NPS-AM-18-231

ACQUISITION RESEARCH PROGRAM SPONSORED REPORT SERIES

The Growth of the Navy Contracting Workforce and Its Impact on Levels of Contracting Activity

1 October 2018

Dr. Ira Lewis, Associate Professor of Logistics

Graduate School of Business & Public Policy

Dr. Johnathan Mun, Research Professor

Department of Information Sciences

Naval Postgraduate School

Approved for public release; distribution is unlimited.

Prepared for the Naval Postgraduate School, Monterey, CA 93943.

Acquisition Research Program
Graduate School of Business & Public Policy
Naval Postgraduate School

The research presented in this report was supported by the Acquisition Research Program of the Graduate School of Business & Public Policy at the Naval Postgraduate School.

To request defense acquisition research, to become a research sponsor, or to print additional copies of reports, please contact any of the staff listed on the Acquisition Research Program website (www.acquisitionresearch.net).

Acquisition Research Program
Graduate School of Business & Public Policy
Naval Postgraduate School

Executive Summary

The U.S. Department of the Navy (DoN) 2010 acquisition workforce (AWF) strategic plan noted that, since the 1990s, the value of DoN contracting had increased by more than 50% while the acquisition workforce had declined by almost 50%. In response, as a component of the Department of Defense (DoD), the DoN set an objective to in-source at least 3,500 civilian positions over the Future Years Defense Program period and hire an additional 1,590 civilians using funds from the Defense Acquisition Workforce Development Fund. These actions would lead to an increase of 8% in the civilian acquisition workforce over the subsequent six years. Given this increase in personnel, the following questions have been asked: *What has been the impact of this change in acquisition staffing within the DoN, and how is acquisition different now than with the previous smaller workforce?* Addressing these issues is not straightforward, due to the complex structure of both the acquisition workforce and of the acquisition activities themselves.

For this first phase of our research conducted during Fiscal Year 2018, we performed a series of parametric, nonparametric, and nonlinear regression analyses to attempt to correlate the growth of the size of the Navy contracting workforce with the total dollar value of contracts issued and the number of contracts during the period of 2008 to 2017. We found that an increase in the average dollar value of contracts, as well as a decrease in the number of contracts, was associated with the growth in the contracting workforce. We also found that contract obligations fluctuate over time, but on average the total dollar amount of contracts is increasing. However, the number of contracts issued is decreasing steadily, forcing the increase in average contract size, defined as the average dollar amount.

Interestingly, there is a negative relation between the total number of contracts and workforce size, indicating that some further analysis was required. We determined that 96.86% of the variation in the number of contracts can be determined by the time trend and workforce size. In practical terms, this indicates that for every full-time employee (FTE) added to the workforce, on average there is

an increase of 30.6 contracts after correcting for the reduction in contract size in the time trend (e.g., for every 100 employees added, there will be an increase of 3,064 contracts, or a 1.8% increase in workforce size will increase the number of contracts by 1% on average).

There are 13 career fields in the Navy acquisition workforce, although the auditing field does not currently have any employees. A potentially useful next phase of our work would involve carrying out the same type of analyses on these other career fields as was done for the contracting career field to determine any relationship between changes in the size of the career field's workforce and contracting activity.

Another fruitful avenue of research would be extending our work on the impact of the growth in the acquisition workforce to the area of program management, notably using the multiple databases made available through DAVE (Defense Acquisition Visibility Environment), a relatively recent service that incorporates DAMIR (Defense Acquisition Management Information Retrieval). The field of program management (PM) is much broader than contract management and arguably incorporates most contract management activity. Notably, PM involves participation by all the acquisition career fields and would have multiple measures of outputs and outcomes. Exploring the PM results of the growth in the acquisition workforce since 2008 represents an exciting avenue of future research.

Future work will also include applying a powerful range of statistical and analytical modeling that may provide a reasonable indication of the impact of the AWF growth initiative. These modeling activities might include the following:

a. Statistical significance comparing before-and-after effects (using two-sample dependent T tests and F tests, ANOVA, MANOVA)

b. Linear and nonlinear correlation matrices with statistical significance

c. Nonlinear econometric models to identify and determine the critical independent variables that are statistically significant, as well as quantifying their impact and results of the dependent variables and related metrics

d. Creating new metrics beyond those mentioned previously, by collapsing multiple variables into composite measures that provide a more comprehensive and cohesive indication of the impact of the growth of the acquisition workforce

e. Monte Carlo simulations to determine the final probability distribution and impact of changed manning levels. These distributions could serve as a benchmark for current and future metrics such as increases in acquisition complexity.

A key element of future work will be separating acquisition programs into levels of complexity; these categorizations could then be used to predict the turnover, schedule risk, and cost risk of new acquisition programs. The resulting models could be of great use to management in assisting with the direction of PM activity.

THIS PAGE LEFT INTENTIONALLY BLANK

NPS-AM-18-231

ACQUISITION RESEARCH PROGRAM SPONSORED REPORT SERIES

The Growth of the Navy Contracting Workforce and Its Impact on Levels of Contracting Activity

1 October 2018

Dr. Ira Lewis, Associate Professor of Logistics

Graduate School of Business & Public Policy

Dr. Johnathan Mun, Research Professor

Department of Information Sciences

Naval Postgraduate School

THIS PAGE LEFT INTENTIONALLY BLANK

Table of Contents

THIS PAGE LEFT INTENTIONALLY BLANK

List of Figures

THIS PAGE LEFT INTENTIONALLY BLANK

Introduction

The U.S. Department of the Navy (DoN) 2010 acquisition workforce (AWF) strategic plan noted that, since the 1990s, the value of DoN contracting had increased by more than 50% while the acquisition workforce had declined by almost 50%. The cuts in workforce reflected the view then held in Congress that the defense acquisition workforce was too large for the acquisition budget and for the size of the uniformed force. Another trend had been the significant growth of contractor support positions, in part due to civil service hiring restrictions.

In response, as a component of the Department of Defense (DoD), the DoN set an objective to in-source at least 3,500 civilian positions over the Future Years Defense Program period and hire an additional 1,590 civilians using funds from the Defense Acquisition Workforce Development Fund. These actions would lead to an increase of 8% in the civilian acquisition workforce over the subsequent six years (DoN, 2010; Schwartz, Francis, & O'Connor, 2016).

Given this increase in personnel, the following questions have been asked: *What has been the impact of this change in acquisition staffing within the DoN, and how is acquisition different now than with the previous smaller workforce?* Addressing these issues is not straightforward, due to the complex structure of both the acquisition workforce and of the acquisition activities themselves (McKeithen, 2016).

THIS PAGE LEFT INTENTIONALLY BLANK

Research Context

Research involving public-sector procurement specialists revealed that these professionals were “skeptical about the possibility that performance measurements can be useful or can increase the quality of decision-making in public procurement” (Diggs & Roman, 2012, as cited in Rendon, 2015). Lewis (2016) expressed some concerns about availability and suitability of data as well as the challenges of relating inputs to outputs in a professional environment.

In a well-cited review of research into organizational performance, March and Sutton (1997) found that the structure and definition of performance were rarely explicitly justified, and that the appropriateness of performance is rarely questioned. Organizational performance is frequently used as a dependent variable, and researchers pay little attention to the complications of using such a formulation to characterize the behavior of organizational phenomena.

Part of the reason for this practice is that organizational research demands and rewards speculations about how to improve performance. March and Sutton (1997) further noted that it isn’t clear that organizational purpose can be portrayed as unitary—a factor familiar to students of public administration—and that the multiple purposes of an organization aren’t reliably consistent. In addition, March and Sutton suggested that organizational researchers live in two worlds; one demands speculations about how to improve performance, while the other requires adherence to rigorous standards of scholarship. Finally, seeking knowledge “about historically ambiguous phenomena such as organizational performance is more a necessary form of disciplined self-flagellation than a pursuit of happiness” (March & Sutton, 1997, p. 705).

Richard, Devinney, Yip, and Johnson (2009) found a limited effectiveness of commonly accepted measurement practices in tapping the multidimensionality of performance. The authors suggested that addressing these findings required researchers to possess a strong theoretical rationale on the nature of performance and to rely on strong theory as to the nature of measures. Further, Richard et al.

found little progress in the unquestioning assumptions about performance since what they termed March and Sutton's (1997) "call to virtue." Given the above research, it is difficult to contemplate how one would measure the addition of thousands of employees, particularly professionals doing complex work, to the Navy's acquisition workforce. On the input side, one is struck by the difficulties in measuring who worked where at what time, as well as what they did. From the output perspective, the "units of work," such as contracts, financial and other reporting documents, e-mails, meetings, and the like, vary significantly in size and importance.

It would also be necessary to account for differences in work hours caused by such factors as training and leave. Measuring the productivity of military acquisition personnel, who make up approximately 10% of the Navy's acquisition workforce, has its own set of challenges above and beyond those associated with civilian personnel. These include the impact of high turnover, promotions, centralized control over most training and development, and so on.

Part of the challenge of determining the increase in output caused by the change in size of the acquisition workforce is related to data limitations. Schwartz et al. (2016) found significant limitations in the data available to inform acquisition research, particularly with respect to reliability and comprehensiveness. The Federal Procurement Data System (FPDS), which is the central database of U.S. government procurement, contains data with limited "utility, accuracy, and completeness" (Government Accountability Office [GAO], 2012).

A DoD report on the performance of the defense acquisition system noted that defense acquisition "is complex, and each measure has its strengths and weaknesses, so attributing performance to a single measure is subject to the limitations of that measure," and that such data, even when combined with other information, constitute a "crude indicator of the effectiveness of these officials' decision making" (DoD, 2015, p. xv).

Nevertheless, it should be possible to discern some basic indicators that, while not definitive, do provide some indication of the impact of the increase in the workforce. As Gates (2009, p. 27) has suggested,

> The AW [acquisition workforce] must be viewed as an input to a process operation, and thought should be given to concrete outcomes that the workforce could be expected to influence. These would not be the high-level outputs of on-time, on-budget systems, but they could include important process-oriented outcomes that reflect top-flight systems engineering practices and could ultimately lead to improvements in the key outcomes of interest. It is also critical to acknowledge that the AW is engaged in a wide range of procurement-related activities and that different types of activities are likely to require separate and distinct outcome measures.

DoN senior management has expressed the need for an improved understanding of measuring AWF productivity. As suggested above, one important caution in considering the impact of the mandated increase in the size of the AWF relates to traceability. Changes in the total number of employees at the DoD or DoN levels may not translate directly at lower levels such as individual offices. There is considerable fluctuation at the office level, due to normal turnover as well as directed changes in personnel billets that may not be related to the mandated increase in AWF size. Gates (2009, p. 4) commented on the challenges of measuring AWF productivity in the face of increasing demand for acquisition personnel:

> Key drivers of the increasing demands include the complexity of service contracting, which is a growing share of all government contracting; the fact that the number of transactions is no longer a good measure of workload; and the fact that best-value procurement approaches are substantially more complex than lowest-price contracting approaches.

In addition, the methodology for counting members of the AWF is quite complex, and considerable data collection and analysis is required to count gains, losses, and switches (personnel moving into or out of the AWF to other positions). The extensive work performed by RAND on defining and analyzing the size and composition of the AWF should be used as a starting point for any analysis of the impact of the mandated increase in AWF to provide a common baseline of personnel resources (Gates, Roth, Srinivasan, & Dougherty, 2013; Powell, 2017).

THIS PAGE LEFT INTENTIONALLY BLANK

Proposed Approach

Within this context, it would be possible to take a limited number of variables that are surrogates for activity levels and compare them to AWF headcounts before and after the increase in workforce size. Broadly speaking, activities could be divided into the program and contract management realms, although it is recognized that these two are not mutually exclusive. Within program management, measures such as number, dollar amount, and program categories (ACATs) under management may serve as useful measures. In contract management, the number and total dollar value of contracts, contract processing time, and some measure of contract complexity, if available, would be helpful.

One factor emphasized by Powell (2017) was the change in the composition of the AWF during the period of growth. For example, there were new hires from inside and outside the civil service with limited acquisition experience, as well as retiring military personnel, many of whom had a substantial acquisition background. It would be desirable to attempt some characterization of workforce demographics rather than reducing the Navy AWF to a single number in all analyses. Management may be particularly interested in measures of before-and-after productivity.

THIS PAGE LEFT INTENTIONALLY BLANK

Data and Methodology

Sources of Information

The information required to conduct the above analyses can be grouped into two categories: independent and dependent variables. The dependent variables represent the output or outcome measures such as number of contracts issued, total dollars under management, and number of projects by ACAT. We are mindful of the comments by Gates (2009), cited above, that emphasize the need for process-oriented measures such as desirable system engineering outcomes, rather than traditional output measures such as the number of contracts under management. We return to this issue later when we discuss dependent variables.

In contrast, independent variables are the inputs that (plausibly) lead to the results characterized by the dependent variables, most notably for our study, workforce size and composition.

Information about AWF size and composition is maintained on the website (http://www.hci.mil) of the Office of Human Capital Initiatives (HCI) within the Office of the Under Secretary of Defense for Acquisition and Sustainment. For example, during our initial research, data on total AWF workforce size as well as numbers by career field (there are 13 in the AWF) are available for Fiscal Year 2008 (FY08) through the first quarter of Fiscal Year 2017 (FY17Q1), as shown in Figure 5.

Other data available from HCI include level of educational attainment or certification under the Defense Acquisition Workforce Improvement Act (DAWIA), years of service, and retirement eligibility. Additionally, workforce information is available by gender and race. Overall, the DoD AWF has increased from 125,879 in FY08 to 161,712 as of FY17Q1, an increase of 28%. Navy AWF personnel as of FY17Q1 numbered 57,268, a 39% increase since FY08.

