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Inflation Cost Risk Analysis to Reduce Risks in Budgeting

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Biographies

Michael J. DeCarlo graduated from the University of Maryland, Baltimore County, with a B.S. in Applied Statistics in 2011. He is now employed by Booz Allen Hamilton as a Consultant in the Business Analytics Center of Excellence. Within this division, Mr. DeCarlo leverages his knowledge in statistical analysis and research methodology in the utilization, marketing and development of an internally developed statistical modeling tool. Specifically, he has worked on cost models and analysis for the consideration of the Military Health System, Centers for Medicare & Medicaid Services, and Accountable Care Organizations Program.

Stephanie Jabaley is currently enrolled at the University of Mississippi in the School of Business. She has worked full-time as an Intern Research Assistant in Booz Allen Hamilton's Business Analytics Center of Excellence providing research support by participating in writing white papers and briefing decks. She also has participated in the development of systems engineering methodologies at Booz Allen.

Eric R. Druker CCE/A graduated from the College of William and Mary with a B.S. in Applied Mathematics in 2005 concentrating in both Operations Research and Probability & Statistics with a minor in Economics. He is employed by Booz Allen Hamilton as a Lead Associate and currently serves on the St. Louis SCEA Chapter's Board of Directors. Mr. Druker performs cost and risk analysis on several programs within the Intelligence and DoD communities and NASA. He was a recipient of the 2005 Northrop Grumman IT Sector's President's award and the 2008 TASC President's award for his work on Independent Cost Evaluations (ICEs) during which he developed the risk process currently used by Northrop Grumman's ICE teams. In addition to multiple SCEA conferences, Eric has also presented papers at the Naval Postgraduate School's Acquisition Research Symposium, DoDCAS and the NASA PM Challenge. He has also performed decision tree analysis for Northrop Grumman Corporate law, built schedule and cost growth models for Hurricane Katrina Impact Studies and served as lead author of the Regression and Cost/Schedule Risk modules for the 2008 CostPROF update.

Abstract

For any project there is a danger of unanticipated cost growth because inflation rates are extremely difficult to estimate. This presents a significant challenge to estimators. Predicting future inflation rates with some precision is possible, however, when the appropriate analysis is implemented. Even with previous recommendations from a major federal and commercial consulting firm, there is evidence indicating that the government has not been making adequate assessments of inflation rates for future budgeting. Without applying proper attention and techniques to the analysis and prediction of inflation rates, budgets run a higher than necessary risk for increased cost growth due to inflation prediction error. This is the inflation cost risk. Historically, the government has been overly optimistic in its predictions resulting in insufficient initial allocation of funding and therefore causing significant setbacks for projects. In this paper the authors will describe a seven-step, statistical analysis, which is a technique to reduce inflation cost risk by providing more precise estimates for future inflation rates based off of historical research. This report includes a correlational study performed alongside of the analysis methodology. The study showed that as the predicted rate's year moved farther into the future, the fidelity of the predicted rate decreased. Using additional statistical techniques – distribution fitting tests and Monte Carlo Simulation – key components describing the behavior of inflation, such as statistics about inflation prediction error and general prediction error behavioral patterns, were obtained and used to observe inflation cost risk. The full analysis that this report demonstrates consists of seven steps – inflation data collection, data normalization, assessment for erroneous data, obtaining descriptive statistics about prediction error, fitting inflation prediction error with appropriate distributions, using historical standard deviations (from the descriptive statistics) with fitted distributions to form error models, make budget decisions or adjustments based on prediction error results. Within the methodology the appropriate goodness of fit tests are used to determine the best fit distribution for the inflation prediction error and Monte Carlo simulation is used to build a model for future inflation prediction error that can then be applied to predicted inflation rates giving more precision to funding allocation. By using this inflation prediction error analysis the government and other organizations will be able to construct budgets with greater confidence in real time.

Introduction

In the current United States' economic condition, government funding is tight and in order to keep within spending limits it is important for government agencies to budget closely. It is apparent that inflation rates estimated by the Office of the Secretary of Defense (OSD) for future years are generally much lower than the actual rates resulting in insufficient funding for projects such as Military Construction (MILCON) over the long run. This error highly affects the amount of money that the program is able to budget and forces the program to borrow money from other programs, cut costs, or end the project completely. The purpose of this research was to find whether or not the government is accurate in their inflation rate estimates, and if not, identify how to lessen the error in future predictions.

