Measurement of Inflation for Unique and Long-Term Procurement Contracts: Defence Perspective

Author:
Tsang, Olivia Oi Yi

Publication Date:
2011

DOI:
https://doi.org/10.26190/unsworks/15367

UNSW

THE UNIVERSITY OF NEW SOUTH WALES

CANBERRA

Measurement of Inflation for Unique and Long-Term Procurement Contracts: Defence Perspective

Olivia Oi Yi Tsang

School of Business, University of New South Wales
at the Australian Defence Force Academy

August 2011

Supervisor: Professor Russel Cooper

A thesis submitted in partial fulfilment of the requirements of the degree of Master of Philosophy in Business at the University of New South Wales – Australian Defence Force Academy

PLEASE TYPE

THE UNIVERSITY OF NEW SOUTH WALES
Thesis/Dissertation Sheet

Surname or Family name: Tsang

First name: Olivia | Other name/s: Oi Yi

Abbreviation for degree as given in the University calendar: MPhil

School: Business | Faculty: Australian Defence Force Academy

Title:
Measurement of Inflation for Unique and Long-Term Procurement Contracts: Defence Perspective

Abstract 350 words maximum: (PLEASE TYPE)

The Defence Materiel Organisation (DMO) procures goods and services on behalf of the Australian Department of Defence. Many high dollar value products are discrete, custom-made procurements. Moreover, the market from which these procurements are sought is also unique. This is because while DMO is a monopsonist, suppliers of complex combat systems often have characteristics of an oligopoly (sometimes even of a monopoly). The objective of this research is to develop a framework that would allow for the calculation of a 'true' defence-contract-relevant measure of inflation for price variation purposes in defence contracting. The current research investigates a 'Three-Stage Modelling Strategy'. The first stage involves 'selecting an appropriate index or indexes' while the second stage requires 'correcting the bias in the index' and the third stage involves 'index forecasting'. The current research also uses an illustrative example of the procurement of combat vehicles to demonstrate the implications of using such a model. Throughout the research, a comparative analysis between the Single Index (i.e. Finished Goods) approach and the Multiple Indexes (i.e. Cost Components) approach was conducted in order to compare the inflation generated under each. One of the important findings from the current research is that there would almost certainly be an understatement in inflation with indexes under the Single Index approach. As for the Multiple Indexes approach, the research found that the composite inflation generated by a collection of cost components indexes would almost undoubtedly be overstated if there was no consideration of productivity in the calculation. In response to these findings, the research introduced and discussed correcting adjustments to counteract these problems.

ORIGINALITY STATEMENT

'I hereby declare that this submission is my own work and to the best of my knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the award of any other degree or diploma at UNSW or any other educational institution, except where due acknowledgement is made in the thesis. Any contribution made to the research by others, with whom I have worked at UNSW or elsewhere, is explicitly acknowledged in the thesis. I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project's design and conception or in style, presentation and linguistic expression is acknowledged.'

Signed ………………………………………………..............

Date ………………………………………………..............

COPYRIGHT STATEMENT

Signed ……………………………………………..........................

Date ……………………………………………..........................

AUTHENTICITY STATEMENT

'I certify that the Library deposit digital copy is a direct equivalent of the final officially approved version of my thesis. No emendation of content has occurred and if there are any minor variations in formatting, they are the result of the conversion to digital format.'

Signed ……………………………………………..........................

Date ……………………………………………..........................

Acknowledgements

The work presented in this thesis was performed under the Defence Materiel Organisation (DMO) sponsored Master of Philosophy program[1]. I acknowledge with sincere gratitude the support and resources made available to me by DMO.

I wish to thank my academic supervisor, Professor Russel Cooper, for his persistent support and patient guidance. I have learnt an enormous amount from Professor Cooper, on areas including index number theory and inflation, and this has greatly enriched my research.

I would also like to thank my other academic supervisor, Professor Des Nicholls, for his excellent support. His guidance, especially on the topic of forecasting, was very precious to this research.

Many thanks also to Dr Robert Bourke, at DMO, for being a committed reader and contributor. I am grateful for his suggestions and insights especially on areas surrounding the defence industry.

I give special thanks to the staff at DMO for their valuable assistance along the way. I am especially appreciative to my colleagues at Human Resources and Financial Investigation Service for their support and advice.

Lastly, I would like to thank my family and closest friends, without their support and encouragement, this journey would not have been possible.

[1] Disclaimer: The views expressed in this academic research are those of the author and do not reflect the official policy or position of the Defence Materiel Organisation.

Abstract

The Defence Materiel Organisation (DMO) procures goods and services on behalf of the Australian Department of Defence. Many high dollar value products are discrete, custom-made procurements. Moreover, the market from which these procurements are sought is also unique. This is because while DMO is a monopsonist, suppliers of complex combat systems often have characteristics of an oligopoly (sometimes even of a monopoly). The objective of this research is to develop a framework that would allow for the calculation of a 'true' defence-contract-relevant measure of inflation for price variation purposes in defence contracting. The current research investigates a 'Three-Stage Modelling Strategy'. The first stage involves 'selecting an appropriate index or indexes' while the second stage requires 'correcting the bias in the index' and the third stage involves 'index forecasting'. The current research also uses an illustrative example of the procurement of combat vehicles to demonstrate the implications of using such a model. Throughout the research, a comparative analysis between the Single Index (i.e. Finished Goods) approach and the Multiple Indexes (i.e. Cost Components) approach was conducted in order to compare the inflation generated under each. One of the important findings from the current research is that there would almost certainly be an understatement in inflation with indexes under the Single Index approach. As for the Multiple Indexes approach, the research found that the composite inflation generated by a collection of cost components indexes would almost undoubtedly be overstated if there was no consideration of productivity in the calculation. In response to these findings, the research introduced and discussed correcting adjustments to counteract these problems.

Contents

List of Tables

List of Figures

Chapter One

Introduction

The classical view in economics is that monopsonists can exploit their bargaining power with a supplier in order to negotiate lower prices. The fact that the Defence Materiel Organisation (DMO) is the major or sole buyer of specialised defence materiel in Australia results in a monopsonistic market. However, on the supply side, companies that produce and sell to DMO have the characteristic of an oligopoly. In some cases, and for certain contracts, the supplier is actually a monopolist. This monopsony-oligopoly (and sometimes monopsony-monopoly) market structure and the complexities of weaponry systems limits the bargaining power of the monopsonist. This effectively creates an industry that is discrete and different to typical monopsony situations.

DMO procures a wide range of goods and services. Some items, such as combat vehicles and warships are considered to be 'unique products' as they are manufactured once and to buyer specifications (i.e. are custom-made). Production of large and complex weaponry systems not only requires substantial injection of public funds but typically requires a few years for the requisite equipment to be developed and manufactured. Additionally, maintaining this equipment may take as long, if not longer. The procurement of specialised materiel is made on a contractual basis prior to the delivery of goods and services. In order to manage unanticipated economic fluctuations over the contractual period, DMO contracts that are valid for more than two years usually include price adjustments to counteract inflation against a nominated price index (or indexes) (CoA, 2008). In entering into a contract that allows price variation based on future inflation, it is prudent for DMO to be aware of the likely and obligatory payment for inflation under each contract, especially when there is little room for budget adjustments.

Ideally, the most accurate and reliable inflationary pressure indicator would be a price index (or indexes) which reflects only the price or cost movement of the sophisticated weaponry system or purchased service. However, the practicality of this is very difficult to achieve as the production of complex military equipment is quite diverse, stretching across many industrial sectors. The 'defence industry' is a group of military equipment production and services companies. The term 'defence industry' is also used as an alternative to describe the defence monopsony-oligopoly (and sometimes monopsony-monopoly) environment. Despite known differences in economic drivers, market structure, contractual obligations, technological options, and political considerations that generate a substantial difference between the defence industry and the commercial industrial base, the defence industry is not an industrial sector which is separately defined under the generally accepted industrial classification codes. Rather it spans many manufacturing sectors such as aircraft, vehicles, shipbuilding, communication systems, explosive and weapon systems, and so forth. As a result, a price index (or indexes) dedicated solely to defence procurement is not published by most statistical agencies. Price variation clauses in DMO contracts have often been restricted to indexes such as the Consumer Price Index (CPI), Producer Price Index (PPI) and Labour Price Index (LPI), which are readily available but to some extent inappropriate for specialised materiel contracting purposes.

Indexing for the purpose of managing unanticipated economic fluctuations presents numerous challenges for the user. The number of indexes that can be used in contract price variation is substantial; for example, due to the multiple cost components involved, a combat vehicle contract may involve an index to cater for the inflation of steel, tyres, vehicle parts, and so forth. Furthermore, the way in which costs can be isolated for the purpose of indexation can represent a challenge in itself, as available indexes may only match relatively broad categories of cost. On the other hand, a simplified approach would be to use a single index, like a shipbuilding index, for the procurement of ships. The dilemma of the two approaches is whether the index should be selected based on the price differential from the raw material cost to the company (i.e. Multiple Indexes or Cost Components approach) or from the change in final product sale price (i.e. Single Index or Finished Goods approach). The latter approach is more preferred by certain major overseas government departments like the UK Ministry of Defence (UK MoD), while DMO has no strong preference.

Since DMO is the primary buyer of products such as combat ships and ammunition, then the price index from those industrial sectors may be suitable for contract price variation purposes. However, for other products like vehicles (and electronic equipment), the difference between the specification of defence and commercial products may mean an index on sale price from the general vehicle or electronic equipment industrial sector may not be able to represent the 'true' inflation of those defence procurement contracts.

Another challenge is the selection of the appropriate index or indexes in order to ensure that contract prices escalate in response to the movement relevant to the signed contract. Using an appropriate index is critical because the financial impact of a biased index can be huge. This was demonstrated when the US Department of Defense Inspector General (DoDIG) (2008) found that the financial impact to the DoD was in the order of millions of dollars due to information provided by the contractor which disproportionately influenced a particular Bureau of Labor Statistic (BLS) index. As a result, the US DoD has since banned the use of such an index for any future contracts.

There are several other complications in the choice of an appropriate index (or indexes). The appropriateness of an index depends on the purpose for its use. One index that is often used in economic analysis is the PPI of the Manufacturing Division. This is similar to the method used by Pappas (2009) in his audit of the Australian Defence budget. However, this particular index captures movement of the general manufacturing sector. This index, which is commonly considered by analysts as an economy-wide (i.e. high-level) index, can add distortions since the inflation reflected by the items or activities may neither be related to nor significant to the individual defence contract.

The complexity in the choice of index continues due to the depth of sub-indexes. Below the high-level manufacturing division index, there are finer commodity groupings indexes. As the index structure becomes finer, the narrower index may only cover an industrial sector that consists of a few producers. Since smaller numbers of price quotes are used to calculate the narrower indexes (as compared to higher level indexes), narrow indexes may be too specific for contract price variation purposes.

There are a significant number of indexes in the manufacturing division which are available from the Australian Bureau of Statistics (ABS), and from other areas of the world. Some have been seasonally adjusted while others have not, and some are produced as input price indexes (i.e. index from material cost perspective) while others are output price indexes (i.e. index from sale price perspective). The vast choice available highlights the fact that the inclusion of any particular index (or indexes) for contract price variation purposes can become complicated.

An added dimension to the indexation challenge is that economic literature has often found that price indexes may overstate (or understate) inflation. This is due to a number of reasons surrounding measurement, and includes coverage bias, substitution bias, quality change bias, and new goods bias. Unfortunately, there seems to be little research on whether the uniqueness of the monopsony-oligopoly structure adds to or counteracts these inherent measurement biases. Yet these biases have potentially significant consequences. When an index used in a price variation clause overstates the inflation that the supplier faces, a buyer such as DMO is likely overpaying in each individual contract. Alternatively, if the defence industry is forced to use indexes for contract price variation that are thought to be understating inflation, this may push companies to sidestep the rationale for the indexation method by instead charging a premium in the baseline price. This is an obvious danger in the monopoly supplier case but is also very much present in the oligopoly supplier case. The monopsonistic position of DMO as buyer can be a drawback as monopsonistic buyers are often not able to compare prices of ‘unique’ or ‘custom-made’ procurement with other buyers.

While publicly available indexes play a prominent role as tools for economists and business analysts in analysing inflation, the underlying market environment which these price indexes reflect is more commercial in nature than the defence monopsony-oligopoly environment. The defence industry has special attributes such as a lack of competition, dealings in technologically advanced weaponry, and research and development (R&D) for specialised military equipment, all of which accentuate the differences (Dunne, 2006). It is also a commonly held view that the manufacturing of specialised materiel is more labour intensive and requires highly skilled labour. For all of these reasons, the monopsony-oligopoly market structure and the complexities of weaponry systems means that the defence industry, to some extent, has different characteristics than industries involved in commercial production. For example, an index like the ABS PPI 231 Motor Vehicles Manufacturing index measures price change for one basket of goods and services (i.e. manufacturing of commercial vehicles), therefore, using this index as an inflation indicator for another basket of goods and services (such as combat vehicles) may not be an appropriate measure. For this reason, the differences in commercial and defence production raises doubts over the appropriateness and efficacy of using publicly available indexes as inflationary indicators for specialised materiel contracts.

Considering that market structure and the level of competitiveness affect the price level, it has been argued that the uniqueness of the defence industry facilitates the result that defence-related inflation deviates from that observed for commercial production. Studies of defence industries (for example, Solomon, 2003) have found that the inflation for procurement of defence products is generally above the rate observed in the overall economy. Acknowledging this inflation gap is vital for DMO and its industry. Furthermore, ways to cater for an inflation gap in contracts will play an important role in maintaining the financial health of the defence industry. For example, unless contractors are adequately compensated, areas like R&D may suffer and lead to what might on face value appear to be a short-term positive for DMO actually becoming a long-term negative. Currently, there is a short supply of economic literature that discusses ways to cater for inflation gaps.

Buyers are often operating under budget constraints. In DMO's case, its budget is supplemented at a fixed annual indexation rate of 2.5% for inflation. While this rate may be only a small amount lower than the current general economy-wide inflation, such as that referenced by the CPI on average over the last five years in Australia, it does seem to be substantially lower than current movement in another key economy-wide index, the Non-Farm Implicit Price Deflator for Gross Domestic Product (GDP). The financial impact of the difference between the application of contracted price variation clauses and this fixed supplementation rate suggests a cautious approach to future DMO commitments is required. Relevant price index forecasting can provide some degree of insight into the inflationary outlook. Understanding the macroeconomic environment in which the index has arisen is one way to aid in forecasting. However, in utilising a broad range of macroeconomic indicators for modelling, econometric problems such as the potential for specification error, the presence of multicollinearity among the indicators, and distinguishing between correlation and causality, pose well known difficulties from the point of view of developing, estimating and interpreting models for forecasting purposes.

Unfortunately, there are few relevant Australian studies published on the type of price indexes currently in use or the types that should be used for contracts involving specialised military equipment and services. Documents such as the Australian Standard for Defence Contracting (ASDEFCON) - Complex Materiel (2008) provide guidance on the selection of indexes, yet the guidance is very simple and broad. This lack of literature also extends to other defence areas, like the US and the UK, who utilise indexation methods. These two countries are also DMO's main import sources of specialised materiel as the capacity to develop and produce specialised materiel is highly concentrated in only a few countries (Skons and Dunne, 2009).

This thesis is concerned with inflation escalation for long-term contracts for the procurement of specialised defence materiel. It aims to provide a framework for DMO and its contractors to calculate the 'true' defence-contract-relevant inflation for the procurement of specialised materiel. It aims to aid in selecting the 'appropriate' index for defence contracting purposes by refining, based on various established principles, a group of acceptable and suitable indexes for use in price variation clauses. The underlying research reported in this thesis will contribute by identifying initiatives that can be employed to improve current indexation methods. Additionally, it aims to address the inflation gap between available measures and the 'true' defence-contract-relevant inflation caused by inherent measurement bias, 'uniqueness' of the defence product and of the defence industry. The thesis will also investigate options for providing relevant price index forecasts aimed to aid contract budgeting and management. Finally the thesis will demonstrate issues through an illustrative procurement case primarily intended to offer, as an example, an application of the proposed model to indexation of materiel contracts.

The thesis consists of eight chapters. The second chapter provides a comprehensive literature review which is divided into three parts. Part one provides a review of economic theories relevant to the topic of inflation indexation. The second part reviews material that describes special features of the defence industry structure, while part three provides a review of prior research on price variation of defence contracts and forecasting of indexes which are of defence interest.

Chapter Three describes the scope of the data used and the research methods of this study. Chapter Four to Six is concerned with examining the ‘Three-Stage Modelling Strategy’ and discussion of the findings. Chapter Seven, ‘Illustrative Application’, uses the procurement of combat vehicles to demonstrate the procedures and initiatives proposed as an outcome of the current research. The second part of Chapter Seven will investigate the difference in historical inflation between the procurement of combat and commercial vehicles.

Chapter Eight summarises the outcomes and evaluates the shortcomings of using the indexation method and price indexes in general. This chapter concludes by briefly highlighting the benefits for DMO, and its industry, of the initiatives proposed by this research.

Chapter Two

Literature Review

Indexation for inflation is a common technique used in a variety of areas like public funding, salary negotiations, pensions, business contracts and many more. Indexation, via the application of price variation clauses, is common in long-term contracts to eliminate contingencies which cater for unexpected costs due to economic fluctuations during the course of contractual performance. Price variation usually involves a periodic adjustment to the prices paid for the contract provisions based on the level of a nominated price index (or indexes). The inflation referenced by any particular price index is the price movement of a large 'basket' of goods and services that are representative of the defined purpose of the index. This chapter briefly reviews some relevant academic literature on the theory of index numbers, then turns to literature which discusses the practical issues at the core of the problem considered in this research, namely the 'uniqueness problem'. The discussion will be viewed from both product and industry perspectives, and some literature specifically related to these issues as it affects defence and its industry will also be reviewed.

2.1 Price index - theoretical framework and price variation

There are several different popular approaches to index number theory. The first to mention is the 'axiomatic' or 'test' approach which determines an index's appropriateness based on a set of desirable properties (Diewert, 2004b). Certain primary properties like positivity, proportionality in current prices, and commensurability (independence with respect to units of measurement) are considered to be basic. Other properties are sufficiently important that they have received special attention within the relevant literature; these include time reversal, circularity, and factor reversal. However, the relative importance of these properties can depend upon the specific use of the index. Diewert (1992b) considered 20 axioms[1], or properties, and found that only the Fisher Ideal index satisfied all of these axioms. The Fisher Ideal index is the geometric mean of the Laspeyres and Paasche indexes, and is a classic example of how the combination of two indexes satisfies all tests, while the indexes on their own do not satisfy the axioms of time reversal, circularity, or factor reversal (Hill, 1988).

Diewert (1997) found that the geometric mean will in many circumstances provide a 'better' average than other averages like the arithmetic mean, because it has a natural time reversibility property. It is interesting to note that although the Laspeyres and Paasche indexes do not involve geometric means, they complement each other and the Fisher index is, at a higher level, a geometric mean of these complementary indexes. As a consequence, the price change under the Fisher index formula, from the current period to the base period, is the reciprocal of the original price change.

However, despite its limitations, the Laspeyres index is still frequently used by statistical agencies. The Laspeyres price index reflects the movement in the value (from the base period to the present) of a basket of goods and services that was purchased in a specific base period. Expenditure in current prices is compared to expenditure in base period prices using the same (base) quantities. This means that quantities which can also be referred to as 'weights' are 'fixed' for both the base and current period. On the other hand, the Paasche index is a measure of expenditure using current prices and quantities as compared to expenditure using prices from an earlier period (i.e. base period) but using quantities of the current basket of goods and services. Discussions of the merits of these two indexes are readily available in the economic literature (see Hill, 1988; Diewert, 2004a).

The data allocation process under the Paasche index can be substantial as both current price and quantities are required in a continuous manner for the index to be accurate and publishable. This feature means that in comparison to the Laspeyres index,

[1] The twenty axioms were: positivity, continuity, identity, constant quantities, proportionality in current prices, inverse proportionality in base prices, invariance to proportional changes in current quantities, invariance to proportional changes in bases quantities, commodity reversal, invariance to changes in the units of measurement, time reversal, quantity reversal, price reversal, mean value test for price, mean value test for quantities, Paasche and Laspeyres bounding test, monotonicity in current prices, monotonicity in base prices, monotonicity in current quantities and monotonicity in base quantities (Diewert, 1992b).

the Paasche index may not be as practical. The features of the Laspeyres index make it more practical for calculation, as only updated prices are continuously required for collection. The calculation of the Fisher index requires the same data as the Paasche index, so computation may likewise be not as practicable due to the frequent requirement of quantity or expenditure share data.

Another well-known index number theory is the ‘economic theoretic’ approach. This approach defines indexes with reference to underlying utility or production functions (Diewert, 2004c). The classic example of an economic theoretic index in the consumer context is the concept of the cost of living index. In the producer context, the economic approach could be considered as an aid to study the ‘true cost of production’ from the perspective of producer input prices or the ‘true value of production’ from the perspective of producer output prices.

It is recognised in economics that the Laspeyres index, being a fixed weight index, would not produce an exact measure of the ‘true’ inflation as prices change over time. This is because a price index computed some periods ago, using the same basket of goods, would not represent the price changes of today because quantities that are representative do in fact change over time (Silver, 2004). This gradual lack of representativeness of a fixed weight index is discussed further below.

It is not only the case that the representative quantity will change over time, but that goods in the basket will also likely improve in quality, while new types of goods will also have been introduced. However, the fixed weights in the Laspeyres index calculation mean any increase in price as a result of improvement in quality will be incorrectly recorded as inflation since there is no recorded change to the characteristics of the improved product or services. Therefore, by using base period weights, the Laspeyres index tends to produce a higher estimate of inflation than the Paasche index. Essentially, in economic terms, the Laspeyres and Paasche index are widely viewed as the upper and the lower boundary of a theoretical index (Hill, 1988).

The search for an index which can produce a closer approximation to the theoretical index is necessary. Diewert (1976) demonstrated that a type of index, which he named ‘superlative index’, would give good approximations to the ‘exact’ formula that should be used if one knew or could utilise a ‘good’ (flexible) representation of the true structure of preferences in the consumer case, or the true nature of the production function in the producer case. One of these superlative indexes is the Fisher Ideal index (Diewert, 1992a). The Fisher Ideal index results in a 'better' measure of the true inflation because it allows for product substitution (i.e. it uses weight information from both base and current periods). In doing so, it approximates a reasonably flexible representation of preferences or technology.

Most of the literature on price indexes has been written in the context of the Consumer Price Index (CPI), because in practice the CPI is often used as the indicator of the cost of living. The CPI is an index which reflects the changes in retail prices paid by consumers. There has been a substantial amount of literature (Moulton, 1996; Diewert, 1996, 1998) on the measurement bias of the CPI. One of the major criticisms of the CPI (which is often calculated using the Laspeyres formula) is that the fixed weight calculation effectively has failed to reflect that a typical consumer often switches their preference based on their budget and the relative price change. This failure is known as substitution bias. Furthermore, since the CPI is based on an average budget, it may be a poor indicator of changes in the cost of living for people that have 'unusual' spending patterns.

Several studies had been able to quantify the measurement bias in the CPI despite the many complications involved. One of the most influential studies was on the US CPI, where Boskin (1996) estimated an upward bias of 1.5% during recent years, and probably 1% in year to come. From the UK perspective, Cunningham (1996) estimated the upper range for the systematic bias to be between 0.3% and 0.8% per annum. For Australia, it was found that that on an annual basis, the CPI was potentially upwardly biased by 0.2% (ABS, 2010f).

Measurement bias and misinterpretation are not restricted to just the CPI. Other price indexes are also prone to mismeasurement. However, there has been little work undertaken on the nature and extent of errors and biases for other indexes such as the Producer Price Index (PPI) or labour cost indexes. The area of bias highlighted for the CPI is also valid for other indexes, but because of the construction of these other indexes, the direction of bias may differ to that seen in the CPI.

In contrast to the CPI, the PPI measures prices from the producer's (i.e. seller's) perspective. These PPI can be constructed as either input or output measures. The manufacturing input PPI relates to cost movement in the materials used by producers. The manufacturing output PPI reflects the sales price of the selected products sold by the producers (ABS, 2006b). Both input and output PPIs are produced as measures from the average producer's perspective.

The substitution bias impacts differently depending on the type of measure, such as input or output PPI. When computing an output index, it is assumed that the producer aims to sell more higher-priced items without accounting for a shift in the quantities used or produced (ABS, 2006b). Therefore, the fixed basket of goods and services means the index has failed to account for actual changes in quantities as price changes. Similarly, when compiling the input price index, a bias occurs because quantities are fixed despite the producer's aim to purchase more lower-priced inputs rather than higher-priced products (ABS, 2006b). Thus, in the context of the PPI, if a Laspeyres index is used to measure producer input prices it will not reflect producer decisions to make input substitutions in order to minimise costs. On the other hand, if a Laspeyres index is used to measure producer output prices it will not reflect producer decisions to take advantage of output price changes by producing a different product mix in an effort to maximise profit.

There is extensive economic literature (see Blanchard and Fischer, 1990; Cohen, 2001) concerned with the causes of inflation, its effects, and the relationship between prices and economic theory. Consideration of classic microeconomic theories like profit maximisation can be useful in understanding how the output prices have arisen. Since a producer strives to operate over the long run, the producer needs to determine the optimum price and output level in order to maximise its return. Other classic economic concepts like economies of scale and economies of scope are also important for producers to consider while setting their sale or output prices.

Another well-known economic theory is the Keynesian (Jackson and McIver, 2001) which takes a more macroeconomic perspective and proposes that output price movements are the result of demand and supply pressures in the overall economy. Therefore, changes in prices are influenced by causes like cost-push, demand pull, and market pressure or power. However, from this aggregate economy-wide perspective the effect of inflation is not as straightforward. This is because price changes can be a costly exercise, with the potential for customers to switch to rival companies. Hence producers may elect to absorb inflation costs in their profit. Frequent price changes can also mean that new menus or price lists may need to be printed. This in turn can increase uncertainty for buyers and may be considered risky. Alternatively, a rise in input costs could be counteracted by increasing productivity. Despite rises in economy wide inflation, the effects on output prices can vary. Many of these factors would arguably contribute to price stickiness (see Blanchard and Fischer, 1990).

An older approach stemming from statistical ideas in index number theory is the 'stochastic' approach. This approach remained dormant for some time, arguably due to criticism raised by Keynes, but received renewed prominence with the work of Clements and Izan (1987). One of the highlights of this approach is its ability to not only provide a point estimate of inflation rates but also an estimate of the standard error of the index. This feature is illustrated both in Clements and Izan (1987) and in a more recent Australian study by Selvanathan and Selvanathan (2006). These two studies used the stochastic approach to calculate the standard error in order to construct confidence intervals for the 'true' rate of inflation. The merits of the stochastic approach are highlighted in Clements, Izan and Selvanathan (2006). As these scholars indicate, sophisticated applications that meet Keynes' criticism require the use of both time series and cross-sectional data. This approach allows the addition of other explanatory factors in its inflation calculation. Hence, implicitly, it may be able to cope with the differential in pricing or inflation stemming from a 'unique' product type or even a 'unique' industry.

Another application of the stochastic approach to index number theory is in international comparisons. As such, Rao's (2005) research on a weighted country-product-dummy method illustrated new possibilities for the stochastic approach. Despite its advantages the stochastic approach remains largely underutilised by many statistical agencies, and even within the economics research field. However this may be changing. The official statistical agency in the UK Office for National Statistics (ONS) recently provided estimates of standard errors for growth rates for a range of indexes under the

PPI series in order to provide a measure of the quality of the indexes (Morris and Green, 2007; Woods, 2008).

However, it is important to note that inflation and contract price variation, while similar, are not identical. Contract price variation is specific to an item or groups of items. Therefore, contract price variation not only includes economy-wide inflation related to the money supply, it is also driven by changes in technology, practices, and particularly supply-demand imbalances that are specific to goods or services in a particular economic sector. For example, the average annual Australian inflation rate (the headline CPI) in 2008, was around 4%. However, over the same period the specific ABS PPI of Iron Ore and Steel Manufacturing escalated by on average 27%. Also during the same period, the LPI for Professional, Scientific and Technical Services (which reflects the price movement in wages cost) inflated by 5%.

As the above figures illustrate, any high-level index, such as the headline CPI, could be a poor indicator when the user's purpose differs from what the index aims to measure. This is due to the weights used in computing the index. Most inflation indexes are calculated from weighted averages of selected price changes. This method of different weights introduces distortion as the weights applied may not be relevant to the user's 'unique' purchase. Therefore, the inflation estimate applicable differs, depending on the specific industry sectors which are of relevance and interest to the user's contract.

There is another dilemma from a practical perspective. A valid price index does not simply compare the prices between two periods. Even if users did encompass pricing data to calculate their own index, taking today's price and comparing it to an earlier period does not necessarily equate to a valid inflation or price index. This is due to the fundamental concept that the inflation rate referenced by a price index should be representative of others in a similar situation (for example, the industrial sector as a whole). Due to the immense magnitude of data required to construct an index, users are unlikely to be able to construct their own index from scratch. Therefore, despite the possible measurement bias contained within price indexes, publicly available indexes are still commonly used and are well accepted for contract price variation purposes.

Statistical agencies in Australia, the US, and the UK, use similar industrial classification systems for their indexes. A classification system distinguishes various levels of industry classification to accommodate both broad analysis and fine dissection of statistical data regarding the economy. It is presented as similar to a hierarchy, with the highest level being the broadest classification level, followed by increasingly detailed dissections. The ABS uses the industry framework of Australian and New Zealand Standard Industrial Classification (ANZSIC) to distinguish four levels of industry. The US BLS uses the North American Industry Classification System (NAICS) which offers five levels of detail, while the UK ONS utilises the UK Standard Industrial Classification (UK SIC) which is a hierarchical five digit system. All three classification systems align to some extent to the International Standard Industrial Classification (ISIC). A comparison of the three countries' classification systems, together with an example, is presented in Figure 2.1.1 and Table 2.1.1.