Dependent variables represent a significant challenge to the researcher in terms of availability, variety, and (perceived) relevance. These are other factors cited by McKernan et al. (2017), is that the contents of the information systems giving

access to these variables are constantly evolving due to factors such as policy and technology. The authors identified four public databases that provided DoD acquisition information: SAM, FSRS, USAspending.gov, and FPDS-NG. We reviewed the offerings of each system, and only the last of these appeared to contain relevant information for our work.

The Federal Procurement Data System–Next Generation (FPDS-NG) may provide some useful data for dependent variables. Established in 2005 and owned by the General Services Administration, this public source of information on contracting activity describes "who is procuring what, when, how, and from whom they are buying, and where the work is being done," including spending with prime contractors; is used by governments, contractors, and the general public; and is considered authoritative (McKernan et al., 2017; Rendon & Snider, 2014). Contract actions are covered since FY04, and FPDS-NG allows the user to generate both standard and customized (ad hoc) reports.

Another potential way of measuring AWF productivity is through financial information such as budget data. There may be a relationship between the number and type of acquisition personnel and expenditures on procurement. From the president's budget, we learn that the requested total DoN procurement funds in FY08 were $38,718,200,000 for an AWF of 41,078 people, giving a figure of $942,553 procured per employee. For FY17, a procurement request of $49,585,801,000 and a Navy AWF of 57,278 result in an average of $865,704 per employee, which is only a minor decrease (DoD, 2007, 2017).

Methodology

We determined that an appropriate first approach would be to try to associate the growth in the contracting career field with levels of activity in Navy contracting. Specifically, we would examine the total dollars of contracts issued and number of contracts in FY08 and FY17 and compare these with the size of the contracting workforce using regression analysis.

There are two important limitations in conducting such work. First, the dollar value of a contract is not consistent with the amount of time involved in developing, drafting, circulating, and approving the document. Second, independent of dollar value, there are significant differences in contract length and complexity that also make the individual document a possibly problematic unit of measure for evaluating workload. However, we feel that dollar value and the number of contracts represent reasonable surrogates for total workload for the purposes of this first phase of our work.

We therefore conducted a series of regression analyses to try to correlate the above factors. Details are provided in the appendix. Data on acquisition workforce size (WORKFORCE) were obtained from the Office of Human Capital Initiatives in the Office of the Under Secretary of Defense for Acquisition and Sustainment. The number of contracts issued (CONTRACTS) and the average total dollar value of contracts issued during the fiscal year (AVG CONTRACT SIZE) were extracted from FPDS-NG. The variables CONTRACTS and AVG CONTRACT SIZE were tested as dependent variables against WORKFORCE and TIME.

The three variables were associated for the same given fiscal year, as well as for a time lag of one year to allow the increase in workforce size to take effect. In all, 16 separate regression models were run to determine the importance of the relationship between the variables.

THIS PAGE LEFT INTENTIONALLY BLANK

Results and Findings

Our analysis of the data indicated that while the size of the Navy acquisition workforce in the contracting career field increased over the period 2008–2017, the number of contracts issued have been decreasing over time. However, the growth in the contracting workforce tracks with the average contract size in dollars, both of which are increasing over time, as shown in Figure 1.

Figure 1: Measuring Output Trends in Contract Numbers and Average Contract Size vs. Contracting Workforce, 2008–2017

We also found that contract obligations fluctuate over time, but on average, the total dollar amount of contracts is increasing. However, the *number* of contracts issued is decreasing steadily, forcing the average contract size to increase, as shown in Figure 2.

Figure 2: Decreasing Average Contract Size, 2008–2017

Given these trends, we set out to determine the degree of correlation between contracting workforce levels and total contract obligations. Linear and nonlinear correlations were computed, along with the statistical significance (*p*-values) of the correlations—note that *p*-values ≤ 0.05 or 0.10 are considered significant. We also calculated correlation coefficients for workforce levels lagged one year, that is, associating the workforce levels in each fiscal year with contracting activity the following fiscal year to allow the impact of a change in workforce level to be felt. The results are shown in Figure 3, with the nonlinear, lagged correlations considered the most significant.

Correlation Coefficients	Linear	Nonlinear	p-value	p-value
Contract Amount to Number of Contracts	0.0825	0.2242	0.8207	0.5334
Contract Amount to Workforce	0.2342	0.0182	0.5150	0.9602
Number of Contract to Workforce	-0.6632	-0.7576	0.0366	0.0111
Workforce to Average Contract Size	0.7064	0.6727	0.0224	0.0330

Correlation Coefficients (Lag 1)	Linear	Nonlinear	p-value	p-value
Contract Amount to Workforce	0.5572	0.4753	0.1191	0.1960
Number of Contract to Workforce	-0.6004	-0.7167	0.0873	0.0298
Workforce to Average Contract Size	0.8263	0.8244	0.0060	0.0063

Figure 3: Linear and Nonlinear Correlation for Contracting Workforce, 2008–2017

Note that the correlations increase significantly (and the *p*-values decrease) due to the introduction of the one-year lag. Interestingly, there is a negative relation (−0.7167) between the total number of contracts and workforce size, indicating that some further analysis is required. As noted previously, there also seems to be a time trend reduction in the number of contracts and corresponding increase in average contract size.

After accounting for the time trend over the 10-year period under review, we found that the number of contracts is highly related to workforce size. The details are shown in Figure 4; 96.86% of the variation in the number of contracts can be determined by the time trend and workforce size, which is found to be statistically significant (p = 0.0259). In practical terms, this indicates that for every full-time employee (FTE) added to the workforce, on average there is an increase of 30.6 contracts after correcting for contract reductions in the time trend (e.g., for every 100 employees added, there will be an increase of 3,064 contracts, or a 1.8% increase in workforce size will increase the number of contracts by 1% on average).

Ranked Models Summary

CONTRACTS = $\alpha + \beta_1$*WORKFORCE + β_2*TIME		
$C = \beta_0 + \beta_1 \omega + \beta_2 \tau$		
R^2: **96.86%**		
Intercept:	214201	
Coefficient:	30.6369	-14408
P-value:	**0.0259**	**0.0000**

AVG CONTRACT SIZE = $\alpha + \beta$*(WORKFORCE $_{t-1}$)	
$\sum = \beta_0 + \beta_1 LN(\omega_{t-1})$	
R^2: **68.28%**	
Intercept: -315275	
Coefficient: 106.7015	
P-value: **0.0060**	

CONTRACTS = $\alpha + \beta_1$*LN(WORKFORCE) + β_2*TIME		
$C = \beta_0 + \beta_1 LN(\omega) + \beta_2 \tau$		
R^2: **96.79%**		
Intercept:	-1139463	
Coefficient:	176726	-14359
P-value:	**0.0281**	**0.0000**

AVG CONTRACT SIZE = $\alpha + \beta$*LN (WORKFORCE $_{t-1}$)	
$\sum = \beta_0 + \beta_1 ln(\omega_{t-1})$	
R^2: **66.48%**	
Intercept: -4969148	
Coefficient: 608577	
P-value: **0.0074**	

Figure 4: Ranked Models Summary for Number of Contracts and Workforce Size

As for average contract size, we found that workforce size contributes to the increase in average contract size over time. The average contract size for the past 10 fiscal years is $306,866; one additional FTE contributes to an increase of $106 in average contract size, or 100 FTEs contribute to, on average, a 3.5% increase in average contract size, or $10,670 per contract.

Conclusions and Further Research

Our research efforts up to this point have of necessity been exploratory. As mentioned previously, research in the field of professional productivity warns against attempts to undertake large-scale measurement efforts. However, we have begun to determine some basic trends from before and after the increase in Navy acquisition personnel, including patterns that might indicate the impact of the change in workforce size on organizational performance.

The first phase of our work has examined the relationship between the growth of the Navy contracting workforce and the total dollar amount of contracts, and the number of contracts issued, from 2008 to 2017. We found that an increase in the average dollar value of contracts, as well as a decrease in the number of contracts, was associated with the growth in the contracting workforce. We also found that contract obligations fluctuate over time, but on average the total dollar amount of contracts is increasing. However, the *number* of contracts issued is decreasing steadily, forcing the average contract size to increase.

Interestingly, there is a negative relation (−0.7167) between the total number of contracts and workforce size, indicating that some further analysis is required. We determined that 96.86% of the variation in the number of contracts can be determined by the time trend and workforce size. In practical terms, this indicates that for every full-time employee (FTE) added to the workforce, on average there is an increase of 30.6 contracts after correcting for the reduction in contract size in the time trend (e.g., for every 100 employees added, there will be an increase of 3,064 contracts, or a 1.8% increase in workforce size will increase the number of contracts by 1% on average).

As shown in Figure 5, there are 13 career fields in the Navy acquisition workforce, although the auditing field does not currently have any employees. A potentially useful next phase of our work would involve carrying out the same type of analyses on these other career fields as was done for the contracting career field to

determine any relationship between changes in the size of the career field's workforce and contracting activity.

Another fruitful avenue of research would be extending our work on the impact of the growth in the acquisition workforce to the area of program management (PM), notably using the multiple databases made available through DAVE (Defense Acquisition Visibility Environment), a relatively recent service that incorporates DAMIR (Defense Acquisition Management Information Retrieval). The discipline of PM is much broader than contract management and arguably incorporates most contract management activity. Notably, PM involves participation by all the acquisition career fields and would have multiple measures of outputs and outcomes. Exploring the PM results of the growth in the acquisition workforce represents an exciting avenue of future research.

Future work will also include applying a powerful range of statistical and analytical modeling that may provide a reasonable indication of the impact of the AWF growth initiative as related to the other career fields and PM outputs and outcomes. These modeling activities might include the following (Mun, 2015):

a. Statistical significance comparing before-and-after effects (using two-sample dependent T tests and F tests, ANOVA, MANOVA)
b. Linear and nonlinear correlation matrices with statistical significance
c. Nonlinear econometric models to identify and determine the critical independent variables that are statistically significant, as well as quantifying their impact and results of the dependent variables and related metrics
d. Creating new metrics beyond those mentioned in the previous section by collapsing multiples variables into composite measures that provide a more comprehensive and cohesive indication of the impact of the growth of the acquisition workforce
e. Monte Carlo simulations to determine the final probability distribution and impact of changed manning levels. These distributions could serve as a benchmark for current and future metrics such as increases in acquisition complexity.

A key element of future work will be separating acquisition programs into levels of complexity; these categorizations could then be used to predict the turnover, schedule risk, and cost risk of new acquisition programs. The resulting

models could be of great use to management in assisting with direction of PM activity.

Career Field	FY 2008	Dec 31, 2016	Change (%)
Auditing	0	0	0%
Business	1792	2405	34%
Contracting	4866	5859	20%
Engineering	16353	21652	32%
Facilities Engineering	3902	5481	40%
Information Technology	800	2868	259%
Life Cycle Logistics	4104	5981	46%
Production, Quality & Manufacturing	1980	3240	64%
Program Management	3485	5514	58%
Property Management	58	64	10%
Purchasing	478	417	-13%
Science & Technology Manager	190	559	194%
Test & Evaluation	2360	3227	37%
Unknown/Other	710	1	-100%
Total	**41078**	**57268**	**39**

Figure 5: Department of the Navy Acquisition Workforce by Career Field

(Source: Office of the Under Secretary of Defense [Acquisition and Sustainment], Office of Human Capital Initiatives, January 2018)

THIS PAGE LEFT INTENTIONALLY BLANK

Appendix

Ranked Models Summary

CONTRACTS = $\alpha + \beta_1$*WORKFORCE + β_2*TIME
C = $\beta_0 + \beta_1\ \omega + \beta_2\ \tau$

R^2:	**96.86%**	
Intercept:	214201	
Coefficient:	30.6369	-14408
P-value:	**0.0259**	**0.0000**

CONTRACTS = $\alpha + \beta_1$*LN(WORKFORCE) + β_2*TIME
C = $\beta_0 + \beta_1\ LN(\omega) + \beta_2\ \tau$

R^2:	**96.79%**	
Intercept:	-1139463	
Coefficient:	176726	-14359
P-value:	**0.0281**	**0.0000**

CONTRACTS = $\alpha + \beta_1$*$WORKFORCE_{t-1}$ + β_2*TIME
C = $\beta_0 + \beta_1\ \omega_{t-1} + \beta_2\ \tau$

R^2:	93.91%	
Coefficient:	21.0977	-13661
P-value:	0.2054	0.0003

CONTRACTS = $\alpha + \beta_1$*LN($WORKFORCE_{t-1}$) + β_2*TIME
C = $\beta_0 + \beta_1\ LN(\omega_{t-1}) + \beta_2\ \tau$

R^2:	93.79%	
Coefficient:	118419	-13608
P-value:	0.2216	0.0003

CONTRACTS = $\alpha + \beta$*WORKFORCE
C = $\beta_0 + \beta_1\ \omega$

R^2:	43.99%
Coefficient:	-64.2112
P-value:	0.0366

CONTRACTS = $\alpha + \beta$*LN(WORKFORCE)
$C = \beta_0 + \beta_1 LN(\omega)$
R^2: 43.82%
Coefficient: -374874
P-value: 0.0371

CONTRACTS = $\alpha + \beta$*WORKFORCE $_{t-1}$
$C = \beta_0 + \beta_1 \omega_{t-1}$
R^2: 36.05%
Coefficient: -60.6375
P-value: 0.0873

CONTRACTS = $\alpha + \beta$*LN(WORKFORCE $_{t-1}$)
$C = \beta_0 + \beta_1 LN(\omega_{t-1})$
R^2: 36.51%
Coefficient: -352743
P-value: 0.0848

AVG CONTRACT SIZE = $\alpha + \beta$*(WORKFORCE $_{t-1}$)
$\sum = \beta_0 + \beta_1 LN(\omega_{t-1})$
R^2: **68.28%**
Intercept: -315275
Coefficient: 106.7015
P-value: **0.0060**

