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A Case Study of EPA Clauses As They Apply to Fixed Price Contracts

Trevor A. Enos

A CASE STUDY OF EPA CLAUSES AS THEY APPLY TO FIXED PRICE CONTRACTS

THESIS

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Abstract

Adjusting fixed price contract prices over long periods of performance is vital to protect both the government and contractor from market price fluctuations. This is accomplished via an Economic Price Adjustment (EPA) clause which currently utilize forecasts of producer price indexes (PPI) as a baseline. There is currently a lack of research on if the use of these forecasts as a baseline for calculating EPAs is the best alternative. This research involves determining the validity of using Global Insight (GI) forecasts for the purpose of calculating EPAs in fixed price contracts. Two EPA clauses are examined as a case study proxy for what may be occurring on a broader scale DoD wide. The PPI of interest to this research is PPI 336411, which covers the aircraft manufacturing industry. The GI forecasts of PPI 336411 are compared to Bureau of Labor Statistics (BLS) managed actuals of the index to assess the accuracy as well as the Forward Pricing Rate Agreement (FPRA) derived escalation rates to determine if the government is estimating escalation in line with the contractor. A change point analysis is then conducted on the historical values of PPI 336411 to determine if significant changes in the dataset are influencing the accuracy of forecasts. Lastly, a retrospective approach to EPA clauses is recommended which utilizes changes in actuals to calculate EPAs, as it resulted in a lower mean absolute percent error (MAPE) than the prospective approach with respect to actuals. The outcome of this research is a recommendation that the EPA clauses be rewritten to support a retrospective approach to calculating EPAs.

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A CASE STUDY OF EPA CLAUSES AS THEY APPLY TO FIXED PRICE CONTRACTS

I. Introduction

Background

Accurate and reliable cost estimates are critical to successfully budgeting for the research and development, procurement, and sustainment efforts of a program's lifecycle. For budgeting purposes, tracking the change in price over time is important for accurate estimates. There are two types of price changes analysts are concerned with: inflation and escalation. Inflation "is an economy-wide increase in the average price level" (Office of the Secretary of Defense, Cost Analysis and Program Evaluation [OSD CAPE], 2017). The more specific form of cost growth, escalation, is the "changes in the price of specific goods and services" (OSD CAPE, 2017). Because escalation contains a component of inflation within it, escalation rates are generally valued over inflation rates when the Producer Price Index (PPI), from which the rate is derived, is known. If an incorrect PPI is used, or an inflation rate is used in place of the escalation rate, the estimated cost growth will deviate further from the actual cost growth, leading to underfunding of contracts.

DoD producer price indexes are typically provided over a five-year period called the Future Years Defense Program (FYDP). However, government programs have financial requirements that extend beyond this five-year period (OSD CAPE, 2017). Therefore, a private firm's forecast of the specific index is usually utilized. However, even most of these forecasts fall short of the anticipated lifecycle of the program. The responsibility then falls on the analyst to determine the method of extrapolation into the years beyond the forecast that “maximizes the realism and stability of the cost estimate” (OSD CAPE, 2017).

When projecting a forecasted rate far into the future, it is understood that there is going to be fluctuation from the actual escalation rate. In the environment of a fixed price contract, this unrealized Real Price Change (RPC) would become the financial burden of the contractor. Federal Acquisition Regulation (FAR) Section 16.104(g) states that in "times of economic uncertainty, contracts extending over a relatively long period may require economic price adjustment..." (FAR, 2017). Historically, Air Force Life Cycle Management Center (AFLCMC) aircraft and aircraft modifications contracts favor longer periods of performance. Because of this, it is reasonable for the government to provide security to the contractor if price escalation exceeds the assumptions made that informed the pricing of the fixed-price bid. As a result, clauses are constructed requiring EPAs to be applied to eligible aircraft and aircraft modification contracts.

These EPA clauses utilize producer price index PPI336411 Aircraft Manufacturing as the benchmark for which eligibility for economic price adjustment is measured (McGlothen, 2017). The index used is indicative of the economic trends of the work performed on aircraft and aircraft modification contracts. Thus, the validity of the use of PPI336411 as a benchmark is not in question. Rather, the issue is with the use of current forecasts for that index as the basis for calculating economic price adjustments (McGlothen, 2017).

Currently, AFLCMC utilizes Global Insight Inc.'s forecasts of PPI 336411 to estimate future years escalation rates. However, there appears to be little analysis applied to this forecasting, with rates beyond the ten-year forecast consistently being projected at

2.4%. The findings of a study conducted by AFLCMC and the Air Force Cost Analysis Agency (AFCAA) from 2002 to 2010 indicated that the "GI forecasts for aerospace price indices and employment cost indices appeared to be consistently lower than the price growth experienced" (McGlothen, 2017). Additionally, Global Insight simply takes the final year's escalation rate of the forecast and applies it to all future years for a program beyond the ten-year forecast, with no variation. This methodology goes against CAPE guidance that states "do not, however, automatically extrapolate the last forecast rate out into the indefinite future" (OSD CAPE 2017). Because of these straight-lined rates, there may be a systematic underestimation of price escalation. It is also believed, based on Forward Pricing Rate Agreements, that contractors are accounting for higher escalation in their proposals, between 3.5% and 4.7%, than GI is forecasting (McGlothen, 2017). Therefore, when current GI forecasts rise above a specified threshold of the baseline forecast specified in the EPA clause, the government is responsible for compensating the contractor for a price change they may already be assuming in the contract.

Problem Statement

Under the EPA clauses examined, when the current year's forecasted index value varies up or down beyond a specified threshold in comparison to a baseline forecasted value for the same index then an EPA payment is triggered. For example, to calculate an EPA payment the current projected annual index value is divided by the baseline projected annual index value, then that value is multiplied by 100. If the current index forecast is above the baseline forecast by a specified threshold percentage, then a payment to the contractor is triggered. Likewise, if the current index forecast is less than the baseline forecast by a specified percentage threshold then a payment to the government is triggered. Previous studies have found Global Insight forecasts to be consistently lower than actual price growth (McGlothen, 2017). Therefore, using an inaccurate Global Insight forecast as the basis of the EPA clause could nearly guarantee an EPA payment. Simultaneously, the contractor may be assuming higher escalation within their Forward Pricing Rate Agreements (FPRA) documents than the Global Insight forecasts. The problem, therefore, is there may be double-payment of contingency allowance for escalation impacts already assumed in the contractor rates.

The goal of the current study is to investigate two EPA clauses as a case study representation of what is potentially happening DoD wide. A discrepancy of even just a fraction of a percent extrapolated across the period of performance of a contract adds up to a significant dollar value. If this is true, then there is potentially a large cost avoidance to be realized by re-wording the EPA clauses.

Research Questions

The purpose of this research is to answer the following questions.

1) What amount is historically obligated for EPA adjustments, and how does this compare to the total contract amount?

2) What is the accuracy of Global Insight forecasts in relation to historically observed escalation rates in PPI 336411 Aircraft Manufacturing?

3) What are the differences between GI forecasted rates and contractor proposal rates as manifested in FPRA documents?

4) Where are there significant changes in the historical escalation rates of PPI 336411 and what do these imply about the validity of forecasting this index?

5) How does a retrospective EPA clause compare to a prospective EPA clause in terms of Mean Absolute Percent Error (MAPE)?

6) What modifications are recommended to the current AFLCMC EPA clause?

Methodology

This research first determines the historical cost impact of EPAs. The research then examines the overall accuracy of the GI forecasts as they relate to historical data managed by BLS. The escalation rates of government program offices are then evaluated compared to the escalation rates of defense contractors, as they pertain to fixed price contracts. The historical index values are then analyzed to see if attempting to model future values is feasible. There are 6 main sources the data was collected from. First, the EPA payments are determined from the ConData database which will be discussed in Chapter 3. Second, the Global Insight forecasts are sourced from the AFLCMC cost and economics division. Third, the historical PPI values are sourced from the Bureau of Labor Statistics website. Fourth, the FPRA documents are used to collect labor escalation rates of defense contractors. The FPRA documents are obtained from the source data of the AFLCMC Cost and Economics Division's contractor wrap rate calculator. And last, the EPA clauses are provided by AFLCMC Cost and Economics Division.

The analysis begins with determining what has historically been paid in EPAs using the ConData Database. Next, a comparison of GI forecasts of PPI336411 to historical values of the same index is conducted to verify the accuracy of the forecasts. Escalation rates pertaining to direct labor are then extracted from the FPRA documents of six contractors and compared to the government forecast of escalation. Once this evidence of what is currently happening is gathered, the validity of modeling future values of this index is then determined by conducting a change point analysis on the historical values of the index. The MAPE of a retrospective approach to EPAs is then compared to the MAPE of the current prospective approach to EPAs. The research concludes with a recommendation as to how to change the current EPA clauses to better reflect what is occurring in the market.

Scope and Limitations

The scope of this research was limited to examining two different EPA clauses. Within a contract there are many clauses related to price adjustments, however this research only covers the use of economic price adjustments.

The number of programs examined was limited by the access to relevant EPA clauses. The EPA clauses are often referenced within the contract yet not fully included within the document, so access to the EPA clause documents were limited.

The number of ACAT I aircraft programs analyzed was limited by the availability of FPRA data. The accuracy of the forecasted escalation rate was limited by the availability of data points. Data for PPI336411 dates back only as far as 1985, leaving only 33 points of actual data on the index.

Thesis Overview

The following chapter, the literature review, delves deeper into prior and related research on this topic of study to identify the gap in the research in economic price adjustments. How the research is conducted is explained in Chapter 3, the methodology section of this paper, to ensure the results are analyzed through a valid analytical process. Next, the findings of the research are discussed in Chapter 4 as well as the implications of these findings and how they impact the DoD as a whole. Lastly, Chapter 5, the summary and recommendations section, discusses the findings and provides recommendations.

II. Literature Review

Background

Why does the cost to develop, produce and maintain DoD systems increase year by year? Three main interrelated factors contribute to the escalation of prices over time. The first is a decrease in the number of systems ordered per production lot. Second, in today's rapidly growing economy, constant technological advances lead to more technological turnover within programs. And third, like the private sector, the DoD's expenditures are affected by increases in prices and wages (OSD CAPE, 2017). This research focuses on the latter, third reason.

In the private sector the changing price of goods over time is a known phenomenon. This general change in price of a basket of goods is commonly referred to as inflation. According to this definition, the purchasing power of a dollar will change as the inflation rate changes (OSD CAPE, 2017). In general terms, inflation is used to describe a rise in the average price level for an economy at the macro level, however, when looking at an economy as a whole, there are thousands of commodities and services that constitute price increases in an economy, making the application of inflation more complex (OSD CAPE, 2017). This complexity arises from specific commodities' and services' prices changing at different rates due to factors such as market shifts, economies and diseconomies of scale, or changes to inputs of production (OSD CAPE, 2017). Because of this difference in price growth it is necessary to utilize escalation to determine the price changes of a specific commodity or service.

Transitioning from the private sector to the Department of Defense creates more complexity with the comparison of dollars appropriated in a given year, but spent over multiple years (OSD CAPE, 2017). To address this added complexity, program offices will utilize escalation rates to compare future year dollars (often referred to as Then-Year dollars) to current year dollars (often referred to as Constant Year Dollars). More detail about the derivation of escalation rates is discussed later in this chapter.

Government Procurement Process and Contracts

Government procurement is the process by which the government acquires goods or services from a contracting entity. The vessel which allows for legal exchange of goods or services is the contract. Contracts are important because 1. "any trade -- as a quid pro quo -- must be mediated by some form of contract", and 2. "they provide the foundation for a large part of economic analysis" (Hart, 1986). Before a contract is awarded there are certain steps that must be taken to ensure a lawful and fair process. In a contract by negotiation the government first submits a Request for Proposal (RFP) to the participating bidders. This RFP outlines the requirements and requests technical and pricing information from the seller (US Department of State, 2018). Proposals are then submitted by the sellers and evaluated by the government based on established criteria in the RFP. Once all proposals are evaluated there may be negotiations held to resolve any issues arising from proposed hours or material required. Upon a consensus the contract will be awarded based on the criteria the government set in the original RFP.

Government contracts fall into two general categories, fixed-price and cost-reimbursement contracts. Which contract the government chooses to use is dictated by the nature of the product or service they are acquiring. For instance, when acquiring a commercial product or awarding a contract based on a sealed bid, the government must use a fixed price contract (DAU, 2017). Cost-reimbursement contracts are recommended when uncertainty in the contract performance does not allow for an accurate estimate of cost (DAU, 2017).

The contract type chosen will determine which party bears the cost risk: the government or the contractor. With a fixed-price contract, cost risk falls on the contractor, as they have complete control over the magnitude of their profit or loss, making this contract type the most auspicious choice for the government under circumstances that favor shifting the risk to the contractor. From the contractor's perspective, a cost-plus-fixed-fee may be the most beneficial contract when the circumstances favor shifting the risk to the government. This contract type places the majority of the cost risk on the government because the profit paid to the contractor is fixed regardless of the performance. There are various other incentive-type contracts that fall on a spectrum of assumed risk between these two contract types. A visual of this spectrum can be seen in Figure 1.

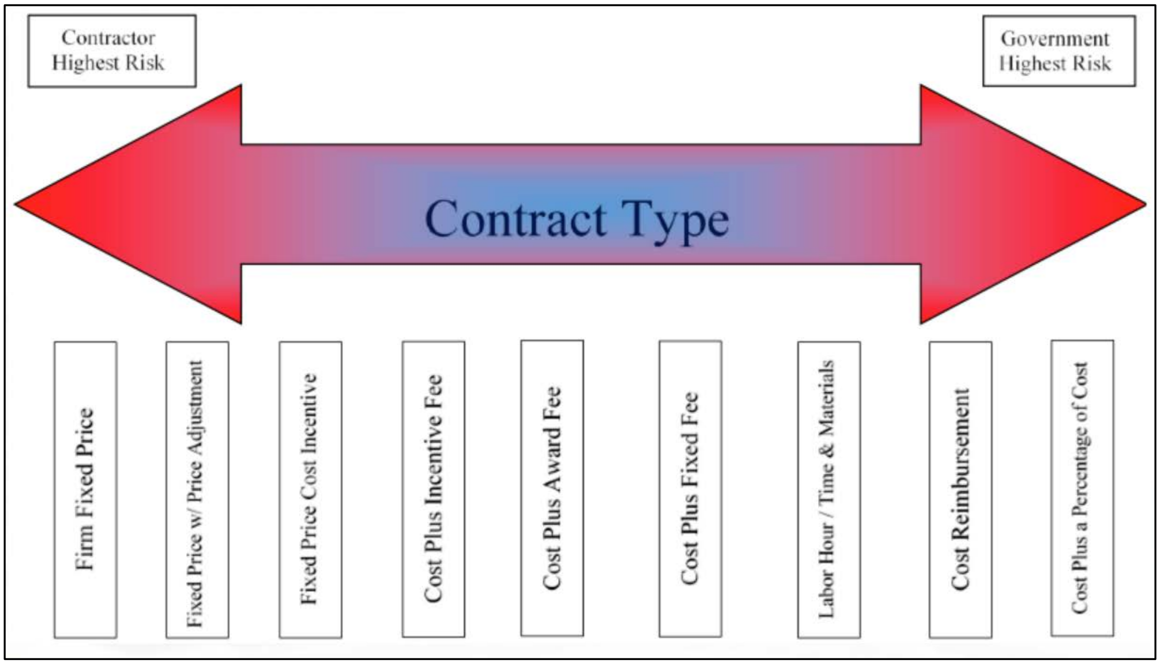


Figure 1: Government Contract Spectrum (State Procurement Office, 2018)

Economic Price Adjustments

This research focuses on fixed price with EPA contracts. As the name implies, fixed price contracts "provide for a price that is not subject to any adjustment on the basis of the contractor's cost experience in performing the contract" (FAR, 2017). The benefit of a fixed price contract is that it shifts the cost risk from the government to the contractor. In other words, if the contractor exceeds estimated costs to complete the work, the government is not responsible for compensation. The economic price adjustment portion of the contract protects both sides, the government and the contractor, of any unforeseen change in the market price of the good or service. The EPA is based on the cost index of labor or material and is utilized when any of the following three circumstances are met:

1. The contract involves an extended period of performance with significant costs to be incurred beyond 1 year after performance begins;

2. The contract amount subject to adjustment is substantial; and
3. The economic variables for labor and materials are too unstable to permit a reasonable division of risk between the Government and the contractor, without this type of clause (FAR, 2017).

Two EPA clauses are referenced in this research, one for KC-46 lots 3-13 and one for the C-5 lots 4-7. The full clauses are in Appendix A.

What is the advantage of incorporating an EPA into a fixed price contract? In a case study of petroleum coke conducted in 1987 by Victor P. Goldberg and John R. Erickson, the problems of quantity and price adjustments in long term contracts are examined as they pertain to the product petroleum coke. In this investigation two potential reasons for using EPAs in long term contracts are concluded. "First, adjusting the price to keep it in line with current market prices gives the parties the proper short-run price signals" (Goldberg and Erickson, 1987). This speaks to the importance of indexing the price of a good to be commensurate with the market price. In the case of coke, the quantity of petroleum coke demanded was a reflection of the refinery's demand for fuel, not for coke (Goldberg and Erickson, 1987). Therefore, indexing the price of a good to the correct input item will have major impacts on the accurate forecasts of short and long-term price changes.

The other reason for incorporating EPAs into long-term contracts includes the overall reduction of incentive for one or both parties to breach contract terms or behave opportunistically (Goldberg and Erickson, 1987). In a long-term contract both parties have an incentive to expend resources to better predict the future costs and prices of goods. Therefore, it is advantageous for both parties to include in their initial agreement an EPA to minimize wasteful spending of valuable resources (Goldberg and Erickson, 1987). This case study provides insight into how EPAs are used and why they are used within the private sector. Similarly, the same uses and reasons for use can be applied in a government contract setting, as long-term private contracts follow similar principles to long-term government contracts.

A third situation for using EPAs is take-or-pay contracts. These take-or-pay contracts often "link sellers and buyers for a long period, generally 20-25 and even up to 30 years" (Creti and Villeneuve, 2004). The drawback of these style contracts is the inflexibility of prices with demand and supply fluctuations. However, this can be mitigated by applying clauses that stipulate a floor price and allows for upward adjustment following price escalators. These price escalators are tied to specific price indexes (Creti and Villeneuve, 2004). This is further evidence of the efficacy of applying EPA clauses in long-term contracts and linking them to price indexes.

The Bureau of Labor Statistics (BLS), from which the government obtains producer price index (PPI) data, spells out guidelines to follow when creating a clause in a contract to account for an EPA. First, a baseline cost of the end item on contract is established with a detailed description of the end item as well as the month and year of the established base price. Second, an appropriate PPI is selected that falls in line closely to the product or service on contract. For the remainder of this paper PPI336411 is the focus, which encompasses the price of aircraft manufacturing and is the benchmark against which the eligibility for an economic price adjustment is determined. Third, the source of the PPI data is documented clearly. Fourth, the frequency of the price adjustment is specified, typically quarterly, semi-annually, or annually. Next, both the contractor and the government agree on a specific base and comparison months within the price adjustment. Lastly, the methodology of the price adjustment is then explicitly explained (US Bureau of Labor Statistics, 2017). For the remainder of the paper, the KC-46 and C-5 EPA clauses pertaining to PPI 336411 is referenced.

EPAs in Defense Programs

FFP contracts on major government programs tend to span long periods into the future. Due to their long periods of performance, these FFPs are eligible to include economic price adjustments. These economic adjustments allow for "upward and downward revision of the stated contract price" (FAR, 2017). These revisions can stem from multiple scenarios. The first being "adjustments based on established prices" (FAR, 2017). If a good or service is generally accepted to cost a specific amount less than what the contractor established in their proposal, then an EPA may be applied to allow for this adjustment. Second, EPAs can stem from "adjustments based on actual cost of labor or material" (FAR, 2017). If the contractor proposed a specific price of a piece of material but the actual cost incurred was less than the proposed amount, then an EPA may be applied to the original proposal. Last, an EPA can come about from "adjustments based on cost indexes of labor or material" (FAR, 2017). These can either be forecasted index values or actual values of the index as reflective of the market.

As previously stated, best practice requires an EPA clause to specify the exact PPI used as a basis to track changes in the price of a good or service over time. BLS maintains data on two different price indexes, both used for distinct and different purposes. The first index is the consumer price index, which tracks the change of all goods and services purchased by consumers in urban households (US BLS, 2017). This index is relevant as it is the base index for calculating inflation. Simply stated, the CPI is the raw data of the price change and the inflation rate is the calculated percent change of price year by year. The second index BLS tracks is the Producer Price Index (PPI). PPIs differ from the CPI in that it measures the change in price over time in the selling price of a good or service from the producer's perspective, rather than the consumer's (US BLS, 2017). Similar to the CPI in relation to inflation, PPIs are used as a base to calculate escalation rates.

Forecasting Escalation: Current Practice

Price escalation rates are derived from producer price indexes (PPI), which are generated by the Bureau of Labor Statistics (BLS) to measure the change in the price received by a producer for a specific good or service they provide (OSD CAPE, 2017). These PPIs are specific to thousands of goods and services and are disaggregated to lower levels within each industry. For example, PPI 3364 covers the aerospace product and parts manufacturing industry. Below this industry level PPI is PPI 336411, which tracks the price changes of aircraft manufacturing specifically (US BLS, 2017). Escalation rates are calculated by simply finding the percent change in the PPI year-by-year. This research focuses on PPI 336411.