Booz Allen Hamilton delivered a report to the US Congress in 2008 that assessed the issue of government agencies and organizations underestimating inflation rates for budgeting. The 2008 report offered several proactive measures as potential solutions to this problem. Even so, a recent study described in the following report found that the United States Air Force's (USAF) fiscal year 2010 Budget uses identical rates in three different subcategories. This is evidence that adequate analysis has not been conducted and the problem of inaccurate estimation of inflation rates continues. The 2008 report to Congress analyzes inflation rates over the years and served as a basis for this current study.

This study analyzes the error of historical inflation rates regarding OSD predicted and actual rates with the goal of finding correlation between how far out a prediction is made and the rate of the previous years. Another goal was to find how inflation prediction error behaves. The study described in this report presents informative data on the erroneous practices in the current system and demonstrates how the government benefits if it improves its estimations. A further concern in this study is that the government presently is not receiving reimbursement of unrealized costs due to overestimated inflation rates. Therefore, both adjusting these rates and including terms for reimbursement in contracts could save money and are essential to mending this error.

Data

For the purpose of demonstration, analysis was performed on data obtained from the USAF's raw inflation indices concerning MILCON projects. The data was obtained from various USAF fiscal year budgets leading up from 1995 to 2010. However, the inflation data obtained for fiscal year 2009 was regarded as unusable for this study because the data was received only in weighted form and not in raw form. This study was conducted with the purpose of observing the behaviors of the raw inflation indices and therefore the weighted data from fiscal year 2009 was excluded from analysis.
It is important to note that the USAF predicted identical rates for MILCON, Research, Development, Testing and Evaluation (RDT&E), and Aircraft and Missile Procurement (A/CMP). The predicted inflation rates for MILCON, RDT&E, and A/CMP are expected to differ due to the materials, personnel, cost and scope specific to each of these projects. The predicted rate for these projects was different from the predicted rates for Fuel and Civilian Pay, but the fact that an identical rate was used shows that adequate analysis was not implemented.

The raw indices were organized in a spreadsheet for analysis once fiscal years determined to be appropriate were selected. In order to observe the change in inflation rate from one year to the next the data needed to be normalized. The first step in normalizing the inflation tables was to convert the raw inflation indices into inflation rates,

a simple calculation performed by dividing the year of interest's raw index value by the index value of the previous year. For example, the raw index reported for 2005 in the fiscal year 2010 data was 0.9006 and the raw index for the year previous, 2004, was 0.8760, so the inflation rate for 2005 was determined to be (0.9006/0.8760) = 1.0280. This calculation was performed for each year reported across all the fiscal year indices obtained, resulting in a compilation of the inflation rates for all those years. This portion of the data is shown in *Table 1* below with the same calculation also being performed on a selection of other indices.

TABLE 1

Historic Year	***FY08 Budget Raw Index***	***Inflation Rate***	***FY10 Budget Raw Index***	***Inflation Rate***
2004	0.9016	1.0200	0.8760	1.0200
2005	0.9268	1.0280	0.9006	1.0280
2006	0.9556	1.0310	0.9285	1.0310
2007	0.9814	1.0270	0.9535	1.0270

The focus of this study is in the error of inflation rate predictions, so a second step of normalization was necessary. This second step was also a simple calculation of subtracting the predicted rates from the realized rates. The way this was organized was in a one-year-out, two-years-out, and three-years-out format up to ten-years-out. For example, fiscal year 2004 predicted inflation rates for 2005 (one-year-out), 2006 (two-years-out), 2007 (three-years-out) and so on. Those predicted inflation rates were subtracted from the actual realized inflation rates of the corresponding years as reported in the fiscal year 2010 index. So, with these normalizations the error of inflation prediction as residual values were obtained and used for analysis.

Two different avenues of analysis were performed – correlational study and modeling using Monte Carlo Simulation. Data from fiscal year 2004 was excluded from the correlational study because it was missing raw inflation indices before 1998. For the correlational study, data was observed from 1989 to 2010. Therefore, data from fiscal year 2004 was not included because it did not included all the necessary information for the years analyzed. This data, however, was still useful and included in the statistical modeling of the inflation error.