AVG CONTRACT SIZE = $\alpha + \beta$*LN (WORKFORCE $_{t-1}$)
$\sum = \beta_0 + \beta_1 \ln(\omega_{t-1})$
R^2: **66.48%**
Intercept: -4969148
Coefficient: 608577
P-value: **0.0074**

AVG CONTRACT SIZE = $\alpha + \beta$*WORKFORCE
$\sum = \beta_0 + \beta_1 \omega$
R^2: 49.90%
Coefficient: 81.4716
P-value: 0.0224

AVG CONTRACT SIZE = $\alpha + \beta$*LN(WORKFORCE)

$\sum = \beta_0 + \beta_1 LN(\omega)$

R^2:	48.12%	
Coefficient:	467967	
P-value:	0.0261	

AVG CONTRACT SIZE = $\alpha + \beta_1$*WORKFORCE$_{t-1}$ + β_2*TIME

$\sum = \beta_0 + \beta_1 \omega_{t-1} + \beta_2 \tau$

R^2:	78.31%	
Coefficient:	63.1889	7272
P-value:	0.1284	0.1468

AVG CONTRACT SIZE = $\alpha + \beta_1$*LN(WORKFORCE$_{t-1}$) + β_2*TIME

$\sum = \beta_0 + \beta_1 LN(\omega_{t-1}) + \beta_2 \tau$

R^2:	77.23%	
Coefficient:	347564 7539	
P-value:	0.1523	0.1433

AVG CONTRACT SIZE = $\alpha + \beta_1$*WORKFORCE + β_2*TIME

$\sum = \beta_0 + \beta_1 \omega + \beta_2 \tau$

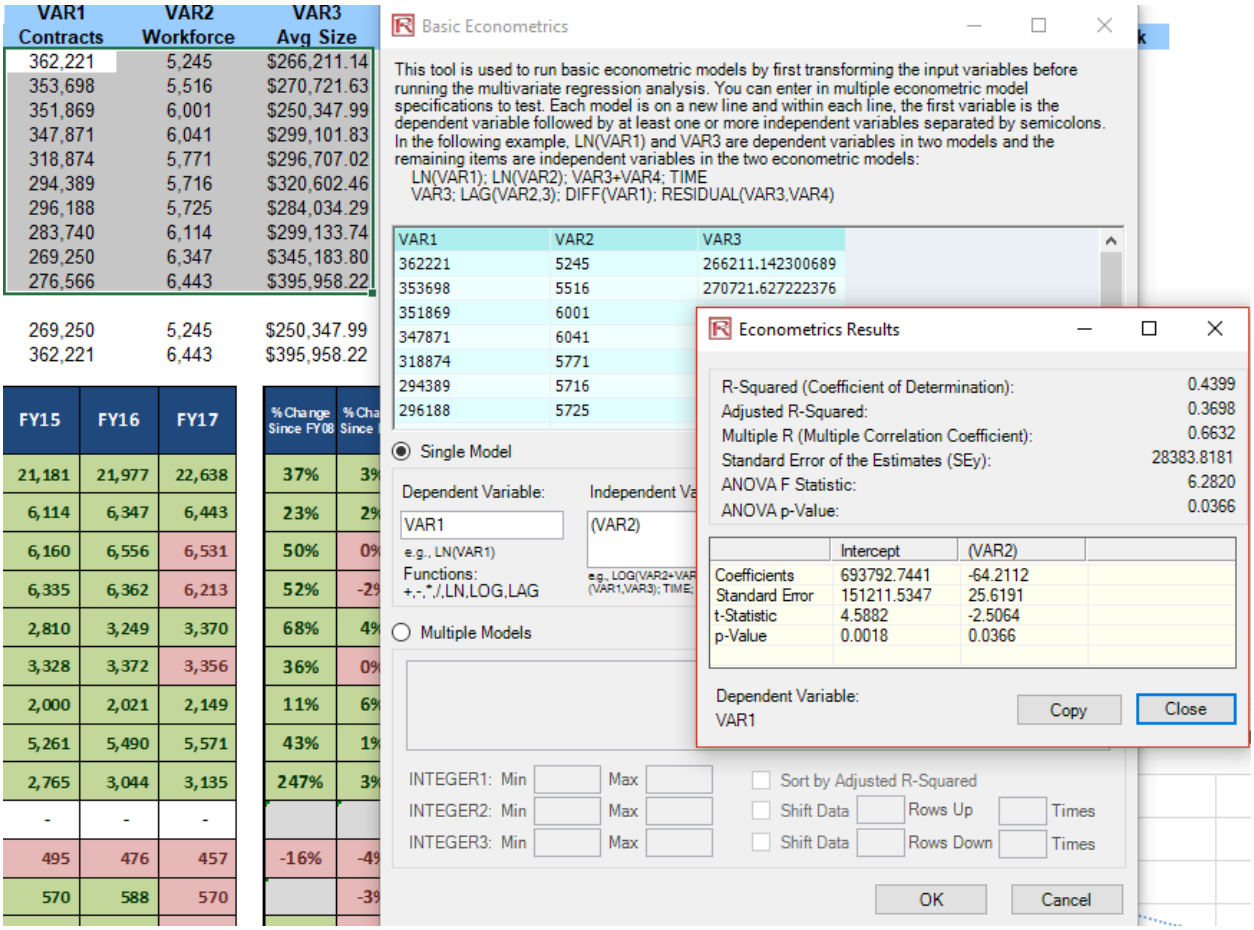
R^2:	68.39%	
Coefficient:	14.6540	10150
P-value:	0.7320	0.0827

AVG CONTRACT SIZE = $\alpha + \beta_1$*LN(WORKFORCE) + β_2*TIME

$\sum = \beta_0 + \beta_1 LN(\omega) + \beta_2 \tau$

R^2:	68.14%	
Coefficient:	64004	10516
P-value:	0.7977	0.0741

CONTRACTS = α + β*(WORKFORCE)

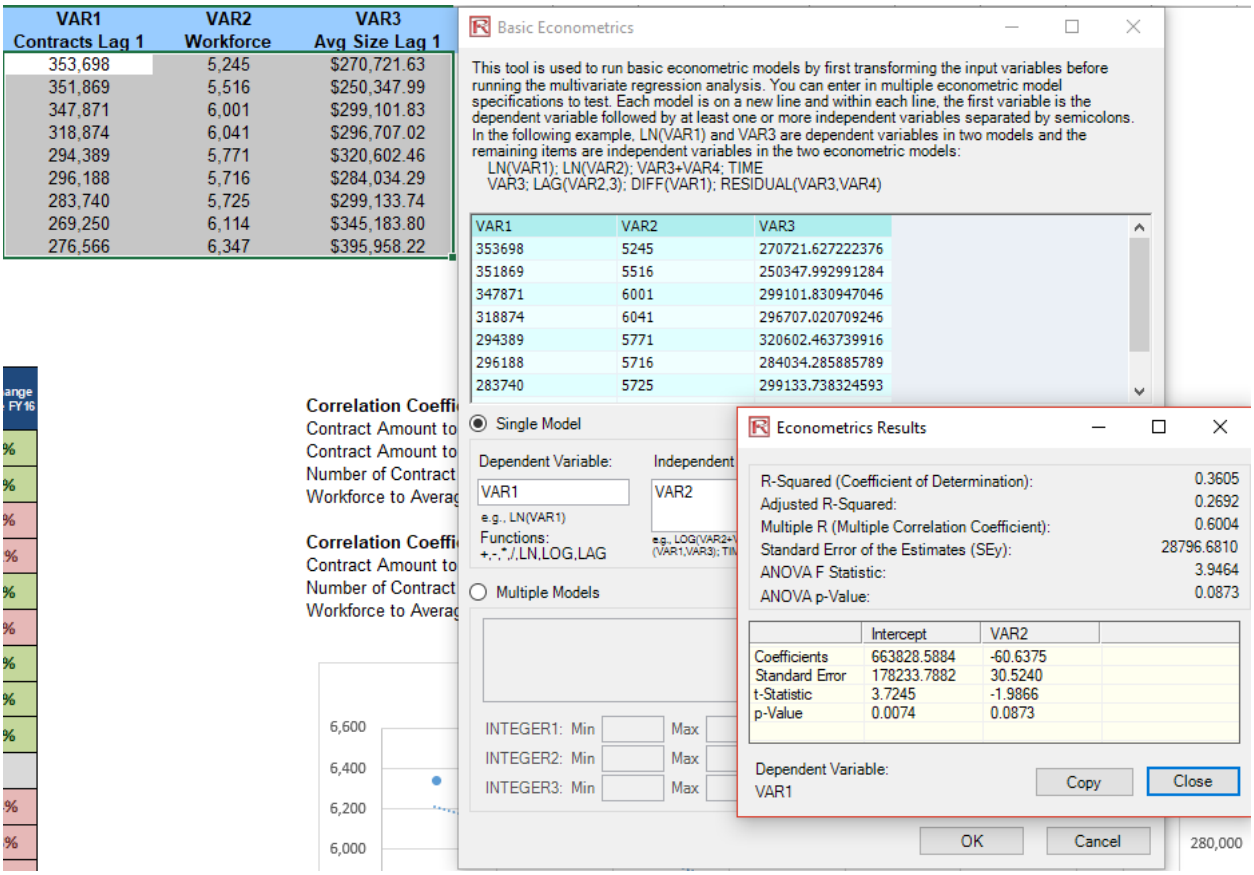


VAR1 Contracts	VAR2 Workforce	VAR3 Avg Size
362,221	5,245	$266,211.14
353,698	5,516	$270,721.63
351,869	6,001	$250,347.99
347,871	6,041	$299,101.83
318,874	5,771	$296,707.02
294,389	5,716	$320,602.46
296,188	5,725	$284,034.29
283,740	6,114	$299,133.74
269,250	6,347	$345,183.80
276,566	6,443	$395,958.22

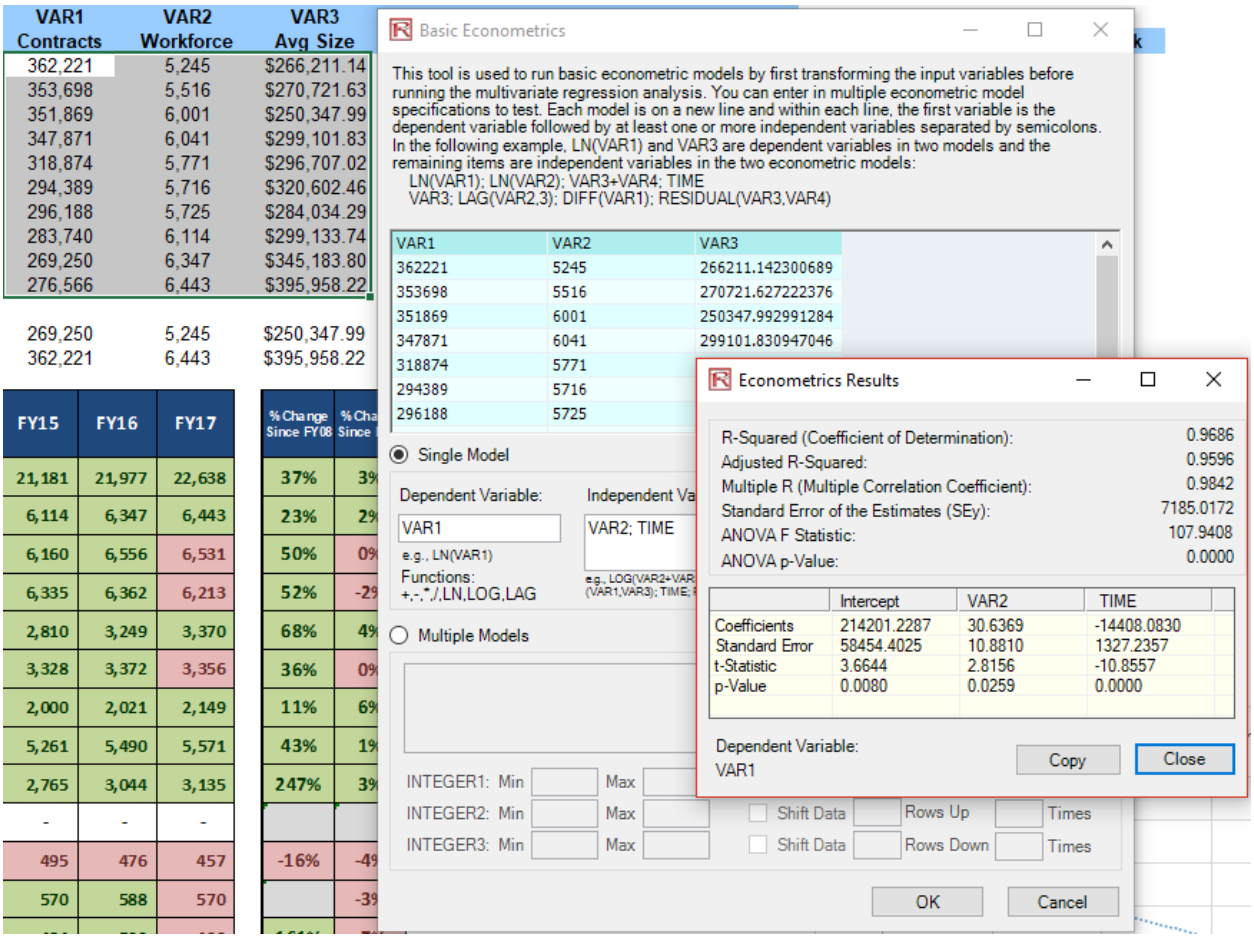
269,250	5,245	$250,347.99
362,221	6,443	$395,958.22