A corporation called Global Insight creates forecasts for thousands of PPIs which the government then uses for contracting purposes. Not only are accurate escalation rates important because there is a clause that requires the government to compensate the contractor for inaccurate escalation forecasts, but also because "accurate and reliable estimates allow proper expression of life cycle costs, budgeting and program requirements..." (Sweitzer, 1997). It is this accurate forecasting of price escalation that allows for proper budgeting and mitigates fees paid to the contractor.

If there is a discrepancy, even minor, in the forecasting of price escalation between the DoD and contractor, these minor differences could result in the government to paying unneeded compensation to the contractor. While there are limited studies that have been conducted on price escalation, there have been studies published on inflation. Recall that inflation is defined as "a persistent rise in the prices associated with a basket of goods and services that is not offset by increased productivity" (Tayari, 2017). Escalation, similarly, is "a persistent rise in the price of specific commodities, goods, or services due to a combination of inflation, supply/demand, and other effects such as environmental and engineering changes" (Tayari, 2017). In other words, inflation refers to the rise in prices of a general basket of goods or services, while escalation refers to a specific good or service. Due to this similarity it is reasonable to apply lessons learned from this study on inflation to research on price escalation.

An internal study conducted by AFLCMC/FZC and the Air Force Cost Analysis Agency (AFCAA) in 2011 compared the Global Insight forecast for aerospace price index PPI 3364 and labor cost indexes to actual growth experienced. The results show that GI forecasts of price escalation are consistently lower than actual growth experienced. These differences "are substantial and become quite severe with compounding over several years' time" (McGlothen, 2017). It is therefore reasonable to assume that consistency between GI forecasts, BLS actuals, and contractor forward pricing rate agreements is pertinent to the accurate representation of costs for government acquisitions programs. This study, however, can be expanded on with eight more years of data from 2009 to 2017, as well as analyzing PPI 336411 instead of PPI 3364, as PPI 336411 is the index referenced in the two EPA clauses referred to in this research. This research also expands on this study by examining more government contractors, determining the historical cost impact of EPAs, and analyzes the historical data to determine if using forecasts as a basis for EPAs is appropriate.

Paul Joskow (1987) conducted a study on price adjustments in long term coal contracts, which concluded that “some contracts track changes in market values very poorly” (Joskow, 1987). As with Acquisition Category I (ACAT I) program's contracts “the vast majority of long-term coal contracts use a base price plus escalation” formula to account for uncontrollable price changes (Joskow, 1987). Joskow explains that fixed price contracts that rely on forecast expectations of future costs are bound to have errors resulting from poor forecast techniques and inability to accurately predict future cost changes.

To combat these price changes Joskow states that some type of cost-plus contract may be utilized. In a cost-plus contract, a contractor is paid for all of “its allowed expenses, typically up to a set limit” and then paid some set amount to account for profit (CSIS, 2008). Joskow essentially states that the amount paid to the contractor in this situation is accounting for the economic price increase over time. However, he then states that cost plus contracts provide minimum incentive to the seller to provide minimum cost supply. These cost plus contracts do not accurately account for “unanticipated changes in market supply and demand conditions” (Joskow, 1987). This deemphasizing of cost plus contracts is mirrored in the public sector through the passage of the Weapons Systems Acquisition Reform Act (WSARA) in 2009. One of the main objectives of WSARA is "to encourage competition to reduce sole-source contracting (often cost-plus based) and pave the way for greater use of fixed-price contracting" (Wang, 2013).

Instead of using cost-plus contracts to account for price increases, Joskow argues that a "base price plus escalation" type contract is a better alternative (Joskow, 1987). This type of contract provides a "base price reflecting supply and demand conditions when the contract is signed and which then provides for adjustments in the base price using a formula that incorporates a weighted average of exogenous input price indexes reflecting" the anticipated change in both raw material and labor costs (Joskow, 1987). This is essentially equivalent to the DoD's usage of a FFP contract with an EPA included, as mandated by the FAR for all contracts spanning multiple years that meet the requirements of an EPA. The key to this method being successful at accounting for market price changes is the accuracy of the forecasting. If the market value of the raw materials "moves along with the changes in prices...then this method seems superior to a cost-plus contract" (Joskow, 1987). Therefore, the accuracy of the indexes used in the forecasting are a key driver in the accuracy of the overall EPA.

An example of how an EPA clause could have been utilized in the private sector to avoid unneeded litigation is spelled out in the 1967 court case of *Alcoa v. Essex.* Alcoa signed a twenty-year contract agreeing to convert Essex's alumina into molten aluminum. The initial contract was for 50 million pounds of molten aluminum per year at a price of 15 cents per pound (Goldberg, 1987). Fixed costs and ceiling prices were established as well, however, in 1973 a large increase in the price of fuel had a major effect on the price of aluminum, causing it to increase at a greater rate than what was on contract. This change in outside economic conditions led to prices originally spelled out in the contract to be compromised by Alcoa. The court ruled in favor of Alcoa because they determined both Alcoa and Essex had tracked the Wholesale Price Index poorly, leading to the un-anticipated change in fixed prices within the contract (Goldberg, 1987).

The case of *Alcoa v. Essex* is a prime example of how a well-defined EPA clause could have been utilized. The contract spelled out an upward allowable price adjustment of 65% of the price of a specified type of aluminum (Goldberg, 1987). Because this ceiling price was not tied to an accurately tracked price index, it was impossible to predict how the price of aluminum would change. This case potentially could have been avoided if a price index representative of aluminum had been agreed upon by both parties and written into an EPA clause that allowed for an upward and downward adjustment of the price of aluminum. If the EPA clause also spelled out an upper and lower minimum threshold of price index adjustment for an EPA to be paid to the required party, then litigation could have been avoided.

As discussed earlier, a case study on the petroleum coke industry discussed the reasons for utilizing EPAs in long term contracts. This study found that 90 percent of the pre-1973 contracts and all of the post-1973 contracts provided some price flexibility (Goldberg and Erickson, 1987). Indexing a price of a good to the historic market price of an input good is one of the mechanisms for incorporating a price adjustment. This is a very similar method to what government contracts do when they write EPA clauses into contracts. A price index is selected that accurately reflects the market price of the end item, and then a maximum and minimum threshold is established for allowable changes in the forecast of the base index. This comparison of the private sector to the government sector is important in that it demonstrates there is a precedence set by the private sector in creating EPA clauses in these warranted situations. However, where the government may be lacking is in how they go about implementing these EPA clauses.

The importance of accurate inflation indexes is examined in a paper published by the Institute for Defense Analysis (IDA). Inflation indexes differ from escalation indexes in that they “cover the entire economy as a whole”, while escalation indexes “cover specific classes of goods and services” (Horowitz, 2012). On the basis of forecasting inflation rates beyond the five-year Future Years Defense Program (FYDP), it is mandated by OMB Circular No. A-94 that the “inflation assumption can be extended by using the inflation rate for the sixth year of the budget forecast” (OMB, 1992). In other words, for the purpose of inflation there is essentially no analysis applied to the inflation forecast extending beyond five years. Instead, projects extending beyond five years “are advised to use the final year's rate in perpetuity” (OMB, 1992). This creates a potential problem, in that using a single year's rate as a basis for future years may be inaccurate. If actual inflation rates grow faster than forecast rates, “programs will be systematically underfunded, leading to unnecessarily high real program cost growth” (Horowitz, 2012). Thus, it may be more beneficial to apply some other technique to forecast beyond five years.

As with inflation, the same issues of forecasting accuracy arise for escalation. As examined previously in the study conducted on AFLCMC on the importance of proper EPA predictions, the report states that in competitive fixed price contracts with EPA, it is reasonable that “historical averages serve as the basis for calculating a fair economic price adjustment” (McGlothen, 2017). This conclusion is backed because historical averages of aerospace indexes used by Global Insight coincide with industry's tendency to forecast price growth at 3%.

Change Point Analysis

One of the goals of this research is to analyze the historical data of PPI 336411 to determine if there are change points that are interfering with the accuracy of GI forecasts. Change point analysis is useful in three applications: determining if process improvements led to a shift in the data, problem solving, and trend analysis (Gavit, Tholmer and Baddour, 2009). This research focuses on utilizing change point analysis as a problem-solving method to determine if trends in the historical data of PPI 336411 are leading to unreliable forecasts. As an example, an article in the BioPharm International journal discusses a situation when change point analysis is used as a problem-solving technique. A medical manufacturing facility is having issues with out-of-range results for sodium concentration in a processing buffer. To determine if the out-of-range batches are a result of a shift in sodium concentration of the buffer a change point analysis should be run on the sodium concentration of the buffer outputs (Gavit, Tholmer and Baddour, 2009). This research focuses solely on historical shifts in PPI 336411 values and how they may be affecting forecast reliability. In this situation, the PPI values are the input and the GI forecasts are the output.

This research uses a combination of cumulative sum (CUMSUM) charts and bootstrapping to detect changes. CUMSUM charts "rely on a visual assessment of whether there is a change in the slope" (Gavit, Tholmer and Baddour, 2009). A cumulative sum is a running total of the deviation of each individual data point from the average of the data. Therefore, a CUMSUM chart is just a plot of all the CUMSUMs in the data set. In times when the values tend to be above the average, the CUMSUM chart will reflect a positive slope, while in times when the values tend to be below the average, the CUMSUM chart will reflect a negative slope. A change point, therefore, is marked by a sudden shift in the slope of the CUMSUM chart and represents a point in time when the overall trend of the data suddenly shifted (Taylor, 2000). These change points create irregular shifts in the data that can make it more complex to accurately forecast future values.

There are many forecasting techniques available, however not many are able to take into account random noise in the data. Two methods that do take this into account are decomposition and intervention models. Decomposition models are used to forecast time series data by decomposing the data into four different factors: trend, seasonal, cyclical, and irregular (Bowerman, O'Connell and Koeler, 2005). The irregular piece of these models captures the error and erratic behavior that is difficult to predict. However, these models "have no theoretical basis-they are strictly an intuitive approach" (Bowerman, O'Connell and Koeler, 2005). Likewise, intervention models are used "when exceptional external events, called interventions, affect the variable being forecasted" (Bowerman, O'Connell and Koeler, 2005). These models are an iteration of Box-Jenkins models and can be very beneficial with data that contains change points. However, the issue with these models is not their accuracy, but rather their application as a basis in an EPA clause. Though there is no insight into what exact methods GI utilizes to forecast PPI values, the use of any forecast as the basis for calculating EPAs is likely to result in unwarranted EPA payments. When the EPA is based on forecast the accuracy of the forecast is inherently going to have an effect on whether an EPA is triggered and what the magnitude is. If EPAs are based on historical averages of actual PPI values, then the forecasting error is taken out of the equation. This is the difference between a prospective and a retrospective EPA clause.

Evidence to suggest a retrospective EPA clause is a plausible solution is outlined in Defense Federal Acquisition Regulations (DFARs). DFARs section PGI 216.203-4 mandates when EPA clauses should be used, how they should be implemented, and all the details on what they should include. This document essentially spells out exactly how to write an EPA clause. It specifies the clause should be based on an index that is not so diverse that it is significantly affected by fluctuations not relevant to contract performance, but also not so narrow so as to minimize the effect of any single company (DFARS PGI 216.203-4, 2012). Though it is agreed an EPA clause should be based on an appropriate index, DFARS does not specify whether the EPA should be based on historical index values or proprietary forecasts of said index. Therefore, it is up to the contracting officer, or whoever is writing the clause, to determine which method is most appropriate.

The expected impact of fixing this escalation issue will vary depending on the overall magnitude and length of the contract. However, "in times of lower price growth, as has been experienced over the past 5 years, the result would be money being returned to the Air Force for application elsewhere" (McGlothen, 2017). The current EPA clause does stipulate this protection to the government but in practice the clause may not be exercised. Considering the current number of active contracts in the Air Force, "it is conceivable that the impact over the next decade could amount to hundreds of millions of dollars of precious obligation authority being spared from improper economic price adjustment payment” (McGlothen, 2017).

Chapter Summary

There is a current gap in the research regarding escalation forecasting and application of FFP contracts with EPAs. This paper aims to accomplish five goals. First, understand what has been historically paid in regards to EPAs. Second, determine the accuracy of Global Insight forecast compared to historic data of PPI336411. Third, identify the quantitative difference between GI forecasted rates and contractor proposal rates within the FPRAs. Fourth, explore the historical data of PPI 336411 for any change points. And last, provide recommendations for changes to the current AFLCMC EPA clause.

The next chapter will discuss the methodology of the research conducted. Then the results and analysis will be detailed in chapter four. And finally, a summary of the research findings will be laid out in chapter five.

III. Methodology

Chapter Overview

This chapter covers the methodologies applied to each research question. The methodologies serve four main objectives. First, a contract modification database is used to identify how many Economic Price Adjustment (EPA) modifications there have been and describe the total obligated amounts for those modifications. Second, Global Insight (GI) data is analyzed to determine the accuracy of current Producer Price Index (PPI) forecasts compared to historical observations. Third, GI data as well as Forward Pricing Rate Agreements (FPRA) are utilized to identify the difference between GI forecasts of PPI data versus what contractors are proposing in the FPRA documents. Last, a change point analysis is conducted on the historical escalation rates of PPI 336411.

This chapter first discusses the data for each of these objectives. Next, the data sources for each objective are examined, as well as data limitations. Last, the methodology for each research question is explained.

Historical Economic Price Adjustments

The 2011 AFLCMC study suggested reducing inappropriate EPA obligations could lead to hundreds of millions of dollars saved in obligation authority. To gain an understanding of the cost impact these EPAs have had through the years, EPA contract modifications from 1981 to 2017 are analyzed to determine how much historically has been obligated as related to EPAs.

Data and Data Sources

The data for this research question comes from the ConData database collected by AFLCMC's cost and economics division. The database contains 46,367 different contracts and contract modifications. They are exported to excel and sorted by a multitude of descriptive columns including PIIN order ID (identification number), division (airframe), cage number (prime contractor), mod ID, total contract price, modification obligation amount, etc. This data requires normalization to a Constant Price. The term Constant Price (CP) is used when costs are normalized with an escalation index (OSD CAPE, 2017). To accomplish the normalization, the BLS managed historical data of PPI 336411 are used to escalate contract obligation amounts to CP 2017 dollars.

The EPA clauses for the C-5 Reliability Enhancements and Re-Engineering Program (RERP) as well as the KC-46 are used as a reference for the entire thesis. Both these establish PPI 336411 as a basis for calculating EPAs.

Data Limitations

The ConData database is derived from the Contract Writing System (ConWrite) which is the main system utilized for all pre and post-award contract activities and hence all contracts are processed through this system (FAR, 2017). The database contains contracts dating back to 1982. It is clear this database is not inclusive, however. Based on 2008 Inspector General (IG) report that examined DoD multiyear contracts of the C-17, F/A-18, and the AH-64D, it was determined Boeing contracts for these three airframes resulted in an EPA liability of between $90.2 million and $260.3 million due to

Boeing contributions to pension plans causing abnormal increases in the BLS PPI (Inspector General [IG], 2008). No contract modifications of this magnitude are found in the ConData database used. The IG's unique methodology indicates there is no consolidated database with accurate EPAs accounted for. Therefore, the implication for the current study is to determine an estimate for EPAs. To obtain an inclusive total of the EPA values, individual calculations for all multiyear contracts would need to be calculated from each respective EPA clause. Therefore, EPA totals found in this research may be an underestimate. Also, the two clauses referenced in this thesis are not inclusive of all EPA clauses. EPA clauses are all written uniquely for what contract they supplement. However, these two clauses were chosen as a proxy to analyze the utility of forecasts as a basis for calculating EPAs. Parallels from this analysis can be applied to other EPA clauses regardless of the index specified.

Methodology

The modification database is first sorted on the division column to include only aircraft contracts. This returns a total of 266 contracts. The database is then filtered on modification description using the keywords "Price Adjustment". This returns all contract modifications related to any type of price adjustment, a total of 80 contract modifications. The modification ID is then filtered specifically on "Price Adjustment" to parse out any modifications not related to price adjustments. This returns a total of 49 modifications. The modification description is then filtered again using the keyword "economic" to return only modifications related to economic price adjustments. This returns a total of 20 modifications. An inclusion and exclusion table is shown in Table 1 that walks through the steps of filtering the data.

Table 1: Inclusion/Exclusion Table

Step	Include	Exclude	Result
Filter division	All aircraft contracts	All data unrelated to aircraft contracts	266 data points
Filter purchase description using keywords "Price Adjustment"	All data related to price adjustments of any kind	All data unrelated to "Price Adjustments"	80 data points
Filter modification ID using keywords "Price Adjustment"	All data categorized as price adjustment modifications	All data unrelated to "Price Adjustments"	49 data points
Filter purchase description using keyword "economic"	All data related to economic price adjustment modifications	All data unrelated to economic price adjustement modifications	20 data points

Once the data is filtered to show all economic price adjustments, the modification obligation amount and original contract price is escalated to a 2017 CP. The obligation amounts are in CP dollar amounts. It is assumed that the dollar values are in CP dollar amounts of the effective date of the contract. CP 2017 is chosen as a normalized date because that is the latest effective date in the list of modifications. To escalate the values to a CP dollar amount, the value of PPI336411 of Oct 2017 is divided by the index value of the effective date of the current contract. This provides an escalation factor that is then multiplied by the modification obligation amount and the original contract price to return an escalated value of the obligation amount and contract price in CP 2017 dollars.

The escalated obligated amount of the EPA and original contract amount are then summed up by airframe. This returns total dollar amount for both categories for a total of 5 airframes. To determine the percent of the total contract that the economic price adjustment makes up, the total obligated amount of the EPA is divided by the total contract price and then multiplied by 100. The airframe, total contract price, total obligated amount, and percent of contract are then consolidated into a table.

Global Insight Forecasts vs Historical Values

Accuracy of GI forecasts compared to actuals are important as they are the baseline from which EPA payments are determined. If the forecasts deviate from the actuals, then they are not reflective of what is happening in the aircraft manufacturing industry. The purpose of the EPA is to provide protection to both the government and contractor from unanticipated changes in the economy, not a forecast. In the 2011 AFLCMC study it was determined GI forecasts of PPI 3364 were historically below actuals of the PPI. This research compares GI forecasts of PPI 336411, a more representative index of the aircraft manufacturing industry than the previously examined PPI 3364, to Bureau of Labor Statistics (BLS) actuals including 8 more years of data than the 2011 AFLCMC study.

Data and Data Sources

The data sources for this section of the research are IHS Global Insight (GI) forecasts as well as BLS managed PPI data from PPI336411. Global Insight is an economic analysis division of IHS Markit. According to the IHS Markit website, IHS Markit connects data across variables to provide their customers with a more detailed view of their field of study (IHS Markit Website, 2017). The DoD utilizes GI to provide detailed forecasts of all Producer Price Indexes which the DoD then applies to building EPA clauses for government contracts.

PPI 336411 was chosen because it pertains to the price of aircraft manufacturing and it is the baseline PPI for the EPA clauses under examination. The BLS historical data of PPI 336411 contains tracked actual index values spanning back to 1985 and is broken out by month. These data points are then compared to the GI forecasts which are completed on a quarterly basis and span back to 2004 for PPI 336411. Therefore, historical data from 2004 to 2017 is the final dataset utilized for comparison.

Data Limitations

The data from BLS spans a total of 33 years, with measured values every month. This provides a total of 396 historically observed data points from PPI 336411. However, the average monthly forecast was used as a snapshot value of the escalation for each year.

Global Insight's forecast span only 13 years, with forecasted values of PPI 336411 observed once every quarter. Therefore, to have one forecast for each year, the quarter four forecasts are used as a determinant of each year's forecast. The limiting data source, in this case, is the Global Insight forecasts because there are fewer data points available than the BLS historical data. Therefore, to address this limitation, the data is only compared from 2005 to 2017. To limit any excess data noise while still allowing for robust analysis, a total of seven forecasts are used, starting with the 2005 quarter four forecast and every other year's quarter four forecast through 2017.

Methodology

The first step in determining the accuracy of the GI forecasts is to compare the GI forecasts of PPI 336411 to the actual performance of the index. The raw index historical values from 2002 to 2017 are plotted along with the average of the GI forecasts of years 2005, 2007, 2009, 2011, 2013, 2015, and 2017. The escalation rate of PPI336411 is then calculated for both the historical data as well as all the GI forecasts using Equation 1.

$$E_{\mathrm{n}} = \left(\frac{(PPI_{\mathrm{n}} - PPI_{(\mathrm{n}-1)})}{PPI_{(\mathrm{n}-1)}}\right) * 100$$

Equation 1: Escalation

In Equation 1, E_n is the escalation in year *n,* and PPI_n is the PPI value in year *n.* The escalation rates of the average GI forecast are then graphed along with the actual escalation rates to provide an analysis of the accuracy of the GI forecasts.