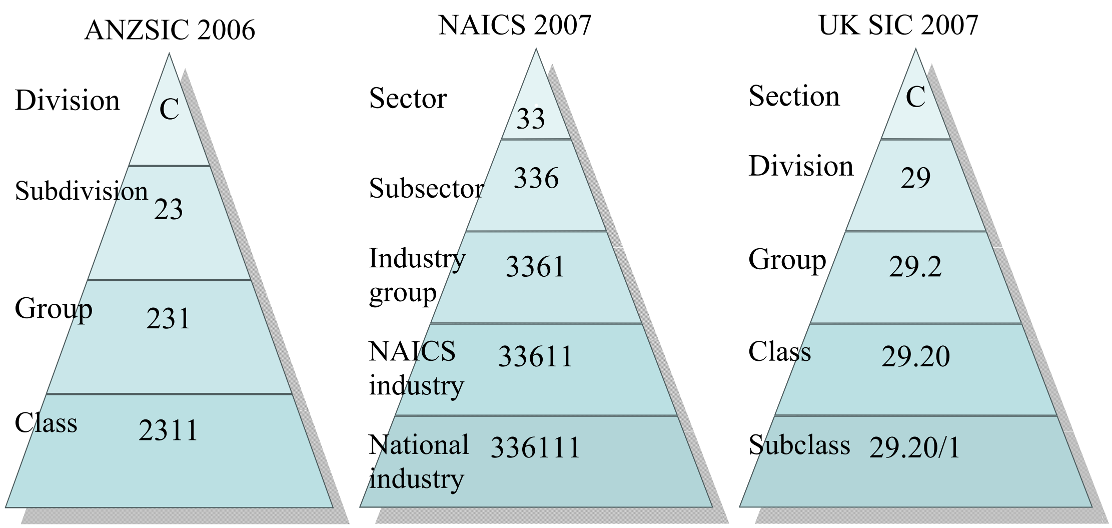


Figure 2.1.1 Comparison of classification systems under ANZSIC, NAICS and UK SIC.

Source: ABS (2006a), ONS (2009) and U.S. Census Bureau

Table 2.1.1 Example of the classification system under ANZSIC, NAICS and UK SIC.

	ANZSIC 2006	NAICS 2007	UK SIC 2007
First dissection	C Manufacturing	33 Manufacturing	C Manufacturing
Second dissection	23 Transport Equipment Manufacturing	336 Transportation Equipment Manufacturing	29 Manufacture of motor vehicles, trailers and semi-trailers
Third dissection	231 Motor Vehicle and Motor Vehicles Part Manufacturing	3361 Motor Vehicle Manufacturing	29.2 Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers
Fourth dissection	2311 Motor Vehicles Manufacturing	33611 Automobile and Light Duty Motor Vehicle Manufacturing	29.20 Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers
Fifth dissection	Not applicable	336111 Automobile Manufacturing US	29.20/1 Manufacture of bodies (coachwork) for motor vehicles (except caravans)

Source: ABS (2006a), ONS (2009) and U.S. Census Bureau

Due to the dissection of the industry level there are hundreds (and even thousands) of indexes available. There is no mechanical rule on which dissection is the correct level for contract price variation purposes. Generally, lower level indexes (i.e. the third, fourth, or fifth levels of dissection) provide progressively greater refinement in classifying industries than at the higher level (i.e. the first or second levels of dissection). Often, higher level indexes like the Division and Subdivision indexes from the ABS are seen as macroeconomic indicators of inflation pressure, while lower level indexes like Group or Class indexes are viewed as microeconomic indicators. The extent of homogeneity in the activities grouped at a particular dissection level increases as the classification is refined. In reality, the practical dilemma in using price indexes in general is associated in choosing the 'right' index (or indexes) among the various dissection levels.

Even within a particular index series, there could be more than one type of sub-series. In Australia and the UK the PPIs are published as input and output indexes. Furthermore, the ABS LPI series also publishes the sub-series of Ordinary Time and Total Time, and these sub-series could either include or exclude bonuses. The series of Ordinary Time excludes price change associated with overtime, while the index series of Total Time includes such elements (ABS, 2004). The Employment Cost Index (ECI), published by the US BLS, contains three sub-series, the first for Total Compensation (which includes all employment costs), the second for Wages and Salaries, and the third for Pay Benefits (BLS, 2011a). The efficacy of using a particular price index (or a particular collection of indexes) depends strongly on the user's purposes, and as such, is particularly challenging when the product and/or the industrial sector of interest is 'unique'.

2.2 The uniqueness of the defence industry

Procurement of military equipment is unique in its kind as there is only one buyer - the Government. In Australia, this is the Department of Defence via the DMO. In such circumstances, monopsonists have traditionally been seen as having buying power. The monopsonist can usually exert substantial control over the type of products and the timing of demand, which typically results in the negotiation of lower prices. However, the uniqueness of the defence procurement and its industry can challenge the perceptions supported by such traditional economic theories.

Defence procurement can be classified in two ways. One type is the procurement of non-specialised items, often in high volumes (Ergas and Menezes, 2004). These are normally classified as commercial-off-the-shelf items which are identical to those available in the commercial market and are immediately available in the market place. The dollar value of procurement in this category is relatively smaller compared to that of complex weaponry systems. Since these non-specialised purchases are sourced from the general commercial market, the inflationary indicator defined by the industrial sector, under the general industrial classification system, is reflective of inflation experienced by these non-specialised procurements.

The second type of defence procurement, which is of concern to this research, is that of complex weaponry systems. These are often classified as 'unique' products that are manufactured once and made to match the buyer's (for example, DMO's) specifications. These weaponry systems include combat vehicles, combat aircraft, and combat communication equipment, and are often high in dollar value but acquired in low quantities (Ergas and Menezes, 2004). Such custom-made products typically feature highly specialised technology and features; far more than their commercial counterparts.

In addition to the different characteristics of combat and non-combat products, another dissimilarity is that large and complicated weaponry systems often require substantial research and development (R&D), whereas commercial products are already produced prior to sale and are sold via numerous marketing channels (Agapos, 1971). As the procurement contracts for complex weaponry systems can involve aspects such as development, production, and service maintenance, it is often not unusual for the buyer (i.e. the Government) to finance R&D and infrastructure (Dunne, 2006).

The skill sets employed within the defence industry may also differ from those of the commercial manufacturing industry. In comparison to other industries workers in the defence industry are often highly skilled. On average, the defence industry employs a higher proportion of engineers and scientists, or those with a higher level of qualifications, than other industries (Dunne, 2006).

A complex weaponry system is most likely created only at the request, and to the specification, of its buyer. Therefore, it is often difficult for producers of weaponry systems to infer relevant buyer behaviour from examining previous related purchases. Lorell, Sanders and Levaux (1995) found that the role of experience (via previous and similar production) has a significant impact on supplier costs and capabilities. Evidence from that particular study showed that expertise in the development of commercial aircraft does not automatically provide the necessary experience base for military aircraft. As relatively few complex weaponry systems have been produced, the number of companies with the experience or capability to develop and produce such specialised materiel is small.

High market concentration in the defence industry can also influence the degrees of competitiveness within it. The Australian maritime and aerospace industries are known for their limited competition. Infrequent demand and the requirement of high-levels of capital and physical infrastructure are considered to be two of the major restrictions in opportunities for new firms to enter these markets (Ergas and Menezes, 2007). Another reason is that security justifications have historically determined the location of plants, which are often far away from metropolitan areas (Dunne, 2006). As such, it is not easy to open new manufacturing plants, or move existing ones. Greer and Liao (1986) also found that the risk from a capital market perspective is higher for defence than it is for commercial businesses. These barriers to entry create a situation where a seller can exercise some degree of market power in reflecting the lack of competition. Therefore, this challenges the traditional theory that the monopsonist has the bargaining power.

Much literature on defence economics (Dunne, 2006; Ergas and Menezes, 2007; Skons and Dunne, 2009) recognises that the uniqueness of the military's needs have created an industry that is different to the commercial manufacturing industry. While the buyer of military equipment has monopsony power on the demand side, on the supply side firms that produce and sell specialised materiel have the characteristic of an oligopoly. To some extent political influences, like restrictions concerning domestic content and national security, also help create an oligopoly (or near monopoly) especially in the domestic market. A bilateral monopoly situation also arises as significant numbers of contracts result from non-competitive methods. This monopsony-oligopoly (and sometimes monopsony-monopoly) market structure, and the complexities of weaponry systems, limit the bargaining power of the monopsonist. The combination of all these elements effectively creates an industry that is discrete and different to a typical monopsony situation. A comprehensive review of the nature and structure of the defence industry can be found in the work of Hall, Markowski and Wylie (2009).

The contractual process involved in procuring a complex weaponry system is another distinctive feature of defence procurement differing to commercial procurement. Procurement of specialised materiel is usually made on a contractual basis prior to the delivery of goods and services. On the contrary, a procurement contract which extends beyond several years is rare in the conventional commercial market. The current practice in DMO procurement contracts is to allow variation of the contractual price by a price index or a series of indexes (DoD CoA, 2008). The latter approach requires selection of several indexes that are reflective of changes in the costs of a variety of inputs. For example, the cost of materials could be escalated with one or more indexes, while the cost of labour is escalated by another. In those cases, percentage weight would be given to each index in calculating the total escalation.

The Australian practice is also similar to other international practices. The basis for selecting an index (or indexes) for US DoD price adjustment can be outlined as follows:

> *"… the index should not be so large and diverse that it is significantly affected by fluctuations not relevant to contract performance, but it must be broad enough to minimize the effect of any single company, including the anticipated contractor(s)… normally contracting officers should not use more than two indexes, that is, one for labor and one for material"* (DFARS Procedures, Guidance, and Information 216.203-4, 2004)

However, the US DoD requires the percentage of the contract price, subject to price adjustment, to be stated clearly. The reason for this is because typically, price adjustment does not apply to the profit portion of the contract nor to certain areas of overheads (i.e. depreciation, taxes, and so forth) (DFARS, 2004). Yet, this is not a requirement in current DMO contracts.

To some extent the UK MoD's advice on index selection can be viewed as going one step further. A general recommendation was for selection to be made from several high-level output price indexes (DESA, 2009). As these are only recommendations there is no mandate to use a particular index, rather, the recommendation is that a relevant output index be used. Furthermore, if an input index is used, in order to cater for elements such as efficiency or productivity, it may have a 20% to 30% Non-Variable Element (NVE) in the price variation formula or a 10% NVE if an output based index is selected. Once again, this practice is not employed in current DMO contracts.

Although the defence industry operates to some degree under the same economic conditions as the industrial sector of which it is a part; contractual, economic, technical and political differences make industries which produce combat aircraft, combat vehicle and combat communication equipment, partly dissimilar to commercial industries. Since the defence industry is not usually separately defined under the generally accepted industrial classification code, price variations in DMO contracts have often been restricted to indexes from series such as the CPI, PPI and LPI. Therefore, there is a persistent concern whether using publicly available indexes, for 'unique' product types such as specialised defence materiels and for a 'unique' market like the defence industry, can facilitate price variation reasonably consistent with that applicable in performing a defence contract.

2.3 Prior research on price variation of military equipment

Theoretical reasoning on several index selection criteria for contract price variation purposes is readily available. For example, the 'right' price index should measure price changes that relate closely to the procured goods and services subject to escalation, while also measuring a sufficiently broad category of items and/or activities to eliminate the influence by any given contractor on the index of interest (Schiefebien, 1977). Other criteria include theoretical soundness, statistically validity, and so forth (LMI, 1968). Schiefebien (1977) also highlighted that labour cost indexes do not usually cover productivity, he states:

> *"…general growth of labor skills with the introduction of more efficient production methods and tools should offset labor escalation to some extent."*

To date, ways to cater for this productivity limitation are not readily found in the literature which discusses or examines the issue. In fact there is very little research in the area of accuracy and suitability of publicly available price indexes for the procurement of specialised equipment from a contract price variation perspective.

There have been two recent investigations conducted by the US DoDIG which found contracts to have contradicted basic index selection criteria. In one investigation, the contract was found to be using a narrow index, BLS PPI - Titanium Mill Shapes, where the index captured an industry that consists of only a few producers but failed to include the largest US titanium producer (DoDIG, 2009). Another case was where the weighing of a particular BLS index was significantly dominated by a single company, and this company had contracts with DoD which utilised such an index in its price variation formula (DoDIG, 2008). As the company in question had become the dominant market force and could unfairly influence the index, BLS ECI - Aircraft Manufacturing, the US DoD has since banned such an index for use in their contracts.

A Canadian study found that the defence-specific inflations for procurement are higher than the rate observed in the general economy. Soloman (2003) observed that in two Canadian Defence acquisition projects that were analysed, the accumulated inflation rates at the end of a 13-year period were 47% and 70%, while the rate for the GDP was 44%. In the UK, Kirkpatrick (2008) recommended that due to particular characteristics of the defence industry, an allowance of an additional 0.5% for inflation of military equipment purchase should be appropriate.

Another US researcher, Wolf (1993), explored whether there was any difference between the use of a GDP deflator and a composite inflation index developed by his study on defence research development costs. The results showed no difference in the observed inflation between the indexes.

To some extent, much of the available literature surrounding inflation in the military budget is still relevant to this research paper. Pappas (2009), in his audit of the Australian Defence budget, used three high-level indexes to forecast the average amount of funding required to offset the impact of inflation for the procurement of military equipment. The three indexes were; ABS PPI (manufacturing) for equipment procured in Australia, ABS Wage Price Index (which is the LPI) for the contract labour component of sustainment and relatively labour intense nature of defence equipment manufacturing, and the US DoD procurement index for equipment procured from any foreign nation. The inflation forecast produced by this model was 3.2% p.a.

Reasonable and accurate forecasts can have a significant impact on public funding. Smirnoff and Hicks (2008) established that inaccurate inflation forecasts, which tend to underestimate unanticipated inflation, annually lead to billions of dollars in procurement cost overruns in the US. A fundamental question in long-term contracting is rather compensating contractors against a nominated price index (or indexes) is the most effective method for handling unexpected cost rise in material and labour. Since procurement of complex weaponry systems normally involves development, production, and even maintenance, there would be a variety of uncertainties associated with long-term contracts. These uncertainties may push the contractor to include a contingency for inflation which they view to be sufficient in order to cover their costs. By investigating alternative contractual agreements, like risk sharing arrangements, Barney (1989) theoretically showed that defence contractors from the US shipbuilding industry to be willing to absorb a portion of the risk associated with inflation only when compensated by higher target profits.

In addition, two US research reports on cost growth can be implicitly useful in understanding the rise in output prices for naval ships and military aircraft. Both studies (Arena, Blickstein, Younossim, Grammich, 2006; Arena, Younossi, Brancato, Blickstein, Grammich, 2008) found that the unit price rises in naval ships and military aircraft were due to economy-wide inflation and customer-driven factors. These customer-driven factors were characteristic complexity, requirement complexity, standard regulation, and procurement rate. Out of these four factors, the factor of procurement rate is of particular interest to the current research. The other three factors were related to inter-generational escalation (i.e. not related to unanticipated inflation in the cost of material and labour). As previously noted, because military equipment is often purchased infrequently and in low quantities, productivity and gains from the learning effect and economies of scale are usually smaller than what is found in commercial production. Arena et al. (2006) found that the rise in unit price generated by the procurement rate for naval ships was between 0.3% and 0.5%. For military aircraft Arena et al. (2008) found that the infrequency or instability of the procurement in some situations generated as much as a 1.7% increase in output prices.

The existence of defence-specific inflation is implicitly recognised in the US. In the publication of the national income product account, the Bureau of Economic Analysis (BEA) includes figures for consumption and investment from their national defence. These deflators are available for various components of defence expenditure such as aircraft, ships, missiles, vehicles, electronics, and so on. Effectively, the US DoD has its own set of inflation measures which would differ from those referenced by the BLS. However, these deflators are more related to the price paid by US DoD rather than the inflation experienced by the companies who sell 'unique' products.

There are four main objectives in the research. Firstly, the current research will expand the number of index selection criteria and provide an analysis of each selection principle to the unique defence monopsony-oligopoly contracting situation. The second objective is to contribute by innovatively providing ways to correct biases (generated from theoretical inherent measurement and specific defence areas) in order to calculate with added accuracy a ‘true’ defence-contract-relevant inflation. Thirdly, the current research will investigate and attempt to forecast indexes of interest to DMO and its contractors despite the many uncertainties that may underlie these estimates. The fourth objective is to investigate whether there is any difference between the historical inflation for the procurement of combat and commercial vehicles from an Australian perspective.

Chapter Three

Research Methods

3.1 Defining the industrial sectors of DMO interest

While Chapter Two identified and discussed relevant literature which will inform the current research, this chapter describes the methods proposed in performing the research. Firstly, since the current research is concerned with the procurement of specialised defence materiels, it is important to define what constitutes 'defence procurement'. Figure 3.1.1 illustrates the breakdown of defence expenditure by sector.

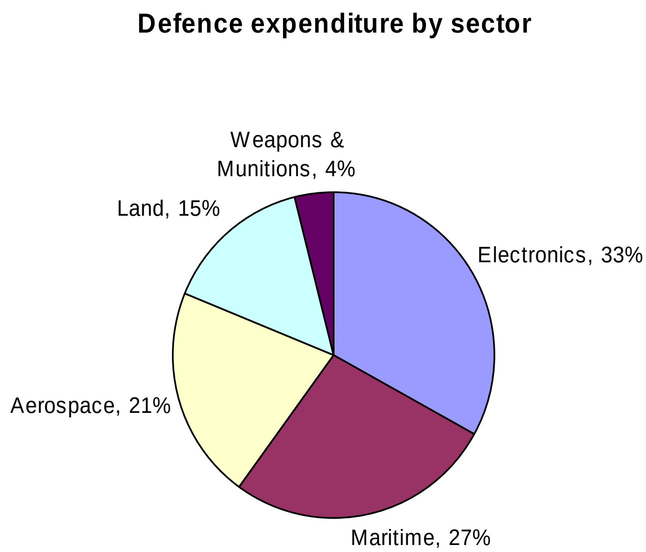


Figure 3.1.1. Snapshot: Defence expenditure by sector
Source: Department of Defence (2010)

The expenditure depicted in Figure 3.1.1 corresponds to four manufacturing areas of final demands; they are (i) shipbuilding and repair, (ii) vehicles, (iii) aircraft assembly, modification and repairs, and (iv) electronics and computing. As this research is concerned with specialised materiel, the focus of the current analysis will be centred on the procurement from these four types of final demand.

Accordingly, based on an examination of the ABS industrial definitions and classifications, ANZSIC 2006, there are six manufacturing industrial sectors that are of relevant interest to this research. They are (i) Chemical, (ii) Polymer, (iii) Primary Metal, (iv) Fabricated Metal, (v) Transport Equipment, and (vi) Machinery and Equipment. These sectors are considered to be defence-related or relevant industrial sectors for the purposes of the current research.

3.2 Data description

As noted earlier, there are a large number of indexes available in the public domain. Figure 3.2.1 depicts the percentage of indexes currently used in DMO contracts based on their country of origin. Figure 3.2.1 and all other empirical analysis in this research on current DMO index usage is based on data sourced from the DMO Survey of Indexes 2010[2].

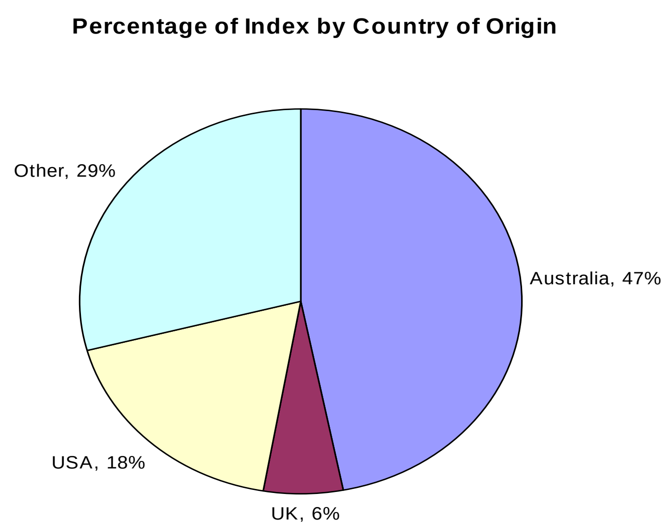


Figure 3.2.1. Snapshot: Index – Country of Origin
Source: DMO Survey of Indexes (2010)

The category of ‘Other’ in Figure 3.2.1 consists of 10 countries–eight from Europe with the remaining two being New Zealand and Canada. Each of these ten countries represents a very small individual percentage. As such, the current research will only focus on the indexes from Australia, the US, and the UK. Indexes analysed in this

[2] The DMO Survey of Indexes 2010 collated a list of 'significant' indexes that is used in contracts with more than 12 months remaining on the contract. Significant Indexes were defined by each Division in DMO, which may be AUD5 million in future expenditure, yet in some cases, this may be more than AUD1 million in future expenditure.

research, for the reason stated above, have been taken from the relevant statistical agencies from each of these countries–they are ABS, BLS and ONS.

The analysis for this research was mostly conducted on historical data of indexes from 1990 to 2009 (sometimes up to 2010 for forecasting purposes). For certain indexes which were not published until after 1990, the data set for that particular index starts from the moment the data became available. In the example of the indexes from UK ONS, most data relevant to the current research was first published in 1996.

Furthermore from the ABS, weighting patterns of their indexes have been used in the current analysis (2010a and 2010b). The movement of macroeconomic indicators for Australia, the US and the UK were sourced from the ABS (2010c).

The productivity rate of 0.3% for material/capital components was sourced from the ABS Multifactor Productivity series[3] (2010d), and is the average rate for the manufacturing division for the past two decades. While the labour productivity rate[4] of 1% and 2% were also sourced from the ABS (2010d). The former is the average for the manufacturing division between financial years 2004/2005 to 2009/2010 while the latter is the average between 1990 and 2009.

The ABS Input-Output Tables (2010e) have been used to infer cost components and weights for construction of an illustrative calculation of the composite inflation for commercial vehicles. This was conducted to enable comparisons with the composite inflation calculated for combat vehicles which uses weights sourced from DMO contract information.

Other relevant information has been obtained from a range of sources. Information on market structure, which provided the revenue of the company and industry, was sourced from IBISWorld. Data on the Australian production and consumption of iron and steel from 1990 to 2009 was sourced from Australian Bureau of Agricultural and Resources Economics and Sciences (2010). Data on interest rates for Australia, the US and the UK and the currency movement of Australian dollar against US dollar and Great British Pound has been sourced from Reserve Bank of Australia.

---

[3] It is important to note that this multifactor productivity publication is still classified as 'experimental estimate' by the ABS.
[4] This labour productivity publication is still classified as 'experimental estimate' by the ABS.

References in this research to the DMO projected (or forecast) inflation and productivity estimation were sourced from the DMO Contractor Survey 2005[5]. The overall projected annual average from this survey was 4.5% for acquisition and 4.8% for sustainment. These two inflation figures are already inclusive of a 1% deduction for productivity gain and apportionment between the industry and DMO[6].

For simplicity, the remaining analysis in the current research uses the 4.5% acquisition inflation figure only and will be referred to as the 'DMO Contractors Survey Forecast'. There are several caveats that should be noted prior to using this forecast. Firstly, it is important to note that the economy was expanding at the time of survey (i.e. 2005) and there were minimal signs of recession at that particular point in time. The Global Financial Crisis (GFC) started in mid-2007. Secondly, it is difficult to ascertain whether the forecast of 4.5% inflation from the DMO Contractor Survey was considered by respondents at the time to be an optimistic or pessimistic forecast. This is simply due to the fact that the estimate was obtained from a survey and not from any empirical analysis of the respondents' financial documents. Thirdly and most importantly, the scope of the current analysis is not to determine if the 4.5% inflation forecast was reasonable. For the purpose of this thesis the 4.5% from the DMO Contractor Survey Forecast is only used as a starting comparison.

Table 3.2.1 shows the average annual inflation for three widely used macroeconomic indicators from financial years 2004/05 to 2009/10, inclusive. Table 3.2.1 also details the average annual inflation for 2004 to 2007 (three-year period) that is until the GFC occurred, as well as 2004 to 2010 (six-year period).

[5] In 2005, 10 of the top DMO contractors were asked to forecast the inflation pressure for the next 10 years to financial year 2014/2015.

[6] The 1% figure is considered more realistic despite the fact that contractors from this survey estimated that they could achieve a 2% productivity improvement per annum.

Table 3.2.1. Movement of macroeconomic variables

	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	Average 2004 to 2007	Average 2004 to 2010
ABS CPI	2.44%	3.20%	2.92%	3.39%	3.14%	2.33%	2.85%	2.90%
ABS GDP deflator	3.81%	4.88%	5.14%	4.66%	4.49%	0.06%	4.61%	3.84%
ABS PPI Manufacturing Division	6.80%	7.18%	4.77%	4.92%	2.30%	-3.02%	6.25%	3.83%

The general inflationary indicators such as the GDP deflator and the Manufacturing Division PPI, before the GFC, were higher on average than the DMO Contractors Survey Forecast of 4.5%. However, the CPI throughout the six financial years was well below 4.5%.

It is important to note that unless otherwise specifically acknowledged, all charts and tables in the remainder of the thesis are constructed or calculated by the author, drawing on the data sources described above. Table 3.2.2. lists additional time-series price indexes data sources.

Table 3.2.2. Additional Official Statistical references used in the research

ABS	BLS	ONS
Cat. no. 6401 CPI	PPI Industries	PPI MM22
Cat. no. 6345 LPI	ECI	Services PPI
Cat. no. 6427 PPI		Index of Labour Costs per Hour

3.3 Approach and methods

In order to propose and develop a framework to calculate the ‘true’ defence-contract-relevant measure of inflation for price variation purposes in defence contracting, three coherent stages are required. The current research refers to this as the ‘Three-Stage’ modelling strategy. These stages are, (i) selecting the appropriate index or indexes, (ii) correcting the bias in the index, and (iii) forecasting the index to provide an inflationary outlook.

Throughout the research a comparative analysis on the two price variation approaches, Single Index and Multiple Indexes, will be presented. The Single Index approach can also be called the 'Finished Goods' approach. This approach uses a single price index computed from the movement of the final product sale price.

On the other hand, the Multiple Indexes approach, which can also be called the 'Cost Components' approach, uses a collection of indexes which reflect the movement of material and labour costs to the contractor in producing the final product. By assigning weights to each individual material and labour cost index based on their relative importance to the specific contract, the formula will calculate a composite index of contract relevant inflation. Figure 3.3.1 provides an example of the two approaches in the case of the procurement of motor vehicles.

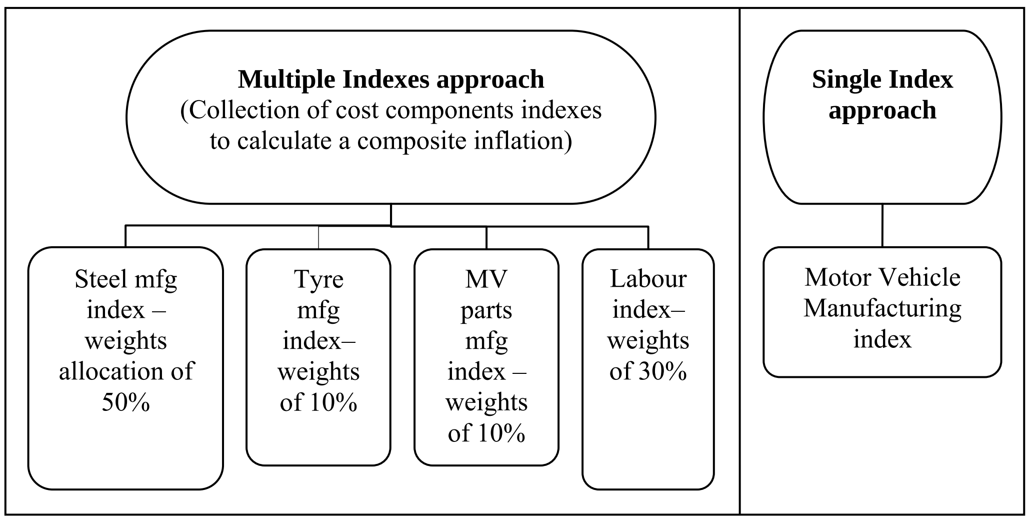


Figure 3.3.1. Price variations approaches – Vehicles perspective

The analysis in Chapter Four will use the example of combat vehicle procurement where possible for the purposes of illustration. Therefore, under the Single Index or Finished Goods approach, the index of ABS Output PPI 2311 Motor Vehicle Manufacturing will be used as an example (the problem of using such an index for the procurement of combat vehicles is discussed in Chapter Five). However, examples which reference the defence industry, such as shipbuilding, aircraft manufacturing, and so forth, are examined where applicable.

For the Multiple Indexes or Cost Components approach, indexes of ABS Output PPI 2110 Iron Ore and Steel Manufacturing and/or ABS Output PPI 1914 Tyre Manufacturing will be referenced where necessary.

As previously mentioned, the current research uses a 'Three-Stage Modelling Strategy'. Stage one in the Three-Stage model is the selection of an 'appropriate' index (or indexes). One of the primary purposes of this research is to survey and refine, based on various established principles, a group of appropriate and suitable indexes for use in contract price variation clauses for the procurement of specialised military equipment. Expanding from existing defence literature (see Schiefebien, 1977, LMI, 1968) and from experience in contracting, nine selection criteria or principles were identified by the current research as important for the determination of appropriate indexes. These can be summarised as: (i) independent and reputable source; (ii) theoretical soundness; (iii) relevant degree of disaggregation; (iv) statistical validity; (v) negligible influence by the contractor; (vi) pertinence to the contract procurement, (vii) not seasonally adjusted; (viii) output indexes, and (ix) not too volatile. The aim of this part of the analysis is to examine why certain indexes are good inflationary indicators for defence procurement purposes while others are not.

In surveying and refining the number of 'appropriate' indexes at the disposal of DMO, for use in contract price variation clauses, an analysis of each selection principle to the unique defence monopsony-oligopoly contracting situation and/or its application will be provided in Chapter Four. Classic economics theories like profit maximisation, Keynesian theories of output prices, economies of scale and scope, to name just a few, will be used to support the rationale and validity of the selection principle and/or be used to analyse the selection principle if applied to a unique situation like the defence monopsony-oligopoly.

In addition, during the examination of selection principles where applicable, empirical analysis adapting from the DMO Survey of Indexes 2010 relevant to the specific criterion will be presented. A variety of empirical analysis using a range of information like market structure, Australian steel production and consumption, and the manufacturing division's productivity rates, will also be used. At the completion of this first stage a refined list of the 'appropriate' indexes under the two price variation approaches will be presented.

While the first stage makes extensive use of the axiomatic approach to effectively measure 'observed' price, the dilemma of unique product and specialised materiel in the case of the defence industry makes it difficult to confine the analysis of the inflation of relevance/interest to just a measure of observed price change. It is also necessary to consider how to measure 'efficient' price change. Therefore the second stage in this proposed framework is to consider whether a 'true' defence-contract-relevant inflation can be developed by correcting the biases in the 'appropriate' index. To begin, the current research will investigate how some of the well-documented measurement biases affect the accuracy of published indexes of potential relevance to defence contracting. These measurement biases are mainly caused during the formation of the index (e.g. Laspeyres index formula) and can be especially relevant when there is a difference between the principles applied in construction and the purpose for which the published index is used. The current research will extend the examination of the theoretical inherent measurement biases associated with index numbers in economic literature by using a 'unique' industry and/or procurement perspective. The current research will theoretically examine key inherent measurement biases: coverage bias, substitution bias, quality improvement bias, and new goods bias.