Data Analysis

Statistical techniques were used on the data to explore the nature of inflation prediction error related to the indices used by the USAF for MILCON projects. These techniques included a correlational study of realized historical inflation rates, distribution fitting for inflation rate prediction error, and Monte Carlo Simulation using the best fit family of distributions for prediction error in order to observe cost growth risk due to prediction error. The results obtained through these techniques allowed inferences to be made about the behavior of inflation. Cost growth risk caused specifically by inflation is known as inflation cost risk and the U.S. Government can plan for and guard against it in the future during budgeting for and contracting of projects.

For the first step of inflation cost risk analysis, realized inflation rates for fiscal years 1989 to 2010 (from the USAF's 2010 raw inflation indices) were compared in order to perceive how inflation rates from year to year are correlated. It was observed that with greater distance between years, the correlation of those years significantly decreases. From one year to five years out predictions were observed resulting in correlations of r = 0.791, r = 0.498, r = 0.200, r = 0.087, and r = -0.131 respectively from one year out to five

years out. These correlations can be observed in the matrix in *Table 2*. This shows that the inflation rates from one year to the year immediately following have a strong, positive correlation. This means a one year inflation forecast is expected to behaves similarly to the previous year with some variation. However, for two and three year distances the relationship is increasingly weaker and with four and five years the relationship begins approaching zero. This means that the present year inflation rate is significantly less reliable in predicting the inflation rate for another year as the distance between years increases.

TABLE 2

Correlation of Future and Current Year Inflation	***Current Year***	***1 Year Out***	***2 Years Out***	***3 Years Out***	***4 Years Out***	***5 Years Out***
Current Year	1					
1 Year Out	0.791	1				
2 Years Out	0.498	0.791	1			
3 Years Out	0.200	0.498	0.791	1		
4 Years Out	0.087	0.200	0.498	0.791	1	
5 Years Out	-0.131	0.087	0.200	0.498	0.791	1

In addition to the correlational study, distributions of prediction error from predicted and realized inflation rates were considered. The realized inflation rates from 1996 through 2000 and 2005 through 2010 were compared alongside the same years' predicted values from previous indices. The differences between the realized rates and predicted rates from one to ten years out were observed. These differences between predictions and actual rates are the individual prediction errors for those years. Analysis was performed on these measurements of error. A *Microsoft Excel* add-in called *EasyFit 5.5 Professional* was used in order to determine the probability distributions for prediction error. This software runs the data through statistical tests for the best fit distribution and gives an output of its parameters. A normal distribution family was determined to be the best and most practical fit in order to build a risk model where the inflation cost risk can be observed.

The method of a Monte Carlo Simulation was used to simulate data according to the obtained normal distributions. This allows simulated data, relative to the actual data, to be observed using the identified parameters from the actual data. Through this method one can simulate and observe thousands of data values from only a few preliminary values. These thousands of data values fill out the distribution with information relevant to the analysis. The results from distribution fitting enabled the Monte Carlo Simulation to determine what additional costs could be accrued with highest likelihood due to inflation cost risk over a ten year interval.

When considering one year out inflation prediction error these predictions don't appear to be far off. In actuality, since 2004 they were only 0.375% less than the inflation rate. This average is accompanied by a standard deviation of 0.85%, meaning there is a relatively large capacity for variation. Inflation error could increase at an additional 1.225% more or 0.48% less than the predicted inflation rate within one standard deviation. This information just means that more precise estimates of future inflation rates must be made in order to protect against unnecessarily under or over budgeting. The standard deviations of inflation error are of special importance in order to obtain future inflation predictions with more precision.

Risk Methodology

The methodology developed by Booz Allen Hamilton to mitigate inflation cost risk envelopes the previously described analysis and goes further to utilize it for more informed budgeting. For the purposes of clarity, there are seven steps to this methodology, some of which have already been described. Starting with obtaining historical inflation data and proceeding through normalizing the data, assessing it for prediction error, obtaining the standard deviations of prediction error, and fitting prediction error for distributions the methodology is completed when the standard deviations and distributions are used to create a risk model through simulation finally resulting in the ability to make budgeting decisions and adjustments based on the results of the risk model.