Because the escalation rates fluctuate up and down at a seemingly sporadic rate, it is difficult to determine the deviation of the GI forecasts to the actual escalation. Therefore, the deviation of the GI forecasted escalation to actual escalation is calculated for each year in the forecasts and plotted on a graph. The deviation of the average forecast from the actuals is also calculated. The deviation is calculated using Equation 2.

$$D_E = E_{GI} - E_A$$

Equation 2: Deviation

In Equation 2 E_{GI} is the GI forecast escalation rate and E_A is the actual escalation rate. To determine an overall accuracy trend of the GI forecasts, the net total deviation and absolute total deviation is calculated for each GI forecast used.

Global Insight Forecasts vs Contractor FPRA Direct Labor Escalation

In the 2011 AFLCMC study it was determined one defense contractor with annual labor escalation was well above GI forecasts. This research compares a total of 6 contractor's direct labor escalation rates to GI forecasts and analyzes any trends. If in general the contractors are assuming higher escalation in the FPRAs than what GI is forecasting, then they may be receiving compensation escalation already assumed in the contract's base price.

Data and Data Sources

The data sources for this section of research include the GI forecasted values of PPI336411 as well as the assumed escalation rates manifested in contractor FPRAs. The

FPRA documents represent 6 different contractors and are provided by AFLCMC cost and economics division. The FPRAs contain the approved labor rates of each contractor on a yearly basis. From these rate values, the assumed escalation rate can be derived by simply calculating the percentage increase of the direct labor portion of the FPRA rate year-by-year. Due to releasability of proprietary information within the FPRAs the names of the specific contractors are not provided.

Data and Limitations

The limitations, already discussed, of the GI forecasted data remain for this research area. The GI data only spans 13 years and only the fourth quarter forecasts are utilized. However, the FPRA documents contain labor rates ranging from 2014 to 2021 depending on the contractor. Therefore, when comparing the derived escalation rates from the GI forecasts to the escalation rates within the FPRA documents, a maximum of five and a minimum of three data points are available for comparison.

The direct labor rates within the FPRAs are not a perfect representation of the assumed escalation by each contractor. Actual escalation rates for firm fixed price contracts are not officially released to the government, therefore the FPRA labor rates are used as a proxy to determine an approximate escalation value each year for the contractors. The direct labor rate portion of the FPRA are chosen as a proxy for deriving escalation because escalation is heavily influenced by labor.

Methodology

As previously discussed, GI data does not provide the escalation rates on a yearly basis. Instead, the quarterly values of PPI 336411 are provided. Therefore, the yearly escalation rates are derived from these values by way of equation 1. Similarly, the

FPRAs do not provide yearly escalation rates. Instead, the FPRAs contain the yearly labor rates for each contractor. The escalation rates assumed in the FPRAs are derived by calculating the yearly percent change of the labor rates.

Within each FPRA the contractor details a multitude of different direct labor rates depending on the type of laborer. Each of these categories of rates are escalated differently, however for comparison purposes, one value of direct labor escalation for each FPRA needs to be obtained. Therefore, descriptive statistics are calculated for each year's escalation values, including all labor categories. The escalation rates of each category are also plotted to show a visual representation of any potential outliers. The median was then chosen in the FPRAs as the consolidated rate for all years because this is the best measure of central tendency for both normal and skewed distributions.

For example, Table 2 shows the direct labor rates of a contractor within the FPRA. As is shown, there are multiple categories of laborers and within each category are different skill classes. All these laborers have different labor rates that are escalated each year differently. The derived escalation rates are shown next to the resource code column. The rates are approximately the same for each but have some variation. To get one escalation rate for each year, descriptive statistics are calculated for each year. The results of this are shown in Table 3.

Table 2: Contractor 1 FPRA Direct Labor Rates and Escalation

	DIREC+C45:M61T LABOR RATES						Escalation Factors			
	Category	Skill Class	2017	2018	2019	2020	2017	2018	2019	2020
	Eng/PMO	1	$ 39.37	$ 40.31	$ 41.28	$ 42.27	0.000%	2.388%	2.406%	2.398%
		2	$ 35.09	$ 35.93	$ 36.79	$ 37.67	0.000%	2.394%	2.394%	2.392%
		3	$ 38.12	$ 39.03	$ 39.97	$ 40.93	0.000%	2.387%	2.408%	2.402%
		4	$ 66.16	$ 67.75	$ 69.38	$ 71.05	0.000%	2.403%	2.406%	2.407%
		5	$ 85.65	$ 87.71	$ 89.82	$ 91.98	0.000%	2.405%	2.406%	2.405%
	Support	1	$ 41.72	$ 42.72	$ 43.75	$ 44.80	0.000%	2.397%	2.411%	2.400%
		2	$ 28.22	$ 28.90	$ 29.59	$ 30.30	0.000%	2.410%	2.388%	2.399%
		3	$ 31.76	$ 32.52	$ 33.30	$ 34.10	0.000%	2.393%	2.399%	2.402%
		4	$ 49.15	$ 50.33	$ 51.54	$ 52.78	0.000%	2.401%	2.404%	2.406%
		5	$ 64.92	$ 66.48	$ 68.08	$ 69.71	0.000%	2.403%	2.407%	2.394%
	Eng/PMO	1	$ 29.95	$ 30.67	$ 31.41	$ 32.16	0.000%	2.404%	2.413%	2.388%
		2	$ 32.13	$ 32.90	$ 33.69	$ 34.50	0.000%	2.397%	2.401%	2.404%
		3	$ 35.21	$ 36.06	$ 36.93	$ 37.82	0.000%	2.414%	2.413%	2.410%
		4	$ 57.43	$ 58.81	$ 60.22	$ 61.67	0.000%	2.403%	2.398%	2.408%
		5	$ 73.67	$ 75.44	$ 77.25	$ 79.10	0.000%	2.403%	2.399%	2.395%
	Support	1	$ 29.95	$ 30.67	$ 31.41	$ 32.16	0.000%	2.404%	2.413%	2.388%
		2	$ 26.83	$ 27.47	$ 28.13	$ 28.81	0.000%	2.385%	2.403%	2.417%
		3	$ 32.47	$ 33.25	$ 34.05	$ 34.87	0.000%	2.402%	2.406%	2.408%
		4	$ 47.52	$ 48.66	$ 49.83	$ 51.03	0.000%	2.399%	2.404%	2.408%
		5	$ 64.33	$ 65.87	$ 67.45	$ 69.07	0.000%	2.394%	2.399%	2.402%
	Eng/PMO	1	$ 22.87	$ 23.42	$ 23.98	$ 24.56	0.000%	2.405%	2.391%	2.419%
		2	$ 23.56	$ 24.13	$ 24.71	$ 25.30	0.000%	2.419%	2.404%	2.388%
		3	$ 34.32	$ 35.14	$ 35.98	$ 36.84	0.000%	2.389%	2.390%	2.390%
		4	$ 52.65	$ 53.91	$ 55.20	$ 56.52	0.000%	2.393%	2.393%	2.391%
		5	$ 65.17	$ 66.73	$ 68.33	$ 69.97	0.000%	2.394%	2.398%	2.400%
	Support	1	$ 22.87	$ 23.42	$ 23.98	$ 24.56	0.000%	2.405%	2.391%	2.419%
		2	$ 23.56	$ 24.13	$ 24.71	$ 25.30	0.000%	2.419%	2.404%	2.388%
		3	$ 30.97	$ 31.71	$ 32.47	$ 33.25	0.000%	2.389%	2.397%	2.402%
		4	$ 44.44	$ 45.51	$ 46.60	$ 47.72	0.000%	2.408%	2.395%	2.403%
		5	$ 55.42	$ 56.75	$ 58.11	$ 59.50	0.000%	2.400%	2.396%	2.392%

Table 3: Contractor 1 Descriptive Statistics of Escalation Rates

Contractor 1			
	2018	2019	2020
Mean	2.400%	2.401%	2.401%
Median	2.402%	2.402%	2.402%
Mode	2.404%	2.413%	2.388%

After the descriptive statistics are calculated, the escalation rates for each year are graphed to show the distribution. This is shown in Figure 2. In this case the rates appear to be evenly distributed around a mean with no potential outliers, therefore, the median is chosen as the consolidated escalation rate for each year. This process is completed for the rest of the 5 contractors, the results of which is shown in Appendix B.

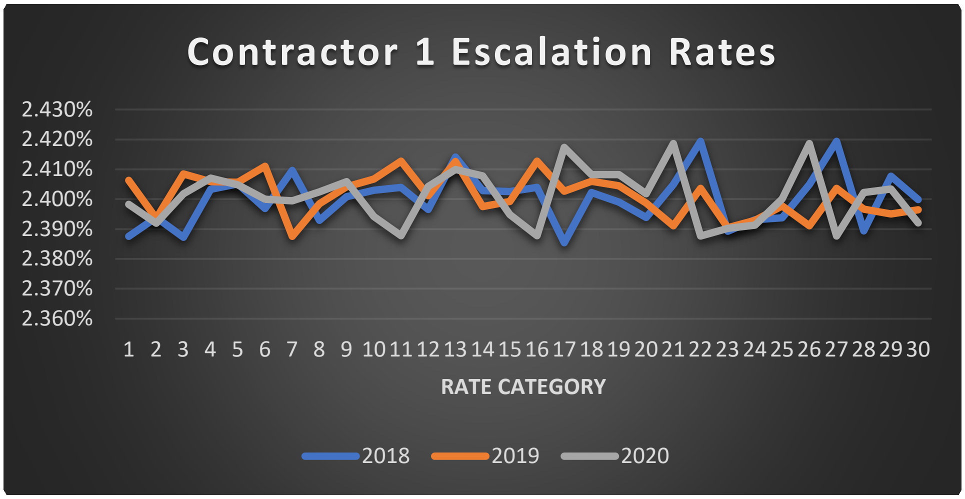


Figure 2: Contractor 1 Escalation Rates

Next, the deviation of the GI forecasted escalation rates to each contractor's escalation rates are calculated using Equation 2 but substituting the contractor's escalation rate for E_A. These deviations are then plotted for each contractor to give a visual comparison of the GI forecasts to what the contractors are assuming in their contracts. A year-by-year deviation for each contractor is also provided in a table to show the frequency of positive and negative deviations.

Change Point Analysis

To this point the accuracy of GI forecasts compared to actuals and contractor FPRAs has been analyzed to provide evidence of the validity of utilizing GI forecasts as a benchmark for EPAs. To gain a better understanding of whether GI forecasts are a valid tool to base EPA payments, the historical values of PPI 336411 are analyzed for any significant change points.

Data and Data Sources

This section of the research uses the BLS managed historical PPI data. As previously discussed, the focus is on the aircraft manufacturing PPI 336411.

Data Limitations

The BLS managed historical data of PPI 336411 date back to 1985 and is documented monthly. The monthly values of the PPI are used, providing 384 data points.

Methodology

Finding significant changes can be a difficult task without a concrete measure of what defines a significant change in a data set. Therefore, a change point analysis is conducted on the historical values of PPI 336411. A change point analysis gives insight into if and when, there is a significant change in the average of the data. If there is a significant change in the data, then further research can be done to determine what factors contributed to this shift. When a data set has significant shifts in the average, basing future values of the data set on a forecasting model may not be advantageous because other factors are influencing the data that may not be able to be predicted.

Determining the Range of Cumulative Sum Values

To begin the change point analysis, the historical values of PPI 336411 are converted to a monthly escalation rate by calculating the percent change each month. These escalation rates are then placed in a column next to the raw index values. The average of these values is then calculated and titled $\bar{x}$. A second column is then created to calculate the difference in each year's escalation rate to the average escalation rate. This column is titled x-$\bar{x}$. The next step in the analysis is to calculate what is known as a cumulative sum. A cumulative sum (CUMSUM) is a moving sum of the x-$\bar{x}$ values. The

CUMSUM (S_n) column starts with a S_0 value of 0. Each subsequent S_n value is calculated using Equation 3.

$$S_n = S_{n-1} + (x - \bar{x})$$

Equation 3: CUMSUM

In Equation 3, S_n is the CUMSUM in time *n*, S_{n-1} is the CUMSUM in time *n-1*, x is the escalation value in time *n*, and $\bar{x}$ is the average of the escalation values from 1986 to 2017. Once all the S_n values are calculated, a range, or S_{diff}, is calculated on the values. The range calculation is shown in Equation 4. An example of these calculations is shown in Table 4. Because there are 384 rows, only the first 40 are shown in Table 4.

$$S_{diff} = S_{max} - S_{min}$$

Equation 4: Range

Table 4: Change Point Variable Calculations

ID	Date	PPI 336411	% change	X-Xbar	CUSUM	Sdiff
	Dec-85	100	0.00%	0		17.86%
1	Jan-86	100.9	0.90%	0.67%	0.67%	
2	Feb-86	100.7	-0.20%	-0.43%	0.24%	
3	Mar-86	100.9	0.20%	-0.03%	0.21%	
4	Apr-86	100.8	-0.10%	-0.33%	-0.12%	
5	May-86	100.4	-0.40%	-0.63%	-0.74%	
6	Jun-86	100.4	0.00%	-0.23%	-0.97%	
7	Jul-86	100.5	0.10%	-0.13%	-1.10%	
8	Aug-86	100.4	-0.10%	-0.33%	-1.43%	
9	Sep-86	98.6	-1.79%	-2.02%	-3.45%	
10	Oct-86	98.6	0.00%	-0.23%	-3.68%	
11	Nov-86	98.6	0.00%	-0.23%	-3.91%	
12	Dec-86	98.6	0.00%	-0.23%	-4.14%	
13	Jan-87	99.5	0.91%	0.68%	-3.45%	
14	Feb-87	100.1	0.60%	0.37%	-3.08%	
15	Mar-87	100.5	0.40%	0.17%	-2.91%	
16	Apr-87	100.0	-0.50%	-0.73%	-3.64%	
17	May-87	99.2	-0.80%	-1.03%	-4.67%	
18	Jun-87	99.3	0.10%	-0.13%	-4.79%	
19	Jul-87	98.9	-0.40%	-0.63%	-5.43%	
20	Aug-87	98.9	0.00%	-0.23%	-5.65%	
21	Sep-87	98.9	0.00%	-0.23%	-5.88%	
22	Oct-87	98.7	-0.20%	-0.43%	-6.31%	
23	Nov-87	98.8	0.10%	-0.13%	-6.44%	
24	Dec-87	98.3	-0.51%	-0.74%	-7.18%	
25	Jan-88	99.7	1.42%	1.20%	-5.98%	
26	Feb-88	99.9	0.20%	-0.03%	-6.01%	
27	Mar-88	99.9	0.00%	-0.23%	-6.24%	
28	Apr-88	100.8	0.90%	0.67%	-5.57%	
29	May-88	100.9	0.10%	-0.13%	-5.70%	
30	Jun-88	101.7	0.79%	0.56%	-5.13%	
31	Jul-88	101.3	-0.39%	-0.62%	-5.76%	
32	Aug-88	101.3	0.00%	-0.23%	-5.99%	
33	Sep-88	102.4	1.09%	0.86%	-5.13%	
34	Oct-88	102.6	0.20%	-0.03%	-5.16%	
35	Nov-88	102.3	-0.29%	-0.52%	-5.68%	
36	Dec-88	105.8	3.42%	3.19%	-2.49%	
37	Jan-89	107.7	1.80%	1.57%	-0.93%	
38	Feb-89	108.2	0.46%	0.24%	-0.69%	
39	Mar-89	109.1	0.83%	0.60%	-0.09%	
40	Apr-89	109.4	0.27%	0.05%	-0.04%	

Identifying Visual Shifts in the CUMSUM Chart

Next, the CUMSUM data is plotted on a graph to identify overarching shifts in the slope of the data. There are points in the data where the slope changes, but it does not cause a change in the overall trend in the data. These points are not identified as potential change points. If the slope changes and causes a change in the trend of the data, then this point is identified as a potential change point. After graphing the CUMSUM data, analysis is conducted to mathematically determine if a change did in fact occur. This is done through a process called bootstrapping.

Bootstrapping the Original CUMSUM Values

Bootstrapping is a process of randomly sampling with replacement from the original data set, deriving a statistic from the randomized sample and comparing to the original sample. In this case, one bootstrap sample is manually created, and then a simulation is run with 10,000 iterations using @Risk software, effectively creating 10,000 bootstrap samples. An average is calculated for the sample. Then S_n values are calculated for the sample and a S_{diff} value is calculated for the bootstrap. The S_{diff} value of the bootstrap is then compared to the original S_{diff} value. If $S_{diff}^{n} < S_{diff}$ then there is evidence to suggest there was a significant change in the average of the data in the given timeframe of 1986 to 2017. If $S_{diff}^{n} > S_{diff}$ then there is not sufficient evidence to suggest a significant change occurred in the average of the data from 1986 to 2017. For both situations, S_{diff} is the range of the original data and S_{diff}^{n} is the range of the bootstrapped data. From the simulation a distribution of the S_{diff}^{n} values are created and the delimiters are adjusted so the right most delimiter is equal to the S_{diff} value of the original data set and the left most delimiter is on the far left of the distribution. This represents the frequency of when $S_{diff}^{n} < S_{diff}$. The resulting percentage between the two delimiters is the empirical coverage of a change occurred in the given time frame. The α used is 0.05, so if the empirical coverage is greater than 95% then there is significant evidence to suggest a change occurred between 1986 and 2017.

Sum Squared Error Estimator of Change Point

Once the range of times are identified where a change occurred in the average of the data, an estimate of what month and year the change occurred is calculated. The estimator used to identify the change point is Sum Squared Error (SSE). The formula used to calculate SSE is shown in Equation 5.

$$SSE(m) = \sum_{n=1}^{m}(x_n - \bar{x}_1)^2 + \sum_{n=m+1}^{384}(x_n - \bar{x}_2)^2$$

where

$$\bar{x}_1 = \frac{\sum_{n=1}^{m} x_n}{n} \text{ and } \bar{x}_2 = \frac{\sum_{n=m+1}^{384} x_n}{384-m}$$

Equation 5: SSE Change Point Estimator

In Equation 5, m represents the point at which it is determined there may be a change point. x_n is the monthly escalation rate. $\bar{x}_1$ represents the average of the data prior to point m while $\bar{x}_2$ is the average of the data after point m. This equation breaks the data into two segments on either side of the tested point and estimates the average of each one of the segments. The point m is then compared to the average of the two segments. The value of m that minimizes SSE is the best estimate of last point before a change occurred (Taylor, 2000).

For the data set, three periods of time are identified as having potential change points within them, 1986 to 1999, 1996 to 2005, and 2005 to 2017. A narrower period of time around each change point is then identified based on the CUMSUM chart depicted in Figure 9 of Chapter 4. For the first change point within 1986 to 1999, the SSE values from January 1995 ($m = 109$) to May 1997 ($m = 137$) are calculated. For the second change point within 1996 to 2005, the SSE values from October 1998 ($m = 154$) to March 2000 ($m = 171$) are calculated. For the third change point within 2005 to 2017, the SSE values from September 2008 ($m = 273$) to July 2011 ($m = 307$) are calculated. Within each one of these ranges, the minimum SSE are identified and this is the best estimate for the change point within each range.

Retrospective EPA versus Prospective EPA (MAPE)

After the change point analysis is conducted, a retrospective approach to EPAs was compared to the current prospective approach by comparing Mean Absolute Percent Error (MAPE).

Data and Data Sources

This section of the research uses the BLS managed historical PPI data. As previously discussed, the focus is on the aircraft manufacturing PPI 336411. IHS GI forecasts of PPI 336411 are used as well.

Data Limitations

For each base year calculation of the MAPE, only 10 years from the specified base year are used. MAPE values from base year 2000 to 2009 are calculated because the year 2000 is identified as a change point in the historical data of PPI 336411 where the inflation rates change from being below the average to above the average. 2009 is the last base year used because there is only historical data through 2018 and with a 10-year assumption from the base year, 2009 is the last year able to be used.

Methodology

MAPE is a variable that measures the error of a forecast value to an actual value in percentage terms. It is typically utilized to compare to forecasting techniques, however, in this situation it is used to compare two approaches to EPA clauses.

The current approach is a prospective approach, which means EPA payments are calculated based on changes in forecasts. If the current years forecast varies by a specific threshold percentage from the established base year forecast, then an EPA may be triggered. In the EPA clause referenced in Appendix A, a base year 2009 quarter 4 forecast of PPI 336411 is used, therefore, for the MAPE calculations, the same base forecast is used. The retrospective approach is similar to the prospective approach, however, instead of using forecasts, historical values are used. Specifically, a base year of the historical index of PPI 336411 is chosen and this is compared to the current year of the index. A ten-year period of performance for the purposes of the EPA clause is assumed. Therefore, the base year of the forecast will be adjusted every ten years. Once it is established which two methods are being compared, the MAPE for both are calculated. The MAPE equation is shown in Equation 6.

$$\left(\frac{1}{n}\Sigma\frac{|Actual - Forecast|}{|Actual|}\right) \times 100$$

Equation 6: MAPE

For the MAPE calculation of the prospective approach, the 2009 quarter 4 forecast is the *Actual* value of the equation. The *Forecast* value used are the 2010-2017 quarter 4 forecast. The 2009 quarter 4 forecasts begin in 2009 and span to 2018. The forecasts are then projected to 2027 using the current practice of maintaining the previous years' forecast escalation rate for all out years. This projection to 2027 is also done for the 2010-2017 quarter 4 forecasts. The MAPE for each quarter 4 forecast from 2010-2017 are then calculated and the average of the MAPEs during this time period is calculated.