Areas where defence is known to differ from the commercial sector are of special interest to this part of the investigation. These areas are lack of competition, lack of productivity, and existence of long-term contracts. Therefore, the analysis will also examine how the inherent understatement or overstatement by each of the measurement (or specific defence) biases has an impact in computing the 'true' defence-contract-relevant inflation.

All biases (both measurement and defence-specific) have varying degrees of impact depending on which of two possible approaches (i.e. the Single Index or Multiple Indexes approach) is used to determine an appropriate measure for contract price variation as a consequence of inflation. One of the problems with defence procurement is that it is different to mass commercial production. For example, the specification of a combat vehicle differs to a commercial/household use vehicle. However, under the Single Index (Finished Goods) approach it is very likely that an index, such as the Motor Vehicle Manufacturing index, would be selected despite its limitations for defence contracting purposes. This is due to the fact that this index may be the most closely matched index available for such procurement as an index which measure price movement specifically for ‘combat vehicles’ is often not available. This dilemma, and the method to correct it, is discussed in Chapter Five. The current research will contribute by innovatively providing ways to correct the identified biases which cause either over or understatement of inflation, and enable the calculation of the ‘true’ defence-contract-relevant inflation.

Considering the importance of accurate forecasting, the research will investigate and attempt to forecast indexes despite the many uncertainties that may underlie these estimates. This is the third stage of the Three-Stage modelling strategy, which is to forecast the ‘appropriate’ index. While a full econometric model of inflation could provide an informative research knowledge base for the third stage, this is a major undertaking well beyond the scope of the current research. To investigate provision of a relevant degree of information appropriate to the scope of this research, Chapter Six will investigate two widely known forecasting techniques: regression modelling (multivariate), and the Holt-Winters multiplicative forecasting procedure (univariate).

The current research applies the multiple regression model with the following form:

$$Y = \beta_0 + \beta_1 x_1 + ... + \beta_k x_k + \varepsilon \tag{1}$$

Where Y is the explanatory variable;
β_0 is the intercept;
β_j is the slope coefficient for the j_{th} explanatory variable; j=1,…,k
x_j is the slope coefficient for the j_{th} explanatory variable; and
ε is the remaining unexplained noise in the data (the error).

In order to identify independent variables for multiple regression modelling, a correlation analysis needs to be conducted as well. The Pearson correlation coefficient between any two variables, say *X* and *Y*, can be depicted as follows:

$$r_{(X,Y)} = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sqrt{\left(\sum X^2 - \frac{\left(\sum X\right)^2}{N}\right)\left(\sum Y^2 - \frac{\left(\sum Y\right)^2}{N}\right)}} \tag{2}$$

Multiple regression in this research was conducted using EViews while correlation analysis was conducted using MegaStat.

To investigate the avenue of forecasting further, a univariate forecasting method, namely the Holt-Winters multiplicative forecasting procedure, was also analysed. Each price index is a time series, i.e. a collection of data at regular intervals over a period of time. A time series is made up of four components: T–trend (long-term direction, underlying level); S–seasonal (systematic, calendar related movement), C–cyclical (unsystematic, business fluctuation in the economy), and I–irregular (unsystematic, erratic and short-term fluctuation) (ABS 2005). This can be represented, using the simple additive form for illustration, as follows:

$$Y = T + S + C + I \qquad \text{where } Y \text{ is the value of the time series} \tag{3}$$

For the current research the univariate forecasting was conducted using MINITAB via the Holt-Winters multiplicative forecasting technique. Drawing upon the relevant elements from equations (1) and (3), i.e. abstracting from the business cycle, treating the deterministic component (trend and seasonal) as multiplicative, and including an additive error (irregular) component, the Holt-Winters multiplicative model can be described as follows:

$$Y = (\beta_0 + \beta_1 t) \times S + \varepsilon \tag{4}$$

Historical data from 1990 to 2010 was used for parameter estimation where applicable. However, to remove the obvious and once-off effect of the GFC, forecasting for some indexes was instead conducted using parameter estimates derived from the data set from 1990 to Sep 2008. Where historical data for certain indexes only became available after

1990, the parameter estimate was derived from the first instance of data availability. The software package, MINITAB, also produced the 95% confidence interval for the forecast index. Discussions of the merits of these three statistical techniques are available in Bowerman, O'Connell and Murphree (2011).

An additional step presented in this research is the illustrative example of the procurement of combat vehicles, intended to illustrate the initiatives recommended by this research. Sensitivity analysis on the various productivity rates between combat and commercial vehicles will be conducted in Chapter Seven in order to determine if there is any difference in the historical inflation between the two vehicles types under the Australian environment. Furthermore, all computation of inflation in this research will be performed based on yearly (i.e. annual) average and geometric means rather than arithmetic measure (unless otherwise stated).

Based on the survey from the existing literature, and findings of the current research, Chapter Eight will describe some of the limitations in the current research and present suggestions on areas for future research. It will also critique the current indexation methods and present alternatives to price variation methods for long-term contracts.

Chapter Four

Application of Selection Principles to the Refinement of Indexes

The first stage of calculating ‘true’ defence-contract-relevant inflation involves selecting an appropriate index (or indexes) which represent the inflation to the procurement. However, a problem that immediately arises is that there are an extremely large number of choices. This chapter aims to address this problem in a structured manner. In doing so the analysis aims to investigate the difference between the use of the Single Index (Finished Goods) approach and the Multiple Indexes (Cost Components) approach in providing a reflection of defence procurement needs. Additionally, in order to enable officers in DMO and its contractor to select indexes with reduced complication, one of the purposes of this thesis is to survey, based on various established principles, a refined group of appropriate and suitable indexes for use in contract price variation clauses for the procurement of specialised military equipment. At the conclusion of this chapter, a refined set of ‘appropriate’ indexes, as tested by the current research, from Australia, the US and the UK, is presented.

4.1 Indexes currently used in DMO contracts

It is necessary to firstly recognise the range of index series that are currently employed by DMO in its price variation clauses for procurement contracts. Figures 4.1.1 to 4.1.3 depict the most commonly used indexes (by series) for current defence contracting sourced from Australia, the US, and the UK. As noted in Chapter 3, unless otherwise specifically acknowledged, all charts and tables in Chapters 4 to 7 are constructed or calculated by the author, drawing on the data sources described in Section 3.2 Data description.

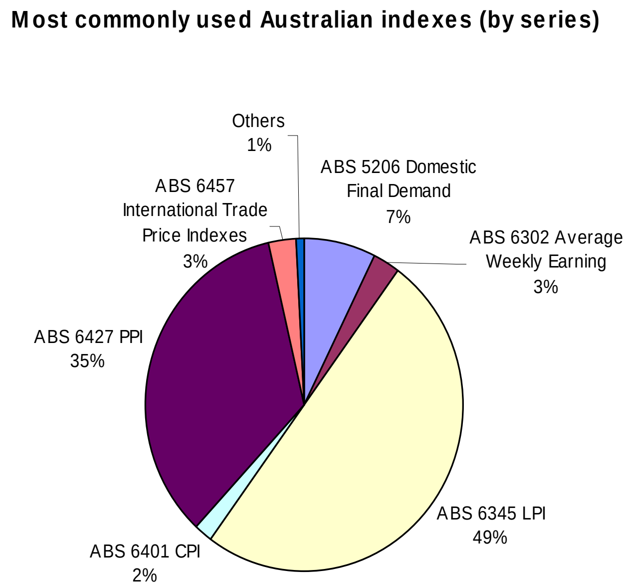


Figure 4.1.1. Snapshot: Most commonly used Australian indexes in current DMO contracts

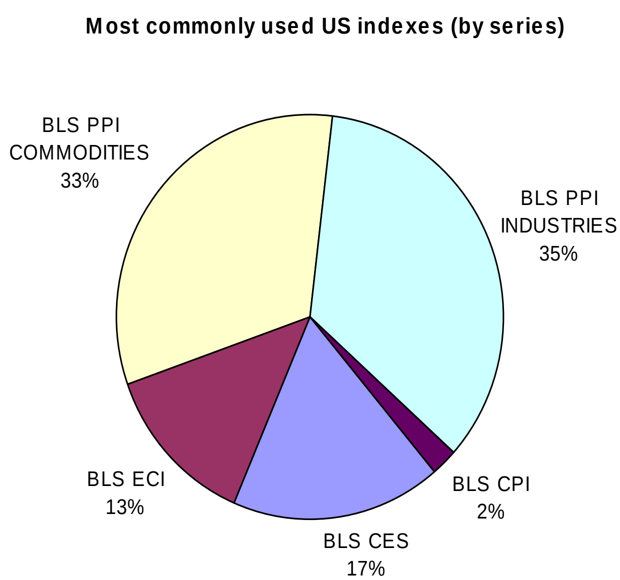


Figure 4.1.2. Snapshot: Most commonly used US indexes in current DMO contracts

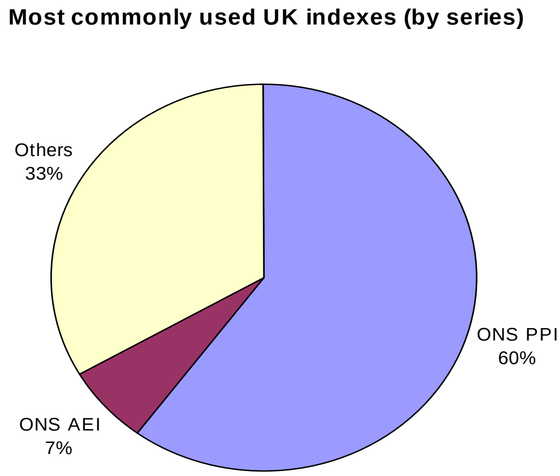


Figure 4.1.3. Most commonly used UK indexes in current DMO contracts

Figure 4.1.1 to 4.1.3 illustrates that there are various types of indexes being used in current DMO contracts. Since the composition of each index series (i.e. PPI, CPI, and LPI) is different, each index will potentially give a different inflationary indication. Some contracts even use 'Other' types of inflation indicators such as those from industry surveys or spot pricing of a commodity.

4.2 A set of principles to reduce the selection task

An 'appropriate' index for contract price variation should closely match the procured product and services cost structure or final sale price. This part of the analysis will survey, from the large number of indexes available, a more representative set of indexes. Based on an examination of the literature, the following principles have been identified to aid in the task of reducing the number of 'appropriate' indexes for defence price variation purposes: (i) independent and reputable source; (ii) theoretical soundness; (iii) relevant degree of disaggregation; (iv) statistical validity; (v) negligible influence by the contractor; (vi) pertinent to the contract procurement; (vii) not seasonally adjusted; (viii) output indexes: and (ix) not too volatile.

The following section analyses each selection principle by first providing the theoretical rationale for choosing or rejecting an index, and then determining its applicability to the ‘unique’ defence monopsony-oligopoly contracting situation. The primarily intent is for an ‘appropriate’ index to satisfy all nine selection principles; however, this may not be possible due to practicality and availability of indexes that match DMO’s needs. Therefore, the analysis also presents remedies should such conflict arise.

4.3 Application of the selection principles

4.3.1 Independent and reputable source

Rationale for considering this criterion

One of the index selection principles is that an appropriate index is to be compiled in a rigorous and independent manner. The use of ‘Official Statistics’ is required by both contracting parties in order to obtain a fair and accurate account of the relevant inflation. For Australia, the US, and the UK, official statistics are published by the ABS, the BLS, and the ONS, respectively. Government official statistical agencies such as these follow strict standards in their methodology and calculation of price indexes.

On the other hand, the use of indexes generated from industry surveys could be viewed as being not suitable. This is due to reasoning which suggests that the construction methods and data sources in such surveys have not been validated or examined. As such, the integrity, objectivity, impartiality, and quality of the industry or contractor’s statistics is not completely assured (DESA, 2009).

Research outcomes for DMO and defence contractor: ‘Independent and reputable source’ criterion

The analysis found that the majority of current indexes used in DMO contracting are from governmental agencies and Figure 4.3.1.1 depicts these results.

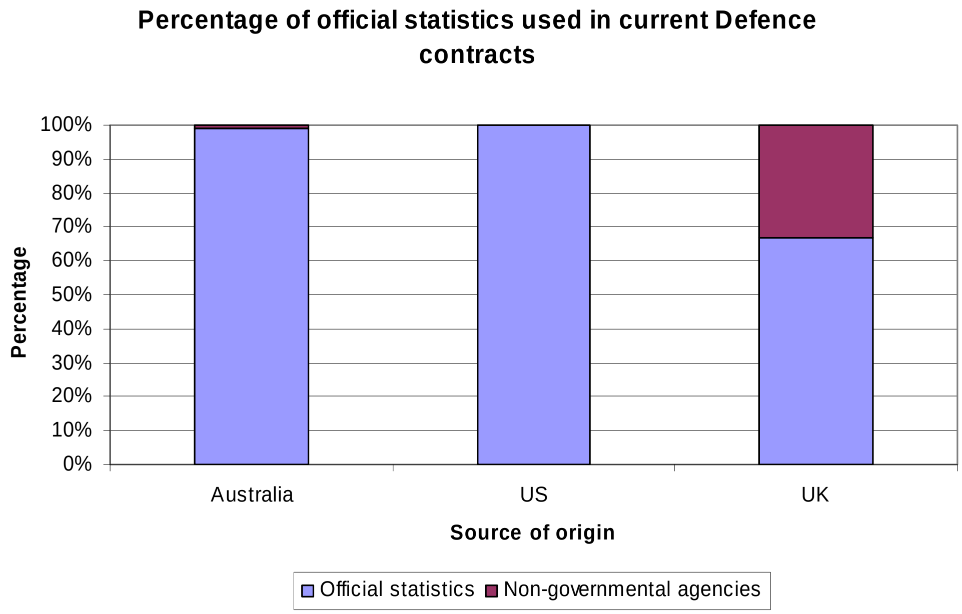


Figure 4.3.1.1. Snapshot: Usage of Official Statistics in current DMO contracts

Current analysis found that the majority of indexes from Australia were sourced from the ABS, except for a small number which were sourced from industry surveys. All US indexes were sourced from the BLS.

Furthermore, analysis found that in addition to indexes from the ONS, current DMO contracts which have a UK origin have used industry indexes such as those from the British Electrotechnical and Allied Manufacturers' Associations (BEAMA). Since these industry indexes are not derived by governmental agencies, the index methodology and data have not been able to be validated. Therefore, further use of these industry indexes is not recommended.

The current research also found that there were situations where raw or spot price movements of certain commodities, from institutions such as the London Metal Exchange[7], were used as the inflationary indicator. However, the use of actual price data for such specific commodities traded (for hedging purposes) is typically not comparable to the use of price indexes as inflationary indicators of the costs of production. Therefore, further use of such actual or spot pricing data is not recommended. The

[7] The London Metal Exchange provides a market where producers can buy a range of futures and options contracts on non-ferrous metals, minor metals, steel, and so forth

inappropriateness of raw or spot pricing data is discussed in depth in the next principle – ‘theoretical soundness’.

4.3.2 Theoretical soundness

Rationale for considering this criterion

Another index selection principle is that an index should be theoretically sound. A price index is theoretically sound when it is measuring relevant and appropriate price changes. This could be the average price changes for goods, services and labour. An index is viewed as theoretically sound when it has been computed from academically proven index methods. Laspeyres, Paasche, and Fisher are three widely acknowledged and academically accepted price index formulas. The ABS, BLS, and ONS mostly use the Laspeyres formula to produce their indexes.

Under this selection criterion or principle, the use of commodity or contractor pricing information as an indication of inflation pressure is not appropriate. One reason for this is that the actual pricing data are not from ‘governmental statistical agencies’ which means they necessarily conflict with the previous index selection principle of ‘independent source’. Additionally, situation-specific pricing information does not equate to an appropriate price index. Computation of a price index requires the collection of pricing and quantity information of a larger ‘basket’ of goods or activities. Once individual price information is compiled, this is aggregated using an appropriate index calculation method like the Laspeyres formula. Often due to various factors like consumer or producer substitution, technical advances, and many more, additional acceptable academic techniques are applied to the calculation in order to obtain an even more accurate and/or realistic index value. The price change calculated by a company’s internal pricing data, or even external commodity pricing data, is not strictly comparable in terms of its theoretical basis to the price change referenced by a price index produced by a government statistical agency. Therefore, use of actual or spot pricing data does not satisfy the criterion of ‘theoretical soundness’.

A price index may contain inherent measurement error, even though it is theoretically based. The reason for this is that inherent measurement biases arise when a user’s purpose for the index differs (even slightly) from the purpose intended by the government agency. The analysis of measurement biases associated with indexes is presented in Chapter Five.

Research outcomes for defence: 'Theoretical soundness' criterion

By removing indexes that are not official statistics (as discussed in the preceding selection principle), Figure 4.3.2.1 depicts the percentage of remaining indexes that are used in current DMO contracts. These are theoretically sound in that they can, in principle, be characterised as measuring relevant and appropriate price changes.

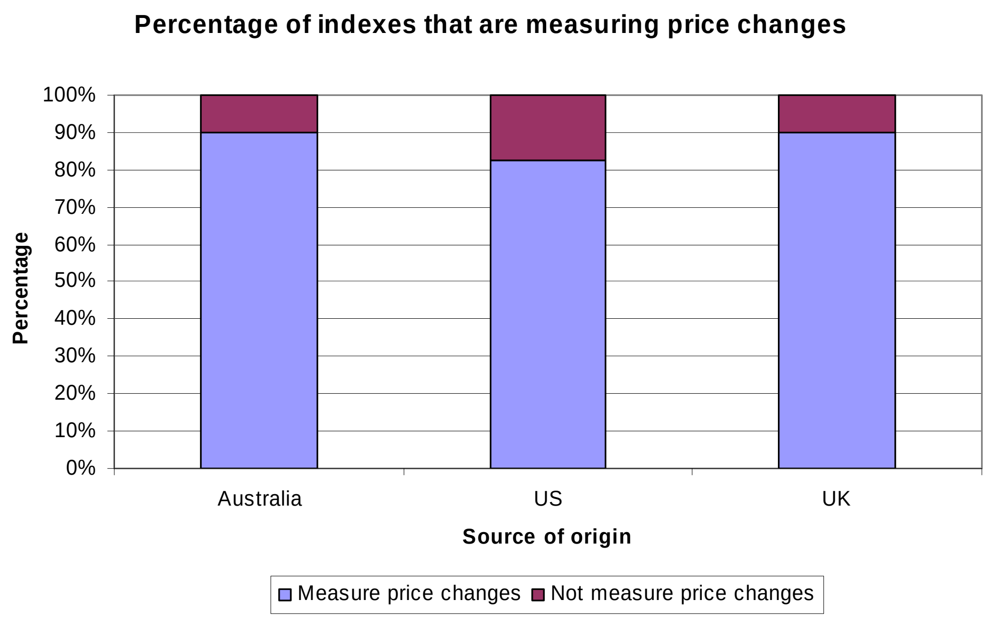


Figure 4.3.2.1. Snapshot: Indication of indexes measuring price change in current DMO contracts

Figure 4.3.2.1 shows that there are a small percentage of indexes used in current DMO contracts that the current research deems to have not satisfied the principle of 'theoretical soundness'. Each of these indexes is presented and discussed in the forthcoming analysis.

For Australian indexes, the current analysis found two index series from the ABS which are used in existing DMO contracts but which, upon closer inspection, do not measure relevant and appropriate price changes and therefore cannot be considered to be theoretically sound. The two series are ABS 5206 Australian National Accounts:

National Income, Expenditure and Product - Domestic Final Demand (DFD) and ABS 6302 Average Weekly Earnings (AWE).

The index series of DFD has often been used as an indicator of the inflation of defence procurement contracts. DFD is a single estimate of the level of spending by private and public sectors, within the domestic economy. Spending is reported on the basis of the consumption of goods and services, and capital investment (ABS, 2000). Therefore DFD is a measure of the level of spending and not a measure of change in prices paid for goods or services. Spending is not equivalent to price, nor is it the same as price change. Since the data collected or used to calculate DFD are not actually prices, DFD is not considered to have satisfied the criterion of 'theoretically soundness' for the purpose of this research. It is therefore recommended that DFD be precluded from any further considerations.

In Australia, based simply on this criterion, theoretically sound indexes for material cost inflation escalation are the ABS Producer Price Index and also the ABS Consumer Price Index. However, the ABS CPI could be considered inappropriate for other reasons. This is discussed in the section devoted to another principle - 'pertinent to contract procurement'.

The ABS AWE is a measure of the level of average earnings at a point in time (ABS, 2007) and is published in monetary value form. Even if reconstructed in change form it would not represent pure price of labour changes because it is also influenced by the number of hours worked. For that reason, AWE does not measure price changes and so is not a price index. Therefore it fails the criterion of being theoretically sound and should also be precluded from further consideration. The theoretically sound index for labour cost or price inflation is the ABS Labour Price Index which is a series that measures labour price changes.

As an international comparison, for US indexes, the analysis found one BLS index series which the DMO currently uses but which, upon closer inspection, does not measure prices change. The series in question is the Current Employment Statistics (CES) Earnings series. As this series measures earnings instead of labour/wage costs, it falls short of being theoretically sound and should be precluded from further consideration. The theoretically sound index for labour cost inflation is the BLS

Employment Cost Index (ECI) whereas the PPI and CPI are also theoretically sound indexes (again the inappropriateness of CPI due to other reasons is discussed later).

From the UK, indexes from the publication of PPI and CPI from the ONS are considered to be theoretically sound indexes. However, for price variation relating to labour or wage, an index series that is theoretically sound was difficult to find. It was observed that the series Average Earnings Index series which had been used in DMO contracts, mostly for price variation in labour cost, had been withdrawn in September 2010 and replaced by a series called, Average Weekly Earnings (AWE). However, again the AWE series would not purely represent the price of labour changes because it is also influenced by hours worked. As such, the ONS series of AWE is considered to have failed the requirement of theoretical soundness for the purposes required. A theoretically sound series that would meet this criterion would be the Index of Labour Costs per Hour. This index series measures the 'average hourly labour costs' (Hopwood, 2005). However, while this index appears to be promising yet it is still classified as an experimental[8] index by ONS. Therefore, the index in its current 'experimental' status is considered to be not 'ideal' for contract price variation purposes though it may be the best available at this point in time. Two indexes from the PPI series are discussed, as an alternative and to counteract this problem, in the forthcoming criterion 'Output Indexes'.

4.3.3 Relevant degree of disaggregation

Rationale for considering this criterion

A price index is deemed to be representative of a certain industry sector when it is based on products and activities that are 'typical' for that industry. Statistical agencies compute an index by first grouping classes of products or activities together with others containing similar characteristics. An activity is a particular method of combining goods and services inputs, as well as labour and capital to produce one or more goods and/or services (ABS, 2006b). Pricing data are gathered from samples that produce products or services that fall into such classes. As these products and activities are similar or homogeneous, they are regarded as representative for the respective markets.

[8] Latest experimental data was published for the first quarter of 2011.

‘Similarity’ or ‘homogeneity’ is seen in terms of products or activities which share similar characteristics.

As mentioned in Chapter Two, statistical agencies like the ABS, BLS, and ONS organise the collection and reporting of indexes according to an industrial classification system. The classification structure and the degree of disaggregation or dissection are therefore important in selecting the most appropriate index for contract price variation purposes. This is due to the fact that indexes at various levels of dissection will represent movement for different collections of activities, which may not be entirely relevant to the particular contract of interest. For an index to be reflective of inflation movements which are specific to that contract, it is essential to select an index which has the appropriate and relevant degree of disaggregation (in product and activity types) to match the procurement.

Generally, the more detailed the classification of product or activity, the more likely its collection of price changes will be concentrated in a small number of firms. This is why lower level indexes which offer progressively greater refinement in classifying industries are usually viewed as microeconomic indicators. The extent of homogeneity in the product and activity types increases as the classification and disaggregation is refined. However, higher level indexes are often used as macroeconomic indicators of inflation, as aggregations of specific industrial sectors’ indexes results in an overall (aggregated) index. This is more reflective of the broader economy than of inflation at the industrial-sector level.

Research outcomes for defence: ‘Relevant degree of disaggregation’ criterion

Generally the purpose of the price variation clause in defence contracting is to cater for legitimate inflation associated with the production, or performance, of a product or service. As such, the appropriate index (or indexes) needs to be specific to the industry sector associated with the activities required to perform the contract. The relevant degree of disaggregation in the classification is vital in selecting an index that will closely match the contract’s inflation pressure. The analysis will use two items of interest–the inflation of steel and vehicles manufacturing industry, and their corresponding ABS indexes–to exemplify the basis of this criterion.

Steel manufacturing industry

For the inflationary indicator of steel manufacturing industry in Australia, there are choices between the various levels of aggregation. Based on the 'relevant degree of disaggregation' criterion, the best matching level would be at the fourth dissection (i.e. class level) for steel. For ABS indexes this would be the index of 2110 Iron Smelting and Steel Manufacturing. At the second level of dissection, the corresponding subdivision would be the subdivision 21 Primary Metal and Metal Product Manufacturing.

Table 4.3.3.1 illustrates the difference between the composition of a second and fourth dissection index. The column on the left presents the activities that are included in the index at the fourth dissection (i.e. 2110 Iron Smelting and Steel Manufacturing), whereas the column on the right shows the composition of the second dissection index (i.e. 21 Primary Metal and Metal Product Manufacturing).

Table 4.3.3.1 – Comparison of second and fourth dissection levels (under ANZSIC 2006) – Steel products example

Primary activities associated with the ABS PPI 2110 Iron Smelting and Steel Manufacturing	**Weighting pattern of Subdivision - 21 Primary metal and metal product manufacturing**		**% Weights**	
Band, steel, manufacturing				
Bar, iron or steel, manufacturing	211	Basic ferrous metal manufacturing	22.20	
Blank, steel, manufacturing	2110	Iron smelting and steel manufacturing		22.20
Direct reduction iron (DRI) manufacturing	212	Basic ferrous metal product manufacturing	5.79	
Ferro-alloy manufacturing (including, manganese, silicon or chrome)	2121	Iron and steel casting		2.18
Flat-rolled product, iron or steel, manufacturing	2122	Steel pipe and tube manufacturing		3.61
High carbon tool steel manufacturing	213	Basic non-ferrous metal manufacturing	64.00	
High speed steel manufacturing	2131	Alumina production		13.51
Pig iron manufacturing	2132	Aluminium smelting		13.78
Powder, iron or steel, manufacturing				

Rail fastening or other rail accessory manufacturing	2133	Copper, silver, lead and zinc smelting and refining		8.33
Rail, steel, manufacturing	2139	Other basic non-ferrous metal manufacturing		28.38
Roof decking, steel, manufacturing				
Section, steel, manufacturing				
Semi-finished product, iron or steel, manufacturing	214	Basic non-ferrous metal product manufacturing	8.01	
Skelp, steel, manufacturing	2141	Non-ferrous metal casting		0.30
Spring steel manufacturing	2142	Aluminium rolling, drawing, extruding		3.66
Stainless steel manufacturing	2149	Other basic non-ferrous metal product manufacturing		4.05
Steel alloy manufacturing				
Structural steel shape manufacturing (not fabricated)				
Tinplate sheet or strip manufacturing				

Source: ABS (2006a, 2010a)

The lowest level of indexes published by ABS is at the fourth dissection level. Table 4.3.3.1 shows that the primary activities included in 2110 Iron Smelting and Steel Manufacturing are not so specialised that its use would restrict or narrow the inflation pressure to only a very small industrial sector. Furthermore, the weighting pattern of index 21 Primary Metal and Metal Product Manufacturing shows that this subdivision index includes other indexes, especially those of non-ferrous metals such as Aluminium and Copper. These lower-level indexes account for 0.72 (i.e. 72%) in weight toward the composition of the subdivision index. In comparison, the index of 2110 Iron Smelting and Steel Manufacturing has a relative weight toward the subdivision index of only 0.22 (i.e. 22%). This strongly indicates that when the product of interest is steel, then the subdivision index movements are diluted by other movements from activities that are less homogenous to those relevant to the steel industry.

Based on the above reasoning, the index of 2110 Iron Smelting and Steel Manufacturing would include more appropriate and relevant activities (homogeneous to the steel industry) than those of the subdivision index of 21 Primary Metal and Metal Product Manufacturing. As such, the subdivision index - 21 Primary Metal and Metal Product Manufacturing, is not considered appropriate for use under this circumstance.

Noting that the activities included in the indexes at different dissections is dissimilar, it would be of use to investigate whether there is any significant difference in the inflation impact between the indexes at these two dissections. The following table shows the average annual inflation for steel at the subdivision and class level.

Table 4.3.3.2. Comparison of average annual inflation at the second and fourth dissection level – steel product example

Time Period	2110 Iron Smelting and Steel Manufacturing* (per annum)	21 Primary Metal and Metal Product Manufacturing (per annum)
2000-2009	6.70%	5.13%
2003-2009	8.97%	6.01%
2005-2009	8.18%	5.95%
2007-2009	6.44%	-5.00%

* 211 and 2110 are the same index because there is only one lower level within 211 Basic Ferrous Metal Manufacturing.

The result in Table 4.3.3.2 provides evidence that there is a large difference in inflation between the two indexes. This result indicates that the iron and steel manufacturing industry at the micro level was experiencing a higher than average inflationary pressure. The contribution from other indexes towards the subdivision index, in this example, produced price movements at the macro level which were lower than the microeconomic index. As a result, the use of a higher level (i.e. first or second dissection) index (or indexes) for contract price variation purposes can potentially ignore price movement which is relevant to a particular procurement.

Based on these findings the current research proposes that indexes at the fourth dissection from the ABS should be preferred to those at the second dissection level. As demonstrated in Table 4.3.3.2, the fourth dissection index is reflective of a reasonable range of activities that would be more homogeneous to the activities required for a DMO contract than the second dissection index. Indexes at the fourth dissection level were not so overtly detailed that they would restrict or narrow the inflation pressure to only a very small industrial sector. Therefore, for ABS indexes, those indexes at the fourth dissection (class level) are preferred instead of indexes at the second dissection level (division level). This is due to the fact that fourth dissection indexes achieve a maximum, yet still relevant, degree of disaggregation.

Vehicles manufacturing industry

The analysis now turns to the examination of indexes from the Australian vehicles industry. The forthcoming analysis aims to illustrate the difference between the composition and consequent inflation impact of an index at the third and fourth dissection. Table 4.3.3.3 shows the activities that are classified under the fourth dissection index of 2311 Motor Vehicle Manufacturing. Table 4.3.3.3 also shows the indexes with the relative weights that contribute to the third dissection (group level) index of 231 Motor Vehicle and Motor Vehicle Part Manufacturing.