FY15	FY16	FY17	% Change Since FY08	% Cha Since
21,181	21,977	22,638	37%	3%
6,114	6,347	6,443	23%	2%
6,160	6,556	6,531	50%	0%
6,335	6,362	6,213	52%	-2%
2,810	3,249	3,370	68%	4%
3,328	3,372	3,356	36%	0%
2,000	2,021	2,149	11%	6%
5,261	5,490	5,571	43%	1%
2,765	3,044	3,135	247%	3%
-	-	-		
495	476	457	-16%	-4%
570	588	570		-3%

$$CONTRACTS = \alpha + \beta^{*}(WORKFORCE_{t-1})$$

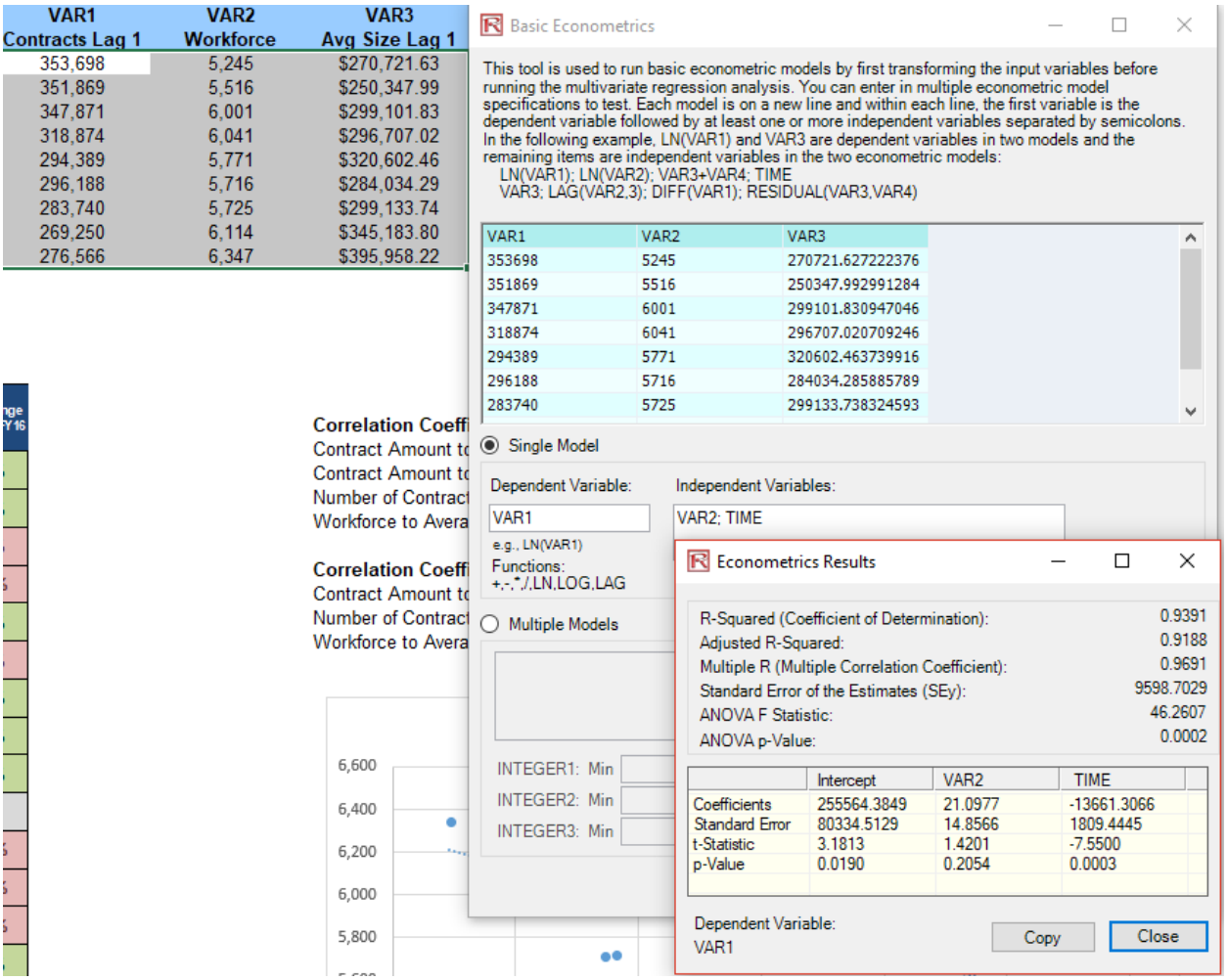


CONTRACTS = $\alpha + \beta_1$*WORKFORCE + β_2*TIME

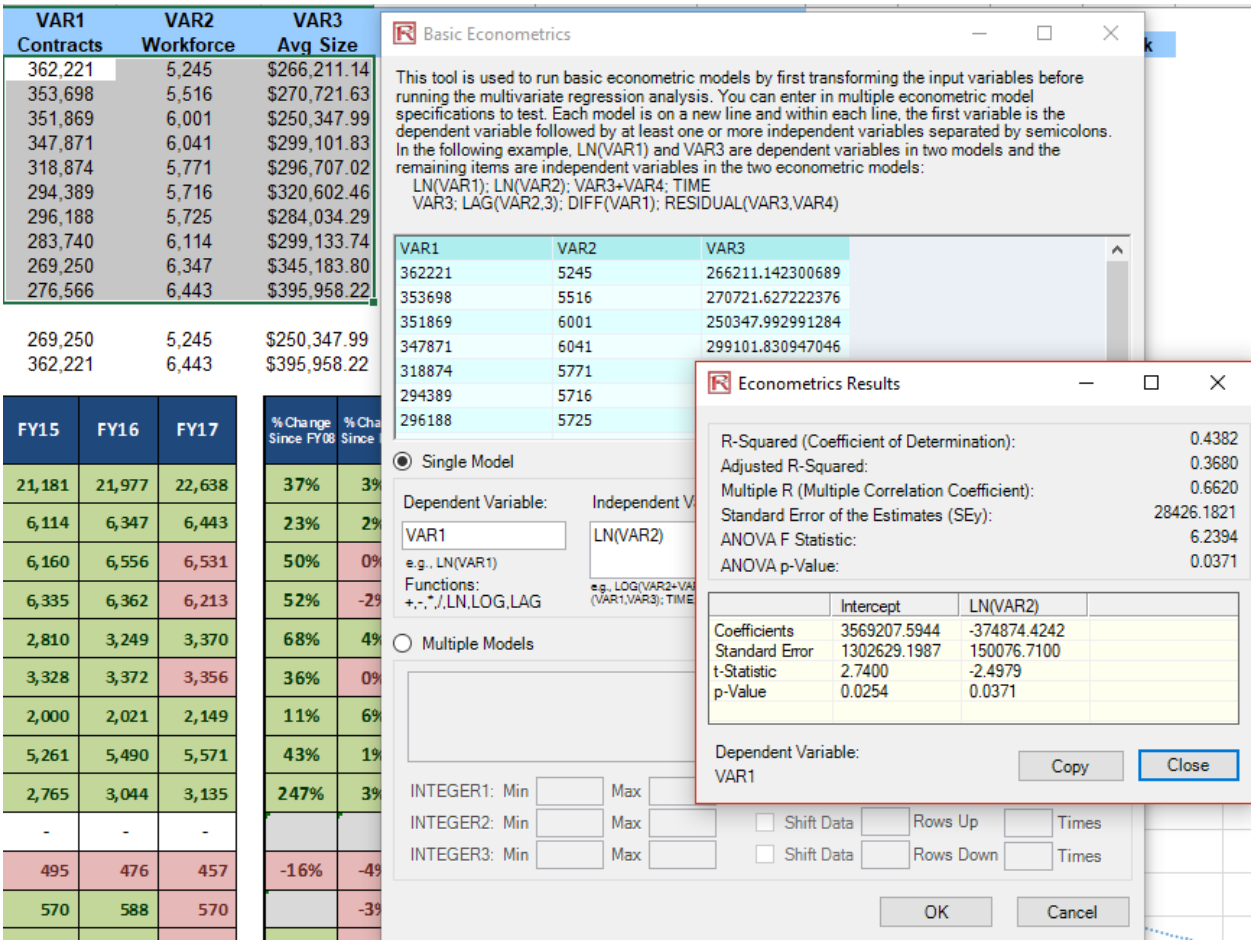


$$CONTRACTS = \alpha + \beta_1 * WORKFORCE_{t-1} + \beta_2 * TIME$$

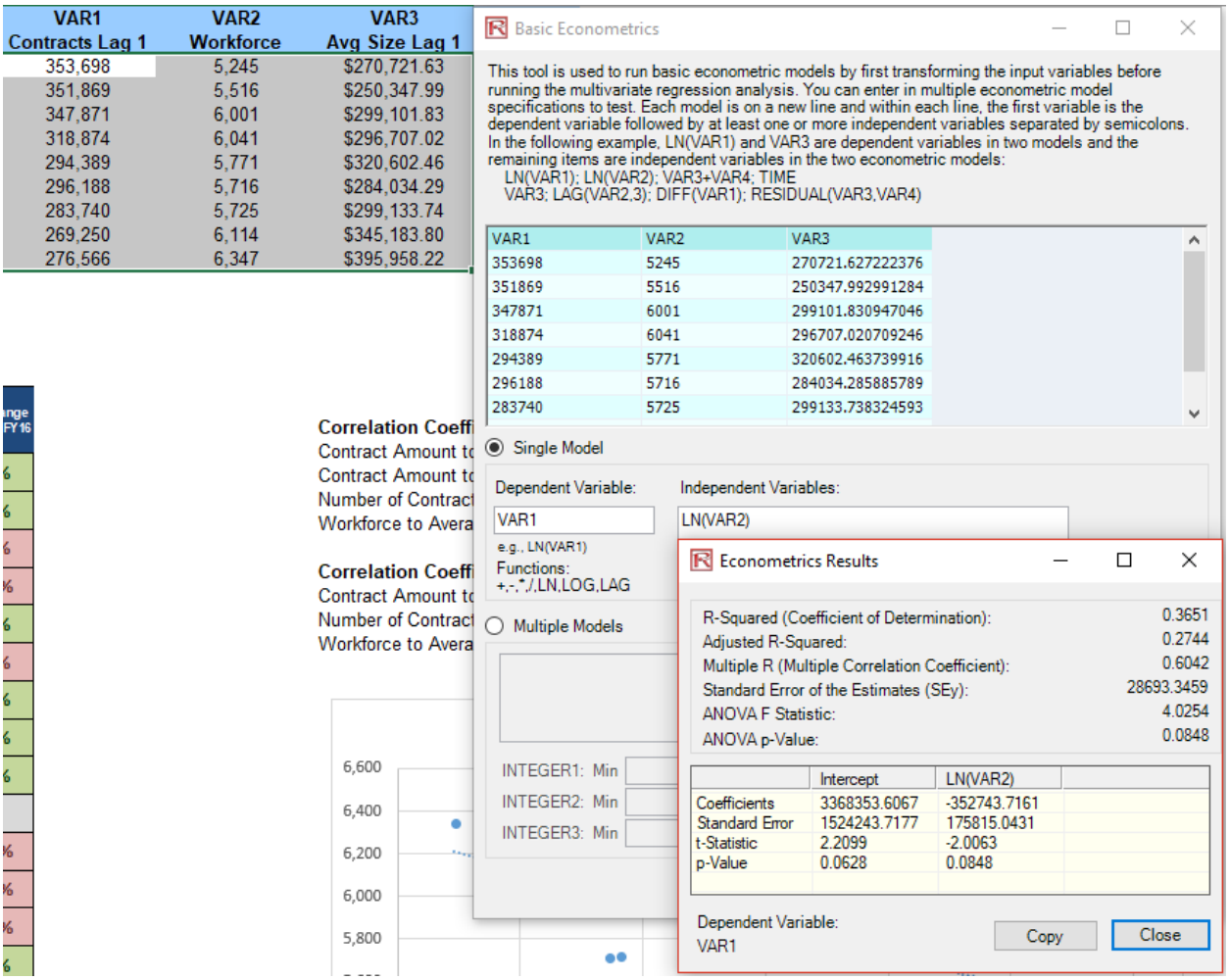
VAR1 Contracts Lag 1	VAR2 Workforce	VAR3 Avg Size Lag 1
353,698	5,245	$270,721.63
351,869	5,516	$250,347.99
347,871	6,001	$299,101.83
318,874	6,041	$296,707.02
294,389	5,771	$320,602.46
296,188	5,716	$284,034.29
283,740	5,725	$299,133.74
269,250	6,114	$345,183.80
276,566	6,347	$395,958.22



CONTRACTS = α + β*LN(WORKFORCE)



$$CONTRACTS = \alpha + \beta * LN(WORKFORCE_{t-1})$$



VAR1 Contracts Lag 1	VAR2 Workforce	VAR3 Avg Size Lag 1
353,698	5,245	$270,721.63
351,869	5,516	$250,347.99
347,871	6,001	$299,101.83
318,874	6,041	$296,707.02
294,389	5,771	$320,602.46
296,188	5,716	$284,034.29
283,740	5,725	$299,133.74
269,250	6,114	$345,183.80
276,566	6,347	$395,958.22

CONTRACTS = $\alpha + \beta_1$*LN(WORKFORCE) + β_2*TIME

VAR1 Contracts	VAR2 Workforce	VAR3 Avg Size
362,221	5,245	$266,211.14
353,698	5,516	$270,721.63
351,869	6,001	$250,347.99
347,871	6,041	$299,101.83
318,874	5,771	$296,707.02
294,389	5,716	$320,602.46
296,188	5,725	$284,034.29
283,740	6,114	$299,133.74
269,250	6,347	$345,183.80
276,566	6,443	$395,958.22

269,250 5,245 $250,347.99
362,221 6,443 $395,958.22

FY15	FY16	FY17
21,181	21,977	22,638
6,114	6,347	6,443
6,160	6,556	6,531
6,335	6,362	6,213
2,810	3,249	3,370
3,328	3,372	3,356
2,000	2,021	2,149
5,261	5,490	5,571
2,765	3,044	3,135
-	-	-
495	476	457
570	588	570