The MAPE of the 2009 quarter 4 forecasts to the historical index values of PPI 336411 is also calculated and compared to the MAPE of the retrospective approach previously discussed.

Conclusion

This chapter detailed the methodologies for each research objective. With the 2011 AFLCMC study as a baseline to verify and compare research results, the validity of the EPA clauses was analyzed by doing the following. First, the historical EPA amounts were totaled in a tabular format to show the cost impact of EPAs in fixed price contracts. Then the GI forecasts of PPI 336411 were compared to BLS actuals of the index to determine the accuracy of the forecasts. Next the GI forecasts were compared to FPRA derived labor escalation rates to determine if EPA payments have a portion already assumed in the contract's base price. Next, a change point analysis was conducted to identify changes in the average of the historical data that may be effecting the accuracy of the forecasts. Last, a MAPE value of the current prospective approach is compared to an average MAPE from 2000-2009 of the retrospective approach. Also, the MAPE of the 2009 quarter 4 forecast as compared to the historical values of PPI 336411 is calculated. The next chapter will discuss the results of the each of these methodologies as well as interpret the findings.

IV. Results and Analysis

Chapter Overview

Chapter 4 discusses the results of each research question as well as the relevance of these results. The chapter provides answers to what historically is being paid to the government and to the contractor in relation to EPAs, the accuracy of Global Insight (GI) forecasts in comparison to actual values of PPI 336411, how Global Insight escalation forecasts compare to what contractors are assuming in FPRAs, and if it is valid to base an EPA clause on an index forecast.

Historical Economic Price Adjustments

Knowing how much is currently obligated due to EPAs is important as it gives insight into a few pieces of data. The first is whether the EPA clause, as written, provides equal protection to both the government and contractor. An EPA clause providing equal protection should over the course of multiple years have close to equal instances of upward and downward adjustments. Second, it provides insight into the cost impact of EPAs.

Table 5 shows the total contract price, total obligated amount, and percent of contract related to economic price adjustments separated by airframe. A negative amount in the “Total Obligated Amount” column indicates a downward EPA, while a positive value indicates an upward EPA. Out of the 266 aircraft contracts and modifications only a total of 20 of the modifications are related to EPAs, which indicates EPAs are not as pervasive as previously believed. Of these 20 modifications, 9 are downward adjustments, which indicate money being returned to the government. This implies that since 1981, the EPA clauses have provided equal protection to both government and contractor in times of unanticipated fluctuations in the aircraft manufacturing industry. The total dollar value of the original contract price of the modifications is $81,057,561,405, while the net obligated amount of the modifications is $693,636. This represents 0.0009% of the overall contracts value. Based on this minimal amount being paid in EPAs, EPAs do not have a significant cost impact to the Air Force on a net basis. However, as shown in Table 5, division 2 has upward adjustments totaling $22,744,725. As a percentage of the total contract price this is not a large amount, though this still represents over $22M in incorrectly allocated money that could have been used for higher priority items. This loss of obligation authority for other priorities represents the opportunity cost of inaccurate forecasts.

Though the cost impact of EPAs is not large in comparison to the overall contract values, there is something to be gained from further analysis. As will be discussed in questions 2, 3, and 4, basing an economic adjustment payment off a change in a forecasted index is not reflective of actual changes in the economy. Instead, if the EPA is to reflect actual fluctuations in the market, it is appropriate to base the payment off how much the current index value deviates from historical averages of the index.

Table 5: Economic Price Adjustment Amount by Aircraft

Division	Modification Count	Total Contract Price	Total Obligated Amount (EPA)	Percent of Contract
1	2	$ 29,653,250,814	$ (7,475,916)	-0.0252%
2	4	$ 10,285,600,121	$ 22,744,725	0.2211%
3	3	$ 18,374,457,653	$ 52,862	0.0003%
4	5	$ 3,572,044,461	$ (3,363,143)	-0.0942%
5	6	$ 19,172,108,357	$ (11,264,891)	-0.0588%
Absolute Total	20	$ 81,057,461,405	$ 44,901,537	0.0554%
Net Total	20	$ 81,057,461,405	$ 693,636	0.0009%

The overall contract price by airframe is then compared to the total EPA amount obligated to determine if contract size has any influence on the EPA amount, positive or negative. Figure 3 depicts a graph of the total contract price and obligated amount by aircraft. Because the EPA amounts are so small in magnitude compared to the overall contract values, the EPA obligated amounts are graphed separately in Figure 4 to show how each airframe differs. The contract associated with division 1 has the greatest value at $29.65B but ranks third out of the five airframes in terms of EPA amount. Contrary, division 4 has the smallest contract value of $3.57B but ranks fourth out of five in EPA magnitude. This is an indication that magnitude of the contract does not have an influence on the magnitude of the EPA. Instead the magnitude and frequency of an EPA is more likely influenced by the wording of the EPA and what assumptions the payment is based on. These will be examined in research questions 2, 3, and 4.

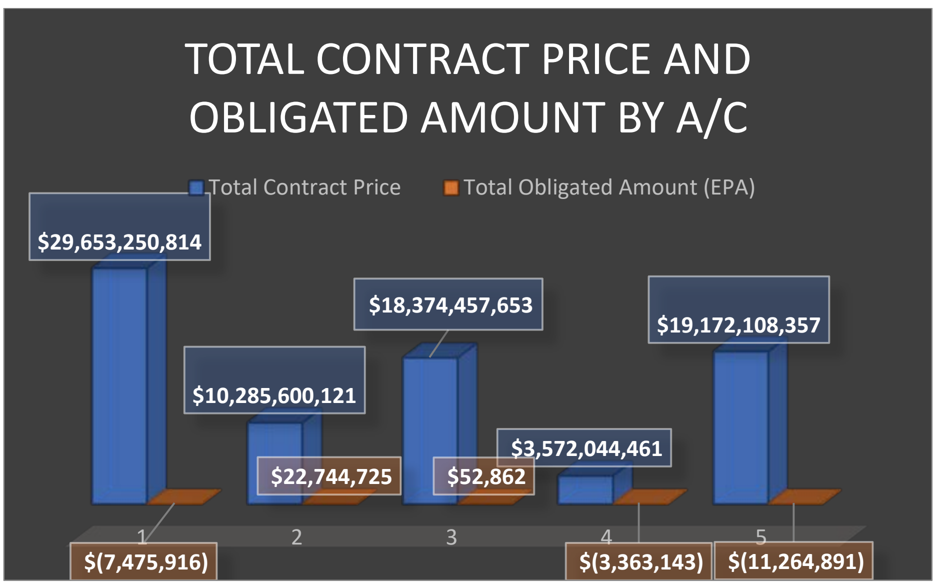


Figure 3: Total Contract Price and Obligated Amount of EPA by Aircraft

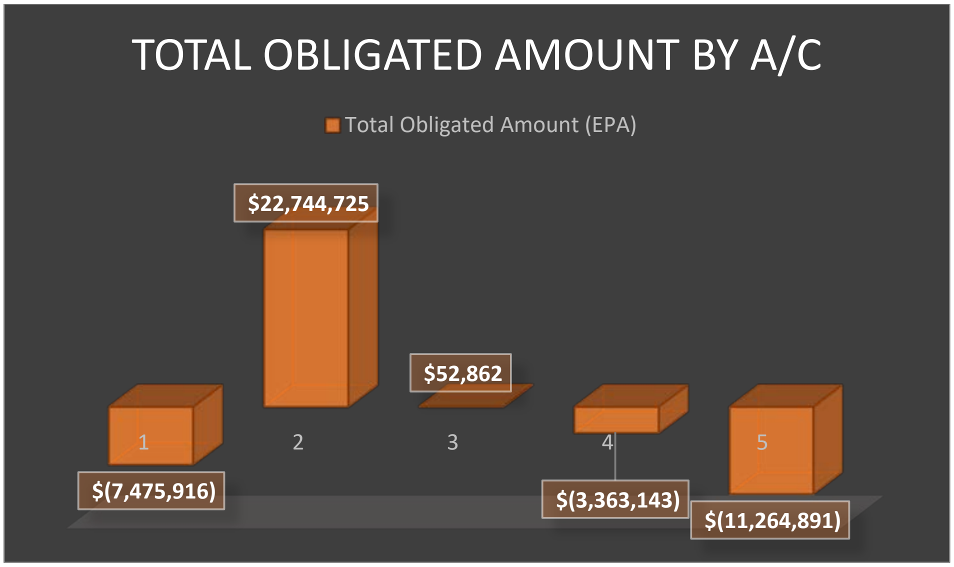


Figure 4: Total Obligated Amount of EPA by Aircraft

Global Insight Forecasts vs Historical Values

After determining that magnitude of contract does not influence magnitude or frequency of EPA, the accuracy of the GI forecasts of PPI 336411 to actuals is examined. Figure 5 shows the average forecast values of PPI 336411 along with the actuals. Based on this graph it appears the forecasts fall well in line with the actual raw index values. However, the EPA clause language does not rely on a forecast of the raw index value as a determinant of payment. Instead it focuses on the escalation of the index. Therefore, the average forecasted escalation rate versus the actual escalation rate is shown in Figure 6.

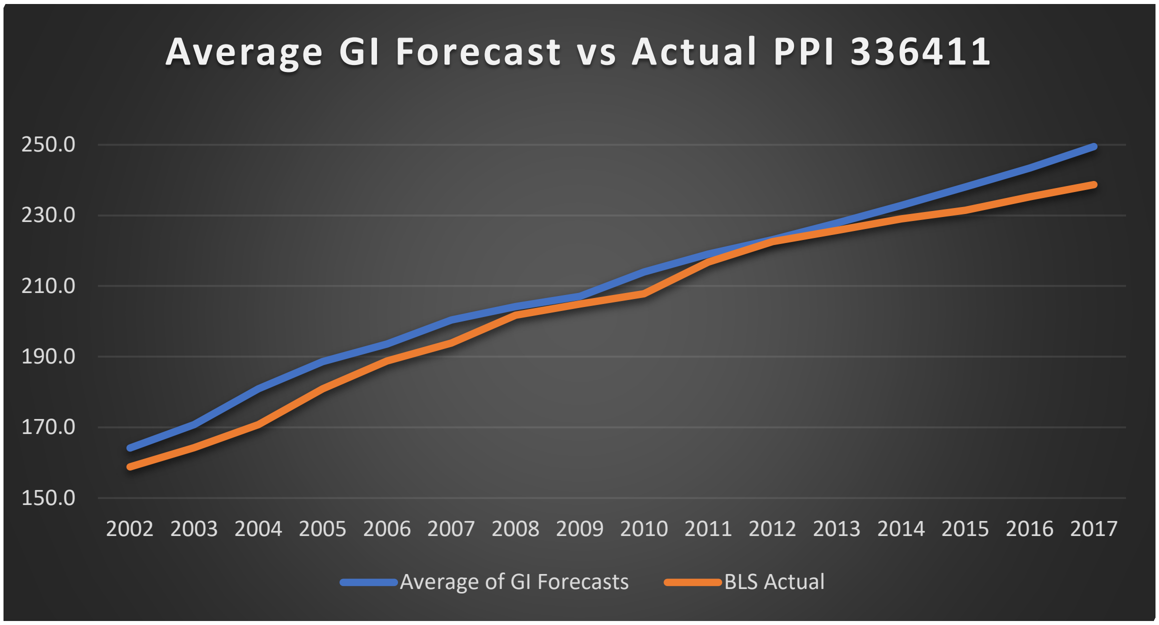


Figure 5: Actual vs Average Forecast (Raw Index Values)

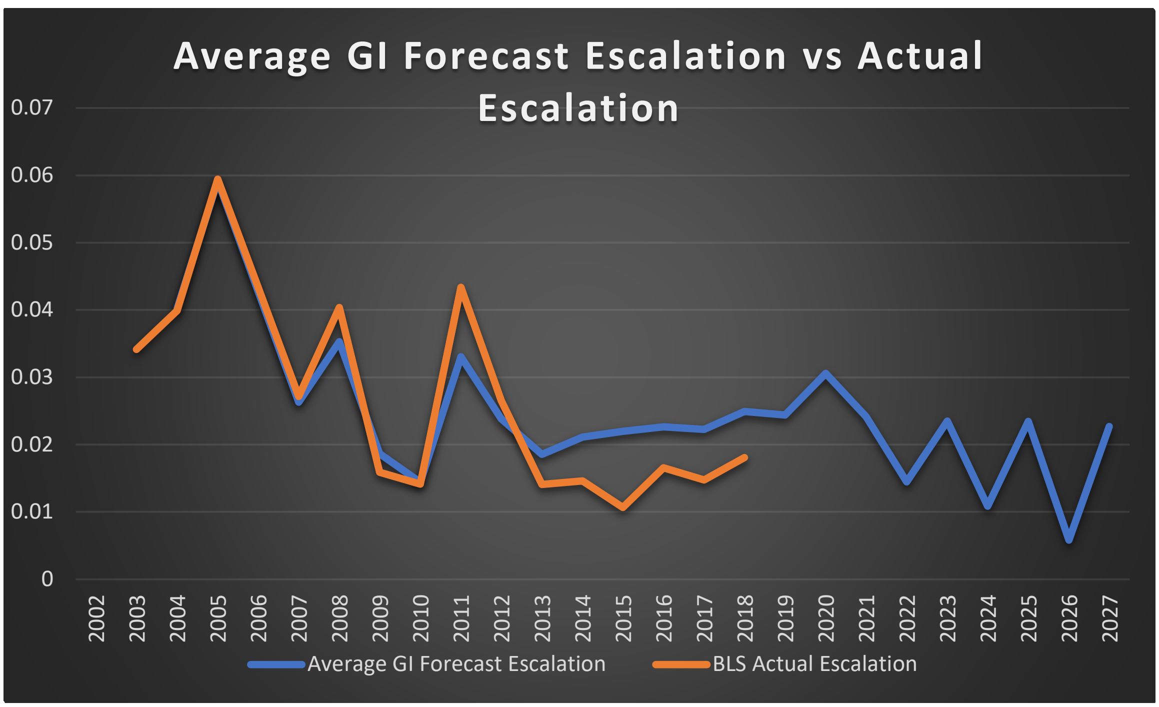


Figure 6: Actual vs Average Forecast (Escalation Rates)

From the escalation graph it becomes clear the forecasted escalation is generally in line with actual escalation from 2005 to 2008. After 2008 the forecasts begin to deviate above and below actuals until around 2013 where they are steadily above actuals through 2017. To get a better visual of the magnitude of deviation of the forecasts from the actuals, the deviation graph is depicted in Figure 7.

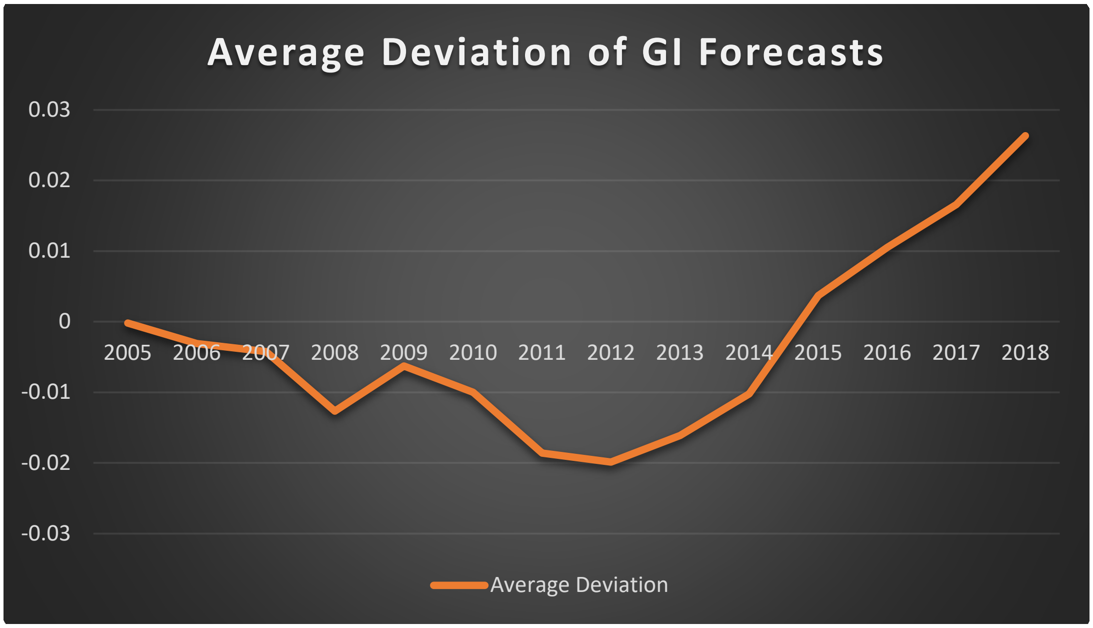


Figure 7: Average Deviation of Forecasts

The deviation graph further clarifies that the forecasted escalation rates deviate and are below the actuals from 2005 to 2014 and above from 2014 to 2017. This means since 2014 GI has over-estimated the escalation of PPI 336411. This is contrary to what was initially explored in the 2011 study by AFLCMC which suggested GI forecasts are generally underestimating the PPI. However, the original study explored the accuracy of PPI 3364 Aerospace product and parts manufacturing which is the highest-level PPI in the aerospace industry. Because the EPA clauses refer to PPI 336411 as the baseline for adjustments, it is appropriate to analyze the accuracy of this index instead of the accuracy of the higher-level index. A sensitivity analysis was also conducted comparing the January, June, and December BLS values of PPI 336411 to GI forecasts. This resulted in similar trends of inaccuracies as when using the average BLS value. The graph of the original study is shown in Figure 8.

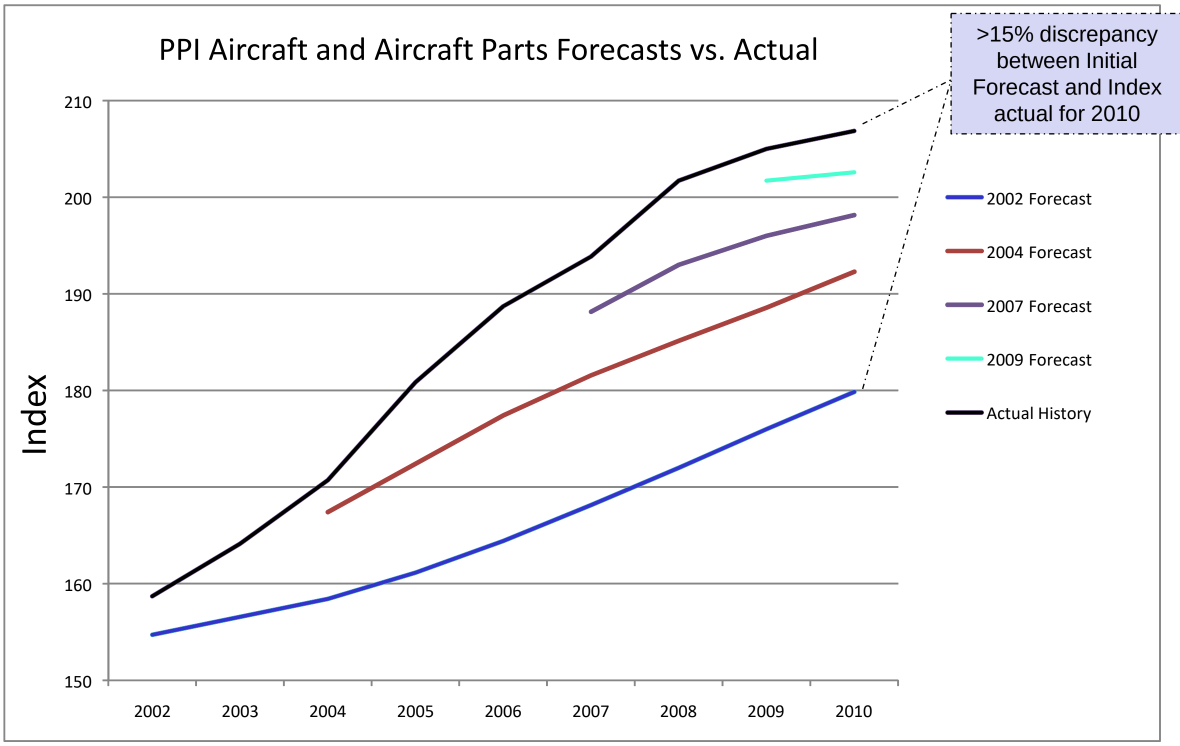


Figure 8: Forecast of PPI 3364 Raw Values vs Actuals (2011 AFLCMC Study)

To detail how each year's forecast specifically deviates from the actuals Table 6 is provided. It depicts the deviation by year of the fourth quarter forecasts of escalation to the actual escalation values managed by BLS. Red cells indicate when the GI forecasts are below the actuals. The right-hand columns show the net total deviation and absolute total deviation to give an indication of the overall accuracy of the GI insight forecasts to the actuals. The bottom row is the average percent deviation of each given year.