Table 4.3.3.3. Comparison of third and fourth dissection levels (under ANZSIC 2006) – Vehicles example

Primary activities associated with the 2311 Motor Vehicle Manufacturing	**Weighting pattern of 231 Motor Vehicle and Motor Vehicle Part Manufacturing**	**Weights**
Bus manufacturing	2311 Motor vehicle manufacturing	57.67
Hydrogen, fuelcell, hybrid or electric vehicle manufacturing	2312 Motor vehicle body and trailer manufacturing	10.26
Motor car manufacturing	2313Automotive electrical component manufacturing	5.79
Motor vehicle assembling	2319 Other motor vehicle parts manufacturing	26.28
Motor vehicle engine manufacturing		
Truck manufacturing (except off-highway)		
Van manufacturing		

Source: ABS (2006a, 2010a)

As seen in the analysis between indexes at the second and fourth dissections, the aim of analysing third and fourth dissections is to select an index with the most similar activity types, which would also be more reflective and provide a more accurate indication of inflation for the procurement of interest.

Table 4.3.3.3 reveals that the weighting pattern for 231 Motor Vehicle and Motor Vehicle Part Manufacturing also captures price movements from industries such as trailers and automotive electrical component manufacturing, among others. If the procurement of interest is motor vehicles then since the index at the third dissection includes activities such as trailer manufacturing, it may not be reflective of activities for vehicles manufacturing. Inclusion of movement from other indexes reduces the relevant degree of disaggregation to the procurement of interest (i.e. vehicles). It is recommended that when considering the procurement of vehicles, use of an index at the fourth dissection would be more reflective than an index at the third dissection level.

Most importantly, the 'relevant degree of disaggregation' criterion is to take precedence over the magnitude of price change explicit in the index. There is no reason, in principle, to choose an index purely because its inflation estimate is the highest, lowest, or even average among the various indexes. Table 4.3.3.4 shows the average annual inflation for the past decade for the various levels of aggregation related to the motor vehicles manufacturing industry.

Table 4.3.3.4. Comparison of average annual inflation at the second, third and fourth dissection levels – vehicles example

Time Period	2311 Motor Vehicle Manufacturing	231 Motor Vehicle and Motor Vehicle Part Manufacturing	23 Transport Equipment Manufacturing
2000-2009	0.54%	0.72%	0.99%
2003-2009	-0.57%	-0.17%	0.10%
2005-2009	-0.63%	-0.09%	0.61%
2007-2009	-0.82%	-0.33%	0.45%

Similarly to the steel industry results in Table 4.3.3.2, the results in Table 4.3.3.4 support the proposition that the magnitudes of the average price change between the various aggregations for motor vehicles manufacturing are different. While it may seem that there is no substantial difference in magnitude, the fact that one index inflates while another is deflating is a valid concern and supports the importance of choosing an index based on homogeneity. Users should not, merely for reasons of simplicity, average out the inflation among the three indexes. Doing so would strongly conflict with the fundamental basis of the 'relevant degree of disaggregation' criterion.

In summary, the current research recommends that for ABS indexes, the fourth level of dissection, which is the class level, should be chosen as this achieves not only the maximum but also the most relevant degree of disaggregation over other dissection indexes where available. A relevant degree of disaggregation of the index to the procured product or services is fundamental in the selection of an appropriate index for contract price variation.

For international contract purposes, given that the indexes from BLS and ONS follow similar classification structures, the same reasoning can be applied to indexes from the US and the UK. Although, BLS and ONS produces PPI beyond the fourth level of dissection, based on conformity with ABS indexes and the notion of relevant degree of disaggregation, the current research recommends that indexes from BLS and ONS be chosen at their respective fourth dissection (or equivalent level) in order to be considered as 'appropriate' indexes for defence contract price variation purposes. For UK indexes, these are the indexes at the class level as well. For US indexes the fourth level of dissection is the NAICS industry[9] level, which is equivalent to the ANZSIC class level.

4.3.4 Statistical validity

Rationale for considering this criterion

An index is considered to have statistical validity, if (i) the measurement is well-founded, and/or (ii) it corresponds accurately to the real world. One possible view regarding this is that an index is statistically valid when constructed using an appropriate sample size which is representative of market composition.

The size of the industry (large or small) has no direct impact on statistical validity. Assuming an industry sector has less than ten firms, in theory, statistical validity is still achieved despite collecting pricing data from only a few firms. For example, if an industry sector is dominated by a few firms, and a selection of those firms is considered to be an appropriate sample size, then the selected sample represents a major proportion of the market composition. If the few dominant firms chosen together represented a large market composition–say over 90% of the industry sector – the

[9] Yet this NAICS industry level can also be referred to as the 5 digits level. This is purely due to the NAICS's highest level beginning with a 2 digits code, instead of a single digit like ANZSIC or UK SIC.

sample size of the dominant few could to some extent be considered appropriate, and therefore the resulting price index to be statistically valid.

Research outcomes for defence: ‘Statistical validity’ criterion

The ABS defines statistical validity via ‘fit for purpose’ statistics (ABS, 2009). This relates to an index being reflective or representative of actual changes within its respective industry sector or category, which is achieved by measuring movements that underpin the industry’s activity. Indexes are only released if they are found to be ‘fit for purpose’. The International Monetary Fund (IMF) has found the validity and reliability of indexes published by the ABS to be of high quality (IMF, 2010). Therefore, all indexes published by the ABS are deemed to be reliable and statistically valid.

For US BLS (BLS, 2011b), PPI and ECI, stratified sampling is conducted on a probability proportionate to size basis[10]. Based on the sampling technique employed by BLS, the current research considers that BLS indexes, like PPI and ECI, will appropriately represent the intended industry and are therefore statistically valid.

For UK indexes, Morris and Green (2007) and Woods (2008) provided estimates of standard errors for growth rates for the PPI in order to calculate the difference between the estimate and its true population growth rate. Results from both of these studies indicate that the standard errors on average are small. Exceptions occur with indexes from industries such as petroleum, base metals and fabricated metals, which are known for their price volatility. As the index is computed using a sample of price quotes from firms, if a different sample was selected, it is likely that a different estimate of the same population growth rate would be produced (Morris and Green, 2007). Volatile pricing in the industry can add to this difference in the estimated population growth rate. However, based on findings from Morris and Green (2007) and Woods (2008), the current research considers the indexes from ONS, especially the PPI, to be statistically valid.

[10] Firms’ participation by way of providing data is voluntary, but BLS has indicated that the degree of cooperation generally remains high.

4.3.5 Negligible influence by the contractor

Rationale for considering this criterion

Another selection criterion is that if an index is susceptible to substantial direct influence from either contracting party, then such an index would not be deemed 'appropriate' as the index is unlikely to be considered 'fair' for contract price variation purposes.

The main justification for this criterion is if the contractor's pricing can significantly affect movement of a price index, then the contractor could become less cost and/or price conscious (Schiefebien, 1977). This is because if a contractor's own weights in a particular index is of significance and the contractor who uses such an index is able to seek compensation for unexpected economic fluctuations, then the contractor may have little incentive to bargain down input costs or become more efficient, since the contractor would be compensated for all price changes regardless. Effectively, the index would be tracking actual prices and to some extent 'non competitive costing or pricing' of that particular contractor rather than the average price movements relevant or experienced by others in a similar situation.

From another perspective, an official price index can be susceptible to error if large weights are allocated to any contractor who comprises part of the index sample. This was seen with the index of BLS ECI - Aircraft Manufacturing industry (DoDIG, 2008). This 'error' was possible because of the large weights given to a particular contractor in the index sample. As discussed under the preceding criterion – 'statistical validity'–construction of an index is normally based on a sample which is proportionate to appropriate market structure or concentration. Whether it is through inadvertent reporting errors or intentional manipulation, large weights applied to any particular contractor in the index sample can be of concern, especially if those contractors are the ones with whom the buyer contracts. This is because the price movement observed/recorded under those situations may not be the actual movement. For these reasons, an index is considered to be unacceptable for use when the imputation could be directly susceptible to significant influence by the contractor and against the buyer's interest.

Research outcomes for defence: 'Negligible influence by the contractor' criterion

This criterion firstly discards the usage of a contractor's own index or pricing information for contract price variation purposes. This is because a contractor's own index can be directly influenced by the contractor in its calculation and data source. As previously examined, the use of a contractor's index is deemed inappropriate as it fails the criterion of not being from 'independent sources'. As it is not from an independent source like official statistics, its methodology and/or data may not have been validated or examined. In order to ensure fairness for both contracting parties, and minimise unjust influence by either, the price index should be from an independent source.

Another viewpoint on the research outcome for this particular criterion is outlined below. While examining this criterion, it is important to note that statistical agencies like ABS, BLS, and ONS do not disclose the weight contribution of an individual company towards a particular index. This is mainly due to issues of privacy. As an alternative, the following analysis uses external market intelligence information sourced from IBISWorld in order to determine the market concentration. The current research uses this information as an estimate of the possible weights assigned to companies of a certain industry in calculating the specific index. However, it should be noted that the market concentration percentage referenced by IBISWorld is based on the preceding year (i.e. 2008/2009) of revenue. This may not align exactly to companies' weights contribution towards a particular index as statistical agencies may not update their weighting pattern of indexes annually.

The current research found that the market concentration of those industries considered to be relevant to defence procurement at the ABS fourth dissection (i.e. class level) was low or medium. Only four industries at the fourth dissection were shown to have a high market concentration, these are presented in Table 4.3.5.1.

Table 4.3.5.1. High market concentration industries relevant to defence procurement

ANZSIC class	Value of market share
1914 Tyre manufacturing	A firm has 98% of the market share.
2110 Iron smelting and steel manufacturing	One firm dominates with 64% while another holds 35%.
2221 Structural steel fabricating	One firm dominates with 83% of markets share while the second largest firm has approximately 10%.
2412 Medical and surgical equipment manufacturing	One firm has 41% while the second largest has 34% of market share.

Source: IBISWorld (2010)

While the market concentration is high for the four Australian industries listed in Table 4.3.5.1, none of the dominating firms in those industries are actually 'defence contractors' (i.e. they are not firms who sell directly to defence). Rather, these industrial sectors are relevant in that the dominant firms within them sell to other sectors containing firms that contract to DMO. Despite these dominant firms having the potential for substantial influence on indexes, the impact on the final buyer (i.e. DMO) may not be detrimental.

The following illustrates such a situation. Assume the widget manufacturing industry is dominated by Company ABC and Company XYZ. Large weights are allocated to pricing change information from these two firms within the 'widget manufacturing index'. The defence contractor, Company 123, purchases widgets from their subcontractor, Company ABC. Since Company 123 cannot directly influence the 'widget manufacturing index', the index is viewed as acceptable for DMO contracting purposes despite its high market concentration by Company ABC and Company XYZ. This is because in theory, firms like Company ABC and Company XYZ are viewed to be selling and operating in an open and competitive pricing market where there is no incentive for either company to influence their particular industrial sector index.

It follows that indexes under the Multiple Indexes (or Cost Components) approach would all satisfy the criterion of 'negligible influence by the contractor'. Therefore the issue of concern from a defence procurement standpoint is when the actual defence contractor can directly influence a particular index.

The current research also uncovered another way to view the defence-relevant industry structure. The analysis found that the majority of DMO's contractors contribute to just two ABS indexes (two indexes which are considered under the 'Single Index' or 'Finished Goods' approach). From a defence-perspective the two most important industries related to this are shipbuilding and aircraft manufacturing.

The index class–2391 Shipbuilding and Repair Services–was considered first. Market intelligence information (IBISWorld) indicated that for the Australian shipbuilding industry, there are four companies which shared close to 66% of the total market revenue in 2009. All four companies are considered to be companies that generate a large portion of revenue through defence contracts. Furthermore, 70% of the shipbuilding market is now estimated to be related to defence. As a result, the coverage of this index would be more closely aligned to defence procurement than other ABS indexes.

The index class of 2394 Aircraft Manufacturing and Repair Services was the second index of concern for defence contracting purposes. The Australian aerospace industry consists of three defence contractors who represent a total of just less than 50% of overall market share. Furthermore, government purchases represent 33.2% of the industry revenue and the defence sector is the largest purchaser of aircraft on behalf of the government. Therefore, the coverage of this index would have some portion that aligns to defence procurement, but due to the large degree of commercial production, the defence portion is unlikely to dominate.

The use of these two indexes, ANZSIC 2006 class of 2391 and 2394, could from one viewpoint be advantageous because they provide an indication of inflation that is reflective of defence procurement (due to the fact they are sourced from several well-known defence contractors). The trade-off here is that since the defence contractors have a reasonably large amount of market share, the related index could be subject to significant influence from these contractors, which could be problematic if those contractors fail to be cost or price conscious or at the extreme, provide deliberate inaccurate reporting of pricing to the statistical agency[11].

[11] The view in this research is that there exists a possibility that the index could be subject to inaccurate influence if the index is dominated by a single company and that company provides pricing that is not favourable to the buyer. However, the current research is not claiming that inappropriate influence will necessarily occur every time under such circumstances.

However, there are two important factors that allow these two indexes to satisfy this current criterion. It should be noted that the market share of defence contractors, for both the shipbuilding and aircraft manufacturing industries, does not result in a single company's significant market domination. This means for the example of the shipbuilding industry, in principle, these few defence contractors would be competing against each other. Therefore, it is unlikely to be advantageous for these defence contractors to not be cost or price conscious. Furthermore, it is unlikely to be advantageous for any one of these defence contractor under these circumstances, to deliberately report inaccurate costs or to inflate the pricing data, as this would in fact provide a benefit to their competitors.

Furthermore, recall that government purchases only represent approximately 33% of the aircraft manufacturing industry market share. This should mean that the related index, which measures the movement of prices in the overall aircraft manufacturing industry, is also capturing price movements from other either smaller defence contractors or from commercial producers. Therefore, the judgement based on the balance of these considerations is that the two indexes ANZSIC 2006 class of 2391 and 2394 both satisfy the current criterion of 'negligible influence by the contractor'.

Comparable findings were also observed from international indexes. The analysis of BLS indexes found defence contractors mainly contributed to three indexes from BLS–those often used in the Single Index or Finished Goods approach. The three BLS indexes under the NAICS 2007 at the fourth dissection level were 33641 Aerospace Product and Parts Manufacturing, 33661 Ship and Boat Building, and 33699 Other Transportation Equipment Manufacturing. Due to its industrial sector classification, each index is currently classified with other similar commercial or non-combat production. Similar to the reasoning applied to the ABS indexes, as military production does not dominate the primary activities of these three indexes, they are unlikely to be susceptible to significant influence by a particular defence contractor.

Additionally, the findings from the ONS indexes are similar to those observed with the ABS indexes. Two industries, aircraft manufacturing and shipbuilding are of interest to the current analysis. Firstly, the aerospace manufacturing industry in the UK is very widespread. One of the major defence contractors in UK only holds 1.7% of the overall market share. With such low market share it is unlikely that the index would be susceptible to significant change due to large weights being allocated to defence contractors in the index sample. Hence, the use of index ONS PPI 30.30 Manufacture of Air and Spacecraft and Related Machinery would be unlikely to be significantly influenced by a defence contractor.

The second index is the ONS PPI 30.11 Building of Ships and Floating Structures. Similarly to the Australian Shipbuilding industry, defence purchases in the UK account for close to 70% of the UK shipbuilding industry production. Furthermore, two companies hold approximately 78% of the market share and both of these companies have major contracts with the UK MoD. However, using the same reasoning as for the ABS indexes presented above, since the market is not dominated by a single company and given that the market also consists of commercial production, the index is unlikely to be susceptible to influence by any particular defence contractor. Hence ONS PPI 30.11 Building of Ships and Floating Structures are judged from this research to also satisfy the current criterion.

There are three ways this dilemma of single company domination in the index, could be managed if it eventuates. One way to avoid significant influence by the defence contractor is to use a related index at the second or third dissection, instead of the fourth dissection level. Indexes of larger aggregations would have a larger sample size over a specific segment index. This would minimise the chance of direct influence by the defence contractor. However, this conflicts with the previous selection principle of ‘relevant degree of disaggregation’. Using more general indexes which utilise a larger population of activities and workers, as well as a greater variety of industries, actually decouples the accuracy or reasonableness in the representation of the inflationary indication of interest.

The conflict between two selection principles is presented in the following illustration. The relative weight for the class index of 2391 Shipbuilding and Repair Services toward the group (third dissection) index of 239 Other Transport Equipment Manufacturing was 20.76%. Additionally, the class (fourth dissection) index had a weight of 4.94% within the subdivision index 23 Transport Equipment Manufacturing. As already discussed, the higher the level of the index the less homogeneous the index becomes in terms of the activities captured by the index. If the procurement interest is ships, then only 4.94% of the subdivision index of 23 Transport Equipment Manufacturing is represented by the movement from the industries of shipbuilding and repair services. The remaining 95% is allocated to other equipment manufacturing like motor vehicles, aircraft, and so forth, which are unlike shipbuilding. The weight of 4.94% is extremely low to provide a reasonable and reflective inflationary indication. Therefore, as presented in the discussion of the 'relevant degree of disaggregation' criterion, the index at the higher aggregation could significantly be affected by activities which are not relevant to defence, and which may even conflict with the particular procurement of interest.

Another way to manage the dilemma would be to constantly monitor these indexes. Continuous monitoring enables significant and/or abnormal changes in the index's movement to be identified immediately.

It may be advisable to avoid using a particular index with firms that dominate a particular industry. For example, avoid using the single output index 2391 Shipbuilding and Repair Services when procuring naval product or services from major defence contractors. Instead it may be advisable to use the Multiple Indexes or Cost Components approach when contracting with those large defence companies on naval contracts.

4.3.6 Pertinent to the contract procurement

Rationale for considering this criterion

Another one of the nine principles is that an appropriate index should measure the price change which is directly relevant to the contract procurement. In theory, this is rather simple. If the procurement is for motor vehicles, and since the activities of motor vehicles manufacturing is covered by an index from the ABS (via ABS PPI 2311 Motor Vehicles Manufacturing), then it is rather straightforward for the user to select such an index. Yet, because indexes are constructed as per a common classification system like ANZSIC, it is likely that a 'unique' product like specialised materiel may fall outside the scope of the activities included in such an index.

The following section will first investigate which index series, such as CPI or PPI, would be most relevant for defence procurement purposes. Sub-series of those under the PPI and LPI would also be examined. Analysis will then turn to indexes which are pertinent to 'unique' or custom-made procurement.

Research outcomes for defence: 'Pertinent to the contract procurement' criterion

Index for the cost of labour

As concluded in the discussion of a previous selection principle concerning theoretical soundness, the appropriate index to measure labour cost in Australia is the ABS LPI. ABS publishes several sub-series for LPI and the variable factors are inclusion or exclusion of bonuses and/or overtime price movements. Payments of bonuses are a subjective matter and can differ between firms and industries. For procurement contract price variation purposes, it would be more appropriate to use an index (or indexes) which excluded bonuses–this would allow trends in 'genuine' wages to be observed.

The ABS LPI publishes indexes under sub-series named 'Ordinary Time Hourly Rates of Pay or Total Hourly Rates of Pay'. The current analysis found that for defence contracting purposes, the use of indexes from the series 'Ordinary Time Hourly Rates of Pay excluding Bonuses' are preferred to 'Total Hourly Rates of Pay excluding Bonuses' as the former ignores movement for overtime. Therefore, the LPI - Total Hourly Rates of Pay excluding Bonuses is recommended to be precluded from further consideration.

Similarly, the recommended theoretically sound wage cost index from the BLS is the ECI. The appropriate index series to use for labour price/cost movement is the sub-series of 'Wages and Salaries', as this series will ignore bonuses and other on-costs.

Earlier the Index of Labour Costs per Hour from ONS was found to have satisfied the criterion of 'theoretical soundness' in its construction. However, as this index is published experimentally, therefore it may not be the 'ideal index' for contract price variation purposes at this stage. However if this index series was to be used in contract for any particular reason, say practicality or no other feasible options, then the appropriate sub-series would be 'Total Wage Cost – Industry level' which also excludes bonuses and other on-costs.

It is important to note that the issue of labour cost indexes failing to account for changes in productivity is examined in the forthcoming index selection principle of ‘Output indexes’.

Index for the cost of material or finished goods

For defence contracting, use of the PPI is a better proxy for costs faced by the producer than using the CPI. The predominant reason for this recommendation is due to the fundamental concept with respect to the purpose of the index. The PPI is an indicator that shows the average price changes obtained by domestic producers for their input or output. The CPI on the other hand is a measure of the average change in prices over time for goods and services purchased for personal household consumption. DMO’s consumption differs greatly to that of personal households. In comparison, the use of the PPI would be much more pertinent to defence procurement than the CPI. Therefore, this research considers the CPI to be inappropriate for defence procurement purposes and recommends that it be precluded from any further consideration.

The PPI also has available sub-series, two of the mostly popular sub-series are the input and output indexes. The analysis of these two types is relegated to the forthcoming selection principle of ‘Output indexes’.

Regarding US indexes, Figure 4.1.2 (which depicts the range of indexes currently used in DMO contracts) reveals that current DMO contracts commonly use two sets of indexes from the BLS PPI–these are Commodity indexes and Industry indexes. The Commodity indexes classification structure of the PPI organises goods and services by similar end-use or material composition, but disregards their industry of origin (BLS, 2011b). On the other hand, the Industry indexes are classified under the NAICS 2007, which is similar to the classification structure of ANZSIC 2006 and UK SIC 2007. For the purposes of contract price variation, the most appropriate indexes are those that recognise the price movement of the manufacturing industrial sectors and not individual commodities. Accordingly, the Industry indexes from the BLS PPI are considered to be more pertinent to the buyer’s purposes than the PPI Commodity indexes. Therefore this research recommends that BLS PPI Commodity indexes to be precluded from further consideration.

Custom-made procurement

This criterion of 'pertinent to the contract procurement' may seem relatively straightforward to apply but, in reality, it may not be that simple. This is because statistical agencies like ABS, BLS, and ONS publish indexes based on an industrial sector classification system. As such, 'unique' activities like combat vehicles manufacturing may often be excluded from the classification system. If, for example, actual procurement is for combat vehicles, there is typically no index called 'combat vehicle manufacturing index'. Even if activities like military armoured vehicles manufacturing were included in the classification system, such as under BLS PPI 33699 Other Transportation Equipment Manufacturing, they would be aggregated with other activities such as the manufacturing of motorcycles, bicycles, metal tricycles, tanks, self-propelled weapons, vehicles pulled by draft animals, among others. On this basis, it would be extremely difficult for contracts related to custom-made procurement to select one, let alone a few, reflective indexes.

The application of the current criterion seems to conflict with the preceding criterion. In order to satisfy the preceding criterion of 'negligible influence from the contractor', the index needs to be free from the dominance of defence contractors in the survey sample. Similarly, the classifications for the activities which underpin the index need to consist of some portion of commercial production. If satisfied, the dilemma then lies in how accurate a publicly available index can be if the sample of respondents includes companies other than defence contractors, and if the manufacturing activities captured in the index also include commercial production. From an alternate angle, if the procurement is 'unique in its kind' then using a publicly available index which records price change from some respondents (whose activities are much less relevant to the 'unique' procurement contract) would fail the criterion of being 'pertinent to the contract procurement'.

An added dimension to the practical dilemma is that the majority of the publicly available indexes may be more reflective of the commercial environment than defence production. The following example of a combat communication system aims to highlight this dilemma. Communication systems used in combat are often more technologically advanced than communication equipment in everyday use, like telephone or radio systems. Therefore, the price change captured by the ABS PPI 2422 Communication Equipment Manufacturing may not be reflective of movements in the manufacturing of combat communication systems. The primary activities associated with the ABS PPI 2422 Communication Equipment Manufacturing are listed in Table 4.3.6.1.

Table 4.3.6.1. Primary activities classified in ANZSIC 2422 Communication Equipment Manufacturing

Primary activities associated with the ABS PPI 2422 Communication Equipment Manufacturing
Cable television equipment manufacturing
Data transmission equipment (bridges, gateways, routers etc.) manufacturing
Intercom equipment manufacturing
Modem manufacturing
Pager manufacturing
Radio broadcast studio equipment manufacturing
Radio transceiver manufacturing
Radio transmitter manufacturing
Remote monitoring alarm system equipment manufacturing
Telecommunication equipment manufacturing
Telephone equipment manufacturing
Telephone switching equipment manufacturing
Telephone, cellular, manufacturing
Television antenna or parts manufacturing
Television studio equipment manufacturing

Source: ABS (2006a)

It is evident from Table 4.3.6.1 that the list of activities associated with the ABS PPI 2422 Communication Equipment Manufacturing are dominated by manufacturing of commercial items. Since the defence industry is only a small portion of the overall economy, even if the price movement of combat communication systems manufacturing was recorded, it would be outweighed by the price movement associated with activities from other commercial communication equipment.

The dilemma of the manufacturing of commercial items domination in an index is more of a concern under the Single Index (Finished Goods) approach than the Multiple Indexes approach. This is due to the Single Index approach's use of an index which reflects the final sale price of the finished goods. The current analysis found eight of the ANZSIC classes which are relevant to defence to be dominated by commercial production rather than defence production, these are listed in Table 4.3.6.2.

Table 4.3.6.2. ANZSIC classes dominated by commercial production rather than defence production

ANZSIC classes dominated by commercial production rather than defence production	
2311	Motor vehicle manufacturing
2312	Motor vehicle body and trailer manufacturing
2412	Medical and surgical equipment manufacturing
2419	Other professional and scientific equipment manufacturing
2422	Communication equipment manufacturing
2429	Other electronic equipment manufacturing
2432	Electric lighting equipment manufacturing
2439	Other electrical equipment manufacturing

For US indexes, under the Single Index approach, the current analysis found seven NAICS industries which would be subject to domination of commercial production rather than defence production. These are available in Table 4.3.6.3.

Table 4.3.6.3. NAICS Industry dominated by commercial production rather than defence production

NAICS Industry dominated by commercial production rather than defence production	
33411	Computer and Peripheral Equipment Manufacturing
33421	Telephone Apparatus Manufacturing
33422	Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing
33451	Navigational, Measuring, Electromedical and Control Instruments Manufacturing
33531	Electrical Equipment Manufacturing
33611	Automobile and Light Duty Motor Vehicle Manufacturing
33612	Heavy Duty Truck Manufacturing

For UK indexes, under the Single Index approach, the current analysis found three UK SIC classes which would be subject to domination of commercial production rather than defence production. These are shown in Table 4.3.6.4.

Table 4.3.6.4. UK SIC classes dominated by commercial production rather than defence production

UK SIC classes dominated by commercial production rather than defence production	
26.20	Manufacture of computers and peripheral equipment
26.30	Manufacture of communication equipment
29.10	Manufacture of motor vehicles

One way to manage this commercial domination dilemma, under the Single Index approach, is to continue using the index but introduce an adjustment in the price variation formula which caters for this problem. This adjustment (which is called the defence-specific adjustment) is discussed in detail in Chapter Five. On the other hand, since the Multiple Indexes approach uses a collection of indexes to reflect the price movement of material cost to the contractors, this could be an alternative solution. The defence contractor is subject to market movement in obtaining raw materials. Therefore, it is acceptable for the indexes under the Multiple Indexes approach to be dominated by activities from commercial markets.

The current criterion of 'pertinent to the contract procurement' shares reasoning similar to the 'relevant degree of disaggregation' criterion. As discussed previously, distortion occurs when using highly aggregated or macroeconomic indexes that may not reflect the weightings of activities relevant to the defence contract. Suppose, for example, that in order to avoid indexes that are susceptible to the contractor's direct and substantial influence (i.e. criterion of 'negligible influence by the contractor'), a naval contract uses the index ABS PPI 239 Other Transport Equipment Manufacturing, instead of ABS PPI 2391 Shipbuilding and Repair Services. Then, since the relative weight of index 2391 toward index 239 is only 20.76 (i.e. 20.76 out of 100), it means that close to 80% of the third dissection index's (239) movement is attributed to activities which are not associated with shipbuilding industries. Using such an index for a naval contract would fail the ‘pertinent to the contract procurement’ criterion.

4.3.7 Not seasonally adjusted

Rationale for considering this criterion

Seasonal fluctuations with pricing data can occur due to seasonal or natural conditions, production cycles, and holidays. Seasonally adjusted data are often preferred in economic analyses as they provide a measure of the general price trend of the economy. However, in general, seasonally adjusted indexes are not appropriate in contract escalation. This is due to the fact that the intent of price variation is to capture actual price changes. Unadjusted data are more ideal as they reflect the actual dollar-value transaction (BLS, 2006). Often seasonally adjusted data are only produced by the statistical agency at the highest level (i.e. headline inflation).

Research outcomes for defence: ‘Not seasonally adjusted’ criterion

Based on the above theoretical reasoning, the use of unadjusted series is recommended for defence contracting. The ABS produces indexes in the series of PPI and LPI–Original Time as unadjusted series. The BLS produces indexes in the PPI and ECI as unadjusted series. ONS produces indexes in the series of PPI (and the experimental Index of Labour Costs per Hour while not recommended to be used at this stage but may be the best available) as not seasonally adjusted.

4.3.8 Output Indexes

Rationale for considering this criterion

Some statistical agencies produce their PPI from two perspectives, as an approximation to the ‘true cost of a unit of production’ or to the ‘true value of a unit of production’. Alternatively, these may be called ‘Input’ or ‘Output’ indexes respectively. The ABS

(2009) view is that the Input PPI[12] is the measure of the change in the amount paid by the purchaser, inclusive of any non-deductible taxes on products, transport and trade margins. On the other hand the Output PPI[13] measures price change received by the producers, exclusive of any taxes on products, transport and trade margins (ABS, 2009). The Output PPI can also be referenced to be a measure of ex-factory pricing changes.

Due to the vast difference in the concept and construction of input and output price indexes, inflation calculations based on these indexes do not necessarily move in parallel. The current analysis will explore the difference in the input and output indexes which are relevant to defence price variation purposes. The analysis will first cover the input and output indexes for the motor vehicles and steel manufacturing industries, followed by an investigation of output indexes, which could perhaps be available for price variation on labour cost.

Research outcomes for defence: 'Output Indexes' criterion

Material components

Figure 4.3.8.1 depicts the percentages of input and output indexes used to escalate the material component in the price variation formula, as they relate to current DMO contracts. The term 'material component' used in the current context means both materials like steel, as well as final products like vehicles.

[12] From the ABS PPI publication of 'Materials used in manufacturing industries'.
[13] From the ABS PPI publication of 'Articles produced by manufacturing industries'.