The methodology continues from the previously described analysis of historical inflation rates in order to obtain a family of distributions and the calculation of standard deviations of inflation error for each year out that the government is interested in. For example, this study was interested in viewing inflation cost risk for a ten year budget item. So, this study used standard deviations for each of the ten years of prediction error. Generally, a software add-in for *Microsoft Excel*, called *Real Time Analytics,* is used within the methodology to determine the inflation cost risk for budget items. This step is performed after best fit distributions are obtained and standard deviations are collected for the prediction error. Using the future predicted inflation rates as the average for the fitted distributions and the standard deviations of inflation prediction error for each year out, *Real Time Analytics* can run Monte Carlo Simulation. This simulation is used to determine how the real year cost will behave and can create a total cost for the entire time interval of interest. In the case of this study the time interval of interest was ten years. The output from *Real Time Analytics* allows decision makers to observe the expected cost growth for a budget when using the current predictions of inflation. These results in turn give the decision makers the power to determine if more money will be needed than was initially expected or if terms should be included for reimbursement when making contracts. This methodology will help make budgeting more accurate even with unknown inflation rates.

Example

As an example, *Real Time Analytics* enabled the information from the previous data analysis to come together in order to show the potential and realistic cost growth for just one hypothetical budget expense over a ten year interval. Using the described methodology, *Real Time Analytics* used the results of choosing the normal distribution family to describe the error and the standard deviations for each year out prediction error in forming a risk model. An average cost growth due only to inflation over ten years was observed to be 10.95%. The figures used to determine this were costs of 1 million dollars a year for ten years accumulating to 10 million dollars. Using the methodology this initial amount grew to an average of 11.095 million dollars.

For the purpose of demonstration, the hypothetical as previously described is shown below. With amounts initially being allocated in Fiscal Year 2011 current year dollars, the methodology for inflation cost risk analysis can be applied. The inflation rates from the FY2010 USAF MILCON budget projected for fiscal years 2012 through 2021 were obtained and used in conjunction with the calculated prediction error standard deviations to create a risk model using an assumed normal distribution. This risk model was implemented to determine the real year dollar values based off the current year dollar budget. Each of these components in the methodology is displayed in *Tables 3 and 4*.

TABLE 3

Budget Year	***FY2012***	***FY2013***	***FY2014***	***FY2015***	***FY2016***
Cost A in FY2011 Current Year Dollars	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000
Predicted Inflation Rate	1.0272	1.0446	1.0624	1.0805	1.0988
Inflation Prediction Error Standard Deviation	0.0106	0.0110	0.0121	0.0136	0.0153
Risk Model	Normal (1.0272, 0.0106)	Normal (1.0446, 0.0110)	Normal (1.0624, 0.0121)	Normal (1.0805, 0.0136)	Normal (1.0988, 0.0153)
Cost A In Real Year Dollars	$1,027,176.00	$1,044,637.99	$1,062,396.84	$1,080,457.58	$1,098,825.36

TABLE 4

FY2017	***FY2018***	***FY2019***	***FY2020***	***FY2021***	***TOTAL***
$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$10,000,000
1.1175	1.1365	1.1558	1.1755	1.1955	
0.0171	0.0189	0.0208	0.0226	0.0244	
Normal (1.1175, 0.0171)	Normal (1.1365, 0.0189)	Normal (1.1558, 0.0208)	Normal (1.1755, 0.0226)	Normal (1.1955, 0.0244)	Sum of Risk Model Distributions
$1,117,505.39	$1,136,502.99	$1,155,823.54	$1,175,472.54	$1,195,455.57	$11,094,253.80

From this setup *Real Time Analytics* was used to simulate real year amounts and create an output for consideration showing the average (mean), the standard deviation, the minimum and maximum, the range, and the standard error in real year dollars of the budget total over the ten year interval. These results are displayed in *Table 5*. A breakdown of the percentiles for expected total cost in real year dollars was also obtained and can be seen in *Table 6*.