Table 6: Deviation of GI Escalation Forecasts to BLS Actuals

Q4 Forecast	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Net Percent Deviation	Absolute Percent Deviation
2005	-0.02%	-0.31%	-0.83%	-2.54%	-1.92%	-1.12%	-2.97%	-3.09%	-2.05%	-0.96%	0.54%				-15.27%	16.35%
2007			-0.02%	0.01%	0.05%	-0.66%	-0.31%	0.28%	-2.14%	-2.87%	-2.13%	-1.36%	-0.15%		-9.30%	9.97%
2009					-0.02%	-1.21%	-4.17%	-4.84%	-3.99%	-2.89%	-1.10%	-0.33%	0.02%	0.43%	-18.54%	19.00%
2011							-0.01%	-0.29%	0.13%	1.06%	2.70%	3.78%	4.88%	5.71%	12.26%	18.57%
2013									0.00%	0.54%	2.19%	3.31%	4.34%	5.12%	10.38%	15.51%
2015											0.02%	-0.15%	0.83%	1.69%	0.69%	2.69%
2017													0.02%	0.22%	0.02%	0.24%
Average	**-0.02%**	**-0.31%**	**-0.42%**	**-1.27%**	**-0.63%**	**-1.00%**	**-1.86%**	**-1.99%**	**-1.61%**	**-1.02%**	**0.37%**	**1.05%**	**1.66%**	**2.63%**	**-4.42%**	**15.84%**

Based on this table, as well as the other graphics discussed in this section, it is evident GI forecasts of PPI336411are generally inaccurate. Forecasts before 2009 have negative net percent deviations which indicates they are below actuals, while forecasts after 2009 have positive net percent deviations which indicate they are above actuals. This general inaccuracy can be a result of a multitude of factors not directly related to the aircraft manufacturing industry. Because there was a switch from underestimation to overestimation in 2009, this may indicate a change point in the historical data which may be causing inaccuracies as will be discussed in the change point analysis section of this chapter. Additionally, this is further evidence the GI forecasts do not fully reflect the state of the aircraft manufacturing industry. If EPA clauses are written to protect the government and contractor of unanticipated changes in the market, but are based on changes in forecasted values, then the EPA clauses are not accomplishing their goal and EPA payments may not be indicative of market fluctuations.

Global Insight Forecasts vs Contractor FPRA Direct Labor Escalation

After examining how accurately the GI forecasts of PPI 336411 represent the actual market, the accuracy of the forecasts to the direct labor component of the contractor FPRA rates is examined. The results indicate not only are GI forecasts not a truly accurate representation of the market fluctuations, but they deviate from contractor's direct labor rates as well.

As discussed in Chapter 3, each FPRA had multiple rates to choose from in each year. Therefore, to get one consolidated rate in each year, descriptive statistics are calculated for each year's rates to determine if the mean or median is more appropriate for said year. The median was chosen for all rates, as this was the most representative rate for skewed distributions and random distributions. Table 7 shows the consolidated escalation rate chosen for each contractor in each year from the FPRA.

Table 7: FPRA Escalation Rates by Contractor

	2015	2016	2017	2018	2019	2020	2021
Contractor 1				2.40%	2.40%	2.40%	
Contractor 2				3.00%	3.00%	3.00%	2.99%
Contractor 3				3.17%	2.31%	2.48%	
Contractor 4	2.73%	2.96%	2.84%	2.60%	2.60%		
Contractor 5				2.06%	2.00%	2.13%	2.17%
Contractor 6				2.82%	2.82%	2.82%	2.82%

Table 8 shows the total deviation of the GI forecasts from each contractor's escalation rates. The empty cells indicate where escalation data is not available from the contractor FPRA. The table is conditionally formatted to show whether the GI forecasts are below the contractor rates. Of the 32 observed comparisons, 24 of the GI forecasts are below the contractor rates. Though only 6 contractors are compared, these 6 contractors make up a majority of prime contractors for ACAT I aircraft programs. With forecasts being consistently lower than the contractor assumptions, the government is more likely to be paying an upward EPA for a change in escalation the contractor already has assumed within the FPRA. A scenario is spelled out below to better explain this potential double payment situation.

A contractor's FPRA has labor escalation of 3.0%, while the baseline GI forecast of PPI 336411 spelled out in the EPA clause is 200. The EPA clause has an upper minimum threshold to trigger an EPA payment of 2.0%. If the current years forecast is greater than 204 (a 2.0% increase from 200), then an upward EPA payment is triggered. Meanwhile, the contractor already accounted for at least 3.0% escalation, but will receive an EPA payment regardless.

Table 8: Total Deviation of GI Forecasts to FPRAs by Contractor

Contractor	2005	2007	2009	2011	2013	2015	2017	Total
Contractor 1			-0.203%	0.498%	0.071%	0.847%	-0.578%	0.634%
Contractor 2			-1.401%	-0.777%	-1.047%	-0.625%	-1.955%	-5.805%
Contractor 3			-1.070%	-0.512%	-0.938%	-0.163%	-1.587%	-4.270%
Contractor 4	-0.130%	-1.330%	-1.930%	-0.531%	-0.794%	-3.315%	-5.468%	-13.498%
Contractor 5			0.545%	1.800%	1.222%	2.267%	0.610%	6.445%
Contractor 6			-1.040%	-1.124%	-1.703%	-0.658%	-2.314%	-6.840%

A graphical representation of the deviation of GI forecasts to Contractor 2 is shown in Figure 9. As is shown, GI is consistently lower than the contractor rates. Though not all the observed contractors are consistently above the GI forecasts, a majority of the GI comparison points across all contractors deviate negatively from the contractor rates. As is shown, contractor 5 shows all positive deviations, meaning GI forecasts were above what was found in the FPRA. Though this stands out as an anomaly compared to other contractors, there was nothing about this specific contractor that would indicate lower FPRA escalation rates would be expected. The other 5 contractor graphics are shown in Appendix B. As was previously discussed, if forecasts are consistently lower than contractor escalation and an EPA is triggered, that EPA is more likely to be a double payment of escalation already assumed in the base price of the contract. Next, the results of the change point analysis are discussed.

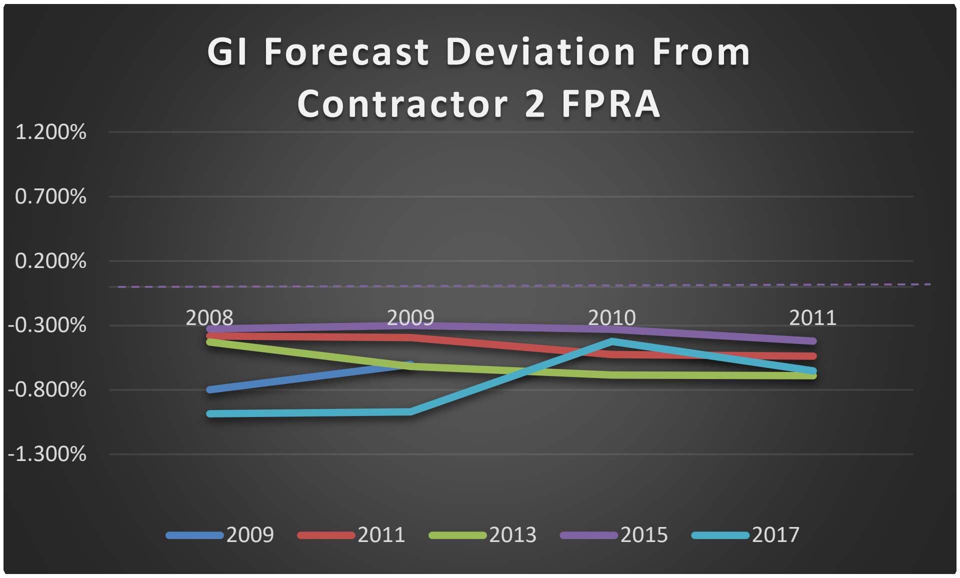


Figure 9: GI Forecast Deviation from Contractor 2 FPRA

Change Point Analysis

After determining the GI forecasts accuracy to actuals and contractor FPRAs, a change point analysis is conducted on historical values of PPI 336411 to determine if basing the EPA clause off a forecast is appropriate. The change point analysis identifies ranges of time where there are significant changes in the average of the data. If there are significant changes in the average of the historical data, then forecasting future values becomes difficult if not near impossible to do so relatively accurately. The GI forecasts are based on the historical values of the index which may be heavily influenced by outside factors, as indicated by a change point.

The first step in the change point analysis is identifying time periods where there are potential changes in the average. The cumulative sum chart in Figure 10 depicts where potential changes in the average of the escalation rate occurred. The cumulative sum is the cumulative sum of the deviations of the observed values from the average of the observations. A period where there is a positive slope on the graph indicates the values during that time tend to be above the average. Likewise, a period where there is a negative slope indicates a time when values tend to be below the average. Therefore, a sudden change in the slope resulting in a change in the overall trend of the data is identified as a potential change point. There are 3 potential change points identified.

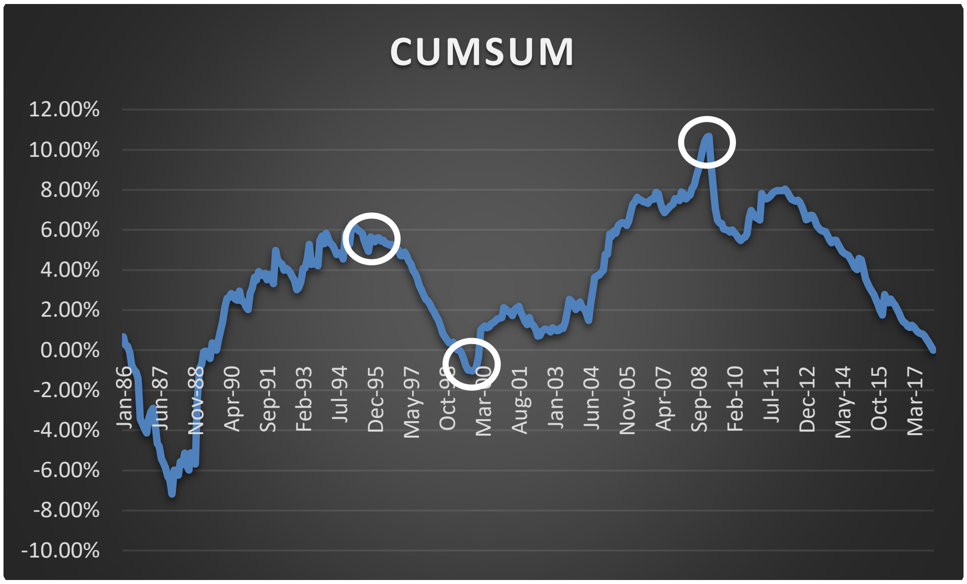


Figure 10: Cumulative Sum Chart

As shown in Figure 10, there are potential change points from 1993 to 1996, 1997 to 2000, and 2007 to 2010. However, first the entire range of data is bootstrapped to determine if at least 1 of these 3 change points flags as statistically significant before narrowing the analysis. Figure 11 depicts the empirical coverage from 1986 to 2017 that a change occurs.

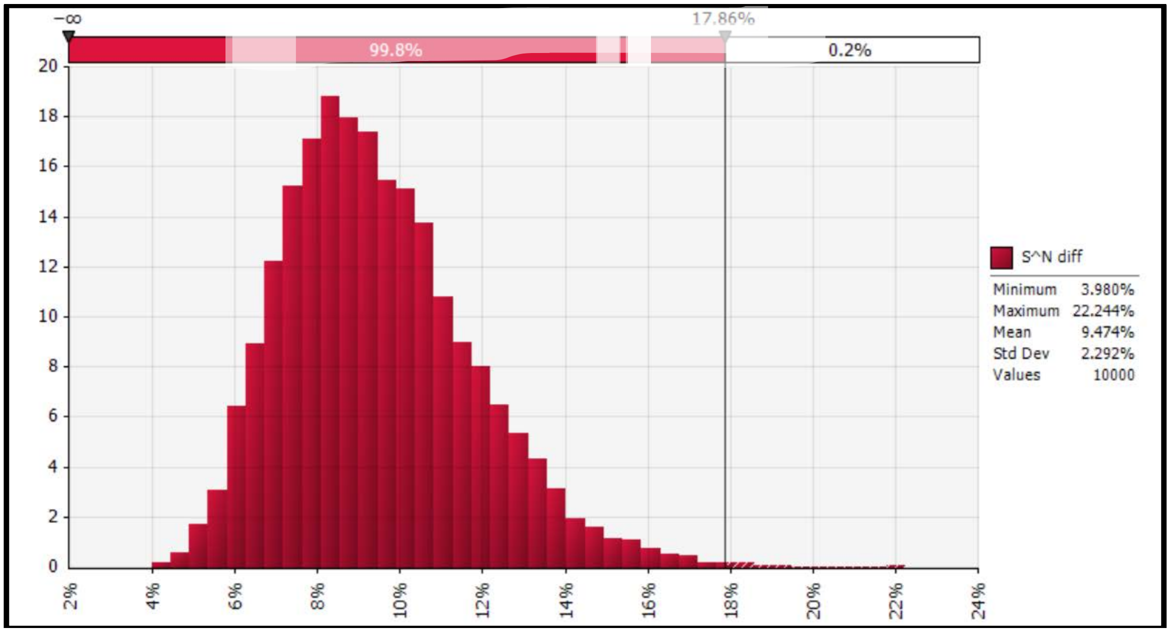


Figure 11: Empirical Coverage of Change Occurring from 1986 to 2017

Figure 11 shows the distribution of the S_{diff}^{n} values. As discussed in Chapter 3 the S_{diff}^{n} values are the range of the bootstrapped data which is then compared to the S_{diff} of the original data set. The x-axis represents the S_{diff}^{n} value while the y-axis represents frequency. The S_{diff} of the original data is located at the top of the graph on the right most end of the delimiter. The frequency of simulation iterations where $S_{diff}^{n} < S_{diff}$ is then tested against an α of 0.05. Figure 11 suggests that with 99.9% empirical coverage a change occurs between 1986 and 2017 based on an α of 0.05. This indicates that further investigation is required to better pinpoint when the changes occur. To identify the time periods where a change potentially occur, the graph of the CUMSUM values of the original data set are analyzed. The chart is shown in Figure 10. To verify that changes did occur during these time frames with greater confidence, the same procedure for a change point analysis explained previously is conducted from 1986 to 1996, 1996 to 2017, and 1996 to 2005, the results of which are provided next.

The results of the first bootstrapping range from 1986-1999 are shown in Figure 12. As discussed in Chapter 3 of this thesis, if $S_{diff}^{n} < S_{diff}$, then there is statistical evidence a change occurs in the time frame. Figure 12 illustrates 99.7% of the time $S_{diff}^{n} < S_{diff}$ which verifies with 99.7% empirical coverage there is a change in the average of the escalation rate between 1986 and 1999. Based on the α of 0.05, this is significant evidence a change occurs in the escalation rate during this time frame.

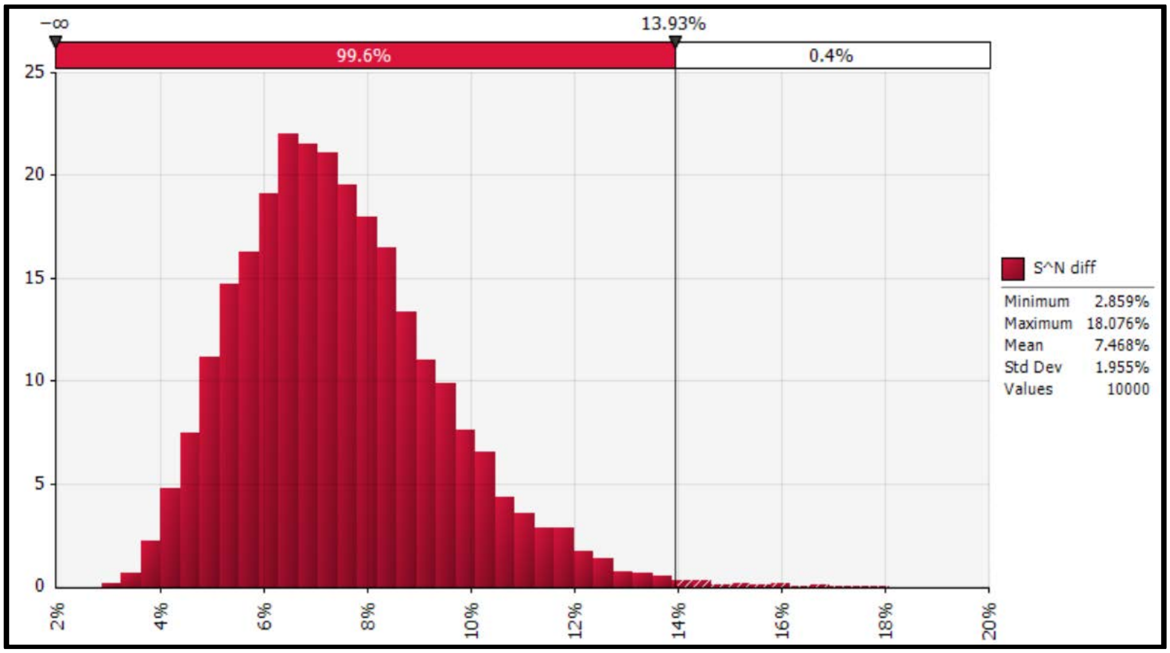


Figure 12: Empirical Coverage 1986-1999

The results of the bootstrapping 1996 to 2005 are shown in Figure 13. Out of 10,000 bootstraps of the data, 9,990 of the iterations resulted in a $S_{diff}^{n} <$ S_{diff}. Therefore, with 99.9% empirical coverage, a change occurs in the average of the escalation rate between 1996 and 2005. Based on an α of 0.05, this is significant evidence a change occurs in the average of the escalation rate.

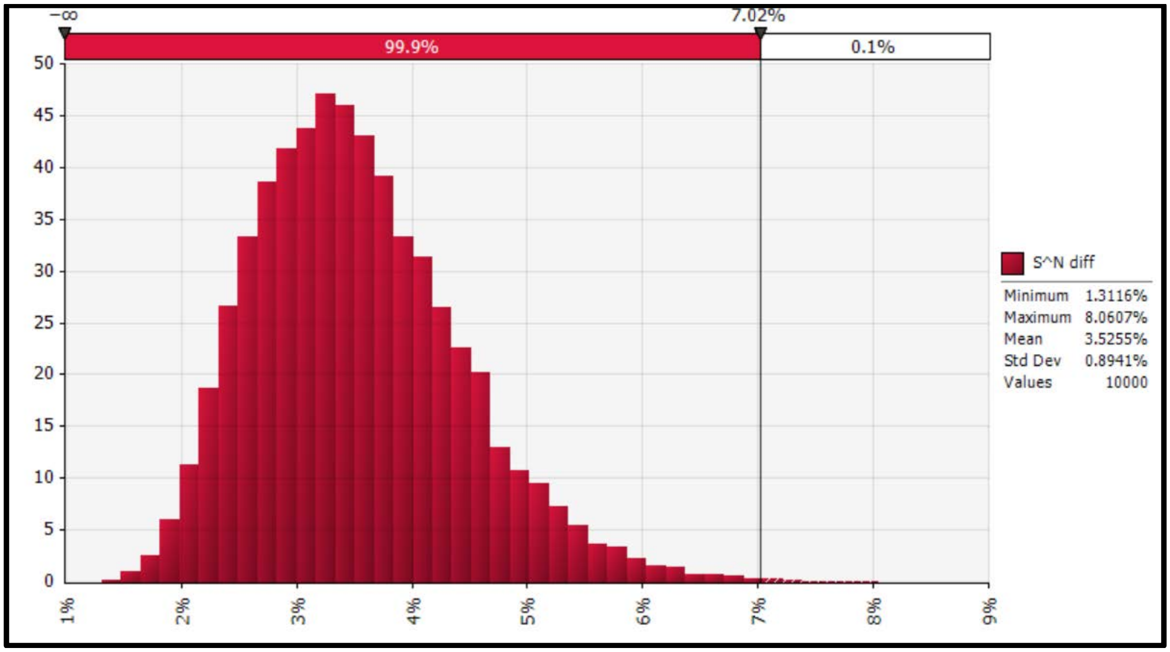


Figure 13: Empirical Coverage 1996-2005

The results of the bootstrapping from 2005 to 2017 are shown in Figure 14. Again, 10,000 bootstraps are conducted and a total of 9,950 of the bootstraps result in a $S^n_{diff} < S_{diff}$. This means with 99.5% empirical coverage a change in the average of the escalation rate occurs between 2005 and 2017. Using an α of 0.05, this is significant evidence that a change in the average did occur.