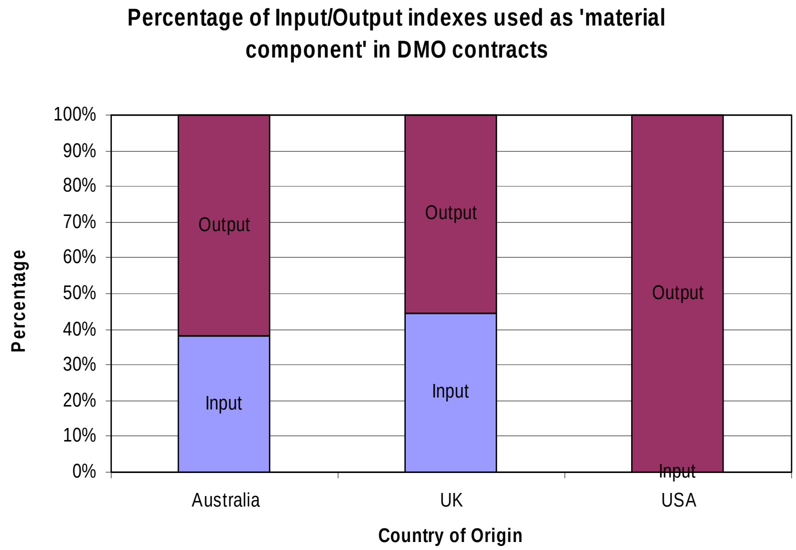


Figure 4.3.8.1. Snapshot: Usage of input and output indexes in current DMO contract (material components)

It is important to note that indexes published by BLS (US) which are suitable for material components are all output indexes. It is clear from Figure 4.3.8.1 that current DMO contracts use both input and output indexes from the ABS and ONS, with the use of output indexes slightly dominating their input index counterparts. As a result, it is important to investigate whether for the unique case of defence procurement, the use of input or output indexes are more appropriate for price variation purposes. The following analysis will use ABS input and output indexes from the motor vehicle and steel manufacturing industry to exemplify the basis of this selection principle.

The weighting patterns in Table 4.3.8.1 show the breakdown of input (materials used) and output (articles produced) indexes for the manufacturing subdivision of transport equipment. The weighting pattern for the input index is on the left while the output index is on the right.

Table 4.3.8.1. Comparison of weights pattern for ABS Input and Output index – Vehicles example

Input Index – Price Indexes of Materials Used in Manufacturing Industries

Subdivision - Transport equipment manufacturing

	Weights	
Mining	0.46	
Food product manufacturing	0.21	
Beverage and tobacco product manufacturing	0.03	
Textile, leather, clothing and footwear manufacturing	0.47	
Textile manufacturing		0.11
Leather tanning, fur dressing and leather product manufacturing		0.05
Textile product manufacturing		0.22
Clothing and footwear manufacturing		0.10
Wood product manufacturing	0.76	
Log sawmilling and timber dressing		0.03
Other wood product manufacturing		0.73
Pulp, paper and converted paper product manufacturing	0.17	
Printing (including the reproduction of recorded media)	0.25	
Petroleum and coal product manufacturing	0.25	
Basic chemical and chemical product manufacturing	1.27	
Basic chemical manufacturing		0.37
Basic polymer manufacturing		0.84
Pharmaceutical and medicinal product manufacturing		0.03
Cleaning compound and toiletry preparation manufacturing		0.01

Output Index – Price Indexes of Articles Produces by Manufacturing Industries

Subdivision - Transport equipment manufacturing

		Weights
Motor vehicle and motor vehicle part manufacturing	76.21	
Motor vehicle manufacturing		43.95
Motor vehicle body and trailer manufacturing		7.82
Automotive electrical component manufacturing		4.41
Other motor vehicle parts manufacturing		20.03
Other transport equipment manufacturing	23.79	
Shipbuilding and repair services		4.94
Boatbuilding and repair services		4.62
Railway rolling stock manufacturing and repair services		4.84
Aircraft manufacturing and repair services		8.38
Other transport equipment manufacturing n.e.c.		1.01

Other basic chemical product manufacturing		0.02	
Polymer product and rubber product manufacturing	4.65		
Polymer product manufacturing		3.88	
Natural rubber product manufacturing		0.77	
Non-metallic mineral product manufacturing	1.80		
Glass and glass product manufacturing		1.35	
Ceramic product manufacturing		0.02	
Other non-metallic mineral product manufacturing		0.43	
Primary metal and metal product manufacturing	9.31		
Basic ferrous metal manufacturing		5.83	
Basic ferrous metal product manufacturing		1.92	
Basic nonferrous metal manufacturing		0.65	
Basic nonferrous metal product manufacturing		0.91	
Fabricated metal product manufacturing	4.61		
Iron and steel forging		1.45	
Structural metal product manufacturing		1.07	
Metal container manufacturing		0.14	
Sheet metal product manufacturing (except metal structural and container products)		0.41	
Other fabricated metal product manufacturing		1.54	
Transport equipment manufacturing	63.62		
Motor vehicle and motor vehicle part manufacturing		54.82	
Other transport equipment manufacturing		8.80	
Machinery and equipment manufacturing	9.13		
Professional and scientific equipment manufacturing		2.49	
Computer and electronic equipment manufacturing		0.97	
Electrical equipment manufacturing		1.72	

Domestic appliance manufacturing		0.42	
Pump, compressor, heating and ventilation equipment manufacturing		0.71	
Specialised machinery and equipment manufacturing		0.34	
Other machinery and equipment manufacturing		2.47	
Furniture and other manufacturing	1.87		
Electricity supply	0.98		
Water supply, sewerage and drainage services	0.15		

Source: ABS (2010a, 2010b)

It is clear from the weighting patterns in Table 4.3.8.1 that the components that contribute to the input index are very different to those that contribute to the output index. The weighting patterns show that the Input PPI is a measure of changes in per unit costs of materials and utilities (for example, electricity and water) irrespective of the output produced. It is important to note that labour costs are not included in the computation of the Input PPI.

On the other hand, the movement of an output index is more complicated. The output index captures the changes in the sale price of transport equipment. From an economics perspective, the movement of the sale or output price can be a result of the movement of several elements. In addition to cost of material and utilities (i.e. cost push theory), from the Keynesian perspective the output index is affected by elements which include demand pull and market pressure or power. In reality the output price index also captures productivity gains, and cost changes in labour, and research and development, which are all excluded from the input based index.

This has implications for the extent to which the three factors; cost push, demand pull, and market power, contribute to the indexes. They can contribute differently between the two types of indexes. Firstly, the economic theory of cost push refers to the rise in production cost and this increase is passed directly onto consumers. In simple terms, when the production cost increases, ceteris paribus, the price of the final product increases as well.

However, some economic literature suggests that output prices are sticky (i.e. resistant to change) with respect to cost changes. Several factors attribute to this price stickiness notion, such as cost incurred by firms in order to change their sale prices. The classic example is that the cost of reprinting a menu may outweigh potential sales.

Another factor in the idea of price stickiness is that the firm will try to hold prices constant to avoid buyers searching and switching to competitors or substitutes. Firms fear a potential loss of buyers that may outweigh the potential gain in adjusting to new sale prices. Moreover, output prices may be sticky due to business strategies such as marketing or long-term investment preferences. Resistance to change in output prices can also be due to more efficient production or processing, enabling absorption of the production cost rise. As a result, the producer can continue operating at the original prices.

Figure 4.3.8.2 demonstrates the annual percentage change between an Input and Output ABS PPI for the Motor Vehicles and Motor Vehicles Parts industries.

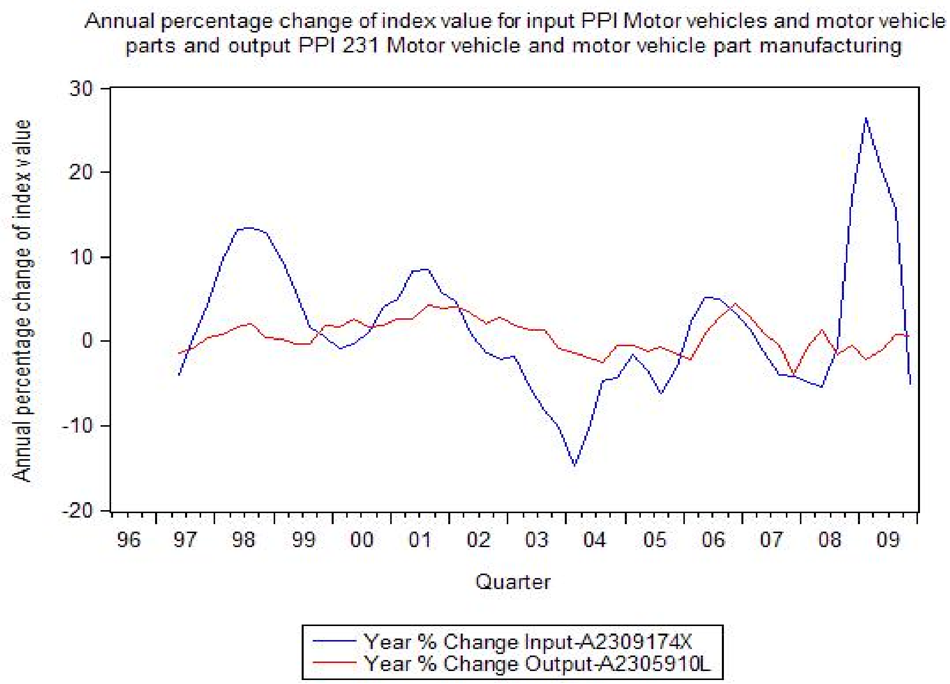


Figure 4.3.8.2. Comparison of changes in index value for ABS Input and Output PPI – Vehicles example

Figure 4.3.8.2 shows that the magnitude of price change observed in the input price index is far greater than the movement in the output price index. This supports the argument that the output prices from industries of motor vehicle and motor vehicle parts are more resistant to change than input cost changes. In other words, the input index is more volatile compared to its output counterpart.

In fact, the current analysis found that out of the 13 sets of defence related ABS input and output indexes analysed, nine of the output indexes also showed resistance to change relative to input cost change (refer to Appendix A for the other sets of graphs). This was demonstrated via the result that the average magnitude of price change was less in the case of the output price index than for input index counterparts. This implies that some degree of price stickiness occurred among the ABS indexes analysed, thus supporting the argument that an increase in input cost does not necessarily result in cost push inflation flowing through to output prices to a similar extent.

Despite the fact that the analysis found that a majority of the ABS output price indexes are sticky relative to input price, there are some instances where the output price index inflates at a higher rate than the input index. Such a situation can be demonstrated in the case of the Output ABS PPI 2110 Iron Smelting and Steel Manufacturing. Figure 4.3.8.3 demonstrates the annual percentage change between an Input and Output ABS PPI from industries of steel manufacturing while Table 4.3.8.2 shows the average annual inflation over different periods for the two indexes.

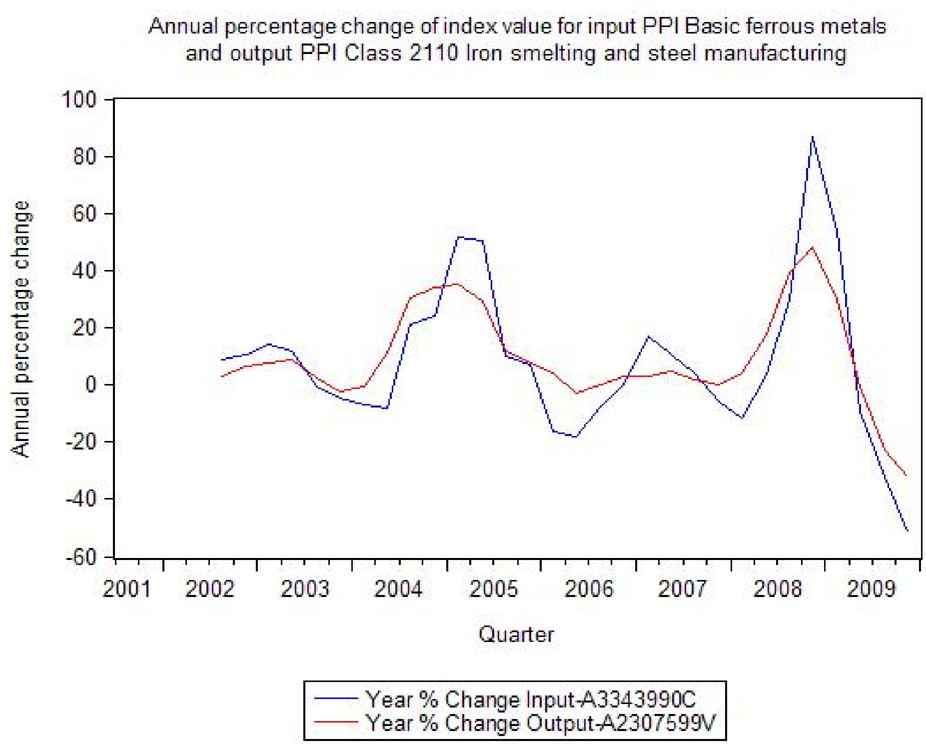


Figure 4.3.8.3. Comparison of changes in index value for ABS Input and Output PPI – Steel products example

Table 4.3.8.2. Comparison of annual inflation for ABS Input and Output PPI – Steel products example

Time Period	Input - Basic ferrous metals	Output - 2110 Iron smelting and steel manufacturing
2003-09	5.60%	8.97%
2005-09	5.55%	8.18%
2007-09	3.55%	6.44%

Figure 4.3.8.3 and Table 4.3.8.2 both present results that show the output index of ABS PPI 2110 Iron Smelting and Steel Manufacturing inflating faster but at a smoother rate than its input index counterpart of PPI Basic Ferrous Metals. There are two economic concepts which help explain this phenomenon, they are demand pull and market power.

The theory of demand pull is associated with the demand of the final product. If the demand from the buyer increases, the price will inflate as well. Demand pull inflation occurs when there is more money and liquidity in the market than the supply of a particular item. With a large amount of money, buyers are chasing too little quantity. Figure 4.3.8.4 shows the movement in price when there is a switch in demand.

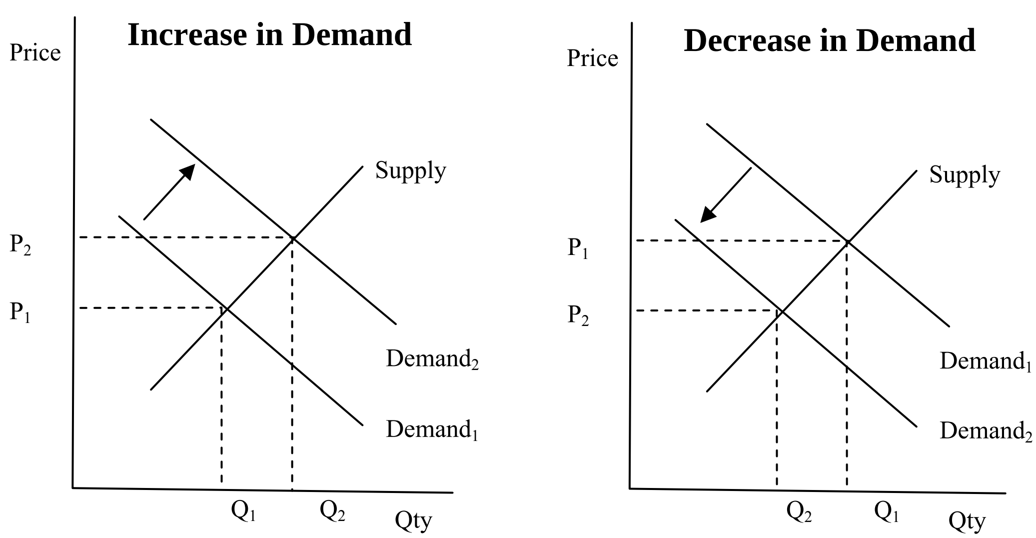


Figure 4.3.8.4. Demand and supply depiction of switch in demand

When buyers are chasing too little quantity, often buyers are willing to pay extra for such a product resulting in inflation. Also, producers will tend to increase prices during a demand boom in order to maximise profit.

Similarly, a supply shock can also affect the output prices. If supply decreases then this will also drive prices up. Figure 4.3.8.5 depicts how price increases when there is a shift in supply.

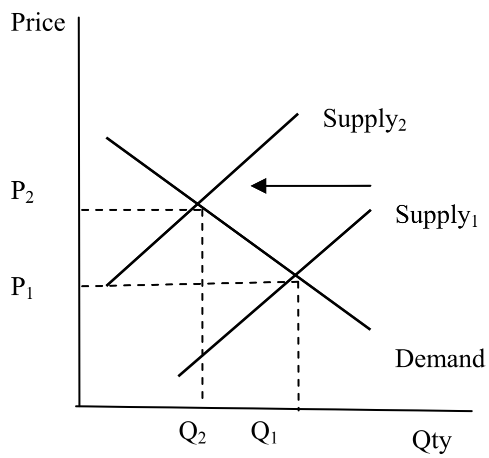


Figure 4.3.8.5. Demand and supply depiction of switch in supply

Consequently, the market trend in consumption is an important element in the analysis of the Output PPI. The following section investigates factors including demand pull and pricing power associated with the output price movements observed in the Australian steel manufacturing industry. Figure 4.3.8.6 depicts Australian Iron and Steel production and consumption, together with the index movement of the Input and Output ABS PPI associated with the steel manufacturing industry.

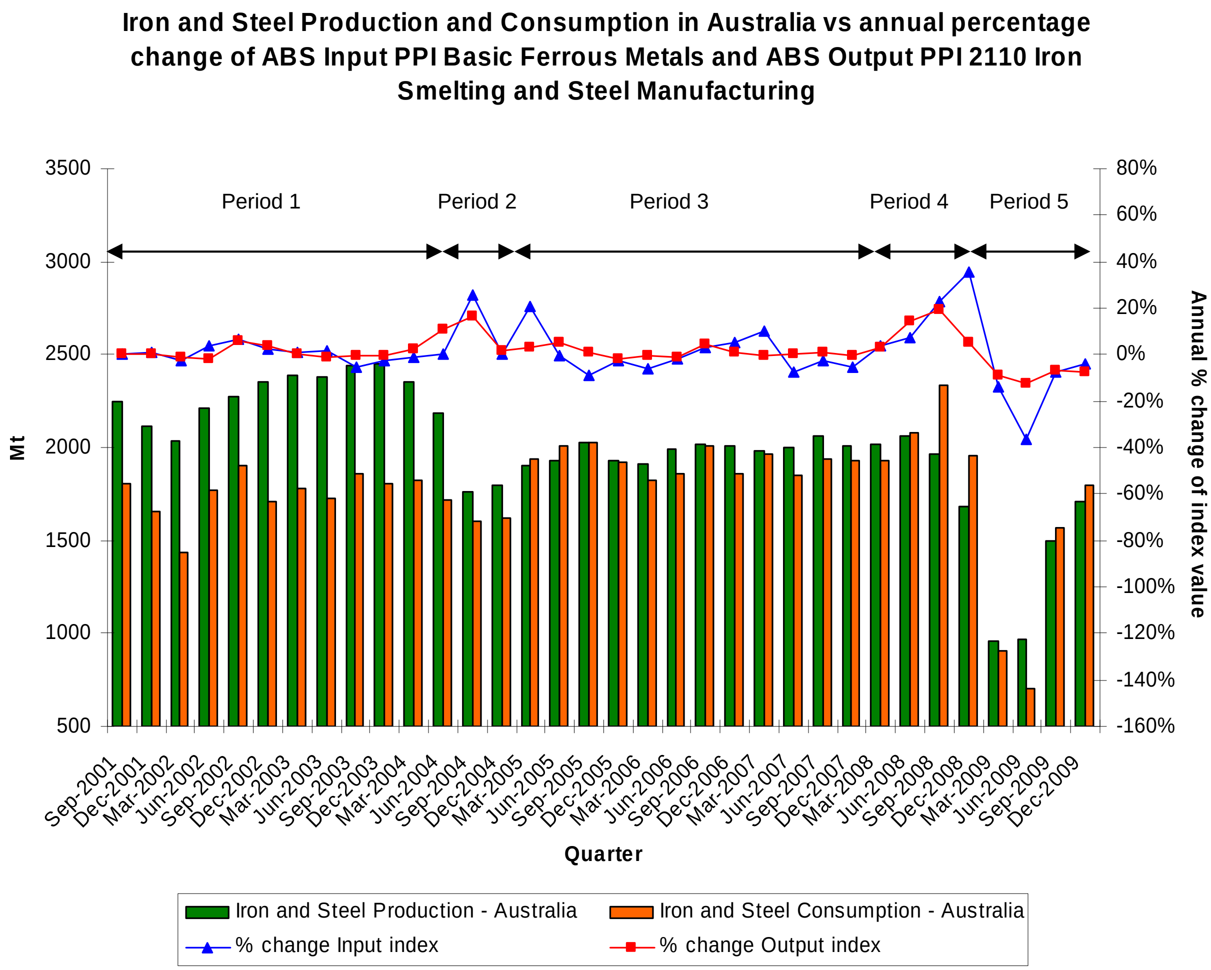


Figure 4.3.8.6 Comparison of production and consumption toward the movement of input and output indexes – steel products example

The following analysis discusses the movements over each of the five different set of time periods as seen in Figure 4.3.8.6. The first period, Period 1 is from Sep-2001 to Jun-2004. The second period runs from Jun-2004 to Dec-2004. Period 3 covers 2005 to 2007, while Period 4 relates to the year 2008. Finally, Period 5 relates to the year 2009.

Firstly, for Period 1, Figure 4.3.8.6 shows that production significantly outweighed consumption during 2001 and up to mid-2004. During the same time period the movement of the input and output prices were similar and the average price change for the output price index was close to zero.

Figure 4.3.8.6 also shows that for Period 2 the output price index spiked in Jun-2004, despite the fact that input prices only began to rise from Sep-2004. This clearly indicates that cost-push is not the contributing factor in the rise of output prices in Jun-2004. It was observed that during the same period, there was a production reduction. In fact, there was a 7.5% decrease in production in Jun-2004 (compared to Mar-2004) and a 24% decrease between Jun-2004 and Sep-2004. These reductions in production resulted in production and consumption becoming more closely aligned. The production at Sep-2004 was 1765 Mt while consumption was 1604 Mt. This means that despite the actual demand (consumption) volume remaining similar to what it has been, the volume available in the market reduced. Therefore the choices available to customers decreased; and because supply (i.e. production) decreased, output prices increased, and this is reflected in the output price index, consistently with the theoretical situation depicted in Figure 4.3.8.5.

As for Period 3, the input price index during 2005 and up until 2007 fluctuated, while the output price index movement was much flatter. This flatness could be the result of price stickiness, which would be resistant to change in output prices despite the input price index drifting upward for a large part of the period. As discussed earlier, stickiness in output prices can be due to producers absorbing the input cost rise as a result of market pressure, or producers becoming more efficient. Likewise when the input price index deflated in mid-2007, the output price index showed little change in trend and did not fluctuate much.

In the fourth period, consumption during Jun-2008 through to Dec-2008 outweighed production, which can have two effects. The general observation is that when demand was greater than supply the output price increased. This was evident by the large upward inflation in the output price index in Jun-2008. The second effect is that increases in consumption also commonly increase input prices, albeit with some lag. This is due to production increasing in order to match the new consumption level. As the production volume increases, this ultimately increases the demand for the raw commodity. In turn, this increase in demand for the raw commodity would drive up raw commodity prices due to producers suddenly chasing too little quantity. As such the input price index would increase.

The last period, Period 5, is for the year of 2009. Steel consumption peaked in mid-2008 while the effect of the Global Financial Crisis resulted in a lagged negative demand shock starting in early 2009. The negative demand shock caused fewer goods to be consumed. Economic theory indicates that consumers still in the market would pay a lower price for the goods due to the sharp drop in demand (see Figure 4.3.8.4 on decrease in demand). Once again, Figure 4.3.8.6 provides a good indication that during 2009 the movement in demand and supply had links to the input and output price index of the steel manufacturing industry in Australia.

Overall, the example of the steel manufacturing industry has shown that fluctuation in demand and supply has relevant links to the movement of input and output price indexes. The analysis will now turn to examining the third element under the Keynesian factors, market pressure or power, also using the steel manufacturing industry as an example.

The third element which can attribute to the output price inflation is the amount of market pressure that the producer is subjected to. Generally, producers who are subject to less market pressure (i.e. limited competition), or those with substantial market power, can charge a premium on top of inflation generated by the demand pull and cost push factors. Furthermore, in situations where demand outweighs supply, producers can charge an even higher premium.

Forces like cost push and demand pull can affect the direction of the movement. The market power position of the producer enables the producer to set their own prices to maximise profit and this has an effect on the resulting inflation. This phenomenon may help explain why an output price index in some situations is inflating faster than its input counterpart. Table 4.3.8.3 shows the difference between the inflation indicated by the input and output price indexes for the steel manufacturing industry.

Table 4.3.8.3. Comparison of annual inflation for ABS Input and Output PPI with difference – Steel products example

Time Period	**Input - Basic ferrous metals**	**Output - 2110 Iron smelting and steel manufacturing**	**Difference**
2003-09	5.60%	8.97%	-3.37%
2005-09	5.55%	8.18%	-2.62%
2007-09	3.55%	6.44%	-2.89%

Over an eight-year period, the Output PPI 2110 Iron Smelting and Steel Manufacturing average annual inflation was greater than its input index counterpart by more than 2.5%. The most likely explanation of this substantial difference in inflation between the input and output indexes is due to the high concentration of the market and these companies exercising their market power. In Australia, the steel manufacturing industry can be seen as similar to a duopoly market structure.

Firms with substantial market power can be price setters. The difference between the input and output price inflation indexes could be as a result of producers in a highly concentrated industry not being afraid of the possibility of losing customers to rival firms or of customers substituting to other products when they are setting their output prices.

The iron and steel industry in Australia is dominated by two firms aggregated to a share of close to 99% of the market. In such situations, economic theory suggests that output prices may often include a premium (i.e. extra profit) as there would not be any adverse impact on sales even if prices were high. The analysis and results in the current research further supports the proposition that the inflation of output prices for this example, steel manufacturing industry, will be higher than input cost changes due to oligopolies or even a monopoly exercising their market power.

Multiple Index approaches – Material

Under the Multiple Indexes approach there are no other suitable or relevant indexes, other than the output index, to calculate the composite inflation for the specialised defence contract. This is because the benefits of using the Multiple Indexes approach lies in its ability to select a range of indexes and allocate weights which best reflect the specialised procurement cost structure. The price change movement of an output PPI like 2110 Iron Smelting and Steel Manufacturing is sourced from the commercial market. The defence contractor is subject to the same pricing conditions and inflation movements as the rest of the producers in its respective industrial sector for the material purchase.

This proposition could be illustrated using the following example of steel. The raw materials or input to make steel are coking coal and iron ore. Since defence contractors are buying steel for the production of combat vehicles, it is irrelevant to compensate them according to movements in the raw material of iron ore. The Multiple Indexes approach is concerned with compensating for the fluctuation in the material cost (i.e. steel) to the defence contractor. Therefore an output index such as those from steel manufacturing is relevant to the defence contracting purposes under the Multiple Indexes or Cost Components approach.

Single Indexes approach – Material

The benefit of the Single Index or Finished Goods approach is to use a single index to calculate the inflation. The use of an output index like ABS PPI 2311 Motor Vehicle Manufacturing will capture factors such as productivity, labour, market pressure and material cost.

If the contract was to use an input index instead, then the price variation formula would require an insertion of a labour component and an adjustment factor for productivity gain and market pressure. The price variation under this revised approach is referred to in this research as the 'Finished Goods approach–extended version', and can be depicted as shown in Figure 4.3.8.7.

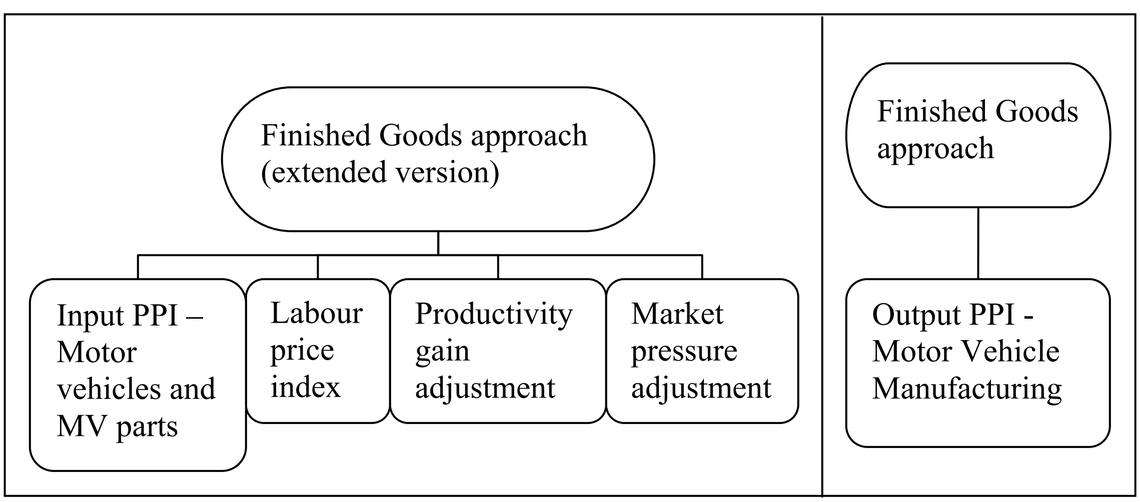


Figure 4.3.8.7. Comparison of the Finished Goods approach with its extended version

The extended version of the Finished Goods approach may be considered a hybrid of the Cost Components and Finished Goods approaches. The extended Finished Goods approach requires an index and adjustments for labour, productivity, and market pressure. All of these are also necessary under the Cost Components approach. However, the benefit of the Multiple Indexes (or Cost Components) approach is that the composite inflation is calculated by identifying each of the significant cost components indexes and allocating appropriate weights to each component to reflect the nature of the specific specialised contract.

On the other hand, the Finished Goods approach-extended version which uses the input price index is effectively forced to use the material categories and weighting patterns that are determined by the statistical agency which publishes the index. The weighting pattern of an Input PPI from ABS is derived from the Australian National Account Input-Output tables. The Input-Output tables are a collection of detailed information on the supply and use of products in the domestic economy and the structure of, and inter–relationships between, industries (ABS, 2010e). Therefore, the weighting patterns can differ for specialised materiels, such as a combat (or armoured) vehicle differs to a commercial vehicle. The weights are a key element in the construction, as for example a 10% rise in inflation of steel or structural steel may have a greater impact for a manufacturer of combat vehicles than commercial vehicles. This could simply be due to the fact that more steel may be required for the armoured body of the combat vehicles. As a result, this difference in weighting patterns can cast doubt on the relevance and accuracy of the inflation calculated under the Finished Goods approach - Extended version for the particular defence contract.