% Change Since FY08	% Cha Since
37%	3%
23%	2%
50%	0%
52%	-2%
68%	4%
36%	0%
11%	6%
43%	1%
247%	3%
-16%	-4%
	-3%

Basic Econometrics

This tool is used to run basic econometric models by first transforming the input variables before running the multivariate regression analysis. You can enter in multiple econometric model specifications to test. Each model is on a new line and within each line, the first variable is the dependent variable followed by at least one or more independent variables separated by semicolons. In the following example, LN(VAR1) and VAR3 are dependent variables in two models and the remaining items are independent variables in the two econometric models:
LN(VAR1); LN(VAR2); VAR3+VAR4; TIME
VAR3; LAG(VAR2,3); DIFF(VAR1); RESIDUAL(VAR3,VAR4)

VAR1	VAR2	VAR3
362221	5245	266211.142300689
353698	5516	270721.627222376
351869	6001	250347.992991284
347871	6041	299101.830947046
318874	5771	296707.020709246
294389	5716	320602.463739916
296188	5725	284034.285885789

Single Model

Dependent Variable: VAR1
e.g., LN(VAR1)
Functions: +,-,*,/,LN,LOG,LAG

Independent Var: LN(VAR2); TIME
e.g., LOG(VAR2+VAR3) (VAR1,VAR3); TIME; F

Multiple Models

INTEGER1: Min Max
INTEGER2: Min Max
INTEGER3: Min Max

OK Cancel

Econometrics Results

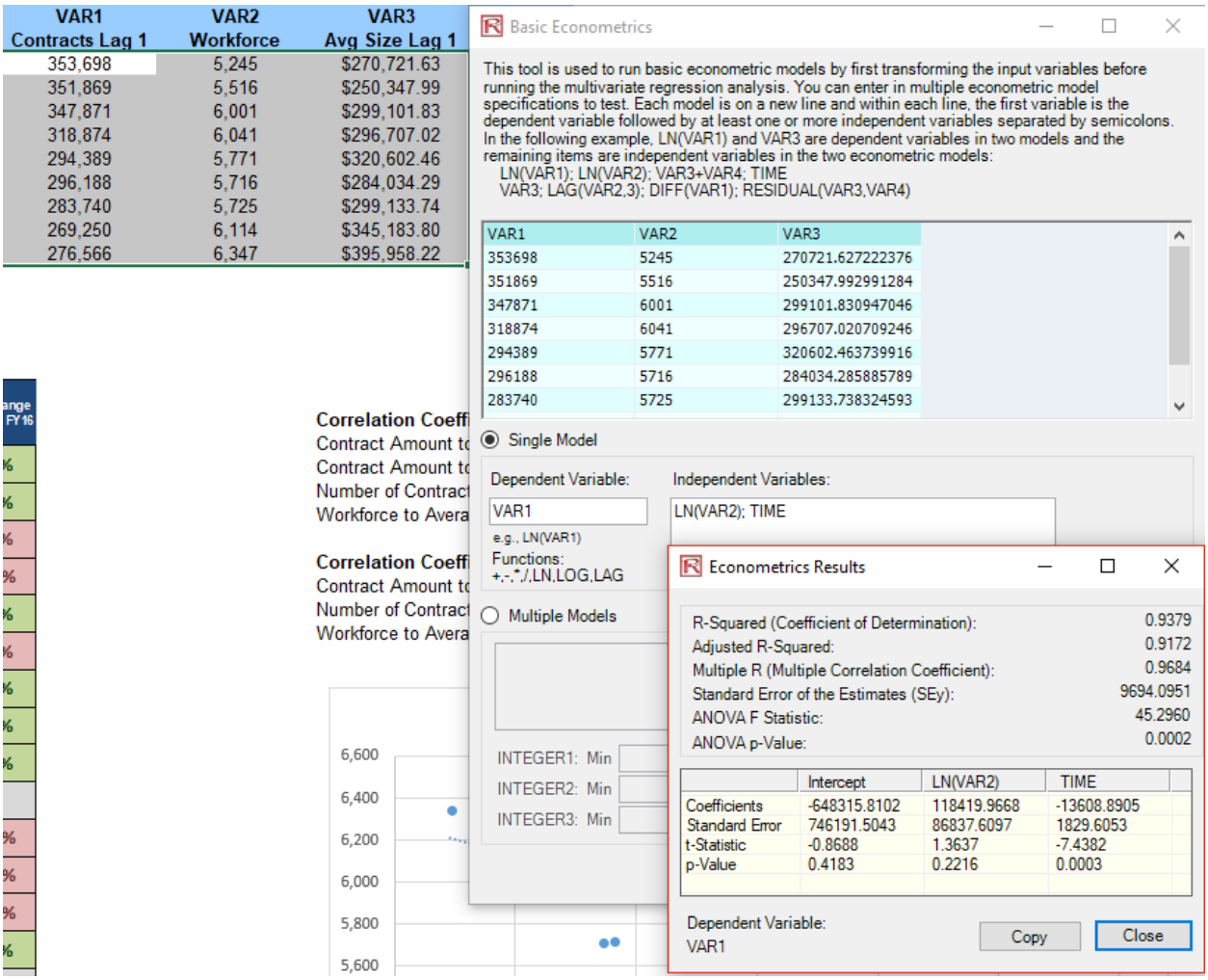
R-Squared (Coefficient of Determination):	0.9679
Adjusted R-Squared:	0.9587
Multiple R (Multiple Correlation Coefficient):	0.9838
Standard Error of the Estimates (SEy):	7262.0061
ANOVA F Statistic:	105.5904
ANOVA p-Value:	0.0000

	Intercept	LN(VAR2)	TIME
Coefficients	-1139463.6308	176726.6432	-14359.5195
Standard Error	550068.1734	64050.6251	1335.6776
t-Statistic	-2.0715	2.7592	-10.7507
p-Value	0.0770	0.0281	0.0000

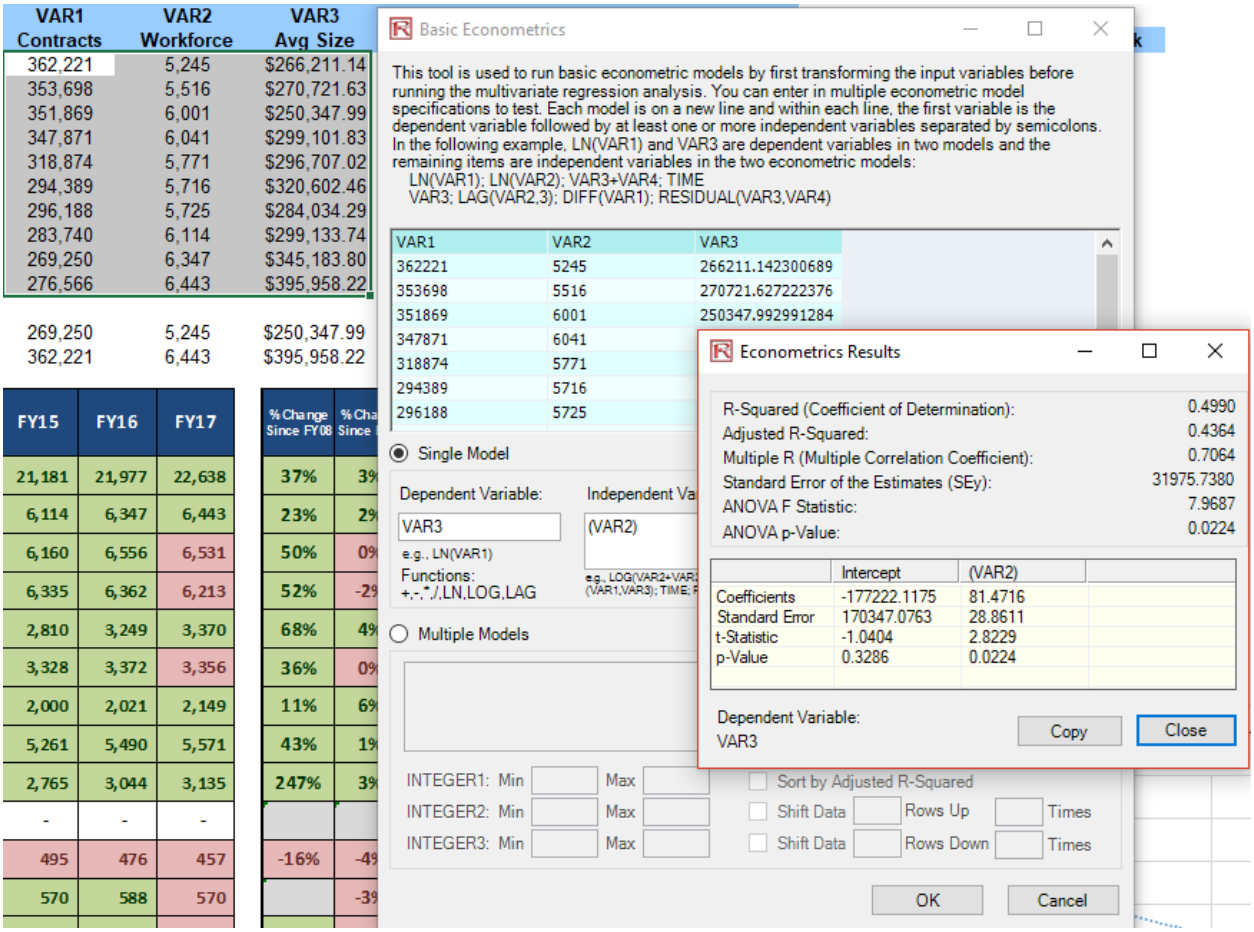
Dependent Variable: VAR1
Copy Close

$$CONTRACTS = \alpha + \beta_1 * LN(WORKFORCE_{t-1}) + \beta_2 TIME$$

VAR1 Contracts Lag 1	VAR2 Workforce	VAR3 Avg Size Lag 1
353,698	5,245	$270,721.63
351,869	5,516	$250,347.99
347,871	6,001	$299,101.83
318,874	6,041	$296,707.02
294,389	5,771	$320,602.46
296,188	5,716	$284,034.29
283,740	5,725	$299,133.74
269,250	6,114	$345,183.80
276,566	6,347	$395,958.22

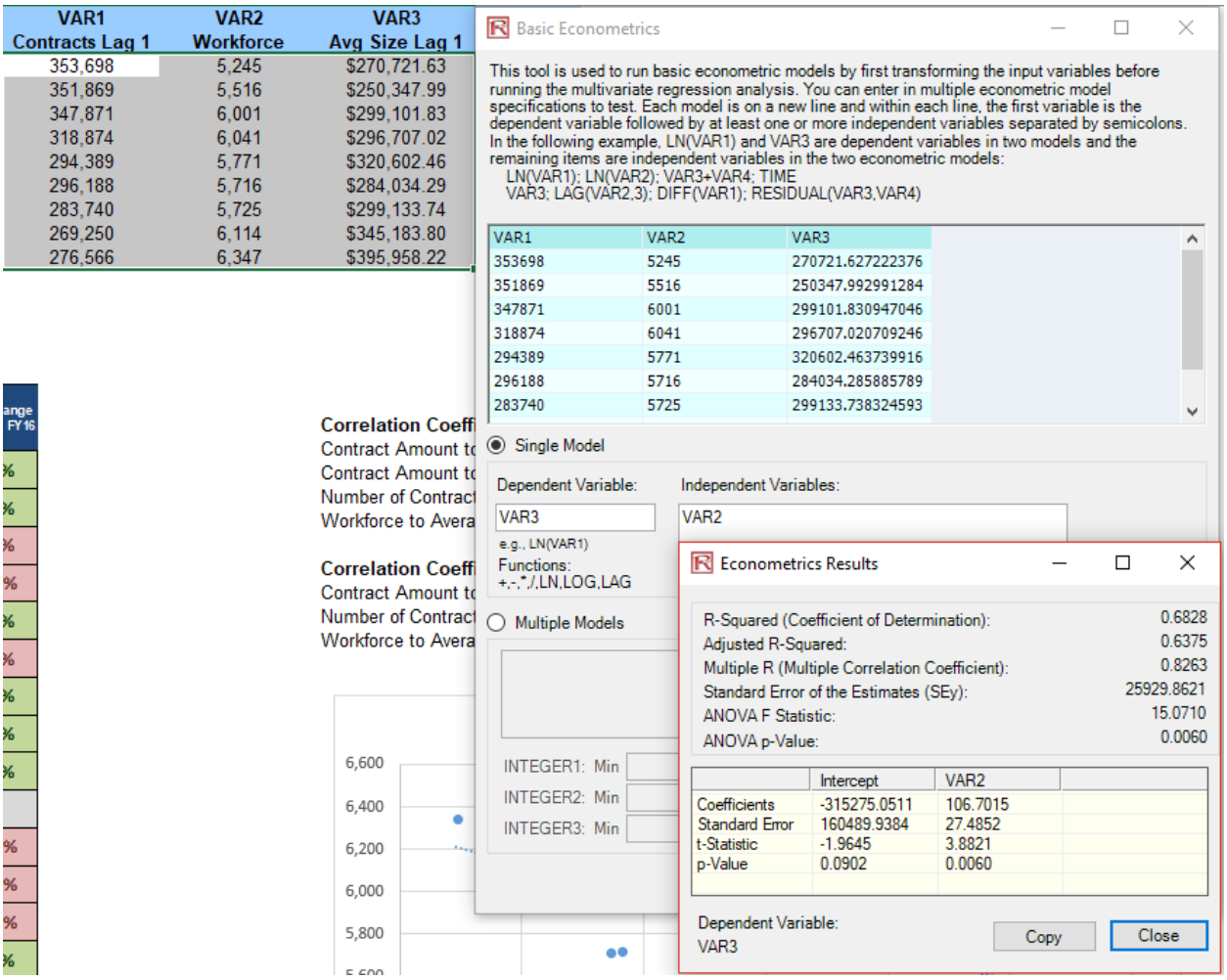


AVG CONTRACT SIZE = α + β*(WORKFORCE)