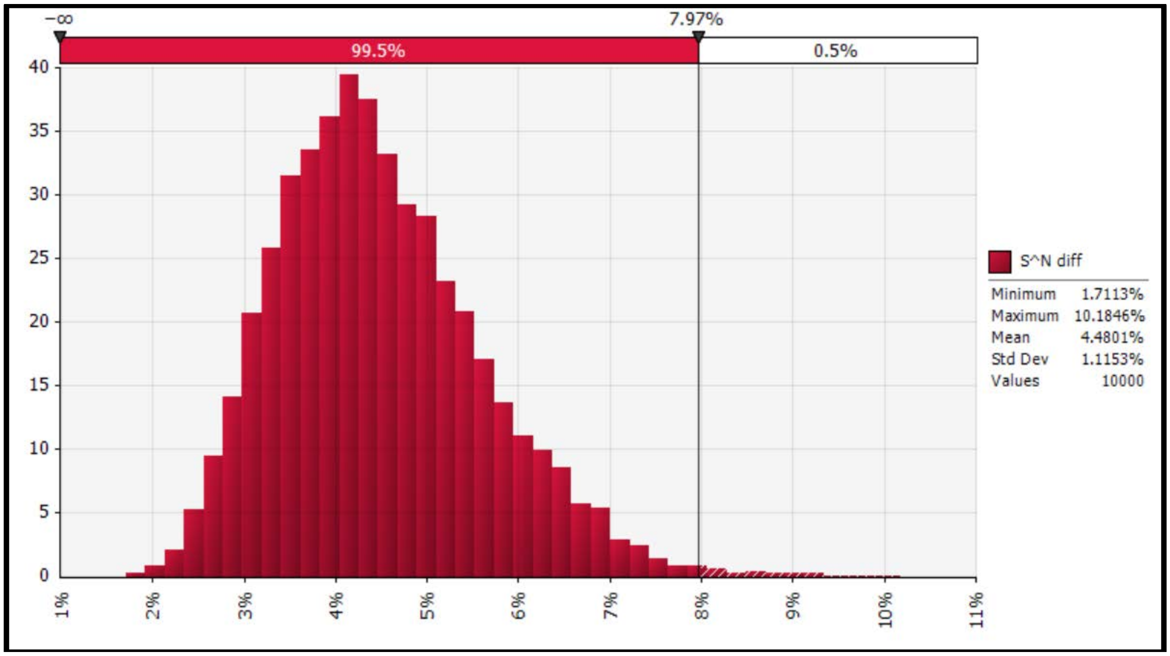


Figure 14: Empirical Coverage 2005-2017

Next the estimates of when the changes in the average of the data occurred are identified. As discussed in Chapter 3, each bootstrapped time period was further narrowed down based on the CUMSUM chart in Figure 10. From January 1995 to May 1997, the point with the minimum SSE was February 1995 ($m = 110$) with an SSE of 0.00597. From 1996 to 2005, the point with the minimum SSE was October 1998 ($m = 154$) with an SSE of 0.00643. From September 2008 to July 2011, the point with the minimum SSE was February 2009 ($m = 278$) with an SSE of 0.00651. All these points are identified as change points. They are then verified by looking back at the raw data to see if there are significant changes. For the first change point, the escalation rate drops from 1.26% in January 1995 to 0.15% in February 1995. This indicates a significant change in the average of the data. For the second change point the escalation rate begins at 0.07% in October 1998 and promptly increases to 0.21% in December 1998. This verifies a change point did in fact occur. For the last change point, the escalation rate drops from 0.29% in February 2009 to -1.24% in March 2009. This indicates a change point did occur.

The results of this research question verify 3 time periods of change in the average of the historical PPI data; 1986-1999, 1999-2005, and 2005-2017. These changes are potentially caused by factors not directly related to the aircraft manufacturing industry, and hence make it difficult to accurately forecast future values of the PPI, recall the results of research question 2 which concluded GI forecasts are generally inaccurate When basing an EPA clause on changes in forecasts of a baseline index, the error of the forecast is inherently included in the value of the EPA. As discussed in Chapter 2, Defense Acquisition Regulations section PGI 216.203-4 spells out the details of how to correctly write an EPA clause, but it does not mandate whether this clause should be based on *historical* values of the PPI or *forecasts* of the PPI. Therefore, it may be more advantageous to base the EPA payments on how the current PPI value compares to historical averages of the index (retrospective EPA), than basing the EPA on changes in forecasts of the index (prospective EPA).

Retrospective EPA vs Prospective EPA Clause (MAPE)

After identifying the change points in the historical data, the MAPE of the current prospective approach is calculated. This produces 8 MAPE values because the 2009 quarter 4 forecast is compared to the 2010-2017 quarter 4 forecasts. An average of these MAPEs is calculated which is 7.0%. This MAPE is then compared to the proposed retrospective approach. The MAPEs using 2000-2009 base years to the current year are calculated using the historical index escalation rates of PPI 336411. The year 2000 is chosen as this identified as a change point in the data as previously discussed. 2009 is an end year, because a 10-year period of performance is used. There are only historical index values up to 2018, so the last base year able to be used is 2009. An average of the MAPEs from 2000-2009 is then calculated which is 47%.

Comparing the current prospective approach to the proposed retrospective approach, it is clear the current prospective approach produces a lower MAPE. However, as it has been previously illustrated, the GI forecasts are not reflective of the economy, there is error. Because the current EPA payments are solely based on changes in GI forecasts, there is inherent error in the EPA payments. To make the EPA payments more representative of changes in the economy, the proposed retrospective approach should be used. To show the retrospective approach is more reflective of the economy than the GI forecasts, the MAPE of the 2009 quarter 4 forecast to the historical values of PPI 336411 is calculated, which is 60%. By utilizing the retrospective approach instead of the prospective approach, the MAPE decreases from 60% to an average of 47% from 2000-2009. It is unknown at this point how taking this retrospective approach will change the EPAs being paid, however, the retrospective approach will allow the EPAs to capture actual changes in the economy, not in forecasts.

Conclusion

This chapter summarized the results of the research. First, the historical EPAs were categorized by aircraft and totaled to detail what cost impact these adjustments have. Out of 266 contracts dating back to a 1982 award date, 20 modifications were found related to EPAs. The net total amount obligated of these adjustments totaled $693,636 out of a total of $81,057,461,405 worth of contracts. This indicates EPAs since 1982 have made up 0.0009% of all contracts from the ConWrite database. Though a cost impact of 0.0009% of all contracts is not a significant amount, there is an instance of a single EPA reaching $22,744,725 which represents a loss of obligation authority for higher priority items on contract. The accuracy of the GI forecasts of PPI 336411 is then analyzed as compared to BLS actuals. The results indicate since 2013 forecasts have deviated consistently above actuals. This is contrary to the original 2011 study which looked at the accuracy of top-level PPI 3364 and suggested GI forecasts of said index tended to be below actuals. A total net percent deviation of -4.42% from the actuals and typical upper and lower thresholds for EPA payments of 2.0%, indicates the forecasts do not accurately reflect the aircraft manufacturing industry, and the EPA modifications currently occurring may be mitigated if they were not based on forecast changes.

After determining GI forecasts are not reflective of the aircraft manufacturing market, the GI forecasts were compared to contractor FPRA labor escalation rates. The results showed GI forecasts consistently below contractor escalation rates which could result in double payment of escalation impacts already assumed by the contractor and therefore unneeded. It is unclear what the value of the EPA payments fall into this category, however, if EPAs continue to be based on changes in inaccurate forecasts rather than changes in actuals, then the probability of an double payment will remain.

Lastly, it is determined through a change point analysis there are three periods of time where there are significant changes in the average of the historical data of PPI 336411. This is a probable reason why the GI forecasts deviate from what is occurring in the index. These changes may be caused by factors not directly related to the aircraft manufacturing industry, and hence are difficult to forecast. With 3 change points over the last 32 years, it is likely more will occur in the future that will not be accounted for in future forecasts.

V. Conclusion and Recommendation

Chapter Overview

This chapter summarizes the results and conclusions drawn from the research conducted. Each research question is answered and given context to the overall recommendation.

Research Questions Answered

The overarching research objective of this thesis was to evaluate the validity of Global Insight (GI) forecasts as a benchmark for EPA payments of current EPA clauses pertaining to firm fixed price contracts of ACAT I aircraft programs. This was an expansion on a study conducted in 2011 by AFLCMC on EPAs in fixed price contracts. The research objective was accomplished answering six research questions.

Historical Economic Price Adjustments

The first research question examines what was historically paid for Economic Price Adjustments. Data derived from the ConData database was utilized to determine a total amount obligated for EPAs by airframe since 1981. This was a new addition to the previous AFLCMC study as no analysis was done on what cost impact EPAs historically have. Based on 2008 Inspector General (IG) report that examined DoD multiyear contracts of the C-17, F/A-18, and the AH-64D, it was determined Boeing contracts for these three airframes experienced significant price increases of around $1.9 billion due to EPAs (IG report, 2008). Because this $1.9 billion in adjustments was not included in the ConData database, this represents a limitation of the data and the ConData may be an underestimation of EPAs. This research found EPAs have a very small cost impact in relation to total contract value. Of all the contracts and modifications in the database, EPA modifications made up 0.043% of the total. Of the 20 EPA modifications, 0.055% of the original contract value was represented by adjustments from these modifications. Though it is a seemingly insignificant amount, there is potentially still cost savings to be realized by rewording the EPA clauses.

Also, out of a total of 20 EPA contracts, 16 were non-zero, of which, 9 were of negative value and 7 were of positive value. This indicates the EPA clauses are resulting in a somewhat even split between upward and downward adjustments, with slightly more downward adjustments. The EPA clauses are created to provide equal and unbiased protection to both the government and the contractor in times of economic uncertainty. The split of upward and downward adjustments illustrates the EPA clauses are succeeding in this goal.

Global Insight Forecasts vs Historical Values

The second research question compared the accuracy of Global Insight forecasts to BLS historical values of PPI 336411. Of the 13 years of forecasts available, only the years of 2005, 2007, 2009, 2011, 2013, 2015, 2017 were compared to actuals, as 7 forecasts was viewed as a valid amount to determine general accuracy.

Including forecasts dating back to 2005, GI tends to forecast escalation of PPI 336411 above actuals tracked by Bureau of Labor and Statistics (BLS). The average net total deviation of the GI forecasts was -4.42% which represents a large amount as historical escalation of PPI 336411 averages only 2.71%. This is shown in Table 6.

Table 6: Deviation of GI Escalation Forecasts to BLS Actuals

Q4 Forecast	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Net Percent Deviation	Absolute Percent Deviation
2005	-0.02%	-0.31%	-0.83%	-2.54%	-1.92%	-1.12%	-2.97%	-3.09%	-2.05%	-0.96%	0.54%				-15.27%	16.35%
2007			-0.02%	0.01%	0.05%	-0.66%	-0.31%	0.28%	-2.14%	-2.87%	-2.13%	-1.36%	-0.15%		-9.30%	9.97%
2009					-0.02%	-1.21%	-4.17%	-4.84%	-3.99%	-2.89%	-1.10%	-0.33%	0.02%	0.43%	-18.54%	19.00%
2011							-0.01%	-0.29%	0.13%	1.06%	2.70%	3.78%	4.88%	5.71%	12.26%	18.57%
2013									0.00%	0.54%	2.19%	3.31%	4.34%	5.12%	10.38%	15.51%
2015											0.02%	-0.15%	0.83%	1.69%	0.69%	2.69%
2017													0.02%	0.22%	0.02%	0.24%
Average	-0.02%	-0.31%	-0.42%	-1.27%	-0.63%	-1.00%	-1.86%	-1.99%	-1.61%	-1.02%	0.37%	1.05%	1.66%	2.63%	-4.42%	15.84%

Additionally, the purpose of an EPA is to provide equal protection to both government and contractor from unanticipated changes in the market. With forecasts deviating from actuals by -4.42%, EPA payments based on these forecasts may not represent actual market fluctuations and hence the EPA clause may not be accomplishing its goal.

Global Insight Forecasts vs Contractor FPRA Direct Labor Escalation

The third research question examined how GI forecasts compare to escalation rates manifested in contractor forward pricing rate agreements (FPRA). A total of 6 contractor FPRAs were analyzed to determine how their direct labor escalation rates compare to GI forecasts of escalation. These 6 top government contractors were chosen because of data availability, but the names of the contractors were excluded to limit the release of proprietary information. The conclusion was GI forecasts were consistently lower than direct labor escalation values derived from the FPRAs. This is shown in Table 8.

Table 8: Total Deviation of GI Forecasts to FPRAs by Contractor

Contractor	2005	2007	2009	2011	2013	2015	2017	Total
Contractor 1			-0.20%	0.50%	0.07%	0.85%	-0.58%	0.65%
Contractor 2			-1.40%	-0.78%	-1.05%	-0.63%	-1.95%	-5.81%
Contractor 3			-1.07%	-0.51%	-0.94%	-0.16%	-1.59%	-4.27%
Contractor 4	-0.06%	-1.19%	-1.95%	-0.55%	-0.82%	-3.34%	-5.49%	-13.40%
Contractor 5			0.55%	1.80%	1.22%	2.27%	0.61%	6.44%
Contractor 6			-1.04%	-1.13%	-1.71%	-0.66%	-2.32%	-6.86%

This underestimation is likely to lead to an EPA payment already assumed in the base price of the contract.

Change Point Analysis

The fourth research question analyzed the historical data of PPI 336411 to find any significant change points in the data. The method used to identify change point dates utilized Sum Squared Error (SSE) and can be narrowed down to a specific month and year of change. To answer this question, a change point analysis was conducted on three time periods where there was a suspected change in the average of the historical values of PPI 336411, 1986-1999, 1999-2005, and 2005-2017. From these time periods using simulation and an SSE change point estimator, it was determined change points occurred in February 1995, October 1998, and February 2009. These change points may be caused by factors unrelated to the aircraft manufacturing industry and could be an explanation for the forecasting GI forecasting inaccuracy.

Retrospective versus Prospective EPA Clause (MAPE)

The fifth research question compared the Mean Absolute Percent Error (MAPE) of the current approach to EPAs to a proposed retrospective approach. Based on the EPA clause in Appendix A, the current approach is a prospective approach, which means EPA payments are calculated based on changes in forecasts. If the current years forecast varies by a specific threshold percentage from the established base year forecast, then an EPA may be triggered. The retrospective approach being recommended instead uses historical values of PPI 336411. Specifically, a base year of the historical index of PPI 336411 is chosen and this is compared to the current year of the index. A ten-year period of performance for the purposes of the EPA clause was assumed. Therefore, the base year of the forecast is adjusted every ten years. For the prospective approach, 8 MAPE values were calculated, utilizing the 2009 quarter 4 forecasts as the base year forecast and comparing to 2010-2017 quarter 4 forecasts. These 8 values were then consolidated to an average MAPE of 13%. For the retrospective approach, 10 MAPE values were calculated using 2000-2009 as the base year index values. These 10 MAPEs were then consolidated into one average MAPE of 47%.

Though the current prospective approach results in a lower average MAPE than the proposed retrospective approach, because the prospective approach relies solely on forecasts, any EPA payment calculated from this will inherently contain elements of forecast error. This results in EPA payments not representative of market changes. Therefore, the retrospective approach should still be used as it results in an average 47% MAPE compared to actuals while the prospective approach results in a 60% MAPE when compared to actuals.

Recommendations

Based on the frequency and magnitude of historical EPA modifications, no change is recommended to the current upper and minimum thresholds in the EPA clauses to trigger an EPA payment. These EPAs make up a very small portion of total contract value and are acceptably split between upward and downward adjustments, which indicates equal protection to government and contractor. The 2008 IG report suggested that there were large sums of unwarranted EPAs being paid to Boeing due to contributions from Boeing to their pension plan heavily influencing the value of the index being tracked for purposes of EPAs. However, based on the current study, it is clear these large EPA payments are not pervasive DoD wide.

Based on the two EPA clauses examined, the early lots of production have between a 2-2.5% upper and lower threshold of deviation of the baseline forecast to the current year forecast. As discussed in Chapter 4, if the current year forecast deviates from the baseline forecast by more than these threshold percentages, then an EPA is triggered. Because historically, EPAs make up a small percentage of overall contract expenses, there is currently no need to change the upper and lower threshold percentage recommendations for the EPA clauses.

Through the research not only was it discovered GI forecasts are inaccurate and hence not reflective of the aircraft manufacturing industry, forecasts are consistently below direct labor escalation derived from FPRAs, and there are 3 historical changes in the average of the BLS managed actuals of PPI 336411. These 3 results are an indication that basing the EPA payments on changes in forecast is bound to lead to EPA payments not reflective of the current market. As previously mentioned in Chapter 4, there are 2 types of EPA clauses, retrospective and prospective. The most common type, retrospective, are written to adjust contract price by analyzing cost from a given point and looking back historically at what has occurred. The less used type, prospective, are written to adjust contract prices in the future using forecasts. Prospective EPAs in their current use are not reflective of market fluctuations. With inaccurate forecasts of the price index, a retrospective EPA is more suitable. A retrospective clause ensures there is no forecasting inaccuracies effecting the contingency payment, and establishes more appropriate parameters for an adjustment indicative of market price fluctuations. Therefore, for fixed price contracts with EPA, any adjustment should be based on changes in tracked actuals of the index rather than changes in forecasts of the index.

Significance of Results

This research provided evidence that prospective EPA clauses are based on inaccurate forecasts and hence are not reflective of the economy. Utilizing a retrospective approach, where an established base year of the historical index is compared to the current year of the index to calculate the EPA, is recommended over the current approach. Though the exact cost impact of this change is unclear, it is clear the change will result in EPA payments more reflective of current market fluctuations and therefore will better accomplish the EPA clause goal of providing equal protection to both the government and contractor in long term contracts when upward and downward fluctuations in the market are anticipated. Changing to using retrospective EPA clauses in place of prospective EPA clauses could potentially result in more obligation authority being returned to the government from unwarranted or inaccurate EPAs.

Future Research

The opportunity to expand on this research is prevalent in a few areas. More EPA clauses should be analyzed to see if there are any trends in the way they are written for specific airframes. Actual EPA calculations could be derived from multiyear contracts to determine the exact cost impact of current EPAs as well. Also, other methods of implementing a retrospective EPA clause can be explored. Lastly, the cost impact of adjusting the EPA clauses to a retrospective approach must be analyzed to see what potential cost savings there will be.

Summary

This research examined the efficacy of using GI forecasts as a basis of calculating EPA payments on fixed price contracts. It was determined GI forecasts are inaccurate when compared to actuals and when compared to FPRA escalation rates. Not only is this causing error in the EPA payments with regards to what is actually happening in the economy, but also there is a potential double payment happening as the contractor is assuming higher escalation than GI. A change point analysis was then conducted and it was determined there were 3 historical change points in the PPI 336411 data that may be inhibiting the accuracy of GI forecasts. This evidence suggested a retrospective approach to calculating the EPA payments was warranted over the current prospective approach. This was further verified as the proposed retrospective approach produced a lower MAPE with regards to actual PPI values compared to the GI forecasts.

Appendix A: EPA Clauses

836 AESG/H025 ECONOMIC PRICE ADJUSTMENT FOR NOT-TO-EXCEED (NTE) OPTION PRICES

LOTS 3 - 13 (FEB 2010)

(a) The provisions of this EPA clause provide for both price increases and decreases to protect the
Government and the contractor from the effects of economic changes as specified by the indices and the
bands as specified in this clause. It shall be the intent of the parties to accomplish any adjustment authorized by this clause prior to the exercise of Option Items subject to this clause. The contractor shall
notify the Contracting Officer in writing not later than 7 calendar days prior to the scheduled Option
exercise date of an Option Item (0301, 0302, 0401, 0402, 0501, 0502, 0601, 0602, 0701, 0702, 0801,
0802, 0901, 0902, 1001, 1002, 1101, 1102, 1201, 1202, 1301 and 1302) if an increase or decrease in the
applicable Item's Not-To-Exceed (NTE) is warranted pursuant to the terms of this clause. The Contractor
shall submit the Costs Subject to Adjustment (CSTA) and Costs Not Subject to Adjustment (CNSTA)
amounts for each item, Aircraft and Warranty. The CSTA and the CNSTA shall be in the same relative
proportion as the CSTA and the CNSTA for the proposal to definitize the NTE. The total CSTA plus
CNSTA for each option item must equal the proposed NTE price calculated from Section J, Attachment 7
for the Aircraft and set forth in Attachment 9, for the Warranty. The economic price adjustment for the
option item NTE shall be accomplished in accordance with the procedure detailed in paragraph (g). The
Contractor's proposal for an adjustment shall include supporting data, in the form required by the Contracting Officer, explaining the calculation; and amount of the increase or decrease.

(b) Promptly after the Contracting Officer receives the notice and data under paragraph (a) of this clause,
the Contracting Officer and the Contractor shall negotiate an adjustment to the Option Item's NTE amount
and update the Option Item's NTE Aircraft unit prices in Section J, Attachment 7; and Warranty price in
Section J, Attachment 9. Failure of the parties to agree on a requested adjustment under this clause shall
NOT affect the Government's right to unilaterally exercise its rights pursuant to Special Contract Requirement H013.

(c) Adjustments under this clause, if any, shall be based upon the formula specified in Paragraph (g)
below. CSTA amounts are subject to either upward or downward adjustments. The CNSTA amounts
include depreciation, cost of money, royalties, leases, data, fixed price subcontracts which do not contain
EPA clauses, and profit. Proposed profit included in the NTEs shall not be subject to economic price
adjustment.