The difference in weighting patterns between combat and commercial vehicles is discussed further in Chapter Seven under ‘Illustrative Application’. The illustrative application example will examine whether there is any significant difference in inflation patterns as a result of the two distinct weighting schemes.

If input indexes are to be used in either Single Index or Multiple Indexes approaches then they will add to the complication, without adding to the accuracy or being reflective of the specialised contract. Consequently, this research does not recommend using input PPI if it can be avoided.

Treatment of specific products by statistical agency

It is important to note that with certain industries, the price movement of its Output PPI is not what it may seem. This is because recording the final sale or transaction price for certain products is not as straightforward as may be desired. The shipbuilding industry is a classic example. Despite desirability that the output price index should be a measure of the 'final sale price movement', for an industry like shipbuilding which produces 'unique' products, that particular output price index could be a measure of two movements–final price (single pricing) and/or component pricing.

For a statistical agency, the creation of the output price index on the shipbuilding industry is difficult due to the fact that a product like a ship is usually produced over a long time and it is an outcome of a contract which is often custom-made (ABS, 2006b). Accordingly, it would be difficult to price the output (i.e. a ship) on, for example, a monthly or quarterly basis, in line with other indexes published by the statistical agency.

The ABS uses 'model pricing' as the solution to this problem created by the lack of transaction pricing for 'unique' products. ABS (2006b) describes a unique product as one where it is only manufactured once to the specification of a customer. For example, while the basic designs of ships are similar, the features of each ship could be different. This difference could be the result of the various engines types, propulsion systems, navigation equipment, and so forth. As such, since a replica of the same ship is rarely made, or intended to be made, the uniqueness of such a product could result in difficulties in pricing the same specifications over time. Yet, model pricing aims at capturing the market conditions that the producer would have faced at some particular period, for example, monthly or quarterly (ABS, 2006b).

The techniques used to collect data from respondents who manufacture 'unique' products are often individually tailored, due to model pricing requiring the pricing of a 'notional' product. A notional product could be one that is based on a previous sale or it could be hypothetical in nature (ABS, 2006b). There are various techniques used to collect prices for model pricing. One of these is estimating the final sale price. Another is collecting prices for individual components and combining the prices into one final price. Therefore, as a practical matter, the inflation movement of the Output ABS PPI 2391 Shipbuilding and Repair Services is already effectively a combination of both the Single Index and Multiple Indexes approaches which this research has been examining.

As noted previously, IBISWorld information indicates that approximately 70% of revenue in the current Australian shipbuilding market was from government purchases. Therefore, the coverage of the ABS PPI 2391 Shipbuilding and Repair Services, to some extent, would be more representative of defence procurement than most other ABS indexes. On the basis of the arguments stated above, the current research concludes that for a unique procurement like that of a warship, the use of the Output PPI under the Finished Goods approach, which is inclusive of movement from single and component pricing, may be simpler to use than the Cost Components approach. This is because the practice of choosing a 'basket' of multiple indexes under the Cost Components approach becomes redundant in some way, as it has already been completed by respondents and/or statistical agency in publishing the Output PPI for a 'unique' product manufacturing –like that from the shipbuilding industry.

Summary on Output Indexes – Material

In summary, input and output indexes reflect different concepts which do not necessarily move in unison. The movement of output prices is more complicated as it can be influenced by factors that are explained by economic theories such as cost push, demand pull, pricing power, and sticky pricing. The output index also caters for factors which were ignored by the input index like labour cost and productivity. Hence, use of an output PPI under both the Single Index and Multiple Indexes approach would better reflect inflation relevant to the materiel contract than an input PPI.

Since output indexes are less volatile than input indexes, the use of the input indexes will not satisfy the next selection principle, namely that acceptable indexes cannot be too volatile. Furthermore, for certain industries which produce 'unique' products like ships, the use of an output PPI under the Finished Goods approach may be sufficient as this output index is effectively a measure of combined inflation from both the Single Index and Multiple Indexes approaches.

Based on the current analysis, similar reasoning could be applied to other international Input and Output PPI indexes if the two types were published[14]. This current analysis therefore supports the use of Output ONS PPI indexes over input indexes for contract price variation purposes where possible.

Labour component

It should also be noted that a labour component is required in the price variation under the Multiple Indexes approach. Since labour is usually viewed as an input by construction, most labour cost indexes are input indexes. If an input index is used, then it is necessary to consider whether there needs to be an adjustment to account for productivity. Considering, the preceding analysis found output indexes to be preferred over input indexes for price variation purposes, it would be beneficial to consider whether an output originated index which captures labour cost may be available.

Research outcomes–labour

The most relevant index which measures the movement in wages in the Australian case are indexes characterised under the series of ABS 6345 Labour Price Index (LPI). There are three indexes sub-series from the LPI Ordinary Time (excluding bonus) series which best fit defence contract purposes, these are: (i) Manufacturing; (ii) Professional, Scientific and Technical Services; and (iii) All Industries. The inflation movement referenced by the index of 'All Industries' is a composite inflation measure which includes movement from 18 different industry divisions: Mining, Construction, Trade, Education, and fourteen others.

An analysis of the three ABS 6345 LPI–Ordinary Time Hourly Rates of Pay excluding Bonuses indexes relevant to defence over the last decade is discussed below.

[14] Input PPI are not published by the BLS.

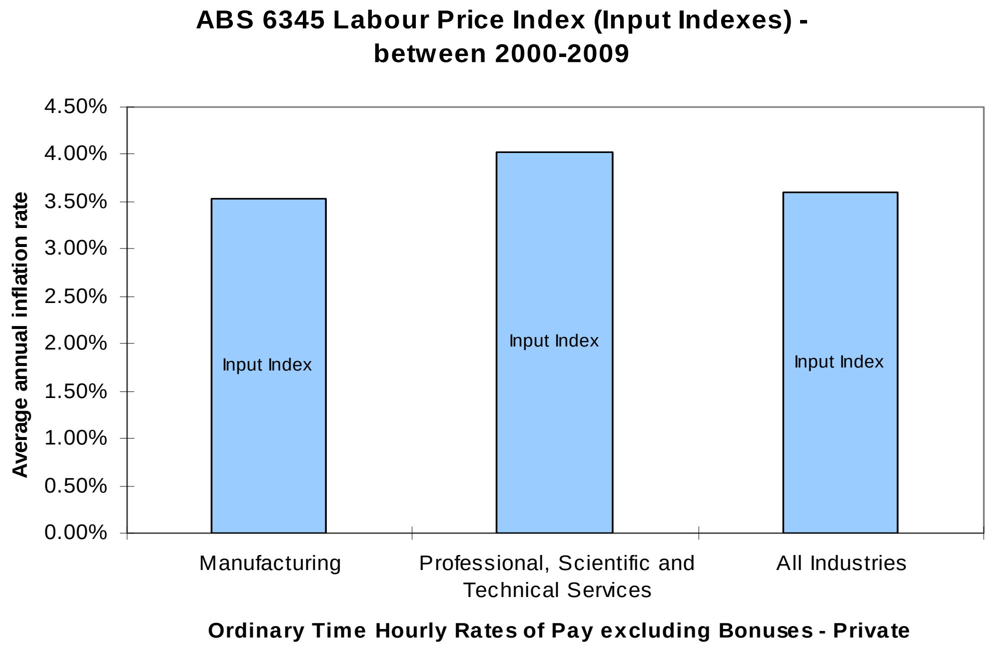


Figure 4.3.8.8 Annual inflation of sub indexes under series of ABS LPI

Figure 4.3.8.8 shows the average annual labour price changes for the category of Professional Scientific and Technical Services was approximately 0.5% higher than the other two categories.

One of the problems associated with using an input index is that the index itself fails to cater for productivity generated from the production process. The LPI is an input price index which measures the cost of purchasing a fixed quantity and quality of labour input, irrespective of the output produced. Hence, inflation referenced by the LPI does not account for the productivity gain arising from capital investment, technology improvement, or improvements in the efficiency of the process. The LPI, being an input index, does not reflect market pressure. To cater for this problem, if any index is used from the series of LPI–Ordinary time, then an adjustment needs be made to the price variation formula in order to obtain the most accurate measure of inflation. This adjustment to productivity in the price variation formula is discussed in Chapter Five.

Furthermore, there is a concern relating to the broad classification of a certain category in the LPI series. The labour price change for an engineer is grouped together with other very differently skilled professionals, such as accountants and lawyers, under the class of ‘Professional, Scientific and Technical Services’. The activities of engineers, accountants and lawyers are not alike; hence their activities are not totally homogenous. The criterion of ‘relevant degree of disaggregation’ has already been discussed and examined in detail. An index is only classified by the current research as ‘appropriate’ for use in price variation purposes if it is homogeneous in the activities associated with the procured product or service of interest. Hence it is vital for labour cost to be escalated as closely to the services performance required of that particular contract. The classification or basis of the LPI - Professional Scientific and Technical Services results in the actual labour market movement being less representative as a result of being combined with other unrelated occupations.

Since the weighting pattern for LPI at the class level is not published by ABS, it is not possible to ascertain how much any one occupation (for example, engineering or accounting) contributes to the overall LPI - Professional Scientific and Technical Services. Therefore, it is not possible to ascertain the exact labour price movement for engineers or accountants due to the broad classification by the ABS.

Alternatively, it would be beneficial to consider whether an output originated index which captures labour cost may be available. As noted above, for price variation purposes an output index is recommended over an input price index. The current analysis found one service industry that is relevant to defence procurement purposes, this is the Division of Professional, Scientific and Technical Services. These output indexes measure changes in the price of services provided by producers of professional, scientific and technical services.

The division of Professional, Scientific and Technical Services are divided into detailed groups and classes. There are four indexes which are relevant to defence contracting, these are 6923 Engineering Design and Engineering Consulting Services, 6931 Legal Services, 6932 Accounting Services, and 7000 Computer System Design and Related Services. Figure 4.3.8.9 depicts the average annual inflation for each of these four service industries between 2000 and 2009.

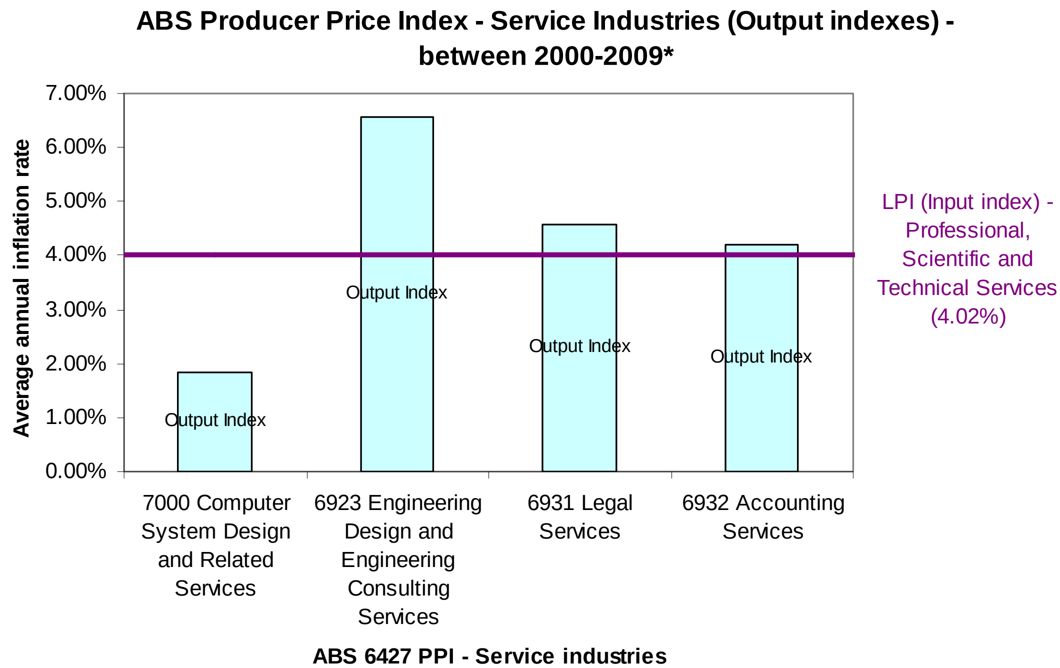


Figure 4.3.8.9. Comparison of ABS LPI and PPI (Service Industries)

*Index 7000 Computer System Design and Related Services first published in the Quarter of Sep 2001. Furthermore, index 7000 can also be referenced as index 700.

Figure 4.3.8.9 shows that the price movement in the engineering services industries (i.e. 6923 Engineering Design and Engineering Consulting Services) was much greater than those observed by the LPI–Professional, Scientific and Technical Services. On the other hand, the price movement for the industries of computer services (i.e. 7000 Computer System Design and Related Services) was well below those observed of the input LPI.

However, it is important to note that, there is no Output Services PPI for the manufacturing division. This is because manufacturing is not a service industry. Also there is no Output Services PPI by the classification of ‘All industries’. Therefore, the use of input index like ABS LPI–Ordinary Time–Private–Manufacturing may need to continue as there is no other feasible alternative.

Considering the limitations associated with the broad classification of the LPI, the use of specific services industries PPI would provide a better alignment to the labour categories in individual contracts. Furthermore, the use of an output index, where possible, would avoid the need to adjust for productivity. Indexes from the ABS LPI series should only be used when there are no comparable indexes from Output Services industries PPI.

Following the same reasoning, where available, the use of Output Service PPI is also recommended for international counterparts. For US indexes, the BLS also publishes services PPI at fourth dissection (i.e. NAICS industry) such as Offices of Lawyers and Engineering Services. Therefore, Services PPI from BLS are also recommended as an alternative to input index series like the BLS ECI.

While the same reasoning found above should be applied to the use of UK indexes, a complication is that ONS Services PPI (SPPI) is still a relatively new publication, and the ONS is still expanding the coverage of SPPI. Therefore out of the 32 SPPI currently available, only one index could be useful for defence contracting. This is the SPPI of Computer Services. A recent updated ONS SPPI revealed that indexes for service industries like Legal Services, Accountancy and Engineering, to name just a few, are still being developed (Jenkins, Jones and Pegler, 2010). However, this research recommends extreme caution in using the SPPI of Computer Services and/or any index from the ONS SPPI series. This is because the publication of the SPPI only officially began in 2010 and as such, there could still be some drawbacks in its coverage and conceptual basis.

However, this problem could be overcome as the current ONS PPI series do publish two indexes for work performed for repair and maintenance. The two indexes that could be seen as most relevant to defence needs especially in repair and maintenance are ONS PPI MM22 33.15 Repair and Maintenance of Ships and Boats, and ONS PPI MM22 33.16 Repair and Maintenance of Aircraft and Spacecraft. As a result, due to the limitation (i.e. its experimental nature) of the ONS Index of Labour Costs per Hour, it is recommended these two ‘repair and maintenance’ PPI be used instead where applicable.

4.3.9 Not too volatile

Rationale for considering this criterion

Prices inflate and deflate at different rates. Sometimes, the price change movement is gradual and steady while at other times, the movement is dramatic. A typical way to characterise price fluctuations would be to measure the historical volatility, calculated using the standard deviation in the price index series over some period. A low standard deviation indicates that the data points tend to be very close to the trend line. The larger the standard deviation the more widespread the price change movements and the more volatile the associated price index. An index that is too volatile is typically not ideal for contract price variation purposes.

Research outcomes for defence: 'Not too volatile' criterion

Figure 4.3.9.1 shows the movements for Australian steel manufacturing and shipbuilding industries over the past two decades.

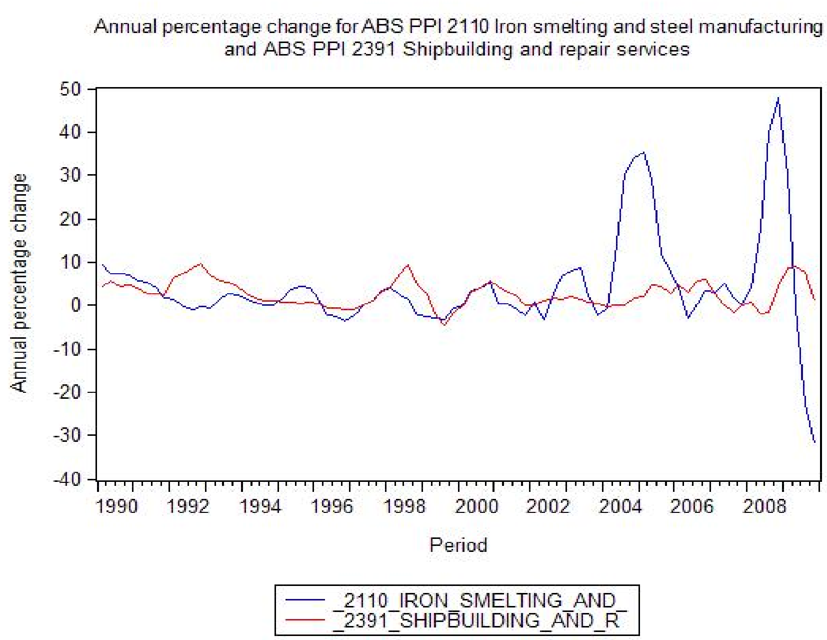


Figure 4.3.9.1: Comparison in annual inflation of ABS PPI 2110 and PPI 2391

Figure 4.3.9.1 shows that the annual percentage changes in the ABS PPI 2110 Iron Smelting and Steel Manufacturing are more volatile than those for ABS PPI 2391 Shipbuilding and Repair Services, particularly in recent years.

Continuing from the steel manufacturing and shipbuilding analysis, using a tolerance of one standard deviation, it can be seen that the index of 2110 (i.e. steel manufacturing) is more volatile than the index 2391 (i.e. shipbuilding) since the standard deviation value for the former is 11.48% while the latter value is only 3%.

Based on the group of defence relevant ABS indexes analysed, it was observed that there was a large variation between the standard deviations of different indexes. The lowest standard deviation was 1.7% while the highest was 20.6%. On examining the standard deviations recorded for all ABS indexes analysed, it was found that, ranking the indexes in order of their volatility as measured by their standard deviations, there was a tightly packed group of low to medium volatility indexes with the first clear gap between the volatilities occurring as standard deviation values jumped from 7.6% to 9.9%. After this level, there were substantial jumps in the volatility measure of the ranked indexes. Based on these observations, in order to avoid arbitrary classification of indexes as either 'too volatile' or 'not too volatile', the current analysis proposes that a volatility tolerance of 1 standard deviation for a period of one year be set at around 8%. Appendix B presents the standard deviations for the ABS indexes analysed in this research.

On these bases, the current analysis observed that out of the group of ABS indexes analysed, only five ABS indexes had a standard deviation greater than 8%. The majority of these five 'volatile' indexes are from industries such as chemical, primary metal and fabricated metal manufacturing. To some extent all these industries are known for their volatility in pricing.

Furthermore, similar results were found for the US and the UK defence related indexes (see Appendix C and D), where a more extensive list of indexes were examined, and hence an 8% tolerance is recommended in all three cases.

There are three ways in which this dilemma, index being too volatile, could be managed. One possible solution is to avoid using the 'volatile' index and instead use an index at an aggregation higher than the 'volatile' index itself. For example, the replacement for ABS PPI 2132 Aluminium Smelting would be ABS PPI 213 Basic Non-Ferrous Metal Manufacturing. It is often possible that due to the larger sample size in the second or third dissection index that the volatility in price movement would have been diluted, resulting in more stable aggregate inflation movement being reflected in these higher level indexes.

However, as discussed previously, caution should be exercised if for contract price variation user was to use an index higher than the fourth dissection, as this conflicts with the selection principle of 'relevant degree of disaggregation'. Aggregation of an index at various levels can result in the indexes being diluted with movements from less homogenous activities that are not related to the product or services of interest. The current research view that the criterion of 'relevant degree of disaggregation' is relatively more important than the criterion of 'not too volatile', since an index which is stable but not representative of the contract procurement could, to some extent, be seen as pointless for price variation purposes.

Another solution is to continue to use the 'volatile' index but to monitor it constantly. Continuous monitoring enables abnormalities in the index movement to be identified immediately. Furthermore, it enables any inflation or deflation to be discussed between the contractual parties.

The third resolution is to utilise techniques such as 'smoothing' to calculate the contract inflation rate. The assumption is that businesses often hedge their material risk when they are operating in a volatile market. Recall that the five 'volatile' ABS indexes found by this research are all indexes which would normally be used under the Cost Components approach. It is highly possible that a firm might not be subject to the same magnitude of volatility as indicated by the index. This area is discussed in detail in Chapter Five under the section 'Long-term contracting'.

4.4 Summary: Finalised set of recommended indexes under the two price variation approaches

In summary, the first stage in calculating the ‘true’ defence-contract-relevant inflation is to select the ‘appropriate’ index or indexes. Based on the nine index selection criteria listed and analysed by this research, Appendix E to G shows a list of the refined set of appropriate indexes from ABS, BLS, and ONS which have been deemed as ‘appropriate’ for defence contracting purposes by this research. However this list is not exhaustive, as introduction of other indexes from other countries is still possible provided they are subjected to the same selection criteria. Once an appropriate index (or indexes) is selected, the user will then need to correct the biases associated with these indexes in order to calculate the ‘true’ defence-contract-relevant inflation with improved accuracy. This issue is examined in the following chapter.

Chapter Five

Bias and correcting adjustment analysis

It is well known in the economic literature that the construction of price indexes can result in inherent measurement biases which produce under or overstatements of the ‘true’ inflation. Furthermore, the uniqueness of the defence industry can also mean that the inflation referenced by the index may not align with the ‘true’ defence-contract-relevant inflation. This chapter is devoted to examining this topic with a view to providing guidelines for correcting these biases.

5.1 - Bias analysis

The second stage in calculating the ‘true’ defence-contract-relevant inflation is to correct the bias associated with the selected indexes. Where possible, the analysis will use the example of combat vehicle procurement to illustrate the direction of biases. Therefore, under the Single Index (or Finished Goods) approach the Output PPI ABS 2311 Motor Vehicle Manufacturing will be used as an example. For the Multiple Indexes (or Cost Components) approach, indexes of Output ABS PPI 2110 Iron Ore and Steel Manufacturing and/or Output ABS PPI 1914 Tyre Manufacturing will be used as reference.

Furthermore, taking into account that indexes from the BLS and the ONS share a similar structure to those published by the ABS, similar reasoning could be applied in the use of these two sets of international indexes.

5.1.1 Coverage bias

Source of coverage bias

Price changes can vary considerably across products and industries. The items included in the index affect the movement of the price index. One form of error or bias occurs when coverage practices specifically developed by the official data agency do not align with the purposes of interest of particular users.

Chapter Four recommended that certain indexes be chosen from the series of ABS PPI and ABS LPI at the relevant level of dissection/disaggregation suitable for defence price variation purposes. Since there are many sub-indexes within these two index series, which are typically constructed to refer to individual industrial sectors, a bias may arise if the sub-index value of inflation is referred to or used for sectors that differ from the industrial sector for which it is primarily defined. This is similar to the previous discussion on using an index that has a relevant degree of aggregation. Ideally, an index has more relevance if it is sourced from items or activities that are homogenous in their nature. As examined in Chapter Four, the use of the index - ABS PPI 2311 Motor Vehicle Manufacturing, for the procurement of vehicles is more appropriate than the use of the ABS PPI 231 Motor Vehicle and Motor Vehicle Part Manufacturing index. This is because the coverage of the latter index includes price movements from industrial sectors such as vehicle parts and trailer manufacturing. It can be a source of error if the price changes for other sectors differ from the specific industrial sector of interest. Therefore, coverage biases arise if the coverage of the index differs from the items or activities relevant to the users' purposes.

Impact of coverage bias under the Finished Goods index approach for defence contract

Firstly, due to the defence industry being a relatively small portion of the overall manufacturing industry, the coverage of published indexes based on the standard classification would be dominated by manufacturing activities of a commercial nature. The characteristics of defence equipment differ to their commercial counterparts. Due to specialised requirements, often modified-off-the-shelf[15] or newly designed goods are procured. However, the price movement of a 'unique' product or 'unique' industry are often excluded from the published index or may be given little coverage. This is sometimes due to defence products/industry being relatively small in comparison to the overall industrial sector. Cases of total exclusion of defence procurement are discussed later under the new goods bias.

[15] Modified-off-the-shelf (MOTS) refers to an off-the-shelf product that has been modified or customised by a producer to respond to specific military requirements.

The difference in the characteristics between commercial vehicles and specialised combat vehicles can cause an implicit coverage bias. Since the specification and capability for defence and commercial purposes are different, the sale price will vary as well. When setting a sale price, a firm considers a range of factors such as production costs, market position, demand from the market, productivity, rate of return, as well as other factors. Undoubtedly, production costs can have an impact on the sale price, and these average sale price changes are reflected in the Output PPI. Since the material and labour composition between commercial and combat vehicles is different, their production costs and ultimately their sale prices will differ. Yet, the coverage of the Output PPI may in fact fail to capture price movements from minor markets like the defence industry.

To illustrate the defence-specific dilemma associated with the coverage of indexes, the following example ignores the effect of all other factors that a firm usually considers when setting the sales price–except production cost. Firstly, suppose that the armoured capability of the vehicles requires extensive labour work. Secondly, suppose the commercial vehicles have a material and labour mix of 0.6 and 0.4 respectively, and the combat vehicles have a material and labour mix of 0.3 and 0.7 respectively. The labour weight for commercial vehicles (0.4) is lower than the combat vehicles' weights (0.7). Therefore, the corresponding inflation for labour would be different. If the labour index inflated at 4% p.a. then the inflation for the commercial vehicles' labour component would be 1.6% (i.e. 4% x 0.4); whereas the combat vehicles' labour inflation would be 2.8% (i.e. 4% x 0.7). Correspondingly, due to the different labour share in this example, the labour cost inflation experienced by the defence contractor is higher than what is seen in the commercial environment.

Another added dimension is when manufacturing combat vehicles requires labour more specialised than what is required for commercial vehicles. As Dunne (2006) has indicated, typically defence industries have a higher proportion of engineers and scientist and/or with a higher level of qualification (i.e. more highly skilled) than other industries. Generally, due to the specification of combat vehicles, this causes the commercial and combat vehicles to differ in the characteristics/skills of labour required to manufacture these vehicles. In this case, costs would be higher for the defence industry, which would also lead to inflation to be higher as well. However, the published labour price index may not reflect the requirement of more specialised labour being used in the defence industry.

Furthermore, suppose the characteristics of some of the intermediate materials also differ. For example, in comparison to standard commercial vehicles, the combat vehicles require more steel. Classic economic theory suggests that firms will minimise their costs where possible in order to maximise their profit. If costs are rising, as is typical, but relative prices are changing, firms shift purchases of materials to those below the average relative costs. For example, substituting one grade of steel for another if the price is too high. The Isoquant graph in Figure 5.1.1.1 depicts two ways of looking at rational economic behaviour, incurring less cost or producing more from the same expenditure on inputs.

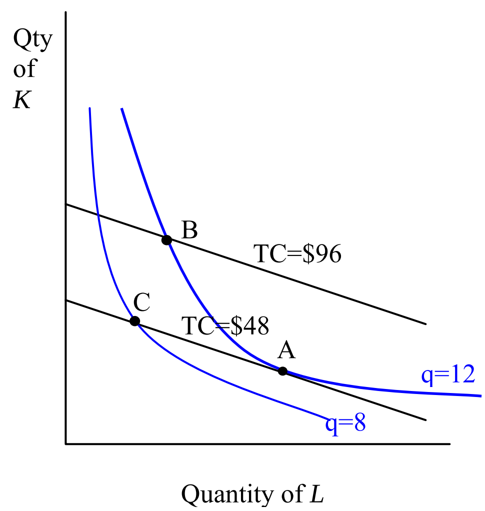


Figure 5.1.1.1. Isoquant for various quantities of labour and capital

In the first instance, a firm prefers point A over point B, because by both producing 12 units of output, point A costs $48 while point B costs $96. In the second instance, a firm prefers point A over point C. Although the costs for both are $48, point C only produces 8 units instead of 12 units. This means that the inputs of point A generated greater volume of output than point C.

However, defence contractors are often unable to substitute intermediate materials due to reasons such as defence's safety requirements and tailor made specifications. Also, defence contractors may experience resource scarcity more frequently than other firms due to their specialised material requirements. This means that the pricing movement captured by the publicly available index being dominated by commercial production is not reflective of the defence contractor's environment at the elementary data level. Since substitution of materials may not occur, the defence contractor would still be purchasing the material at a higher cost. Under this situation, the inflation on intermediate materials experienced by defence contractors is higher than those for commercial firms.

Given the likelihood that inflation for both labour and material cost is higher in defence production, ceteris paribus, the overall inflation of the defence items (i.e. combat vehicles) should also be higher than commercial vehicles. Since the published motor vehicle manufacturing index's coverage is mostly dominated by commercial production, the average price change is unlikely to be reflective of defence procurement. Due to such specialised characteristics of defence procurement, it is considered that published indexes tend to understate the inflation experienced by defence contractors. In theory, this understatement means that the user (i.e. DMO and defence contractor) needs to add the inflation impact generated by the coverage bias back into the Output PPI in order to obtain the correct inflation relevant to the individual defence contract. This could be expressed in the following format:

Defence-contract-relevant inflation = Motor vehicle mfg index + inherent coverage bias of Output PPI

Alternatively, it can also be expressed as:

Motor vehicle manufacturing index = Contract-relevant inflation - inherent coverage bias of Output PPI

This specialised labour and materials bias differs from the concept of substitution bias which stems from the Laspeyres index formula. The current bias refers to the coverage of activities in the published index's basket being non-representative of the defence procurement mix.

Impact of coverage bias under the Cost Components approach for defence contracting

The aim in using multiple indexes to generate a composite measure of inflation is to enable the major intermediate material and labour cost movements to be reflected in their importance to the individual contract. This is conducted by selecting several indexes and allocating weights to each index in the price variation formula which best reflects specialised procurement requirements. Based on these premises, price variation formulas would be specifically tailored for their particular contracts.

From the Cost Components approach of price variation, the Output PPI provides an inflation measure that is sourced from the commercial competitive market. Defence contractors are subject to the same pricing conditions and inflation movements as those in the industrial sector for their intermediate materials purchases. For example, the coverage of the ABS PPI 1914 Tyre manufacturing index is reflective of the tyre markets. As tyres are viewed as an intermediate material in the production of vehicles, the defence contractor like every other vehicle manufacturer is required to buy tyres at the competitive market rate. The coverage of the tyre manufacturing index is therefore reflective of the cost movement relevant to the defence contractor in obtaining the intermediate materials. Consequently, those published Output PPIs listed at Appendix E under the Multiple Indexes approach are appropriate for defence as well as for commercial purposes when calculating the contract relevant inflation under the Multiple Indexes approach.

