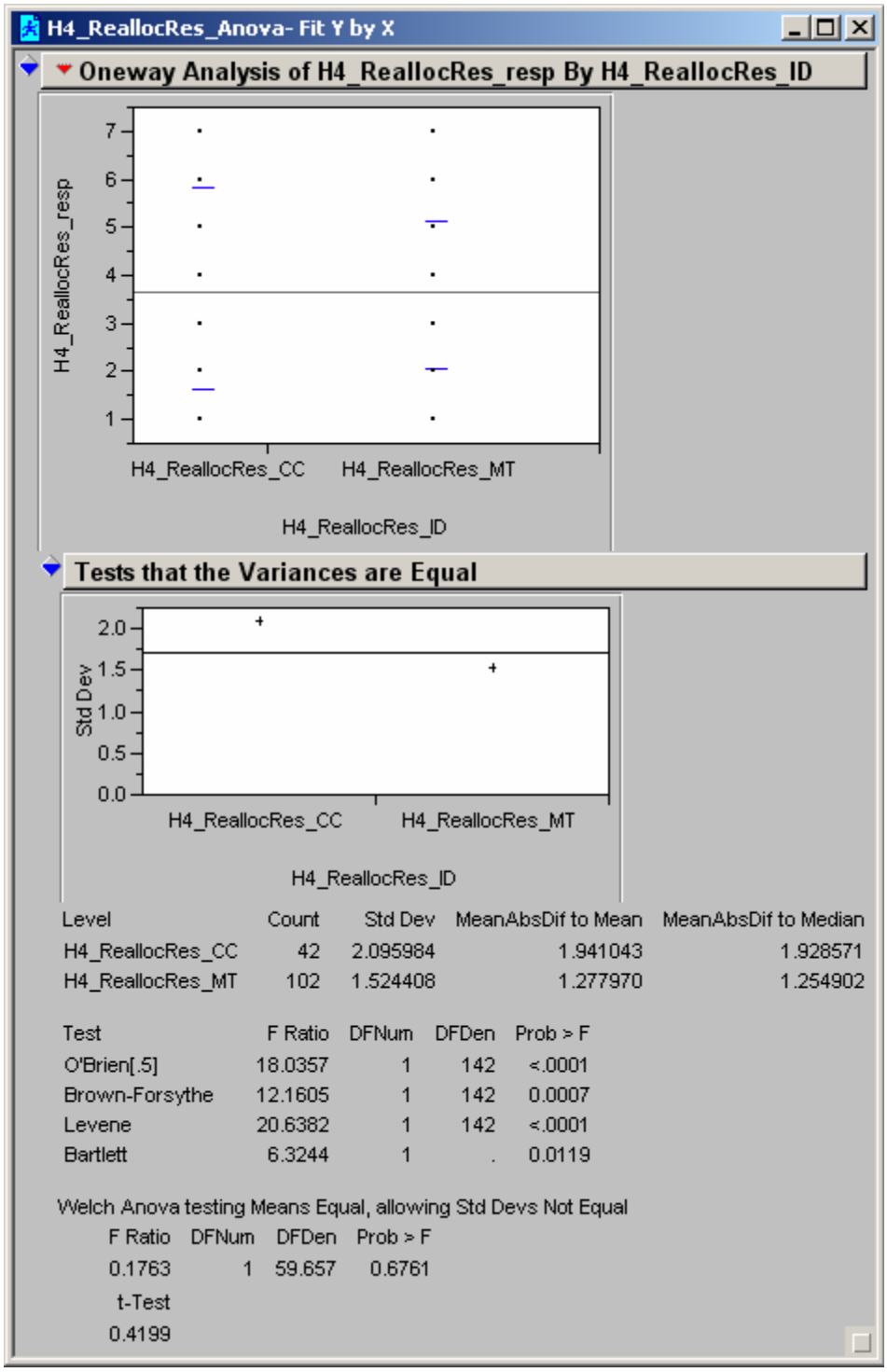

Figure 13: Test of unequal variances Reallocation of Resources factor Hypothesis 4

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Vita

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His first assignment was at Tinker AFB, Oklahoma as a Switching Systems Engineer. While station at Tinker, he deployed overseas in August 1997 to spend five months in Vaihingen, Germany as a Transmission Systems Staff Officer for Headquarters Unites States European Command. In August of 1998, he was assigned to the Advanced Programs Division of the National Air Intelligence Center where he served as a Technical Analysis Branch Chief. In August 2001, he entered the Graduate School of Engineering and Management, Air Force Institute of Technology. Upon graduation, he will be assigned to Pacific Air Forces as a staff officer at Hickam AFB, Hawaii.

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14. ABSTRACT

The productivity paradox is a theory that suggests that investments in Information Technology (IT) do not necessarily lead to associated gains in the productivity of the organization (Malakoff, 2000; Hitt and Brynjolfsson, 1996). This perception leads practitioners to question if acquiring new IT systems for the sake of having the latest technology will make their organization any more productive (Liebmann, 1996). Understanding the problem that is facing the practitioners, this research was undertaken to attempt to answer some of the underlying questions relating to the perceptions held about the relationship between IT expenditures and workplace productivity with respect to Air Force communication squadrons.

The research indicates that there may in fact be a perception of an IT productivity paradox. Both commanders and maintainers feel that procurement and administrative changes have been made in IT planning due to the understanding of a potential IT productivity paradox.

Ultimately, the Air Force work centers have the perception that they are getting and adequate return on investment for IT expenditures, indicating that their IT planning procedures have been effective. However, the results also indicate that they have a perceived need for newer technologies to be able to keep their network infrastructures to the necessary level to support their customer's needs. This indicates that IT planning in the Air Force must continually change to strike the appropriate balance between the demands of the customers and the capabilities of the technologies.

15. SUBJECT TERMS

Productivity Paradox, Technology Turnover, Return on Investment, Technology Advancements, Procurement Process Changes, Administrative Changes, Technology Availability, Perceived Technology Need, Budgeted Funding, Fallout Funding, Environmental Forces, Customer Satisfaction

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