TABLE 5

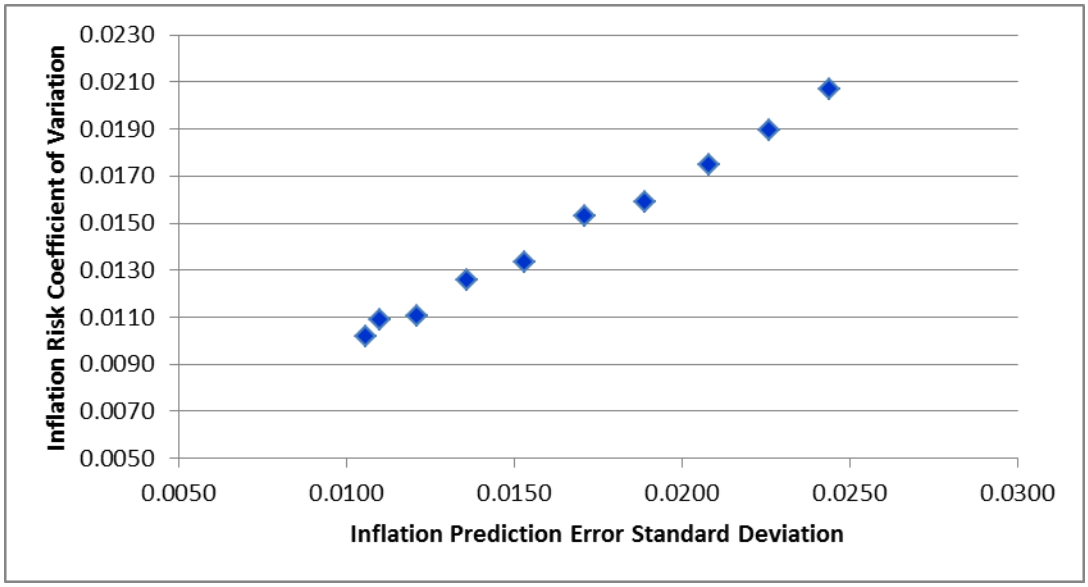
Statistics	Values
Mean	$11,094,809.03
Standard Deviation	$55,533.52
Min	$10,921,661.14
Max	$11,276,646.81
Range	$354,985.66
Standard Error	$1,756.12

TABLE 6

Percentiles	Values
10%	$11,026,114.52
30%	$11,064,158.21
60%	$11,107,463.03
70%	$11,124,182.69
80%	$11,141,603.32
90%	$11,162,820.90
100%	$11,276,646.81

In addition to the descriptive statistical results, the coefficient of variation for each budget year was calculated and plotted with the standard deviations for observation of any relationship. It was found that as the standard deviation of inflation prediction error increases, the coefficient of variation for corresponding real year dollar amounts also increases. This shows that as the range of error increases the inflation cost risk becomes much more unpredictable, the range of error represented by the increasing value of the standard deviation and the unpredictability represented by the growing coefficient of variation. This can be observed in *Figure 1*.

FIGURE 1



Further Research

Inflation Cost Risk Analysis should be performed even when the United States' economy is strong and growing in order to aid in maintaining this growth and using funds efficiently. Even more so, it cannot be emphasized enough how important this analysis is when the economy is in recession. With this in mind, there is opportunity through the future studies of inflation behavior during times of economic decline, to improve Inflation Cost Risk Analysis to be able to factor in the state of the economy and acquire the best results for that current state. In order to do this a detailed look at the inflation rates and indices for the years proceeding, during, and following recession years would be

necessary and the accurate recording of inflation rates that were predicted for these years as well as the actual inflation rates for these years is essential to this research. This research would enable budgets to be leaner, more effective and efficient spurring economic success.

Conclusion and Recommendations

It was estimated that the government is contracting out more funds than presently needed due to the over-estimation of annual inflation rates. While most contractors are reimbursed for any additional cost, due to inflation under-estimation, there are no indications that the government has pursued similar contract terms. It should be the governments focus to receive funds back that have already been contracted due to inflation over-estimation. This study demonstrated that because inadequate analysis of inflation rates, the government continues to be inefficient in determining appropriate allocation of funding. The methodology formed by this study should be adopted and implemented within government budgeting practices. It will ensure that additional losses due to inflation cost risk are minimized. On the other hand, the government is also at risk of missing out on the potential reimbursement of unused contracted portions of funding. With this in mind, Booz Allen Hamilton proposes that surpluses paid out to contractors be reimbursed to the government. This can be implemented by writing conditions in contracts that require contractors to return funds received on a project that are not put to use. These conclusions and recommendation are based on the research and analysis described in this report. The expected effect of following these recommendations is softening the impact of inflation by reducing the amount of cost growth due to previously ignored inflation cost risk. By implementing the techniques and methodology described in this report the government will reduce unanticipated costs, predict inflation rates and determine real year dollar amounts for extended program budgets with a higher degree of confidence. Therefore, the implementations recommended by Booz Allen Hamilton for this specific task should be carried out immediately. Additionally, it is important to be reminded that inadequate techniques, such as the ones used when the USAF set identical inflation rates for RDT&E, A/CMP, and MILCON budgets, can be costly mistakes. Over the long term this negligence will cause higher cost growth, and risk prolonging, stunting and ending projects unfinished. By implementing the described methodology these adverse effects will be avoided.

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