It should be noted that the coverage of the LPI can be problematic for defence contracting. The LPI, being an input index, measures costs for the firm in the purchase of a fixed quantity and quality of labour input, irrespective of the output produced. Thus, in particular, the published LPI fails to account for productivity. The discussion of productivity is examined later under the productivity section. In short for the purpose of contract price variation, due to its index coverage, the resulting inflation from any LPI is overstated as it fails to account for productivity. As such, if productivity gains are expected, usage of the LPI will overstate the labour cost inflation.

Suppose the price variation formula for the contract is as follows:

Combat vehicles inflation = (0.15 × tyres inflation) + (0.15 × steel inflation) + (0.7 × LPI)

In the situation as shown in the formula above, if the LPI is overstated then the portion of the composite inflation that was contributed by the LPI would also be overstated. Of course the precise extent of overstatement would depend not only on the overstatement in the LPI but also on the importance of LPI in the composite formula. Only if the LPI experienced zero inflation would no overstatement occur.

By adding an adjustment to the formula, this overstatement of inflation can be corrected. This adjustment is similar to the productivity adjustment which is discussed later in the section of productivity.

5.1.2 Substitution bias

Sources of substitution bias

Indexes published by statistical agencies are usually computed using the Laspeyres index formula. Laspeyres indexes define the prices of goods or services, using quantity weights in a base period or region, and then an aggregation of expenditure on those goods or services to examine change over time or differences over space. However, economic literature often states that because the Laspeyres formula uses out-of-date quantity and weights information, it produces a measurement bias.

Substitution by producers can create biases in both output and input price indexes. In a competitive environment, firms switch production due to profit motives, but the Laspeyres formula does not account for such market movements. The Laspeyres formula, which uses base weights, will hold quantities constant at the base period despite any changes in quantity in the current market. Consider a simple case where all output prices are rising. However, the price rises are not uniform. Effectively, the Laspeyres formula fails to account for firms switching production to outputs that are priced above the average price increase. The outdated weighting information inherent in the Laspeyres formula is therefore unrepresentative of the ‘true’ price movement (i.e. efficient price change). The usual situation that is analysed is one in which firms are operating at capacity. Without increasing their resources they can nevertheless switch production to the product with the greater price increase, hence increasing their profits. At the margin, they simply move around their transformation curve. In this situation, economic theory predicts that the Laspeyres formula, which does not allow for the movement around the transformation curve, will systematically understate actual price movements for the Output PPI since relatively too little weight will be given to the greater price changes.

Despite the idealised result, the reality of substitution bias with Output PPI is more complicated as there are two-sides to the production switch decision. From a buyer's perspective, the buyer will switch due to their budget constraints, and will therefore demand cheaper goods where possible. Producers, in consideration of the buyer's behaviour, may switch to producing lower-priced goods. Generally, this can involve decisions to change capacity, or may be a decision taken in the presence of excess capacity. As a result, it is plausible that the Output PPI may overstate price movements. Figure 5.1.2.1 shows two diagrams which can provide a simple illustration of the demand and supply shifts in this situation.

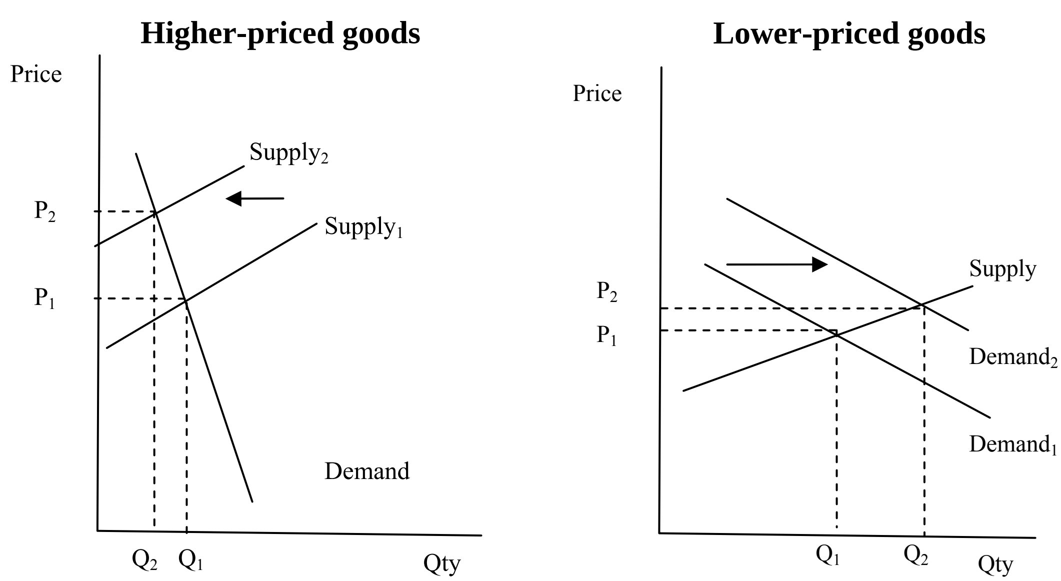


Figure 5.1.2.1. The (Counterintuitive) Case: Laspeyres Output Price Index Overstates Inflation

Figure 5.1.2.1 shows the effects on prices and quantities when firms switch production to those goods in heavy demand. This shift can occur even when the relative output price rises more for lower-demand goods. The situation depicted is one in which more profit is to be made by the firm switching to produce more of the lower-priced goods. Yet the Laspeyres Output PPI, which uses Q1 weights, will fail to account for this switch and will give too much weight to the large increase in higher-priced items and low weight to the smaller increase in lower-priced items. Therefore, the production switch theory can also imply that the inflation reflected by the Output PPI is overstated.

Despite this demonstration that the situation can arise when firms switch to producing more of the product whose price has risen less (because of the dominance of the greater demand), the general consensus in the literature is that it is more likely on average that firms will switch to production of those items that have risen more in price. This is more likely when firms are already near capacity and the decision at the margin is simply on the most profitable allocation of outputs, not requiring simultaneous consideration of changes in the size and resource mix of the firm. If the consensus view is conceded, therefore this inherent measurement bias, as a result of the fixed weights structure with the Laspeyres formula, in fact understates the 'true' inflation because it fails to give greater weight to the relatively higher priced item.

∴ Output PPI = 'True' inflation – inherent substitution bias of Output PPI

However, even if the consensus view is accepted, a caveat based on the above demonstration should be noted. On balance, with these countervailing forces, substitution bias in the case of the Output PPI may not be substantial because of these two opposing forces, which would tend to cause some reduction in the overall bias.

The direction of substitution bias is more straightforward to analyse if an input index is used instead. The previous section has already investigated and concluded that input PPIs are not appropriate for defence contracting purposes. However an LPI, being an input index, will suffer from an upward substitution bias, meaning such indexes have been overstated. To briefly illustrate the reasoning behind this, suppose a firm hires both technicians and engineers and the engineers' wages increase faster than those of technicians. As a result, the firm tends to substitute using technicians to perform less specialised parts of the duties previously conducted by the engineers. Since fewer engineers and more technicians are employed now compared to the base period, the Laspeyres formula being fixed quantity will have in fact provided engineers with too much weight while technicians have been given too little weight. Economic theory predicts that the Laspeyres LPI, due to its construction, overstates the average change in labour cost.

∴ LPI = 'True' inflation + inherent substitution bias of LPI

Impact of substitution bias using the Finished Goods approach for defence contracts

While substitution bias can cause an inherent understatement of the Output PPI, the impact differs between commercial industries and a monopsonistic industry with a specific charter, such as the defence industry. Substitution bias causes the Output PPI's inflation to be understated when firms switch production relatively easily in the commercial sector. However, it is not unusual for defence procurement to be of either modified-off-the-shelf or newly designed goods. This specialised nature means that the majority of defence contractors are unlikely to be able to switch production effortlessly. Additionally, if the producer is contracted with DMO to produce a certain number of vehicles, then the producer with limited resources for rapid expansion is unlikely to be able to switch production despite the defence product being lower in profitability, relative to other products. Due to the defence's uniqueness, the inherent understatement in the published index caused by the substitution bias is not applicable to defence contracting. At least with respect to this consideration, inflation referenced by the likes of Laspeyres motor vehicle manufacturing index, is likely to be reflective of the 'true' inflation for defence procurement.

∴ Output PPI (such as Motor Vehicle Manufacturing index) ≈ Defence-contract-relevant inflation

Impact of substitution bias under the Cost Components approach for defence contracts

On the other hand, the inherent substitution bias remains if the overall inflation is calculated by use of a collection of multiple indexes. The use of indexes such as a tyre manufacturing index or a steel manufacturing index is intended to be reflective of the individual cost elements relevant as much as possible to the defence contract.

As discussed above, substitution bias generally causes an Output PPI constructed using the Laspeyres formula to be inherently understated, though possibly not to a large extent due to countervailing factors previously discussed. However, any inherent understatement within the tyre manufacturing index would be directly carried over to the composite inflation calculated by the price variation formula under the Multiple Indexes approach. Therefore, the inflation calculated by the collection of multiple indexes, in theory, understates the 'true' inflation for the defence contract. However, if the price variation formula also contains a LPI, then the LPI, which contains an inherent overstatement, may potentially offset all or part of the understatement caused by the PPI.

Therefore, whilst the tyre manufacturing index and the LPI (manufacturing) individually and respectively contain an inherent under and overstatement of the 'true' inflation, the impact may be neutralised for defence-specialised procurement when it is combined in the same formula to calculate the composite inflation for a particular defence contract. This concept could be illustrated as follows:

∴ Defence-contract-relevant inflation = (Tyre manufacturing index inclusive of understatement from inherent substitution bias) + (LPI inclusive of overstatement from inherent substitution bias)

5.1.3 Quality improvement bias

Source of quality improvement bias

As time lapses, advances in technologies enable the quality of goods, and even services (e.g. maintenance services), to improve. Changes in technology normally result in two possible outcomes, namely improving the quality of goods and/or reducing the cost of production. The analysis of reduction in cost, which can also be seen as an increase in efficiency, will be discussed later under the subject of 'Productivity'. Nonetheless, the fixed quantity in the Laspeyres formula ignores the effect of quality improvement.

In order to maximise profit, firms switch production to either produce items that are relatively better in quality or cheaper in production cost. Items which are better in quality are priced higher, resulting in higher profit if the higher quality arises from technological improvements that generate better quality at comparable cost. For example, if one was to buy a vehicle and there was a choice between the 2010 or 2011 versions, then in general the older version (i.e. the 2010 model) would be priced to be cheaper than the newer version. This is because the new model would typically possess better features than its predecessor. The improvement in these features means the latest version is better in quality than the older version. The higher price of the 2011 version is also due to it being 'better in quality'.

However, the fixed quantity in the Laspeyres formula, which is used to calculate the relevant index, does not recognise that the price of the product now reflects it being of better quality than its predecessor. Therefore, the inflation is overstated as the higher prices are not aligned with the greater quality improvement of the product. In other words, quality adjustment bias generally causes the published Output PPI to inherently overstate the 'true' inflation.

∴ Output PPI = 'True' inflation + inherent quality improvement bias of Output PPI

Impact of quality improvement bias using the Finished Goods index approach for defence contracts

Whilst quality improvement/adjustment bias overstates the inflation reflected in published indexes, its effects on defence procurement can vary under different situations. In one situation, this overstatement of inflation is magnified when the market improves the quality of an item not relevant to defence. If the quality has not improved for the defence items, then there is no reason why the price should rise for defence procurement–this adds to the inherent overstatement of inflation.

On the other hand, there are situations which can counteract or reduce some degree of the inherent overstatement. For example, when the quality improvement occurs in both defence and commercial variants of an item, but where the quality improvement in defence materiel is greater than commercial variants. If the defence industry makes a greater quality improvement, then it is reasonable to assume two outcomes. Firstly, the particular item will generally be priced higher than its previous version. The second outcome is that the defence variant of the item is priced higher than its commercial counterparts.

For the purpose of illustration, assume the specifications of the defence vehicles and commercial vehicles are identical. Also assume that between the years 2010 and 2011, commercial vehicles has improved engines which enabled them to last for an extra X hours, whereas the defence vehicles' engines were improved to last for an extra X+500 hours. While such improvements are required and accepted by the defence, given the rate of quality improvement for the defence vehicles is greater, its price should also be higher than the commercial vehicles. In comparison, ceteris paribus, the defence vehicles' inflation should be greater.

However, given that defence procurement represents only a very small portion of the industry which the index measures, the weight assigned to the commercial item outweighs defence materiel. As such, the index mostly reflects commercial, and not defence, items. Since published indexes, like the motor vehicle manufacturing index, have been diluted by activities from outside the defence industry, this lowers the estimated inflation. The defence industry often uses cutting edge technology and due to its specialised nature, the rate of technology improvement is often higher than that of commercial items. Consequently, the inflation relevant to defence industry has been understated when using the published index. Since the quality adjustment bias causes inherent overstatement, the uniqueness of defence procurement may neutralise the inherent overstatement in the published index. The following formulas illustrate the results of these factors:

Output PPI MV mfg index = Defence-contract-relevant inflation + inherent quality improvement bias of MV Mfg index – bias from quality improvement in defence items greater than commercial production

If Inherent quality improvement bias of MV mfg index ≈ Bias from quality improvement in defence items greater than commercial production

Then Output PPI Motor Vehicle Manufacturing ≈ Defence-contract-relevant inflation

Impact of quality improvement bias under the Cost Components approach for defence contracts

On the contrary, the inherent overstatement of inflation as a result of quality adjustment bias remains if the overall defence-contract-relevant inflation is calculated under the Multiple Indexes approach. The use of an index such as the tyre manufacturing index is reflective of a specific cost element relevant to the defence contractor. However, quality adjustment bias causes each index to contain an inherent overstatement. This inherent overstatement within the tyre manufacturing index is directly carried over to the composite inflation calculated by the price variation formula under the Multiple Indexes approach. Therefore an adjustment is necessary in order to correct for this overstatement.

If Tyre manufacturing index = Defence-contract-relevant inflation + inherent quality improvement bias

Then Defence-contract-relevant inflation ≈ Tyre manufacturing index overstated by inherent quality improvement bias – bias correcting adjustment

Discussion of bias correcting adjustments is presented later in section 5.2.

5.1.4 New goods bias

Source of new goods bias

New goods are frequently introduced into the market. A bias arises when the published index does not adequately reflect the prices of new goods. There are two reasons that a buyer purchases new goods: either they are cheaper in price or better in quality. As such, the new goods bias is similar to the quality adjustment bias. The underlying assumption of both biases is that firms switch their production mix to either produce items that are relatively cheaper in production cost or better in quality. Items which are better in quality are priced higher, resulting in a higher profit. Similar to the quality adjustment bias, the Laspeyres formula fails to account for this switch in production. By holding the quantity constant, there are no weights assigned to the new goods while the weights assigned to the obsolete products have become too high. Economic theory suggests that the exclusion of new goods leads to published indexes inherently overstating inflation.

∴ Output PPI = 'True' inflation + inherent new goods bias of Output PPI

Impact of new goods bias using the Finished Goods index approach for defence contracts

One of the limitations of the coverage of indexes is that they do not cater for specific defence procurement. Due to its uniqueness, defence products and services may be excluded from the general basket of goods which statistical agencies use to compute indexes. This exclusion is similar to the new goods bias. The assumption of the new goods bias is that new goods delivered are better in quality and so, in quality-adjusted terms, should be lower in price. In fact, with many modern technological developments, especially in computers and electronics, prices have actually fallen when quality has improved. However, innovations in defence products normally do not lead to cheaper prices, but predominantly lead to better quality than their commercial variants. Similar to the reasoning presented for the quality adjustment bias, published indexes like the motor vehicle manufacturing index being diluted by activities that are not from the defence industry, results in inflation which is not reflective of defence needs, and typically is lower. Therefore, the uniqueness of defence procurement can offset, or reduce, some part of the inherent overstatement of inflation by the new goods bias.

MV mfg index = Defence-contract-relevant inflation + inherent new goods bias of MV Mfg index – bias with defence's quality improvement (similar to new goods bias) greater than commercial market

If Inherent new goods bias of MV manufacturing index ≈ Bias with defence's quality improvement (similar to new goods bias) greater than commercial market

Then Output PPI Motor Vehicle Manufacturing ≈ Defence-contract-relevant inflation

Impact of new goods bias under the Cost Components approach for defence contracts

The aim of using multiple indexes in the price variation is to cater for the uniqueness in the intermediate material and labour composition for each of the defence specialised procurements. When using cost components indexes, the inherent overstatement of inflation caused by the new goods bias remains. This is because the inherent overstatement within published indexes, like the tyre manufacturing index, will be directly carried over to the composite inflation calculated by the price variation formula. Therefore, the inflation calculated by the collection of multiple indexes, in theory, overstates the true inflation for the defence contract.

$\therefore$ 'True' inflation = (Tyre manufacturing index overstated by inherent new goods bias)

If Tyre manufacturing index = Defence-contract-relevant inflation + inherent new goods bias

Then Defence-contract-relevant inflation ≈ Tyre manufacturing index overstated by inherent new goods bias – bias correcting adjustment

Discussion of the bias correcting adjustments is covered in section 5.2.

5.1.5 Market competitiveness

Source of bias from competition

The publicly available index captures price movements of the industrial sector. These industrial sectors are generally competitive in nature. A source of bias arises when these indexes are used as inflation indicators for other types of market environments such as a non-competitive business environment.

In order to maintain its competitive advantage, a firm maximises its profit by reducing its production cost or becoming more efficient. The competitiveness of the market affects the rate of inflation seen in the output PPI which is a measure of sales price. When a firm determines its sale price, its pricing strategy involves analysis of the firm and its competitors' strengths and weaknesses. The pricing strategy varies depending on the size of competition in the market. Without competition, a monopoly producer can sell at any price. However, a producer in a competitive market needs to set its price appropriately. If the price is set too high, the firm loses its customers to its competitors. Therefore, competition causes the price for goods to be such that the firms do not earn excessive profit and the price lies at the level determined by a perfectly elastic demand curve. As such, the Output PPI reflects the price change inclusive of market pressure. The general perception is that inflation for a competitive market is lower than that observed in monopoly/oligopoly markets. Hence the general perception that published indexes are reflective of movements within a competitive market, but understate the inflation for a monopoly or oligopoly market.

If Output PPI = Inflation for competitive market

And Inflation for competitive market < Inflation for monopoly/oligopoly market,

Then Output PPI ≠ Inflation for monopoly/oligopoly market

And most likely:

Output PPI < Inflation for monopoly/oligopoly market

Impact of bias from competition using the Finished Goods approach for defence contracts

There is a challenge in determining if the price index which is predominantly reflective of the competitive market can also be reflective of the defence industry. The defence industry is often dominated by a few large contractors, comparable to an oligopoly. The constraints on the supply of goods and services are caused by a number of factors which were raised in Chapter Two. These include the specialised nature of the defence goods and services, the limited demand for bulk purchases and the high level of capital investment required. Economic theory suggests that firms with substantial market power or those in monopoly/oligopoly markets can set sale prices at a profit-maximising level without any adverse effect, even though sales may be reduced, because the resulting sales (at a higher price) will maximise profits. Based on these considerations, a published index constructed from competitive prices which does not reflect the market power of defence suppliers, will understate the 'true' inflation for the defence industry.

However, this also signifies that the buyer (such as DMO) to some extent is allowing firms with a monopoly/oligopoly power to charge a premium and may also result in oligopolies not necessarily needing to be efficient in their production if they can charge a premium regardless of their sale prices.

One of the characteristics of competition is that it enables the buyer to substitute their buying preference. In response, the producer may also switch production to lower priced goods to cater for buyer substitution (this was examined previously in section 5.1.2 Substitution bias). Therefore, while the pricing information recorded by the index captures market pressure, the quantity information recorded by the index fails to adjust accordingly to competition. The fixed base period quantity/weight structure of the Laspeyres Output PPI has neglected the effect of competition. The published index instead reflects an environment which neglects the benefit of competition. Although this might appear to be a problem for representing the competitive situation, in fact the use of a Laspeyres Output PPI, like the motor vehicle manufacturing index, might reasonably represent the inflation applicable to the defence industry environment (which tends to be non-competitive in nature).

If Motor Vehicle mfg index = Inflation for competitive market neglecting competition effects

And Inflation for monopoly/oligopoly market ≈ Inflation with no competition effect

Then Motor Vehicle Manufacturing index ≈ Inflation for monopoly/oligopoly market

∴ Output PPI Motor Vehicle Manufacturing ≈ Defence-contract-relevant inflation

Impact of bias from competition under the Cost Components approach for defence contracts

One of the features of the Multiple Indexes approach is to escalate based on the cost of certain major materials and labour. The defence contractor, like other firms in the general economy, is buying intermediate materials from a competitive market. This occurs regardless of whether or not the contractor itself is in a monopoly or competitive market. The market position allows the firm to set their sale prices; it does not provide it with the ability to set its material purchase costs. Therefore, indexes under the Cost Components approach, like the tyres manufacturing index, are accurate in reflecting the defence-contract-relevant inflation experienced by the contractor in buying the tyres. As a result, the composite inflation calculated by the group of multiple indexes is considered by this research to be acceptable for use in price variation.

$\therefore$ Defence-contract-relevant inflation relating to tyres = Tyre manufacturing index

5.1.6 Productivity

Source of bias from productivity

As analysed previously, in addition to improving the quality of the goods, technology advancement can also improve the firm's productivity. Technological advances enable a reduction in the overall production cost. For example, the amount of steel required to manufacture a vehicle today could be less than what was previously needed. Hence, technology advances enable firms to produce the same output with less input. Alternatively, this enables firms to increase their productivity by using the same input to increase output. Productivity gains during the production process arise from factors such as capital investment, technological improvement, more efficient organisational arrangements, and innovations in process and product.

Continuing with the notion that firms make productivity gains to maximise profit when setting sale prices, firms also determine the portion of the productivity gain which becomes profit to the company or is shared with the customer. In sharing the productivity gain with customers, the firm may hold or lower sale prices in order to attract or retain customers. Since the Output PPI measures the price change received by the seller (exclusive of tax, freight and margins), it has in fact already captured some of the efficiency gain. Conversely, as LPI is an input index it does not capture any productivity.

Unfortunately, productivity gains do not arise equally in all sectors. Generally, bulk production generates productivity gains greater than ad-hoc production. This is as a result of outcomes such as reduced overheads and learning curve effects. Publicly available indexes, while capturing efficiency gains, are predominantly from the general market which is competitive in nature. Defence procurement constitutes a very small portion of the general market. Since procurements of large complex materiel are typically infrequent and in low volumes, it is often argued that this unpredictability lowers the contractor's level of efficiency gain when compared to those in bulk production. Furthermore, due to its specialised nature of product or service specification, efficiency achievement is very difficult to compare with those in bulk commercial production. It is also argued that since defence items require new and specialised design work, high levels of productivity gains are not feasible as the defence contractor cannot benefit from previously achieved outcomes. Thus, the productivity captured by the published index is not truly reflective of the position of defence contractors. Accordingly, published indexes which are dominated by commercial products have been argued to understate the true inflation of defence items.

If Output PPI = inflation inclusive of competitive market's productivity

And Competitive market's productivity > Productivity achieved by defence industry

Then Output PPI ≠ Inflation for defence industry

And will most likely be:

Output PPI < Inflation for defence industry

Impact of bias from productivity using the Finished Goods approach for defence contracts

While not all sectors generate equal productivity gains, this does not necessarily mean that all defence contractors using the published index are at a disadvantage. In fact, examinations conducted by this research suggest that only a few selective contractors may be disadvantaged by the understatement caused by lower productivity gains.

The following example illustrates how the specialised nature of defence materiel affects productivity. Begin by assuming that the specification and work load is more specialised for combat vehicles than commercial vehicles, and also assume that the production volume of combat vehicles is less than commercial vehicles. While it is true that the defence contractor may not be able to benefit from any cost reduction associated with an increased scale of production, the contractor, who is not limited to selling only to defence, may still be able to benefit from economies of scope.

Economies of scope and economies of scale are two different conceptual theories. In economic analysis, it is not uncommon to consider that a typical manufacturing firm does produce two or more products using the same set of skills, knowledge, and capital within the firm. In fact, firms often achieve economies of scope by lowering their average costs (i.e. achieving productivity gains) through producing more than one product. Productivity gains may be lower only when contractors produce a single product type and if they only sell that product to a single customer. Under this line of argument, and for this example, the motor vehicle manufacturing index will only understate the inflation experienced by a firm which produces only a specific type of combat vehicle, and sells this solely to one customer. This equates to only one product or service and only one customer. In reality, this understatement of inflation only impacts a few selective contractors (these few contractors are addressed below).

Accordingly, in any situation where defence contractors are able to achieve economies of scope in place of economies of scale, infrequent and low volume demand from defence might not totally affect a firm's ability to achieve some productivity gains. The defence contractor would still be keen to generate productivity gains in order to stay in business by selling other items. Of course, the opportunity for productivity gains could be minimal in a situation where the defence contractor cannot produce any other type of product and cannot sell to any other customer, except to DMO. Such a scenario is obviously possible, as seen in certain parts of the current Australian defence industry, where political and geographical influences from the past restricted these firms from achieving synergy with multi-plants production.

Furthermore, the degree of competitiveness in the market can also affect the apportionment of productivity gains. In a competitive market, a firm shares as much of this gain as is necessary to maintain its competitive advantage. However, oligopolies, due to their dominance and ability to set sales prices, may not share as much of these efficiency gains. Given that most defence contractors are in an oligopoly environment, the efficiency gain shared by defence contractors may be lower than the firms in the competitive market. However, this signifies that the buyer (i.e. defence) is allowing the contractor with a monopoly/oligopoly power to charge a premium or withhold sharing efficiency gains due to its market position. The reasoning that the monopoly/oligopoly's inflation is higher, is not due to the fact that their production cost is higher, rather, the higher inflation is due to their market power.

To summarise, unless it can be shown that a defence contractor is burdened by government regulations or other valid limitations outside its control, there is no strong reason why a defence contractor cannot be expected to generate similar productivity gains and apportion those gains consistently with circumstances in the commercial market. As such, the motor vehicle manufacturing index can reasonably represent the inflation movement for defence contracting from the producer's perspective. The only exception is the selectively few defence contractors who cannot achieve economies of scale and scope. However, it would be unfair to the buyer if the firms themselves elected not to attempt to achieve economies of scale and/or scope, simply by failing to diversify or attain additional similar contracts.

If Output PPI = Inflation inclusive of competitive market's productivity

And Competitive market's productivity ≈ Achieving economies of scale OR scope

Then if Defence contractors achieve economies of scope ≈ Productivity achieved by competitive market

So that Output PPI ≈ Inflation reflective of defence contractors

Then MV manufacturing index ≈ Defence-contract-relevant inflation

Of course, there may be situations where economies of scale or scope cannot be achieved due to valid limitations outside the contractor's control. In such a situation the publicly available PPI under the Single Index approach could very likely understate the inflation relevant to those selective few defence contractors.

Impact of bias from productivity under the Cost Components approach for defence contracts

The price variation formula under this approach contains a collection of indexes. While these indexes are reflecting the major materials and labour cost inflation, the overall inflation calculated by the formula ignores the value adding process contributed by the defence contractor.

While it is true that, for example, the steel manufacturing index (being an Output PPI) already captures the productivity of steel manufacturers, such productivity is restricted to the steel manufacturing industry. This productivity of the steel manufacturing industry is different to the productivity achieved by the defence contractor in making use of steel products to produce final goods (for example, vehicles). The defence contractor could be in a position to generate productivity gains by using less steel in manufacturing the vehicles. As such, the productivity in the steel manufacturing industry is somewhat irrelevant to the defence contract if the procured products are vehicles.

Secondly, the LPI, being an input price index, measures the firm's ability to purchase a fixed quantity and quality of labour input–irrespective of the output produced–therefore the LPI does not capture productivity. Under the Multiple Indexes approach, if the LPI is used, then any productivity gain from efficient use of labour would be excluded in the final composite inflation. In addition, suppose the defence contractor achieves extra productivity gains by reducing the number of labour hours needed to produce the same quantity of armoured vehicles. With the weights for labour and steel already assigned to the price variation formula, the composite inflation calculated would fail to include the productivity gain generated by the production process of the combat vehicles. This exclusion enables the formula to overstate the true inflation. Hence an adjustment to the formula is required, and can be shown as follows:

Combat vehicles inflation = (0.15 x tyres inflation) + (0.15 x steel inflation) + (0.7 x labour inflation) - (adjustment)

The difficulties remain in determining the level of productivity gain and how much of that gain is apportioned to the buyer. When determining the correct level of productivity gain, issues such as infrequent and low volume procurement are only relevant to contractors who cannot achieve either economy of scale or economy of scope. Discussion of this adjustment is presented in section 5.2.

5.1.7 Long-term contracts

One of the unique features of a typical defence contract is its long contract duration which is somewhat unlike commercial procurement contracts. Defence contracts can range from two to 30 years. One of the characteristics of a long-term contract is that it may allow the contractor to plan their production and purchase of material (and even labour) better than short-term contracts. As such, the average inflation cost experienced in a long-term contract could be less in comparison to a short-term contract. Another benefit of a long-term contract is its ability to cancel out some of the high inflation caused by an increase in demand relative to supply. On this basis, a long-term contract does not increase inflation but may in fact reduce the inflation cost rise.

Impact of bias from long-term contracts using the Finished Goods approach for defence contracts

One of the classic economic theories is that the inflation will be high when a product is in great demand. This is because when demand outweighs a fixed supply, ceteris paribus, potential buyers drive the price up by bidding for the limited goods. The demand for a vehicle is based on buyers' expenditure decisions, which again differ between commercial buyers and defence. An index under the Finished Goods approach, like the motor vehicle manufacturing index, is mostly reflecting the demand fluctuation of commercial buyers. Factors which contribute to the expenditure decision include buyer confidence, with respect to the economic outlook (i.e. the buyer may postpone a purchase when the economic outlook is pessimistic), prices of alternative choices (other domestic and imported brands), and the costs of using the vehicle (i.e. petrol, maintenance), and so on. However, due to operational requirements, defence is not likely to postpone the purchase of vehicles during an economic downturn. Additionally, the quality of the product is usually considered as being more important than cheaper pricing. Effectively, the need to meet Defence's operational requirements is considered (usually) as relative more important than the effect on running costs of the vehicle.

In comparison, defence demand is relatively more stable than commercial demand. This difference can affect the inflation between commercial and defence production. Defence's 'true' inflation is understated when the commercial buyers' demand is low. Conversely, defence's 'true' inflation is overstated when the commercial buyers' demand is high. These under or over estimations may cancel each other during a long-term contract so that over the long run, the published index is reflective of the situation of the defence contractor. However, this suggests that inflation measures based on a rolling average may also be more appropriate to smooth out the effect of fluctuations. This technique is discussed in section 5.2.