(d) IHS Global Insight, Inc.'s index PPI336411 Aircraft (Dec 1985=100) shall be used as the standard of
measurement for this clause.
(e) The following rules shall apply in making numeric calculations under this clause:
(1) Round decimals to 4 decimal places;
(2) Round dollar calculations to the nearest whole dollar;
(3) Round up numbers equal to or greater than 5;
(4) Round down numbers less than or equal to 4;

(5) Round percentages to 2 decimal places (e.g. 3.47%).
(f) For purposes of calculating the adjustments required by this clause, the following projected average
annual index rates shall apply. The source of the baseline projected indices shown below is IHS Global
Insight's 4th Quarter 2009 forecast. For years beyond 2019, the last data point of escalation will be
projected at the same rate (straight-lined) on an annual basis through the final NTE period of performance. Table 1 reflects the index and the projected index based on IHS Global Insight PPI336411
Aircraft (Dec 1985 = 100).
Table 1 - Baseline Projected Average Annual Index Rates
Projected Time Period (Dec 1985=100)
Index Rate
CY2015 228.9 (3.0%)
CY2016 234.5 (2.4%)
CY2017 238.8 (1.8%)
CY2018 244.1 (2.2%)
CY2019 250.1 (2.4%)
CY2020 256.1 (2.4%)
CY2021 262.2 (2.4%)
CY2022 268.5 (2.4%)
CY2023 274.9 (2.4%)
CY2024 281.5 (2.4%)
CY2025 288.3 (2.4%)
CY2026 295.2 (2.4%)
CY2027 302.3 (2.4%)
CY2028 309.6 (2.4%)
(g) The economic price adjustment shall be calculated as follows:
(1) The contractor shall obtain IHS Global Insight's current projected annual index values for the above projected time periods. For FY NTE values, use the same CY index values, for example NTE FY
2022 will use CY 2022 index values.
(2) Divide this current projected annual index by the baseline projected average annual index rate identified in paragraph (f) above for that particular year;
(3) Subtract 1 from this result and multiply the resulting answer by 100;
(4) Adjustment for Lots 3 - 5: If the resulting value is greater than or equal to +2.5%, calculate the upward adjustment by multiplying the result by the proposed CSTA dollar amount. If the resulting value is
between - 2.5% and +2.5%, do not calculate an adjustment. If the resulting value is less than or equal to -
2.5%, calculate the downward adjustment by multiplying the result by the CSTA dollar value proposed.

(5) Adjustment for Lots 6 - 13: If the resulting value is greater than or equal to +1.00%, calculate the upward adjustment by multiplying the result by the proposed CSTA dollar amount. If the resulting value is between -1.00% and +1.00%, do not calculate an adjustment. If the resulting value is less than or equal to -1.00%, calculate the downward adjustment by multiplying the result by the proposed CSTA dollar value.

(h) Notional Computation worksheet:

Example calculation for Lots 3 - 5:

Example 1
CY2020
Example 2
CY 2020
Example 3
CY2020

STEP FORMULA RESULT RESULT RESULT

1 Global Insight's Projected Annual Index (7 days prior to option exercise) (Example)
248.5 252.5 265.5

2 Baseline Projected Average Annual Index Rate from paragraph (f) Table 1
256.1 256.1 256.1
3 Divide Step 1 by Step 2 and round to 4 decimal places
.9703 .9859 1.0367
4* Subtract 1 from Step 3 and multiply by 100 to convert to %
-2.97% -1.41% 3.67%
5 Input applicable CSTA value for aircraft and engines from the annual EPA proposal
$3.0B $3.0B
6 Adjustment (Multiply Step 5 by Step 4) -$89.1M $110.1M
7 Applicable NTE Price (annual EPA proposal) $3.5B $3.5B
8 Adjusted NTE Price $3.4109B No Change $3.6101B

* If the resulting value is between -2.50% and +2.50%, no adjustment will be calculated; therefore, do not proceed to Step 5.

EXAMPLE 1: The EPA adjustment is a $89,100,000 decrease in the NTE Price.
EXAMPLE 2: There is no EPA adjustment since the trigger band was not exceeded.
EXAMPLE 3: The EPA adjustment is a $110,100,000 increase in the NTE Price.

(i) Once an adjustment to an eligible Item's NTE amount has been accomplished under this clause, or a determination made that no adjustment is permitted pursuant to paragraph (g)(4) above, said Item shall not be subject to further Economic Price Adjustment.

(j) In the event the IHS Global Insight Indices used are discontinued; or if IHS Global Insight suspends publication of an index identified in paragraph (d) above or significantly alters the method of calculating

the index, the parties shall agree upon an appropriate substitute index for use under this clause. If the
parties cannot agree on a substitute or comparable index within 90 calendar days after an index has been
discontinued or altered in method of calculation, the Contracting Officer may, acting unilaterally and
subject to Contractor appeal in accordance with paragraph (k) below, either adopt the IHS Global Insight
index as altered or establish a new index.
(k) Any dispute arising under or related to the terms and/or procedures set forth in the foregoing paragraphs shall be resolved in accordance with the provisions of this contract's Disputes clause.

(End of Clause)

AFMC CLAUSE CONTROL

C-5 RELIABILITY ENHANCEMENTS AND RE-ENGINING PROGRAM

(RERP)

LOW RATE INITIAL PRODUCTION (LRIP)

FA8625-07-C-6471

CONTRACT NUMBER: H-128

CLAUSE TITLE: Economic Price Adjustment (EPA) for Lots 4 – 7 Not-to-Exceed

Prices

CLAUSE DATE: Jan 08

CATEGORY:

☐ **One-time Use Provision/Clause**

UNIFORM CONTRACT FORMAT SECTION: Section H

APPLICABLE FAR PART/SUBJECT AREA: FAR Part 16

INITIATOR'S NAME: Vicki A. Fry PHONE: 255-1054

RATIONALE FOR DETERMINATION OF CATEGORY: Clause applies only to subject contract for LRIP for C-5 RERP.

JUSTIFICATION: Per SAF/AQ direction, the Contracting Officer is definitizing terms and conditions for Lots I through III of LRIP and is capturing Not-to-Exceed (NTE) prices for Lots I through VII. Clause H-127 captures the NTE amounts for Lots I through VII. It is the intent of the Parties to definitize FFP option prices for Lots I through III in February 2008; negotiations have been on-going through the IPT Pricing process and the Contractor has submitted a TINA-compliant proposal for Lots I through III. The Contractor adamantly requires the attached EPA clause to afford protection from unusual inflation over the long-term contract for Lots IV through VII. The clause would provide for adjustment only to the NTE amounts. Definitization of FFP prices for each lot then would be based on TINA-compliant proposals. The Contractor has a long-term arrangement with the engine supplier for all lots and the arrangement includes provisions for EPA as established in Clause H-125 of subject contract. The clause indicates that it is not anticipated that the FFP prices, once definitized, would be subject to further EPA with the exception for the engines. The clause states, however, that should it be determined during negotiations of definitive FFP amounts that further EPA is required, the FFP as adjusted shall not exceed the established NTE amounts. It is noted that the NTE amounts cited within the clause are subject to further review by the 716 AESG. Changes to the text of the clause, however, are not anticipated absent further direction during the review and clearance process. A separate determination and finding will be accomplished as required by FAR to document use of this EPA clause.

Communication concerning the negotiation of this clause is documented at Attachment 1.

The undersigned contracting officer has determined that the attached clause language does not duplicate or deviate from the FAR and FAR Supplements and is necessary for use in the subject contractual document.

VICKI A. FRY DATE

Contracting Officer

716 AESG

255-1054

Legal Office Coordination Date

CONTROL NUMBER: (assigned by COCO) Not Applicable

Not Applicable____

COCO Approval (for Contractor/Program Unique Provision/Clause) Date

CLAUSE:

H128 ECONOMIC PRICE ADJUSTMENT (EPA) FOR LOTS 4 – 7 NOT-TO-EXCEED PRICES (Jan 2008)

(a) The Lot 4 through 7 Not-to-Exceed (NTE) prices established at H-127, NTE Prices (Jan 2008), shall be adjusted to account for abnormal fluctuations in costs, as measured at the national level and reflected in the indexes identified in paragraph (c) below. Such adjustments, if any, shall be based upon the formula specified in paragraph (f) below. The NTE prices are subject only to upward adjustments. Prior to definitization of each lot, adjustments to the NTEs will, if necessary, be made in accordance with this clause.

(b) Of the NTE prices specified at H-127, economic adjustments determined under this clause apply to the NTE amounts, less the GE propulsion system, for priced labor and materials (as identified in tables 1, 2 & 3). EPA adjustments for GE propulsion system and spares are covered in contract clause H-125, Economic Price Adjustment for Engine (Jan 2008). Prior to the definitization dates, the Contractor shall submit a proposal, compliant with the Truth in Negotiations Act, to support definitization of each effort; such proposal(s) shall constitute the basis for negotiation of fair and reasonable Firm Fixed Prices for each option at less than or equal to the specified NTE amounts. It is the intent of the Parties that Firm Fixed Prices for Lots 4 through 7, upon definitization, shall not be subject to further Economic Price Adjustment except for that specified in Clause H-125. If it is necessary to include EPA provisions in Firm Fixed Prices for Lots 4 through 7 upon definitization, the extent to which the FFP is adjustable shall not exceed the NTE amount for each lot as determined through this clause at time of definitization.

Table 1 - Labor and related NTE Amounts for Installation for CY2013-CY2016 subject to EPA

CLIN(s)	CY13	CY14	CY15	CY16
4004	$ 134,300,000			
5004		$ 188,900,000		
6004			$ 189,200,000	
7004				$ 200,800,000

Table 2 - Material and related NTE Amounts for Long Lead and Material/Fabrication effort by CLIN for CY2011-CY2015 subject to EPA

Effort	CY10	CY11	CY12	CY13	CY14
Lot 4 Long-Lead	$ 106,200,000				
Lot 4 Material/Fabrication		$ 317,600,000			
Lot 5 Long Lead		$ 163,600,000			
Lot 5 Material/Fabrication			$ 503,000,000		
Lot 6 Long Lead			$ 171,900,000		
Lot 6 Material/Fabrication				$ 530,000,000	
Lot 7 Long Lead				$ 172,400,000	
Lot 7 Material/Fabrication					$ 540,700,000

Table 3 - Spares and Support Equipment (less GE Propulsion System and GE Propulsion Spares)

Effort	CY11	CY12	CY13	CY14
Lot 4 Spares	$ 44,100,000			
Lot 4 SE	$ 11,162,000			
Lot 5 Spares		$ 60,000,000		
Lot 5 SE		$ 17,110,000		
Lot 6 Spares			$ 59,900,000	
Lot 6 SE			$ 8,911,000	
Lot 7 Spares				$ 73,700,000
Lot 7 SE				$ -

(c) Global Insight's forecasted indices shall be used as the standard of measurement for this clause.

(1) The index used for calculations of this clause for Table 1 above is Global Insight's index for ECIPWAIRNS, Wgs & Sal, Private, Aircraft Mfg (2005:4=100).

(2) The index used for calculations of this clause for Table 2 and 3 above is Global Insight's index for WPIPIND, PPI Industrial Commodities (1982=100).

(d) The following rules shall apply in making numeric calculations under this clause:

(1) Round decimals to 3 decimal places;

(2) Round dollar calculations to the nearest whole dollar;

(3) Round up numbers equal to or greater than 5;

(4) Round down numbers less than or equal to 4;

(5) Round percentages to 4 decimal places (e.g. 3.47%).

(e) For purposes of calculating the adjustments required by this clause, the following projected average index rates shall apply. The source of the projected indexes shown below is Global Insight's 3rd Quarter 2007 Forecast. Table 1 reflects the projected indexes for ECIPWAIRNS, Wgs & Sal, Private, Aircraft Mfg (2005:4=100). Table 2 & 3 reflects the projected indexes for WPIPIND, PPI Industrial Commodities (1982=100).

	Table 1	**Table 2 & 3**
	(2005:4=100)	**(1982=100)**
Projected Time Period	**Index Rate**	**Index Rate**
CY2011	118.3	178.2
CY2012	122.0	180.0
CY2013	125.9	182.2
CY2014	129.9	184.4
CY2015	134.1	186.9
CY2016	138.4	189.4

(f) The economic price adjustment shall be calculated as follows:

(1) Determine the twelve month index average for a particular year by summing the twelve Global Insight monthly values and dividing by twelve.

(2) Divide this twelve month index average by the forecasted index rate identified in paragraph (e) above for that particular year;

(3) Subtract 1 from this result and multiply the resulting answer by 100;

(4) If the absolute value of the result is greater than 2.0%, calculate the adjustment by multiplying the result by the appropriate dollar value set out in the applicable Table 1 and Table 2; if the absolute value of the result is less than or equal to 2.0%, do not calculate an adjustment.

(g) Notional Computation worksheet:

Step	Formula	Example 1 CY 2011 Result	Example 2 CY 2011 Result
(1)	Projected Labor Index rate from paragraph (e) Table 1	118.30	118.30
(2)	Forcased Labor 12 month index average rate (example)	116.056	121.151
(3)	Divide Step (2) by Step (1) and round to 3 decimals	0.981	1.024
(4)*	Subtract 1 from Step (3) and multiply by 100 to convert to %	-1.90%	2.40%
(5)	Input NTE Price for Labor & Related from Table 1 (example value)		$ 200,000
(6)	Multiply Step (5) by Step (4)	$ -	$ 4,800
(7)	Adjustment with 2% trigger band	$ -	$ 4,800

* If the absolute value of the result is less than or equal to 2.00%, no adjustment will be calculated; therefore, do not proceed to step (5).

Example 1: There is no EPA adjustment since the trigger band was not exceeded.

Example 2: The EPA adjustment is a $4,800 increase in the NTE Price.

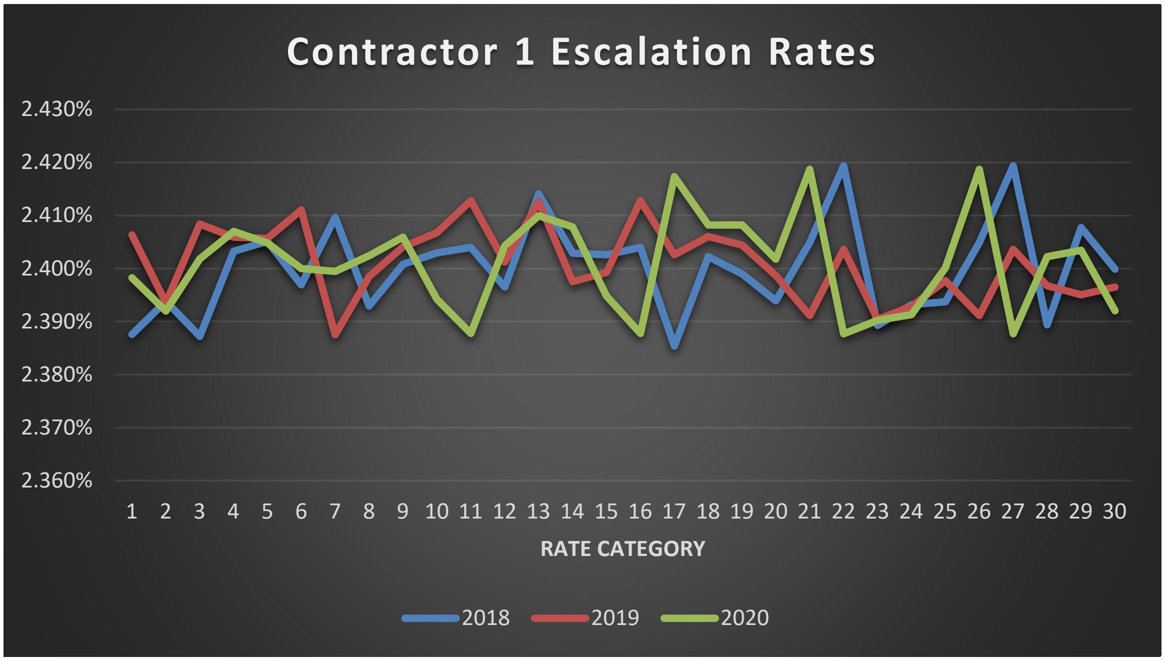
(h) In the event the Global Insight Indices used are discontinued or if Global Insight suspends publication of an index identified in paragraph (c) above or significantly alters the method of calculating the index, the parties shall agree upon an appropriate substitute for the discontinued or altered index for use under this clause. If the parties cannot agree on a substitute or comparable index (or cannot agree as to whether the alteration to the index is "significant") within 90 calendar days after an index has been discontinued or altered in method of calculation, the Contracting Officer may, acting unilaterally and subject to Contractor appeal in accordance with paragraph (i) below, either adopt the Global Insight index as altered or establish a new index.

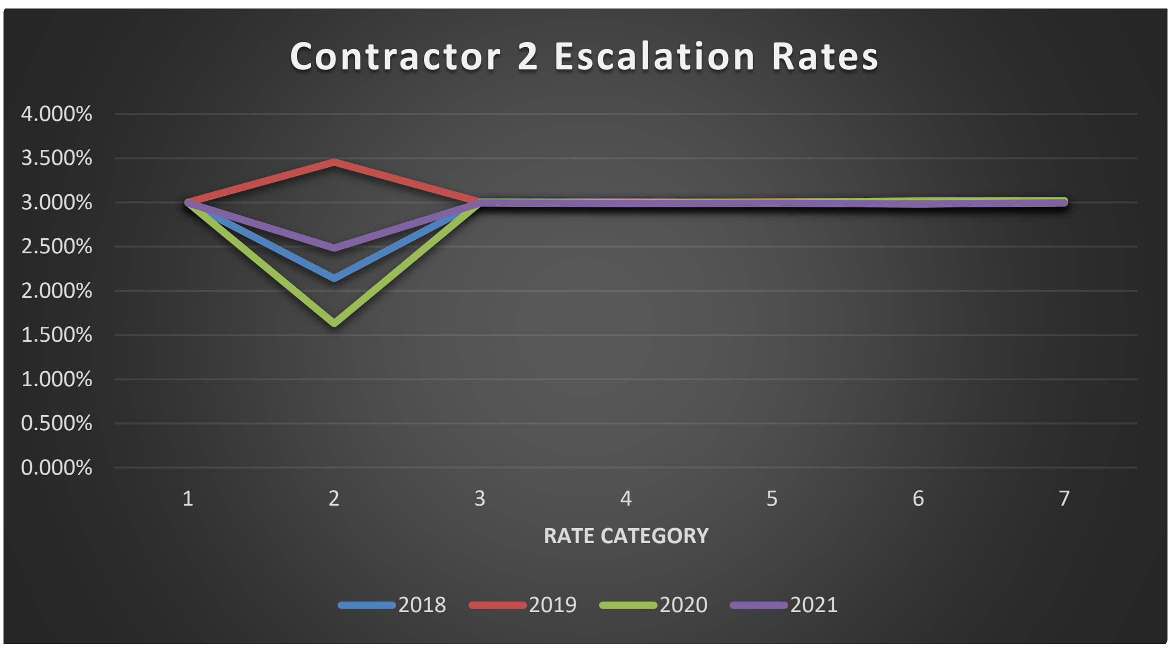
(i) Any dispute arising under or related to the terms and/or procedures set forth in the foregoing paragraphs shall be resolved in accordance with the provisions of this contract's Disputes clause.