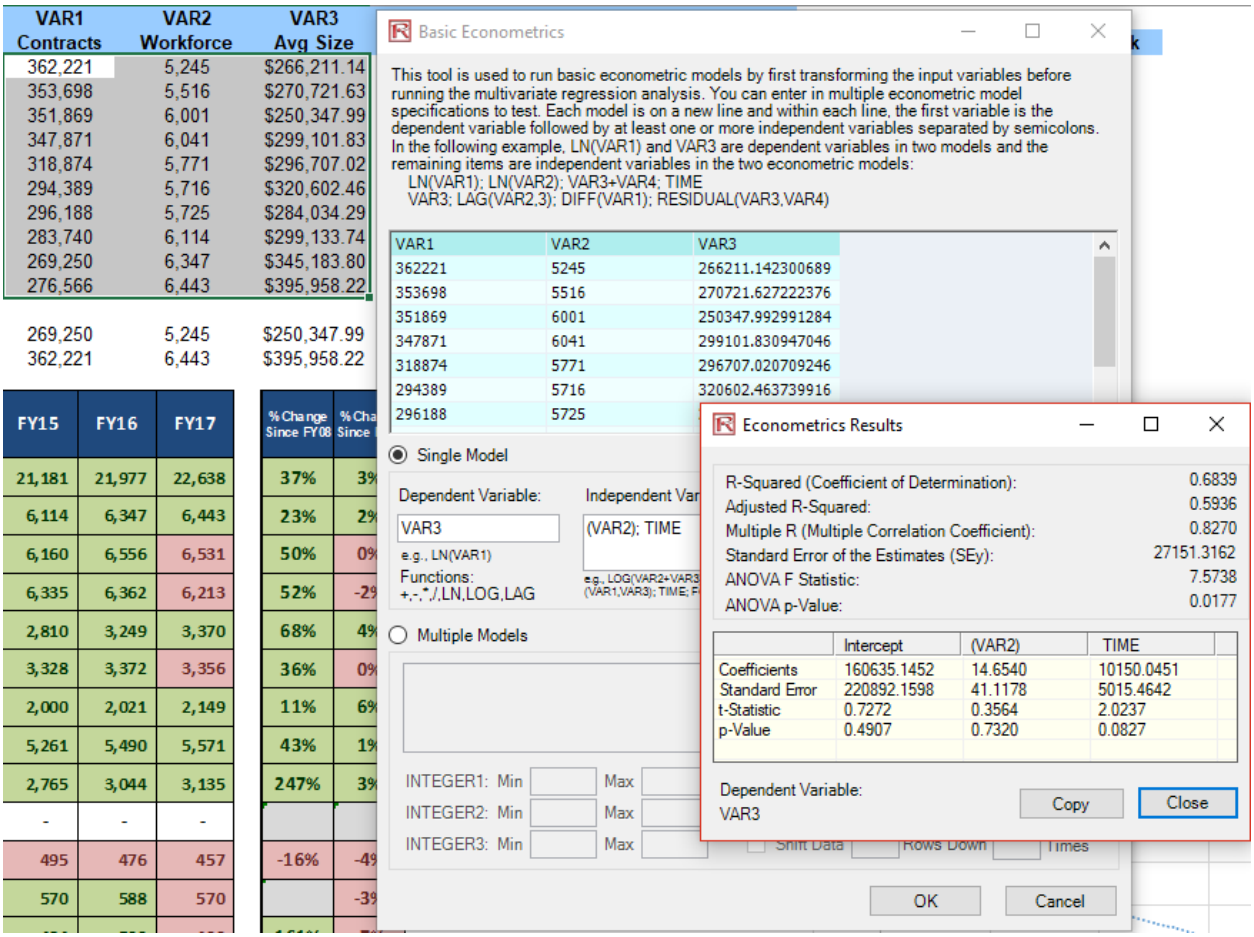


AVG CONTRACT SIZE = $\alpha + \beta^{*}(\text{WORKFORCE}_{t-1})$

VAR1 Contracts Lag 1	VAR2 Workforce	VAR3 Avg Size Lag 1
353,698	5,245	$270,721.63
351,869	5,516	$250,347.99
347,871	6,001	$299,101.83
318,874	6,041	$296,707.02
294,389	5,771	$320,602.46
296,188	5,716	$284,034.29
283,740	5,725	$299,133.74
269,250	6,114	$345,183.80
276,566	6,347	$395,958.22

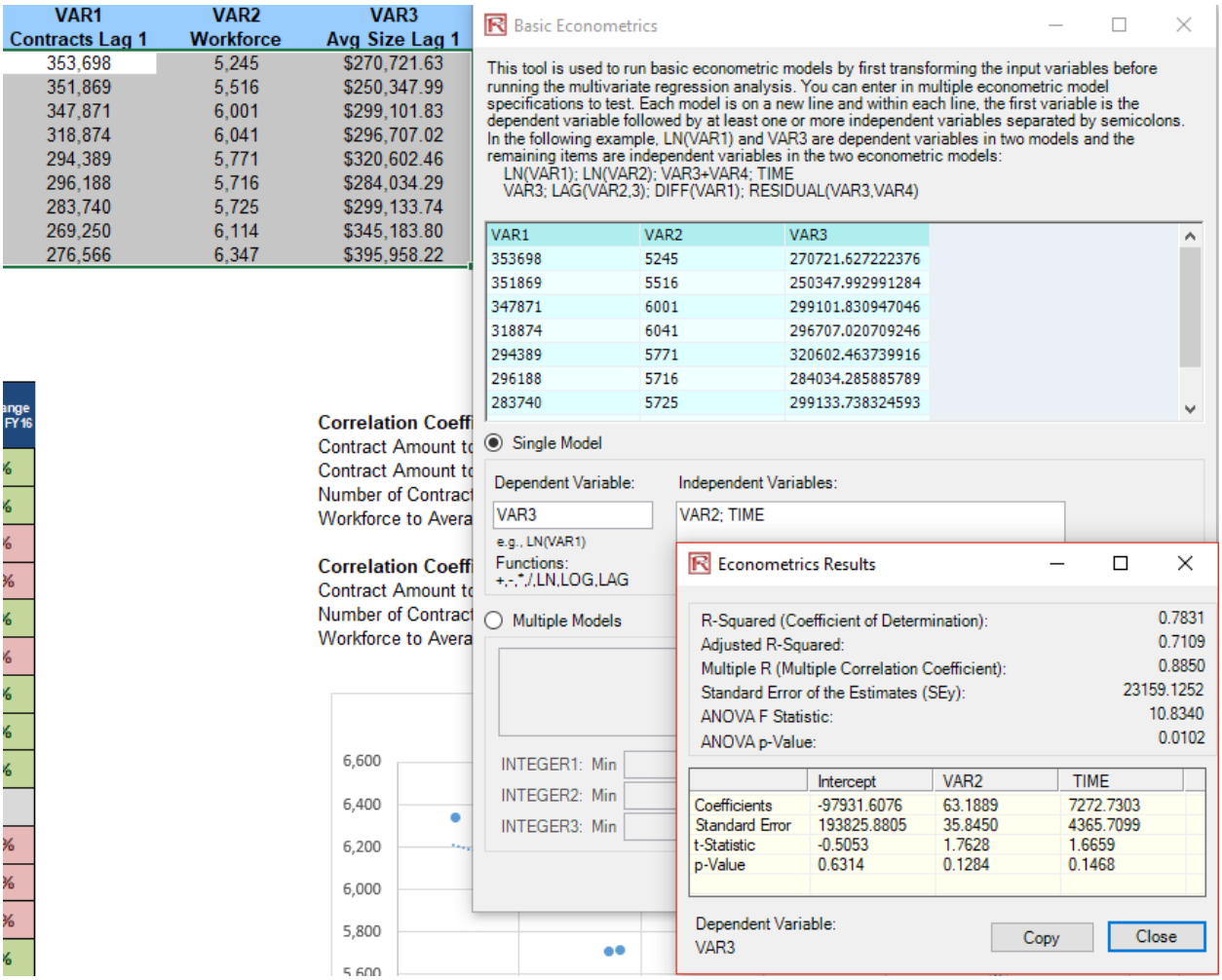


AVG CONTRACT SIZE = $\alpha + \beta_1$*WORKFORCE + β_2*TIME

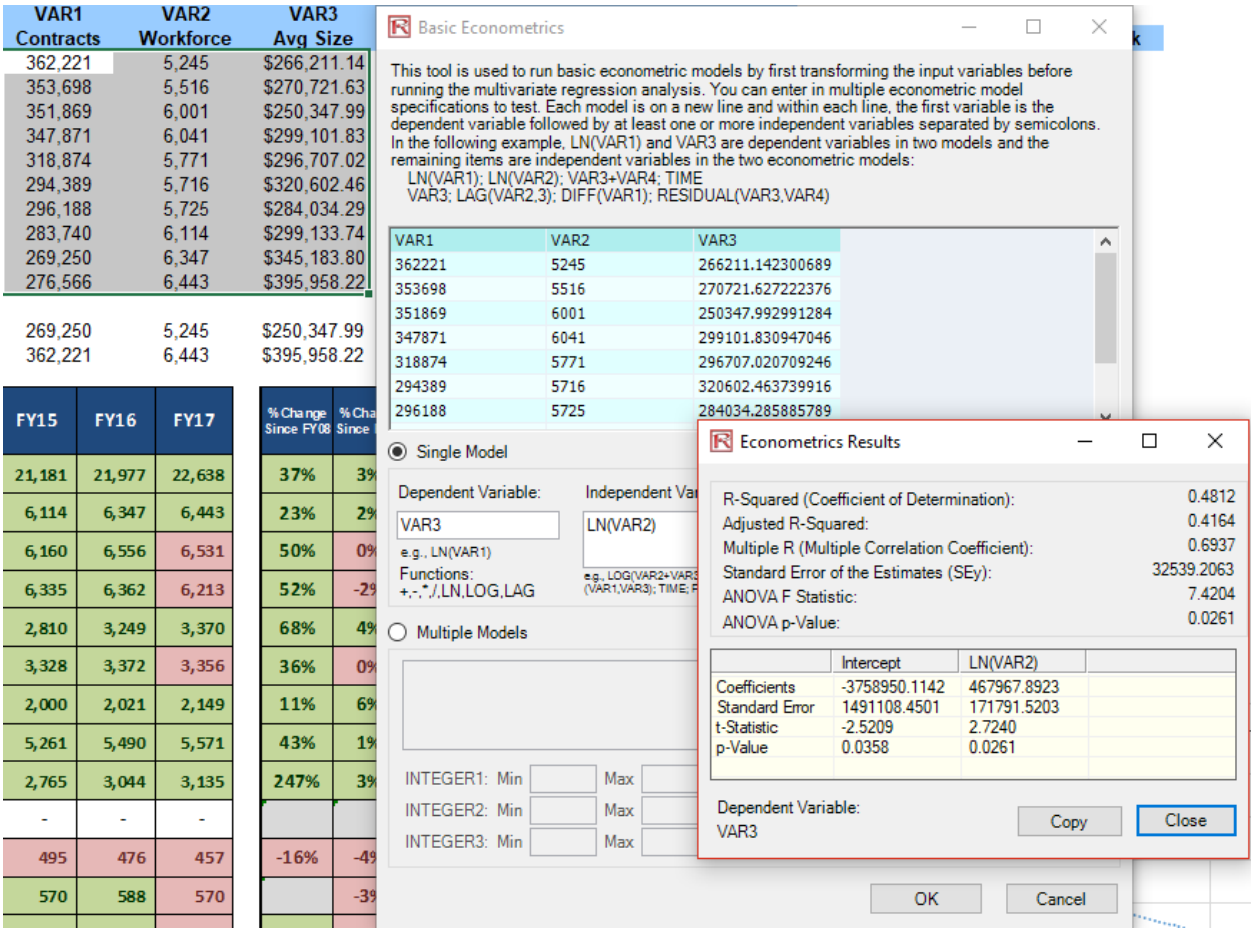


$$\text{AVG CONTRACT SIZE} = \alpha + \beta_1 * \text{WORKFORCE}_{t-1} + \beta_2 * \text{TIME}$$

VAR1 Contracts Lag 1	VAR2 Workforce	VAR3 Avg Size Lag 1
353,698	5,245	$270,721.63
351,869	5,516	$250,347.99
347,871	6,001	$299,101.83
318,874	6,041	$296,707.02
294,389	5,771	$320,602.46
296,188	5,716	$284,034.29
283,740	5,725	$299,133.74
269,250	6,114	$345,183.80
276,566	6,347	$395,958.22



AVG CONTRACT SIZE = α + β*LN(WORKFORCE)

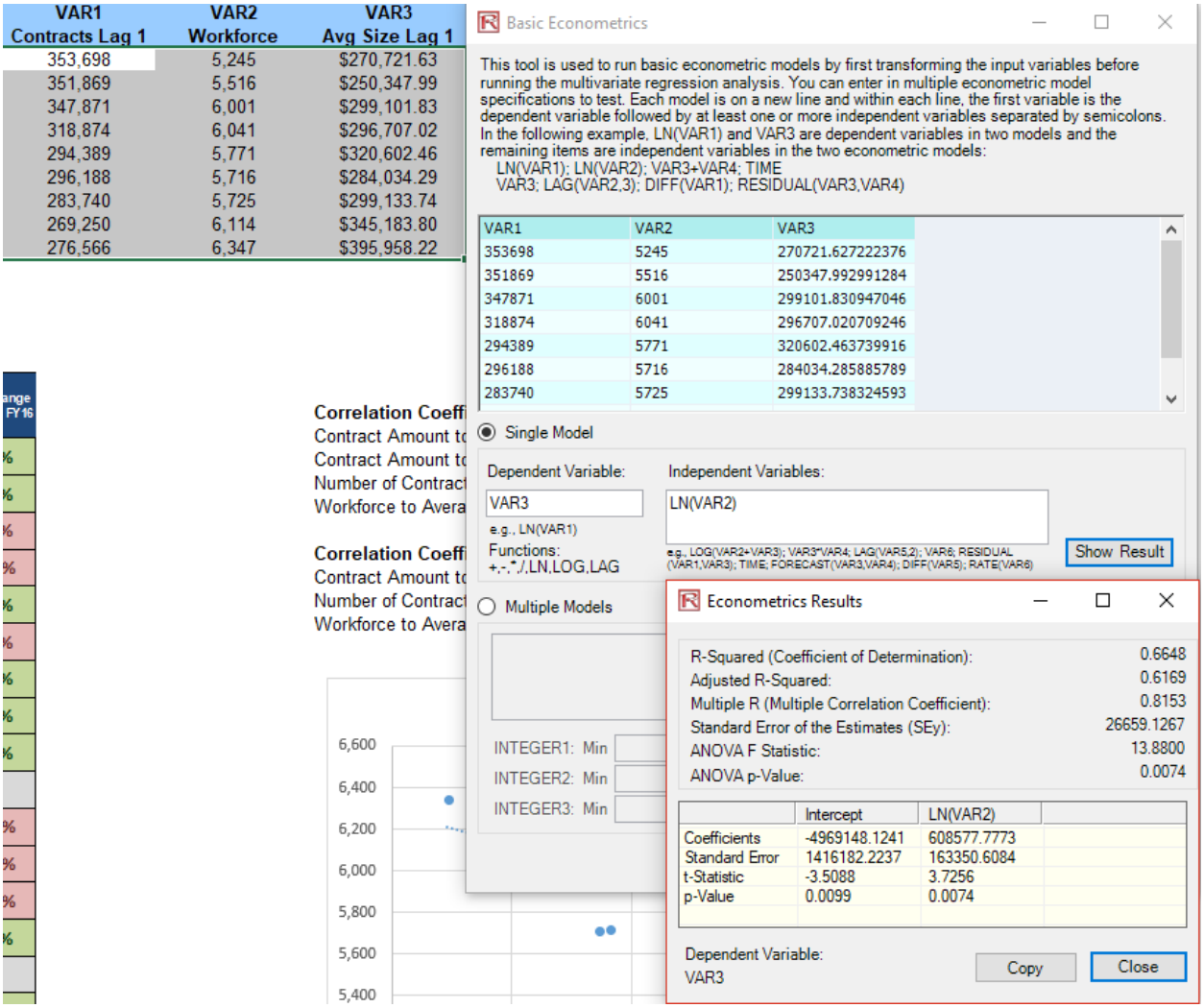


VAR1 Contracts	VAR2 Workforce	VAR3 Avg Size
362,221	5,245	$266,211.14
353,698	5,516	$270,721.63
351,869	6,001	$250,347.99
347,871	6,041	$299,101.83
318,874	5,771	$296,707.02
294,389	5,716	$320,602.46
296,188	5,725	$284,034.29
283,740	6,114	$299,133.74
269,250	6,347	$345,183.80
276,566	6,443	$395,958.22
269,250	5,245	$250,347.99
362,221	6,443	$395,958.22

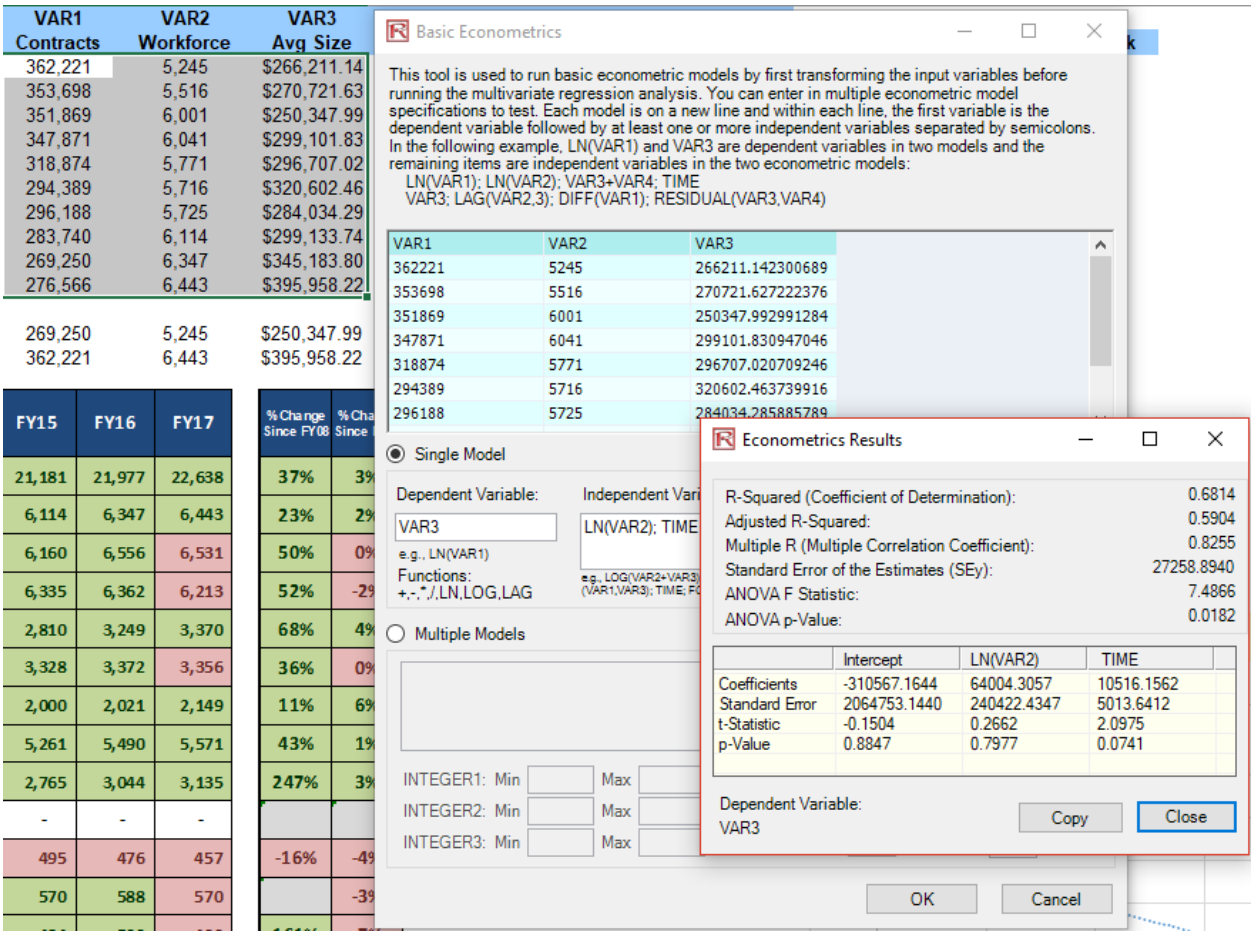
FY15	FY16	FY17	% Change Since FY08	% Cha Since
21,181	21,977	22,638	37%	3%
6,114	6,347	6,443	23%	2%
6,160	6,556	6,531	50%	0%
6,335	6,362	6,213	52%	-2%
2,810	3,249	3,370	68%	4%
3,328	3,372	3,356	36%	0%
2,000	2,021	2,149	11%	6%
5,261	5,490	5,571	43%	1%
2,765	3,044	3,135	247%	3%
-	-	-		
495	476	457	-16%	-4%
570	588	570		-3%

AVG CONTRACT SIZE = $\alpha + \beta$*LN(WORKFORCE $_{t-1}$)

VAR1 Contracts Lag 1	VAR2 Workforce	VAR3 Avg Size Lag 1
353,698	5,245	$270,721.63
351,869	5,516	$250,347.99
347,871	6,001	$299,101.83
318,874	6,041	$296,707.02
294,389	5,771	$320,602.46
296,188	5,716	$284,034.29
283,740	5,725	$299,133.74
269,250	6,114	$345,183.80
276,566	6,347	$395,958.22

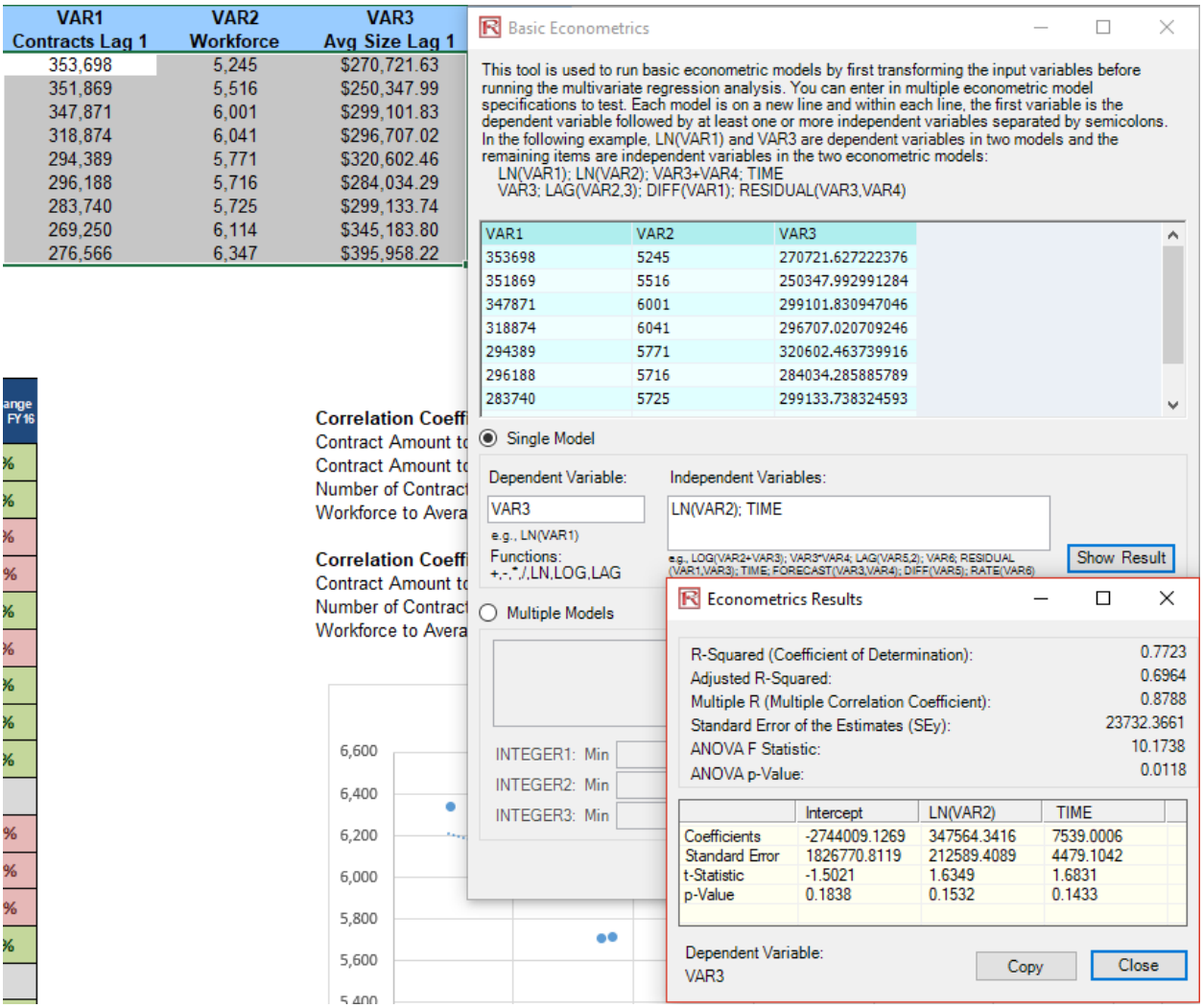


AVG CONTRACT SIZE = $\alpha + \beta_1$*LN(WORKFORCE) + β_2*TIME



$$\text{AVG CONTRACT SIZE} = \alpha + \beta_1 * \text{LN}(\text{WORKFORCE}_{t-1}) + \beta_2 * \text{TIME}$$

VAR1 Contracts Lag 1	VAR2 Workforce	VAR3 Avg Size Lag 1
353,698	5,245	$270,721.63
351,869	5,516	$250,347.99
347,871	6,001	$299,101.83
318,874	6,041	$296,707.02
294,389	5,771	$320,602.46
296,188	5,716	$284,034.29
283,740	5,725	$299,133.74
269,250	6,114	$345,183.80
276,566	6,347	$395,958.22



THIS PAGE LEFT INTENTIONALLY BLANK

References

Department of Defense (DoD). (2007, February). *Department of Defense budget fiscal year 2008: Procurement programs (P-1)*. Washington, DC: Office of the Under Secretary of Defense (Comptroller).

Department of Defense (DoD). (2015, September 16). *Performance of the Defense Acquisition System*: *Annual report*. Retrieved from https://dod.defense.gov/Portals/1/Documents/pubs/Performance-of-Defense-Acquisition-System-2015.pdf

Department of Defense (DoD). (2017, March). *Department of Defense Budget: March budget amendment to the fiscal year 2007 President's Budget request for BASE + Overseas Contingency Operations (OCO): Procurement programs (P-1)*. Washington, DC: Office of the Under Secretary of Defense (Comptroller).

Department of the Navy (DoN). (2010, August). *DoN acquisition workforce strategic plan*. Retrieved from http://www.secnav.navy.mil/rda/workforce/Documents/donawfstrategicplanaug2010.pdf

Diggs, S. N., & Roman, A. V. (2012, December). Understanding and tracing accountability in the procurement process. *Public Performance & Management Review*, *36*(2), 290−315.