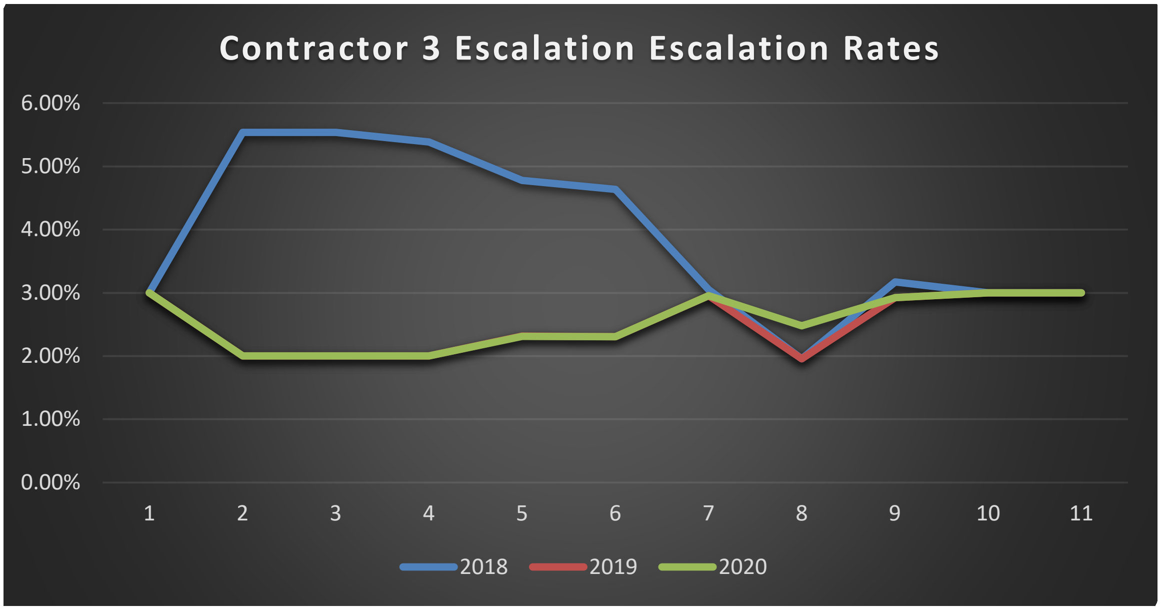
(End of clause)

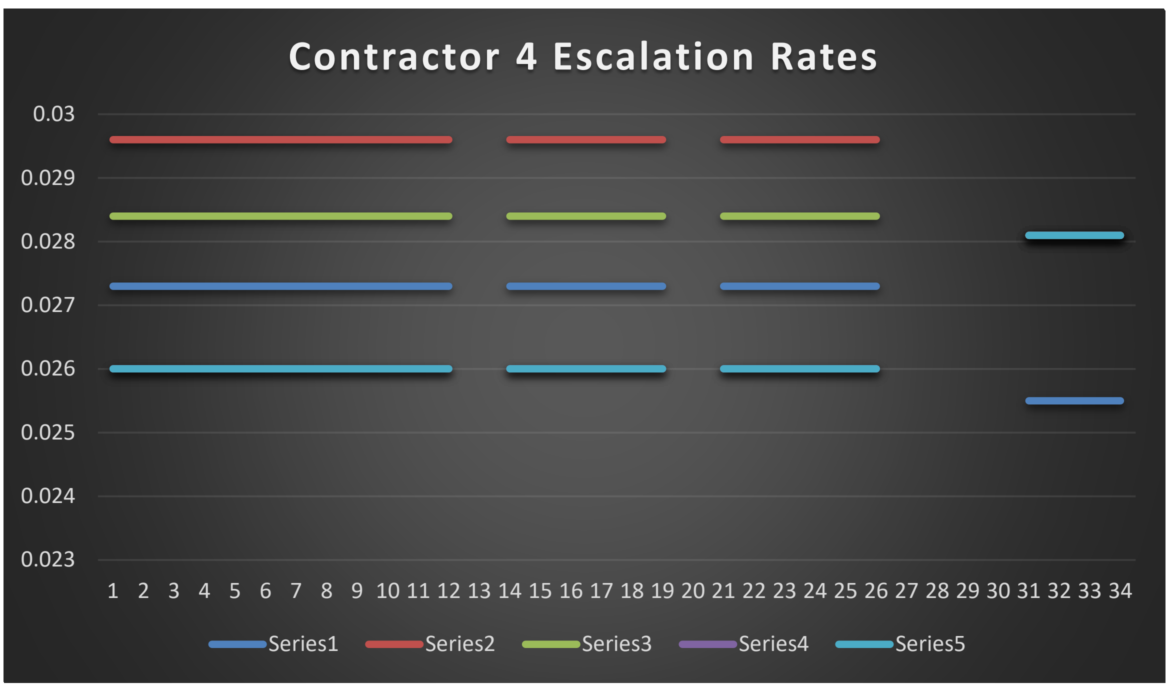
Appendix B: Contractor FPRA Escalation Rates and GI Forecast Deviation Graphs

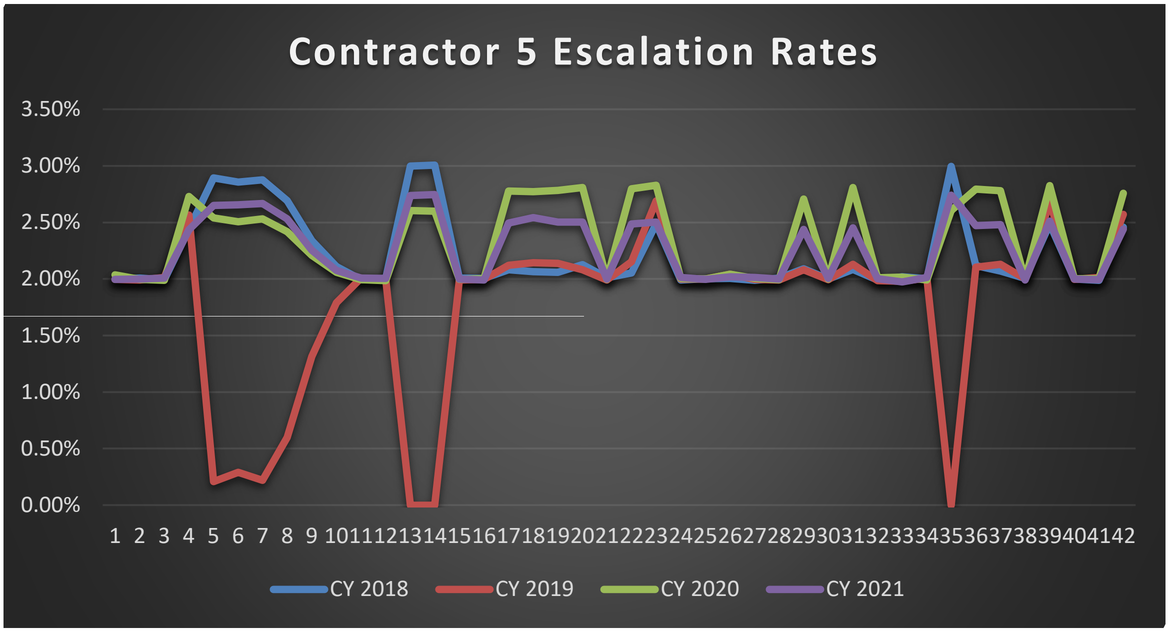
Contractor Escalation Rates

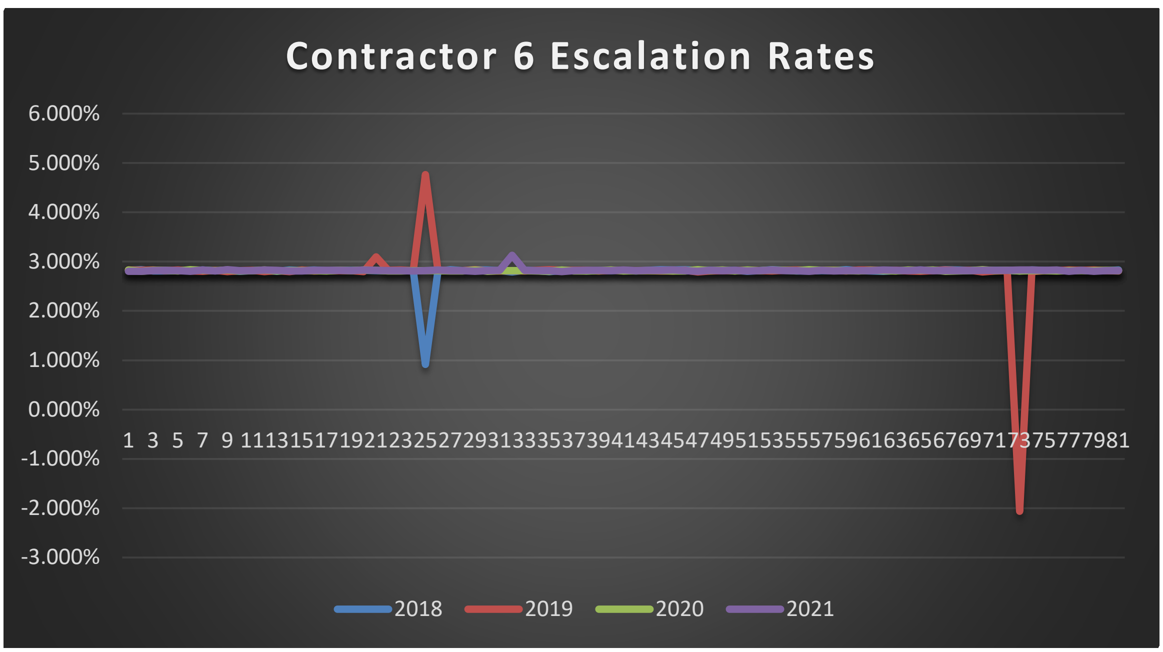




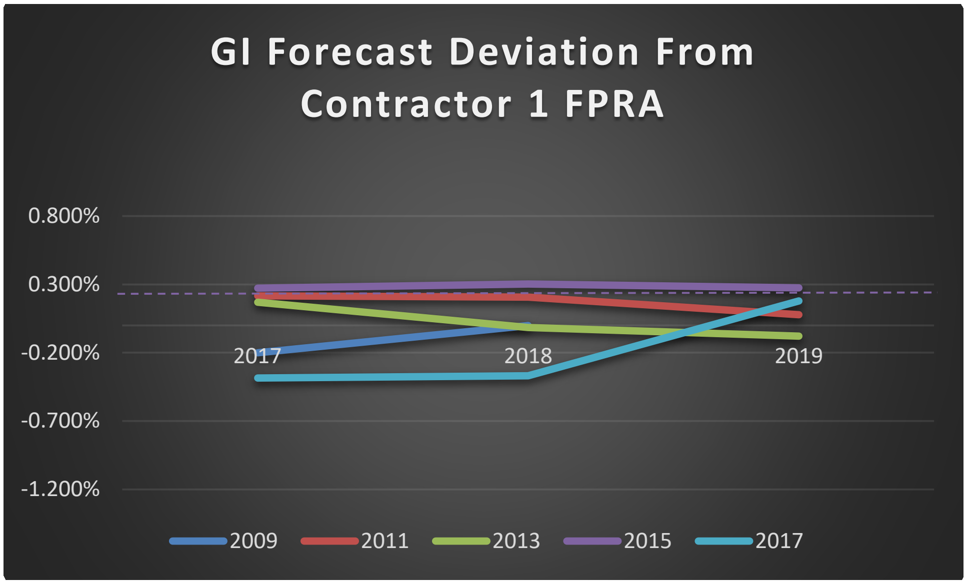

Contractor 3 Escalation Escalation Rates
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
1 2 3 4 5 6 7 8 9 10 11
2018
2019
2020

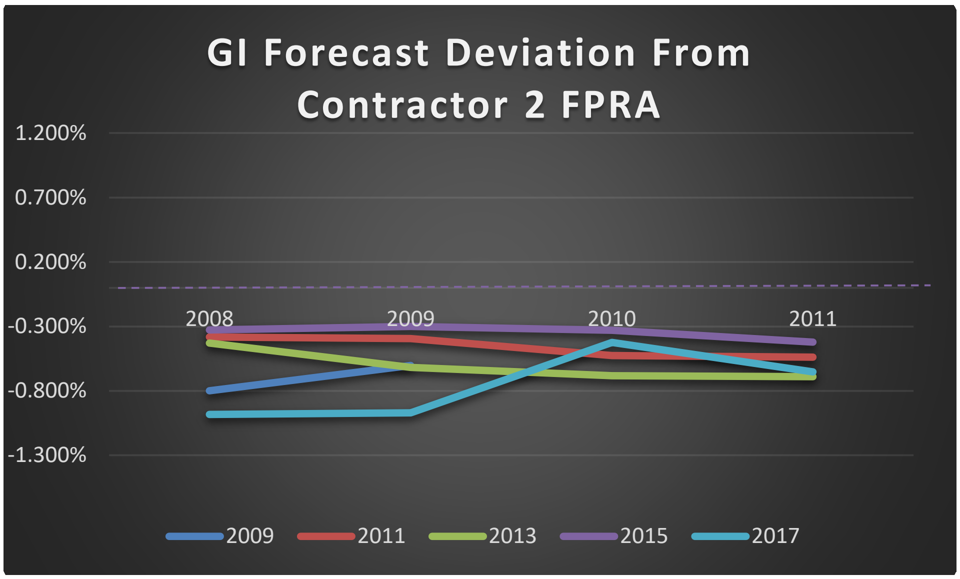

Contractor 4 Escalation Rates
0.03
0.029
0.028
0.027
0.026
0.025
0.024
0.023
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
Series1
Series2
Series3
Series4
Series5

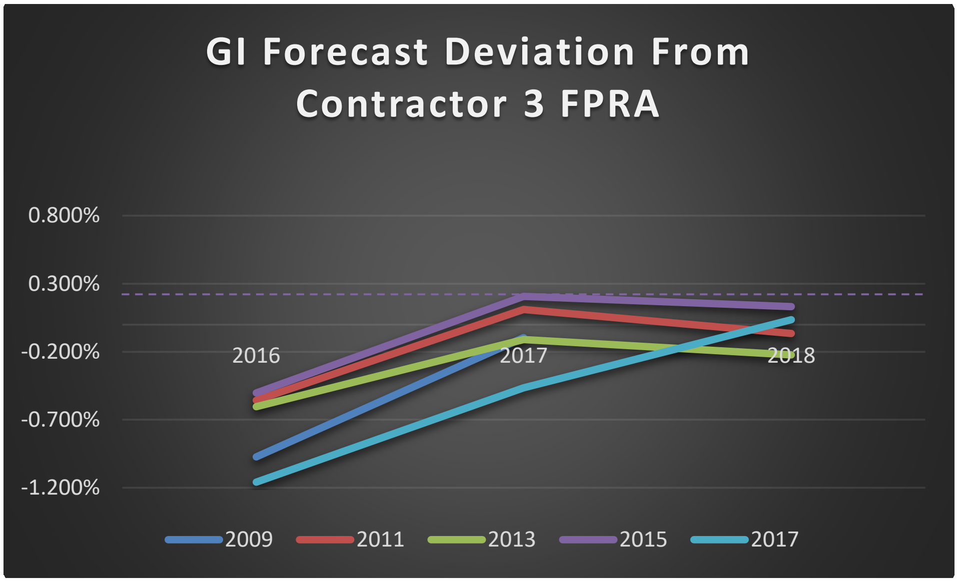

Contractor 5 Escalation Rates
3.50%
3.00%
2.50%
2.00%
1.50%
1.00%
0.50%
0.00%
1 2 3 4 5 6 7 8 9 101112131415161718192021222324252627282930313233343536373839404142
CY 2018
CY 2019
CY 2020
CY 2021

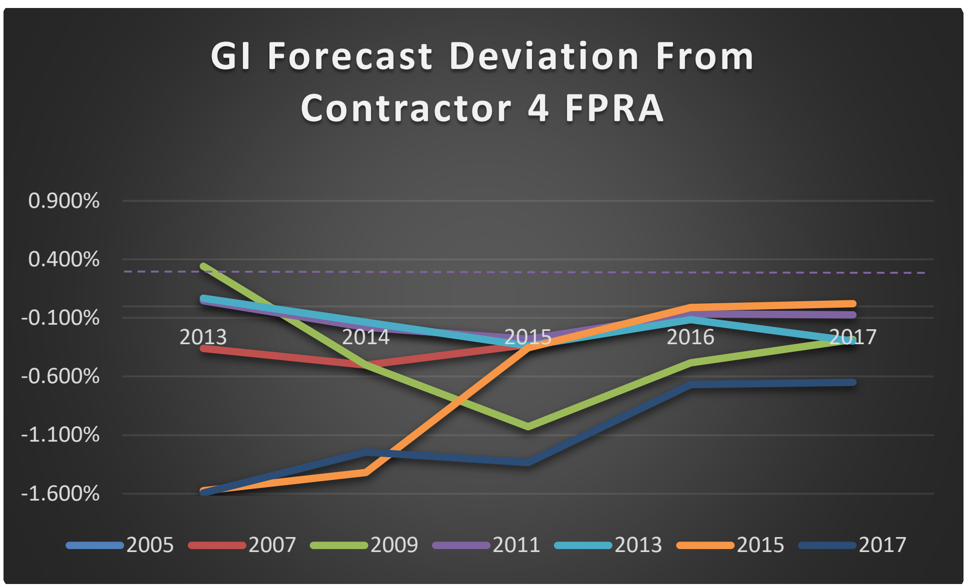

Contractor 6 Escalation Rates
6.000%
5.000%
4.000%
3.000%
2.000%
1.000%
0.000%
-1.000%
-2.000%
-3.000%
1 3 5 7 9 1113151719212325272931333537394143454749515355575961636567697173757779 81
2018
2019
2020
2021

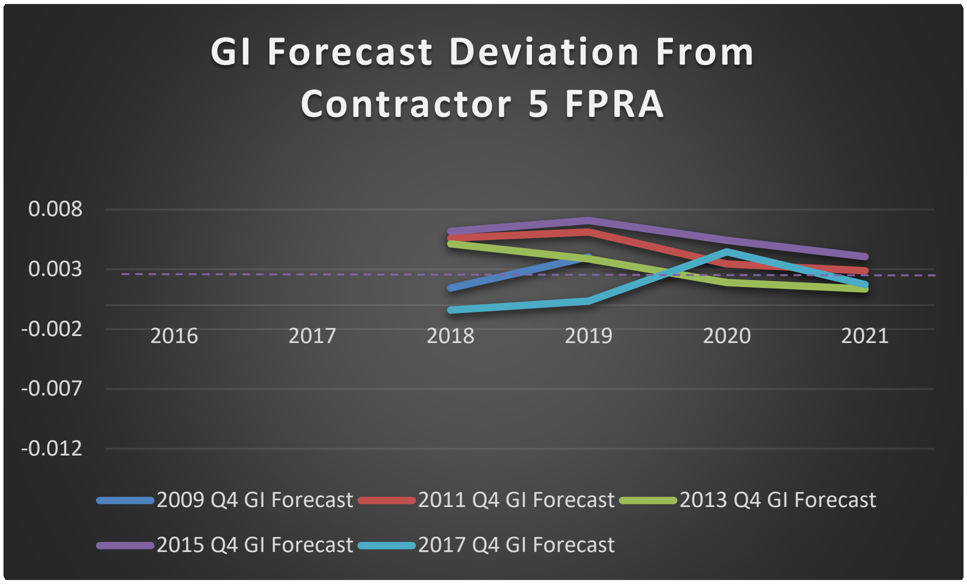
Global Insight Forecast Deviation from FPRA Rates Graphs

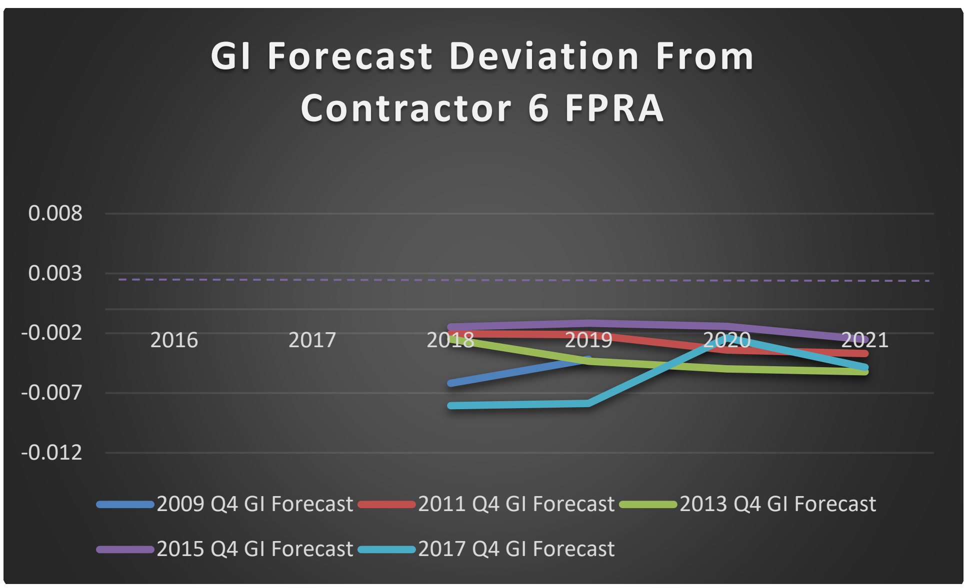





GI Forecast Deviation From Contractor 3 FPRA
0.800%
0.300%
-0.200%
-0.700%
-1.200%
2016
2017
2018
2009
2011
2013
2015
2017


GI Forecast Deviation From Contractor 4 FPRA
0.900%
0.400%
-0.100%
-0.600%
-1.100%
-1.600%
2013
2014
2015
2016
2017
2005
2007
2009
2011
2013
2015
2017


GI Forecast Deviation From Contractor 5 FPRA
0.008
0.003
-0.002
-0.007
-0.012
2016
2017
2018
2019
2020
2021
2009 Q4 GI Forecast
2011 Q4 GI Forecast
2013 Q4 GI Forecast
2015 Q4 GI Forecast
2017 Q4 GI Forecast


GI Forecast Deviation From Contractor 6 FPRA
0.008
0.003
-0.002
-0.007
-0.012
2016
2017
2018
2019
2020
2021
2009 Q4 GI Forecast
2011 Q4 GI Forecast
2013 Q4 GI Forecast
2015 Q4 GI Forecast
2017 Q4 GI Forecast

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14. ABSTRACT
Adjusting fixed price contract prices over long periods of performance is vital to protect both the government and contractor from market price fluctuations. This is accomplished via an Economic Price Adjustment (EPA) clause which currently utilize forecasts of producer price indexes (PPI) as a baseline. There is currently a lack of research on if the use of these forecasts as a baseline for calculating EPAs is the best alternative. This research involves determining the validity of using Global Insight (GI) forecasts for the purpose of calculating EPAs in fixed price contracts. Two EPA clauses are examined as a case study proxy for what may be occurring on a broader scale DoD wide. The PPI of interest to this research is PPI 336411, which covers the aircraft manufacturing industry. The GI forecasts of PPI 336411 are compared to Bureau of Labor Statistics (BLS) managed actuals of the index to assess the accuracy as well as the Forward Pricing Rate Agreement (FPRA) derived escalation rates to determine if the government is estimating escalation in line with the contractor. A change point analysis is then conducted on the historical values of PPI 336411 to determine if significant changes in the dataset are influencing the accuracy of forecasts. Lastly, a retrospective approach to EPA clauses is recommended which utilizes changes in actuals to calculate EPAs, as it resulted in a lower mean absolute percent error (MAPE) than the prospective approach with respect to actuals. The outcome of this research is a recommendation that the EPA clauses be rewritten to support a retrospective approach to calculating EPAs.

15. SUBJECT TERMS
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