Gates, S. M. (2009). *Shining a spotlight on the Defense Acquisition Workforce—Again* (OP-266). Retrieved from http://www.rand.org

Gates, S. M., Roth, E., Srinivasan, S., & Dougherty, L. (2013). *Analyses of the Department of Defense acquisition workforce: Update to methods and results through FY 2011* (RR-110). Santa Monica, CA: RAND. Retrieved from http://www.rand.org

Government Accountability Office (GAO). (2012, April). *Defense acquisitions: Further actions needed to improve accountability for DOD's inventory of contracted services* (GAO-12-357). Retrieved from http://www.gao.gov

Lewis, I. (2016, October 19). *The Naval Acquisition Workforce: Toward understanding the impact of its growth* (NPS-AM-17-001). Monterey, CA: Naval Postgraduate School, Acquisition Research Program. Retrieved from http://acquisitionresearch.net

March, J. G., & Sutton, R. I. (1997, November–December). Organizational performance as a dependent variable. *Organization Science*, *8*(6), 698−706.

McKeithen, M. L. (2016, December). *An organizational climate assessment of the Army Contracting Workforce* (MBA professional project). Monterey, CA: Naval Postgraduate School. Retrieved from http://calhoun.nps.edu

McKernan, M., Moore, N. Y., Connor, K., Chenoweth, M. E., Drezner, J. A., Dryden, J., . . . Szafran, A. (2017). *Access to acquisition data and information in the Department of Defense: Doing data right in weapon system acquisition* (RR-1534). Santa Monica, CA: RAND. Retrieved from http://www.rand.org

Mun, J. (2015). *Modeling risk: Applying Monte Carlo risk simulation, strategic real options analysis, stochastic forecasting, and portfolio optimization* (3rd Ed.). Hoboken, NJ: Thomson-Shore.

Powell, M. H. (2017). *The Defense Acquisition Workforce Growth Initiative: Changing workforce characteristics and the implications for workforce retention* (RGSD-383). Santa Monica, CA: RAND. Retrieved from http://rand.org

Rendon, R. G. (2015). Benchmarking contract management process maturity: A case study of the US Navy. *Benchmarking: An International Journal*, *22(7*), 1481−1508.

Rendon, R. G., & Snider, K. F. (2014). Retrieving what's already there: Archival data for research in defense acquisition. In J. Soeters, P. M. Shields, and S. Rietjens (Eds.), *Routledge handbook of research methods in military studies* (pp. 78−91). London, England: Routledge.

Richard, P. J., Devinney, T. M., Yip, G. S., & Johnson, G. (2009, June). Measuring organizational performance: Towards methodological best practice. *Journal of Management*, *35*(3), 718−804.

Schwartz, M., Francis, K. A., & O'Connor, C. V. (2016, July 29). *The Department of Defense acquisition workforce: Background, analysis and questions for Congress* (R44578). Washington, DC: Congressional Research Service.

Biographies

Ira Lewis, PhD, MBA, BA

EDUCATION

Arizona State University, Doctor of Philosophy (Logistics and Operations Management), 1992

University of Ottawa, Master of Business Administration, 1982

University of Ottawa, Bachelor of Arts, 1980

EXPERIENCE

1998–Present	Associate Professor of Logistics, Naval Postgraduate School, Monterey, California
1982–1998	Various positions in program analysis and evaluation, Department of National Defense, Ottawa, Canada

ACADEMIC PUBLICATIONS

- Ira Lewis, *The Defense Acquisition Workforce Growth Initiative: Toward an Assessment of its Impact on Department of the Navy Acquisition Activity*, October 2017, Naval Postgraduate School, Graduate School of Business and Public Policy, Acquisition Research Report Series, NPS-HR-18-006.

- Ira Lewis, *The Naval Acquisition Workforce: Toward Understanding the Impact of Its Growth*, October 2016, Naval Postgraduate School, Graduate School of Business and Public Policy, Acquisition Research Report Series, NPS-AM-17-001.

- Ira Lewis, *Persistent Platforms—The DDG 51 Case,* September 2015, Naval Postgraduate School, Graduate School of Business and Public Policy, Acquisition Research Report Series, NPS-AM-15-124.

- Kenneth Doerr, Donald R. Eaton, and Ira A. Lewis, “Measurement issues in performance-based logistics” in Adedeji B. Badiru and LeeAnn Racz, Ed., *Handbook of Measurements: Benchmarks for Systems Accuracy and Precision*, pp. 287–302. Boca Raton, FL: CRC Press, 2015.

- Raymond E. Franck, Ira Lewis and Bernard Udis, *Impact of Export Control and Technology Transfer Regimes: International Perspectives*, January 2012. Naval Postgraduate School, Graduate School of Business and Public Policy, Acquisition Research Report Series, NPS-AM-12-001.

Johnathan Mun, PhD, MBA, MS, BS, CQRM, CFC, FRM, MIFC

EDUCATION

Lehigh University, Doctor of Philosophy, Finance and Economics, 1998

Nova Southeastern University, Master of Business Administration, 1995 (Summa Cum Laude)

University of Miami, Bachelor of Science, 1994 (Magna Cum Laude)

EXPERIENCE

2005–Present:	Research Professor, Naval Postgraduate School, Monterey, California
2005–Present:	Chairman and CEO, Real Options Valuation, Inc., Dublin, California
2001–2010:	Visiting Professor, University of Applied Sciences and Swiss School of Management, Switzerland
2001–2004:	Vice President of Analytics, Decisioneering-Oracle, Denver, Colorado
1999–2001:	Senior Manager and Economist, KPMG Consulting, California
1998–2001:	Adjunct Professor, Golden Gate Univ. and St. Mary's College, California
1998–1999:	Manager, Viking, Inc. (FDX Corporation), California

PUBLISHED BOOKS

- *Real Options Analysis: Tools and Techniques for Valuing Strategic Investments and Decisions,* Third Edition, Thomson-Shore (2016).
- *Modeling Risk: Applying Monte Carlo Risk Simulation, Strategic Real Options Analysis, Stochastic Forecasting, and Portfolio Optimization,* Third Edition, Thomson-Shore (2015).
- *Modeling Risk: Applying Monte Carlo Risk Simulation, Strategic Real Options Analysis, Stochastic Forecasting, and Portfolio Optimization,* Second Edition, Wiley Finance (2010).
- *Credit Engineering for Bankers,* Elsevier Academic Press (2010).
- *Advanced Analytical Models: Over 800 Models and 300 Applications from Basel Accords to Wall Street,* Wiley (2008).
- *The Banker's Handbook on Credit Risk: Implementing Basel II and Credit Risk,* Elsevier and Academic Press (2008).
- *Modeling Risk: Applying Monte Carlo Simulation, Real Options Analysis, Stochastic Forecasting, and Optimization,* Wiley Finance (2006).
- *Real Options Analysis: Tools and Techniques for Valuing Strategic Investments and Decisions,* Second Edition, Wiley (2005).
- *Valuing Employee Stock Options: Under 2004 FAS 123,* Wiley Finance (2004).

- *Applied Risk Analysis: Moving Beyond Uncertainty,* Wiley Finance (2003).
- *Real Options Analysis Course: Business Cases and Applications,* Wiley Finance (2003).
- *Real Options Analysis: Tools and Techniques for Valuing Strategic Investments and Decisions,* Wiley Finance (2002).

ACADEMIC PUBLICATIONS

- "A New Theory of Value: The New Invisible Hand of Altruism," in *Intellectual Capital in Organizations*, Routledge (2015).
- "A Risk-Based Approach to Cost-Benefit Analysis: Monte Carlo Risk Simulation, Strategic Real Options Analysis, Knowledge Value Added, and Portfolio Optimization," Chapter 11 in *Military Cost-Benefit Analysis,* Taylor & Francis (2015).
- "Real Options in Practice," Chapter 2 in H. B. Nembhard and M. Aktan (Editors), *Real Options in Engineering Design, Operations, and Management,* CRC Press (2012).
- "Hands-On Applications of Real Options SLS," Chapter 15 in H. B. Nembhard and M. Aktan (Editors), *Real Options in Engineering Design, Operations, and Management,* CRC Press (2012).
- "Capturing the Strategic Flexibility of Investment Decisions through Real Options Analysis," Article #5 in U. Hommel et al. (Editors), *The Strategic CFO: Creating Value in a Dynamic Market Environment,* Springer, Berlin (2011).
- "Monte Carlo Risk Simulation," Chapter 17 in J. B. Abrams, *Quantitative Business Valuation: A Mathematical Approach for Today's Professionals,* Second Edition, Wiley (2010).
- "Real Options," Chapter 18, J. B. Abrams, *Quantitative Business Valuation: A Mathematical Approach for Today's Professionals,* Second Edition, Wiley (2010).
- "Real Options and Monte Carlo Simulation versus Traditional DCF Valuation in Layman's Terms," Chapter 6 in K. B. Leggio (Editor), *Managing Enterprise Risk,* Elsevier (2006).
- "Strategic Real Options Valuation," Chapter 7 in R. Razgaitis, *Deal Making Using Real Options,* Wiley (2003).
- "Managing Bank Risk," in *Bank Risk,* Morton Glantz, Academic Press (2003).
- "Make or Buy: An Analysis of the Impacts of 3D Printing Operations, 3D Laser Scanning Technology, and Collaborative Product Lifecycle Management on Ship Maintenance and Modernization Cost Savings," *Acquisitions Research,* 2015.
- "Applying Fuzzy Inference Systems, ASKE, Knowledge Value Added, and Monte Carlo Risk Simulation to Value Intangible Human Capital Investments," *AIP (American Institute of Physics) Conference Proceedings,* 2013.
- "Naval Ship Maintenance: An Analysis of Dutch Shipbuilding Industry Using the Knowledge Value Added, Systems Dynamics, and Integrated Risk Management Methodologies," *Acquisitions Research* (U.S. Department of Defense), 2013.
- "Applying Fuzzy Inference Systems, ASKE, Knowledge Value Added, and Monte Carlo Risk Simulation to Value Intangible Human Capital Investments," Math and Science Symposium in Malaysia, December 2012.

- "Human Capital Valuation and Return of Investment on Corporate Education," *Journal of Expert Systems with Applications* Vol. 39, No. 15, 11934–11943, Nov. 2012.
- "Integrated Risk Management: A Layman's Primer" (in Russian), *Journal of Economic Strategies,* No. 6–7, 48–62, 2012.
- "Application of Real Options Theory to Department of Defense Software Acquisitions," *Defense Acquisition Research Journal,* Vol. 18, No. 1, 81, Jan. 2011.
- "AEGIS Weapons System and Advanced Concept Builds for the U.S. Navy," Acquisition Research Symposium, 2010.
- "Advanced Capability Builds: Portfolio Optimization, Selection and Prioritization, Risk Simulation, KVA, and Strategic Real Options Analysis," *Acquisitions Research* (U.S. Department of Defense), Sept. 2009.
- "Application of Real Options Theory to Software Engineering for Strategic Decision Making in Software Related Capital Investments in the U.S. Department of Defense," *Acquisitions Research* (U.S. Department of Defense), Feb. 2009.
- "Ship Maintenance and Project Lifecycle Management," Acquisitions Symposium (U.S. Department of Defense), 2008.
- "A Primer on Integrated Risk Management for the Military," Acquisitions Symposium (U.S. Department of Defense), 2007.
- "AEGIS Platforms: The Potential Impact of Open Architecture in Sustaining Engineering," *Acquisitions Research* (U.S. Department of Defense), Oct. 2007.
- "Return on Investment in Non-Revenue Generating Activities: Applying KVA and Real Options to Government Operations," U.S. Department of Defense, HICSS, 2007.
- "AEGIS and Ship-to-Ship Self-Defense System Platforms: Using KVA Analysis, Risk Simulation and Strategic Real Options to Assess Operational Effectiveness," *Acquisitions Research* (U.S. Department of Defense), 2006.
- "A Methodology for Improving the Shipyard Planning Process: Using KVA Analysis, Risk Simulation and Strategic Real Options," *Acquisitions Research* (U.S. Department of Defense), May 2006.
- "Reducing Maintenance Program Costs with Improved Engineering Design Processes Using KVA Analysis, Risk Simulation, and Strategic Real Options," *Acquisitions Research* (U.S. Department of Defense), 2005.
- "Real Option Analysis: Implementation for Financial Planners," *Financial Planning Journal,* 2003.
- "A Stepwise Example of Real Options Analysis of a Production Enhancement Project," Society of Petroleum Engineers (SPE) 13th European Petroleum Conference, Aberdeen, Scotland.
- "Using Real Options Software to Value Complex Options," *Financial Engineering News,* 2002.
- "The Contrarian Investment Strategy: Additional Evidence," *Journal of Applied Financial Economics,* 2001.

- "Time-Varying Nonparametric Capital Asset Pricing Model: New Bootstrapping Evidence." *Journal of Applied Financial Economics,* 2000. Paper presented at the 1999 Southern Finance Association Conference, Key West, FL.
- "The Contrarian/Overreaction Hypothesis: A Comparative Analysis of the U.S. and Canadian Stock Markets," *Global Finance Journal,* Vol. 11, No. 1–2, 53–72, 2000.
- "Tests of the Contrarian Investment Strategy: Evidence from the French and German Stock Markets," *International Review of Financial Analysis,* Vol. 8, No. 3, 215–234, 1999.
- "Dividend-Price Puzzle: A Nonparametric Approach," *Advances in Quantitative Accounting and Finance,* Vol. 7, 1998.

Acquisition Research Program
Graduate School of Business & Public Policy
Naval Postgraduate School
555 Dyer Road, Ingersoll Hall
Monterey, CA 93943

www.acquisitionresearch.net