Impact of bias from long-term contracts under the Cost Components approach for defence contracts

The cost minimisation theory in economics implies that firms often hedge their risk by purchasing commodities/materials via futures and options contracts. In doing so, the commodity/material is planned to be purchased at the lowest/best price possible. However, while the inflation shown by the index is reflective of the market movement, it may not be reflective to those performing a long-term contract.

For example, suppose the tyre manufacturing index showed a rate of 5% and 10% inflation for years one and two, respectively. Under the cost minimisation theory, firms minimise cost where possible–a longer contract allows more opportunity to hedge material/commodity risk. Suppose the defence contractor, using industry forecast information, purchased the tyres necessary for two years of production at the start of year one, when the inflation experienced was only at 5%. Now suppose that the contractual price variation formula is as follows:

Combat vehicles contract inflation = (0.15 x tyres inflation) + (0.15 x steel inflation) + (0.7 x labour inflation)

The above formula, by fixing its weight at 0.15 for the cost of tyres, will in fact overstate the inflation experienced by the contractor in year two. This is because it would have applied 10% inflation to the tyre weight of 0.15 in year two, whereas the hedging method allowed the purchase of tyres to be at only 5% inflation. This hedging of material risk is very similar to the efficiency gain considerations already discussed. Therefore, this hedging of material risk issue can form one of the considerations when determining a productivity adjustment for the price variation formula. Furthermore, the practice of hedging of material risk by contractors suggests that in the long run the inflation based on a rolling average may also be more appropriate to smooth out the effect of fluctuation. The technique of smoothing is discussed in section 5.2.

5.1.8 Summary on the bias analysis

Theoretical inherent measurement biases and three major areas of difference between the commercial market and the defence industry were investigated. While some of the classical theoretical explanations suggest under and overstatements of the publicly available index, when applied to a unique industry like defence industry, these under and overstatements in some cases may neutralise each other. The direction of biases are summarised in Table 5.1.8.1.

Table 5.1.8.1. Summary of the impact of the biases for the two price variation approach - defence procurement perspective

Area	**Single Index or Finished Goods approach**	**Multiple Indexes or Cost Components approach**
Coverage bias	Understate the 'true' defence-contract-relevant inflation	Composite inflation overstated as input LPI has overstated 'true' defence-contract-relevant inflation.
Substitution bias	Uniqueness of defence product and industry has neutralised the inherent bias to some extent.	Uniqueness of defence product and industry has neutralised, the inherent bias to some extent, if an input labour index and an output PPI is used in the same formula.
Quality improvement bias	Uniqueness of defence procurement has neutralised the inherent bias	Composite inflation overstated if no adjustment is made.
New goods bias	Uniqueness of defence procurement has neutralised the inherent bias	Composite inflation overstated if no adjustment is made.
Bias from competition	Uniqueness of the defence industry has neutralised the bias.	No bias.
Bias from productivity	If defence contractor can achieve economy of scope then there is no bias. Otherwise, understate the 'true' inflation if contractor cannot achieve economies of scale and/or scope.	Input LPI overstates the 'true' inflation due to fail to cater productivity. Composite inflation overstated if no productivity adjustment is made.
Bias from long-term contracts	Under or over estimation neutralised over the course of long-term contracts.	Composite inflation overstated if no adjustment is made (or consider rolling averages).
Overall	**Inflation of interest is understated due to the uniqueness of the defence procurement and its industry.**	**Composite inflation overstated if no adjustment is made.**

However, in some other cases, several variants to the price variation formula are required in order to calculate the most accurate and reflective defence-contract-relevant inflation.

5.2 Bias correcting adjustments

The previous section, 5.1 – Bias analysis, concluded that inherent measurement biases with publicly available indexes, together with differences between commercial markets and the defence industry, cause some under and some overstatement of inflation for a variety of reasons. Therefore, an adjustment to the inflation, as indicated by the index or calculated by the price variation formula, is necessary in order to correct these under or overstatements.

5.2.1 Application of adjustments

Defence-specific adjustment for the Single Index or Finished Goods approach

In order to counteract the inherent bias associated with the Finished Goods approach (i.e. its tendency to understate applicable inflationary pressures), an up-scale adjustment is required. The 'defence-specific adjustment' aims to cater for the understatement in the published index by up-scaling the inflation indicated by the index. The purpose of this defence-specific adjustment is to account for inflation pressure stemming from the uniqueness of the defence industry and its specialised goods. This adjustment is necessary due to the lack of coverage of specialised materiel in the published indexes. On the other hand, if the coverage of the published indexes is dominated by defence production, and not by commercial production, then the up-scale adjustment may not be necessary. Defence-specific adjustment is only necessary when the procurement is of specialised defence materiel.

Among the ABS indexes analysed in the current research, it was found that the manufacturing activities captured in the classification of ABS PPI 2391 Shipbuilding and Repair Services are not dominated by activities which are commercial manufacturing in nature. Table 5.2.1.1 shows the primary activities classified under the ABS class of 2391 Shipbuilding and Repair Services.

Table 5.2.1.1. Primary activities for ANZSIC 2391 Shipbuilding and Repair Services

Primary activities associated with the ABS PPI 2391 Shipbuilding and Repair Services
Drydock operation
Hull cleaning
Ship repairing
Ship wrecking
Shipbuilding
Submarine constructing

It was noted in Chapter Four that approximately 70% of the Australian shipbuilding industry's revenue is from government, with defence being the major buyer from the government. As the result, the movement of the ABS PPI 2391 Shipbuilding and Repair Services may be considered to be more closely aligned to the activities of the defence industry than other published ABS indexes found to be appropriate at Appendix E. Table 5.2.1.2 shows the movement of this index over the past six financial years.

Table 5.2.1.2. Inflation movement of ABS PPI 2391 Shipbuilding and Repair Services

	2004/05	**2005/06**	**2006/07**	**2007/08**	**2008/09**	**2009/10**	**Average 2004-2007**	**Average 2004-10**
2391 Shipbuilding and Repair Services	2.07%	3.76%	3.62%	-0.62%	5.04%	5.98%	3.15%	3.31%

Table 5.2.1.2 shows that the ABS PPI 2391 Shipbuilding and Repair Services average annual inflation rate–during the three and six year periods–was 3.15% and 3.31% respectively. Between 2004 and 2007 (i.e. before the GFC) this index fluctuated between 2% and below 4%. The index also deflated in financial year 2007/2008. For financial years 2008/2009 and 2009/2010 (i.e. after the GFC), the index's annual inflation was above 5%. It should be noted that commentary on the economic effect of the GFC is complicated and is beyond the scope of this research.

The annual average inflation for the three-year period and the six-year period of the ABS PPI 2391 Shipbuilding and Repair Services is just over 3% per annum, which is 1.0 to 1.5% below the DMO Contractor Survey Forecast of 4.5%. However, as this particular index is strongly dominated by defence products and/or activities, any naval contract using this index may only need a small or even negligible up-scale factor to be applied as the index is already measuring the price movement of the naval industry.

Application of the up-scale adjustment

Previous discussion in this research indicated that combat vehicles and combat communications equipment are often very unlike their commercial equivalents. Therefore, published indexes in those industrial sectors may only reflect inflation movements for the commercial manufacturing industry and not the inflation pressures applicable to the defence industry. The following analysis illustrates the implication of the up-scale adjustment for these two types of defence procurements.

The up-scale adjustment rating scale presented in Figure 5.2.1.1 is specifically developed by the current research to cater for the gap in inflation. Up-scale adjustment only applies if the index is inflating below a benchmark rate of 4.5%. This benchmark rate of inflation of 4.5% originated from results of the DMO Contractor Survey Forecast. The up-scale adjustment is based on a scale between 0% and 3%. The resulting up-scale inflation is capped at 4.5%. Figure 5.2.1.1 is the rating scale proposed and applied in this research to illustrate the impact of the up-scale adjustment to inflation for the uniqueness of the product and/or industrial base.

Figure 5.2.1.1. Defence-specific 'uniqueness' adjustment

The up-scale adjustment applies when the product has been modified for defence purposes and/or is a defence-specific product or service (i.e. custom-made). The lower end percentage applies when the product is slightly (mildly) different from the commercial equivalent. The upper end of the scale applies when the product is highly specialised (i.e. custom-made for defence purposes).

Consider the purchase of combat vehicles which is a highly specialised product, given that ABS PPI 2311 Motor Vehicle Manufacturing is dominated by manufacturing activities that are commercial in nature. Hence an upper-end of the scale percentage, say 3%, could be deemed appropriate in such a situation. The inflation for PPI 2311 Motor Vehicle Manufacturing between the financial years of 2004 and 2010, before and after the defence-specific adjustment, are shown in Table 5.2.1.3. For illustrative purposes, movement of three macroeconomic indicators are presented as well.

Table 5.2.1.3. Comparison of inflation movement of macroeconomic indicators and microeconomic index – vehicles perspective

	2004/05	**2005/06**	**2006/07**	**2007/08**	**2008/09**	**2009/10**	**Average 2004-2007**	**Average 2004-2010**
Published Index: 2311 Motor Vehicle Manufacturing	-1.94%	-1.63%	2.60%	-1.62%	-1.74%	0.42%	-0.32%	-0.65%
After defence-specific adjustment: 2311 Motor Vehicle Manufacturing	1.06%	1.37%	4.50%*	1.38%	1.25%	3.42%	2.31%	2.16%
ABS CPI	2.44%	3.20%	2.92%	3.39%	3.14%	2.33%	2.85%	2.90%
ABS GDP deflator	3.81%	4.88%	5.14%	4.66%	4.49%	0.06%	4.61%	3.84%
ABS PPI Manufacturing Division	6.80%	7.18%	4.77%	4.92%	2.30%	-3.02%	6.25%	3.83%

*refer to explanation below

Except for the financial year of 2006/2007, the defence-specific adjustment up-scales each inflation, as referenced by the index, by 3%. For financial year 2006/07, the 3% adjustment would result in an inflation of 5.6%, which would be greater than the 4.5% cap. As the after-adjustment inflation is capped at 4.5%, the resulting inflation allowed for 2006/07 would only be 4.5%.

The annual average inflation for the three-year period and the six-year period of the ABS PPI 2311 Motor Vehicle Manufacturing after the defence-specific adjustment was just over 2% per annum. In comparison, these revised average annual inflations are lower than the common macroeconomic inflationary indicators such as the CPI, GDP deflator, and PPI Manufacturing Division.

The analysis now turns to the investigation of combat communication equipment. Table 5.2.1.4 shows the results of a 3% defence-specific adjustment to the PPI 2422 Communication Equipment Manufacturing. Since the characteristics of defence and non-defence requirements in communication equipment are undoubtedly different, with defence purposes likely to be requiring more technologically advanced functionality, therefore a high value of the up-scale adjustment may be appropriate. The following example illustrates the effect on the inflation if an up-scale adjustment of 3% was applied.

Table 5.2.1.4. Comparison of inflation movement before and after productivity adjustment and against macroeconomic indicators - communication equipment perspective

	2004/05	**2005/06**	**2006/07**	**2007/08**	**2008/09**	**2009/10**	**Average 2004-2007**	**Average 2004-2010**
Published Index: 2422 Communication Equipment Manufacturing	2.44%	1.77%	0.86%	1.04%	7.63%	-3.48%	1.69%	1.71%
After defence-specific adjustment: 2422 Communication Equipment Manufacturing	4.50%	4.50%	3.85%	4.04%	7.63%	-0.48%	4.28%	4.01%
ABS CPI	2.44%	3.20%	2.92%	3.39%	3.14%	2.33%	2.85%	2.90%
ABS GDP deflator	3.81%	4.88%	5.14%	4.66%	4.49%	0.06%	4.61%	3.84%
ABS PPI Manufacturing Division	6.80%	7.18%	4.77%	4.92%	2.30%	-3.02%	6.25%	3.83%

As the example in Table 5.2.1.4 shows, the capping rule does not apply to the inflation in financial year 2008/09. As the inflation rate of 7.63% for the PPI 2422 Communications Equipment Manufacturing is well above the allowable upper rate for adjustment of 4.5%, hence the actual market inflation is applicable without adjustment. That is, as the index already shows inflation of over 4.5%, no additional adjustment will apply to that inflation for that period.

In comparison, the after-adjustment average inflation rate for the communication equipment manufacturing industries of 4.01% p.a. (between 2004 and 2010) is very similar to the average inflation rates shown by macroeconomic indicators like the PPI-Manufacturing and GDP deflator, except the CPI (i.e. CPI was lower).

The defence-specific adjustment can also apply to the services PPI (which may be used as an alternative to LPI). In situations where the labour services required for a defence contract is so specialised that it differs significantly from those available in the commercial market, an up-scale adjustment would be applicable.

Productivity adjustment under the Multiple Indexes approach

It was earlier determined that the composite inflation calculated by the Multiple Index approach would overstate the defence-contract-relevant inflation if productivity was ignored during the calculation of the composite inflation. This is due to an overstatement which arises from failure to include productivity gains generated by defence contractors during the production process. Since the Multiple Indexes approach tends to overstate the inflation pressure applicable, a downscale adjustment is required to the formula. This downscale adjustment is, for the purpose of this research, referred to as the productivity adjustment.

Productivity gains can be generated in two ways. One way efficiency gains can be generated is by using less labour or producing greater output with the same labour. Another way to generate productivity gains is by improving the production process, for example, by reducing material usage or shortening production times (i.e. incorporating better processes) to produce that same quality of output. Both of these ways in applying the productivity adjustment are discussed below.

Firstly, Table 5.2.1.5 shows the movement in percentage of the ABS Experimental Estimates of Industry Multifactor Productivity - Labour Productivity indexes for the manufacturing division.

Table 5.2.1.5. Movement of ABS Labour Productivity Indexes - Manufacturing Division

	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	Average 2004-2007	Average 2004-2010
ABS Labour Productivity indexes; Manufacturing	-2.63%	3.22%	2.62%	0.19%	1.96%	4.80%	1.07%	1.04%

Since the averages for the three and six year periods are similar, and in order to smooth out the impact of the negative impact of productivity on indexes, the current analysis will use 1%[16] (i.e. average annual rate) as the productivity adjustment for the labour components for illustrative purposes. It is important to note that that the precise productivity achievement and apportionment is unique to each firm and/or each contract performance. The measurement and apportionment of productivity is an area that requires considerable further dedicated research.

Table 5.2.1.6 reflects the measure of inflation before and after the productivity adjustment has been made on an LPI which is of interest to defence.

Table 5.2.1.6. Comparison of inflation movement before and after productivity adjustment - ABS LPI (Ordinary Time – Manufacturing) perspective

	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	Average 2004-2007	Average 2004-2010
Published Index: LPI - Ordinary - Private; Manufacturing	3.71%	3.81%	3.67%	4.46%	3.53%	2.35%	3.73%	3.59%
After productivity adjustment: LPI - Ordinary - Private; Manufacturing	2.71%	2.81%	2.67%	3.46%	2.53%	1.35%	2.73%	2.59%

The consideration of productivity would be complicated if the contract were to use the LPI instead of the service PPI–due to the fact that downscale and up-scale adjustments

[16] In addition to using a labour productivity of 1%, supplementary analysis (see Chapter Seven) also uses a labour productivity of 2%.

can both occur. Assume the LPI for Manufacturing Division is used. Since LPI does not capture productivity, a downscale to all LPI is required in order to reflect productivity. If the contract's manufacturing labour requires some defence-specific skills, then a defence-specific up-scale would apply to the already adjusted LPI.

The second avenue where productivity gain could be generated is from a firm employing a more efficient process. This includes results from training and learning, research and development, and capital improvement, all of which need to be considered. Determining the productivity rate is therefore a challenging exercise.

The movement of the ABS Experimental Estimates of Industry Multifactor Productivity - Gross Value Added Based Multifactor Productivity Indexes - Manufacturing Division, is presented in Figure 5.2.1.2.

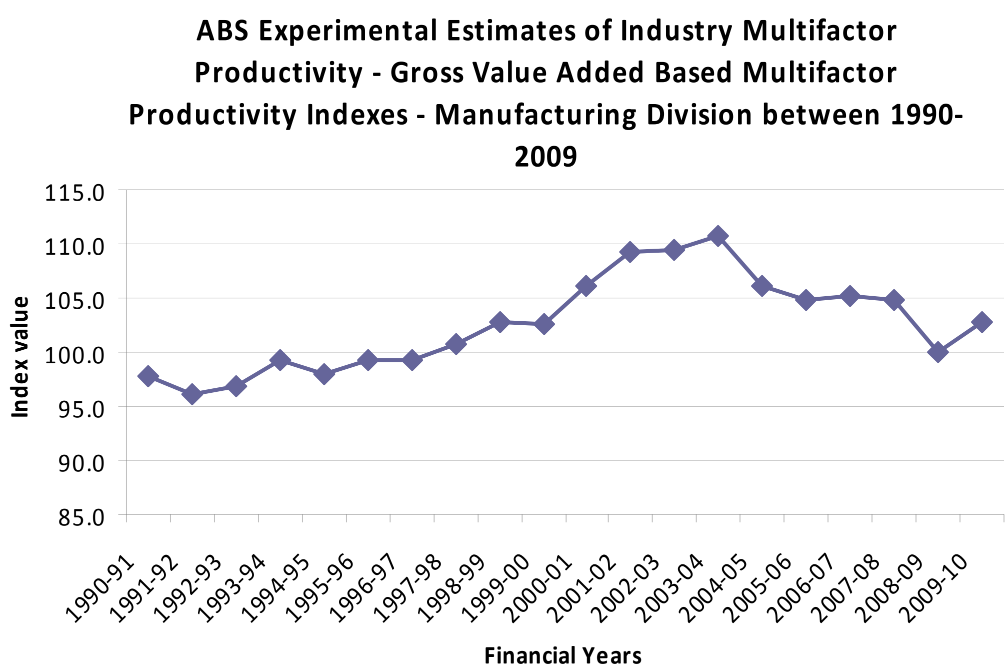


Figure 5.2.1.2. Historical movement of ABS Multifactor Productivity

Figure 5.2.1.2 shows that the Multifactor Productivity (MFP) index for the manufacturing division moves in cycles. While MFP estimates tend to be model-based and are subject to some measurement error, it is generally accepted that cyclical movements could be expected due to a business-conditions-based time profile of companies investing in capital.

The average of the ABS MFP between financial years 2004 and 2010 was 1.23% which was close to the 1% eventually used in the DMO Contractor Survey. For a longer term profile, for example between 2000 and 2009, it was 0.02% while between 1990 and 2009, the MFP was 0.3%. This range of estimates is of course consistent with variation due to a cycle, so that the result obtained depends upon the stage of the cycle that is sampled. However, there is no denying that other errors due to the model-based measure of MFP may also be affecting the variation in these estimates.

In addition, the 2005 DMO Contractor Survey recorded, on average, a 2% productivity measure. The accuracy of such a measure is subject to some obvious reservations, one of which is that this measure is based on survey responses in which there may have been a temptation for respondents to claim higher productivity than could realistically be achieved in the interests of appearing attractive for future contracts[17]. Nonetheless, if taken on face value this means that the composite inflation calculated or each of the indexes under the Multiple Indexes approach in principle would need to be reduced by 2%.

Table 5.2.1.7 presents an illustration of the productivity adjustment or deduction for the ABS PPI 2110 Iron Smelting and Steel Manufacturing using the 0.3% long-term model-calculated MFP and the 2% industry survey claimed productivity rate.

[17] It is important to note that the current research is not claiming that overestimation of productivity occurred.

Table 5.2.1.7. Comparison of inflation movement before and after productivity adjustments – steel product perspective

	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	Average 2004-2007	Average 2004-2010
Published index: 2110 Iron Smelting and Steel manufacturing	32.18%	5.00%	2.86%	5.69%	27.76%	-24.01%	13.35%	8.25%
After productivity adjustment of 0.3%: 2110 Iron Smelting and Steel Manufacturing	31.88%	4.70%	2.56%	5.39%	27.46%	-24.31%	13.05%	7.95%
After productivity adjustment of 2%: 2110 Iron Smelting and Steel Manufacturing	30.18%	3.00%	0.86%	3.69%	25.76%	-26.01%	11.35%	6.25%

The theory behind price variation is to cater for unexpected fluctuations in intermediate material and labour costs experienced by the contractor. Other costs which are non-intermediate material or labour in nature fall outside the intent of the price variation objective. In the calculation of composite inflation, one could either clearly state the portion of the price to be escalated or allocate a non-variable element into the formula. This is consistent with practice from other international defence departments like US DoD (2004) and UK MoD (2009). Furthermore, by implicitly treating other costs like certain parts of overheads and profit as non-variable elements in the formula–which would not be subject to escalation–there would be an incentive for contractors to be efficient in their management of cost control.

The price variation formula, if a weight of, say 0.25, for the non-variable element is applied, would consist of the following elements:

Defence-contract-relevant inflation = {[(0.1 x tyres inflation) + (0.1 x steel inflation)] - (productivity adjustment for material and/or capital)} + [(0.55 x labour inflation) - (productivity adjustment for labour)] + (0.25 x zero inflation for the non variable element)

Assume that tyres and steel inflation was 3% while the labour inflation was 4%. Also assume that the productivity for labour and material/capital are 1% and 2% respectively. The weight of 0.25 for the non-variable element is treated as contributing 0% inflation to the defence-contract-relevant inflation measure for price variation purposes. To avoid problems with zero values, particularly as use of geometric means is recommended in much of the economic literature, only the non-zero components, adding up to 0.75 in terms of their weights, are used in the following example of a geometric mean formula. In this formula the term ***ln***, means natural logarithm, and the term ***exp,*** is the antilog. The calculation could take the following form[18]:

Defence contract relevant inflation = exp {[0.1 x ln(1+3%) + 0.1 x ln(1+3%)] – [0.2 x ln(1+2%)] + [0.55 x ln(1+4%) – 0.55 x ln(1+ 1%)]}

Continuing the example above, Table 5.2.1.8 summarises the possible inflation under the various forms.

Table 5.2.1.8. Comparison of arithmetic and geometric means with and/or without productivity deduction and/or non-variable element

	With non-variable element		**Without non-variable element**	
	Arithmetic	**Geometric**	**Arithmetic**	**Geometric**
With productivity deduction	1.85%	1.81%	2.47%	2.42%
Without productivity deduction	2.80%	2.79%	3.73%	3.73%

It is important to note that productivity rate and the percentage for the non-variable element will differ for each contract performance - nonetheless results from Table 5.2.1.8 have shown that these components do impact on the final inflation.

[18] It should be noted that the missing non variable component could have been added in the form, +0.25 x ln(1+0%), in the formula, but this is of course zero when no escalation allowance is to be made for inflation in other costs.

5.2.2 Smoothing the inflation of long-term contracts

The earlier research (under section 5.1.7) examined and found that contracts which are long-term in nature could benefit from better management in production and control of material costs than is possible with short-term contracts. For example, in the interests of profit maximisation, firms would try to hedge their material risk where possible. The long-term feature suggests that inflation based on a rolling average which smooths out the effect of fluctuations may also be more appropriate as it aligns closer to business practice.

Smoothing of a time series is often used in economic analysis as it allows the removal of random variation, thereby revealing trends and cyclic components. There are many ways an index might be smoothed. The economic statistics literature identifies one such technique to smooth an index series as ‘exponential smoothing’. One of the important features of exponential smoothing is that it assigns exponentially decreasing weights over time to past observations. One of the possible outcomes in using exponential smoothing is that the defence-contract-relevant inflation would be smoothed in a way more aligned to business practices which relate to long-term contracts. Figure 5.2.2.1 show the historical and smoothed (i.e. fitted) series of an index.

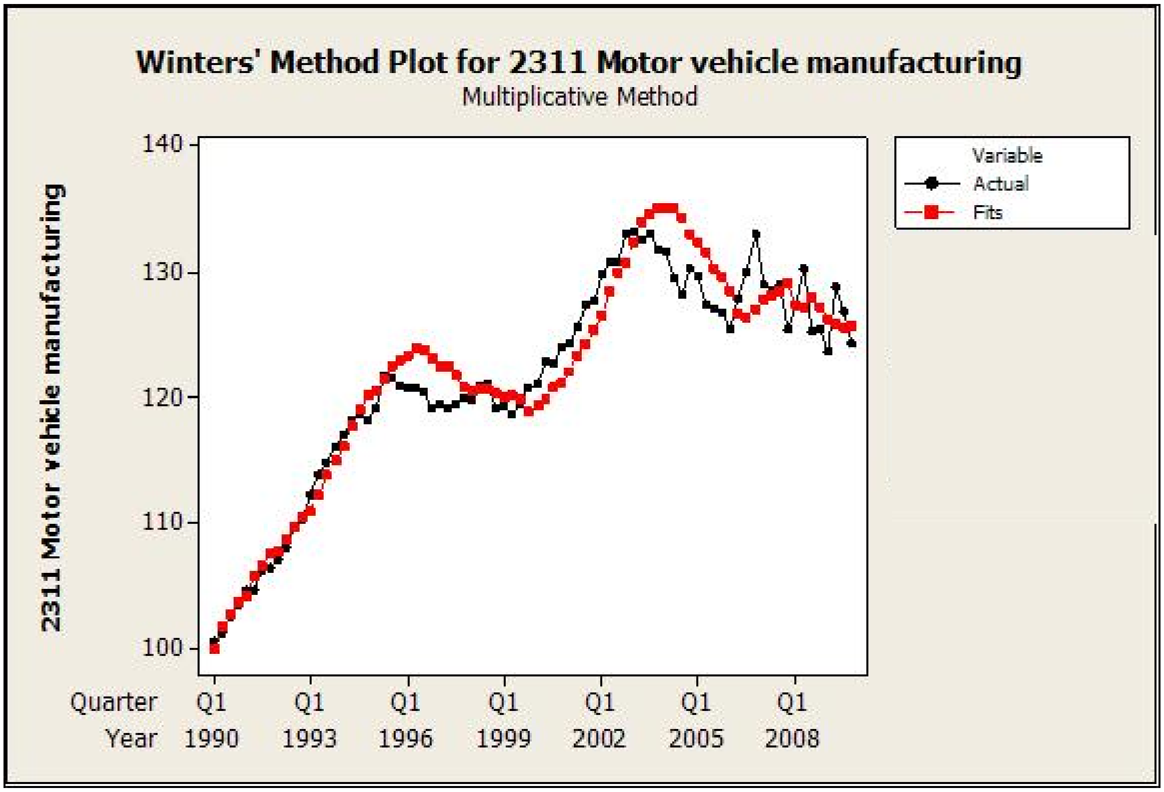


Figure 5.2.2.1. Comparison of historical and smoothed index value – vehicles perspective

Figure 5.2.2.1 shows that the smoothed index number series still reflects the direction of the index movements but without the extreme fluctuations–particularly in recent years. Effectively, the inflation calculated in this way would be more stable. Contract escalation from smoothed index series could minimise, to an extent, some of the volatility observed in certain indexes. This could aid in the use of an index considered to be 'too volatile' (as discussed in Chapter Four), allowing it to still be used for defence price variation purposes.

In addition to calculating inflation based on a smoothed index series of historical data, an alternative could be to base contract relevant inflation on forecasts. Forecasting an index aids in providing an inflationary outlook for the purposes of contract budgeting and management. A brief overview of the topic of forecasting is examined in the next chapter.

5.2.3 Summary on introducing correcting adjustments to an index

This part of the analysis represented the second stage in calculating the 'true' defence-contract-relevant inflation. It was concerned with the identification of biases and the consideration of correcting biases in selected indexes so that they could best match users' requirements. Two adjustments, a defence-specific adjustment, and a productivity adjustment (or deduction), were recommended and illustrated. Furthermore, calculating inflation based on a smoothed index series was also presented as an alternative.

Chapter Six

Index Forecasting

The third stage of the research is to generate forecast estimates for the 'selected' index or indexes. The aim of forecasting in this situation is to provide DMO and its contractor with some estimates on the upper and lower boundary of inflation for price variation. There are a variety of forecasting techniques available to determine the inflation outlook. This chapter will report on research using two techniques: the multivariate method (i.e. regression modelling), and univariate time series forecasting (i.e. Holt-Winters multiplicative forecasting).

6.1 Multivariate method - multiple regression

Forecasting can be conducted by developing a regression model based on explaining a given price index by reference to background economic conditions. Regression allows estimation of a model to determine how a dependent variable (i.e. price index) is affected by changes in another variable (e.g. some macroeconomic factor which may be related to the dependent variable). It is often the case that predictions are more accurate when more than one independent (or explanatory) variable is used. The research to this point has identified a refined set of price indexes that may be helpful with defence contract price variation considerations. Unfortunately, it is not possible within the current research to construct microeconomic models that might 'explain' these price indexes. Instead, this research will investigate seven common and crucial macroeconomic variables which can be seen to be related to individual industrial sector price indexes. Namely, stock market movement, inflation, industrial production, real GDP, interest rate, unemployment, and currency price movements.

One approach to determine if each of these seven macroeconomic variables is significantly related to the price index is by undertaking a correlation analysis. Correlation measures the strength of a linear relationship between two variables, in this case the index and each of the macroeconomic variables. A significant correlation coefficient shows that two variables tend to be linearly related. One of the proven correlation relationships was developed by Pearson.

Table 6.1.1 tabulates correlations of the indexes found suitable for defence contracting at Appendix E with each of the seven selected macroeconomic variables.

Table 6.1.1. Correlation between selected indexes and various macroeconomic variables

Indexes	**ASX All Ords**	**CPI**	**Industrial production volume index**	**Interest rate**	**Real GDP volume index**	**Unem-ployment rate**	**USD AUD**
1351 Clothing manufacturing	0.847*	0.961*	0.962*	-0.623*	0.972*	-0.790*	-0.010
1352 Footwear manufacturing	0.689*	0.911*	0.846*	-0.494*	0.883*	-0.689*	-0.106
1811 Industrial gas manufacturing	0.857*	0.971*	0.897*	-0.420*	0.943*	-0.773*	-0.254
1813 Basic inorganic chemical manufacturing	0.106	0.352*	0.242	-0.181	0.300*	-0.145	0.006
1831 Fertiliser manufacturing	0.592*	0.782*	0.697*	-0.264	0.738*	-0.600*	-0.204
1892 Explosive manufacturing	0.600*	0.735*	0.606*	-0.221	0.677*	-0.513*	-0.506*
1912 Rigid and semi-rigid polymer product manufacturing	0.716*	0.939*	0.909*	0.245	0.945*	-0.732*	-0.670*
1914 Tyre manufacturing	0.815*	0.960*	0.920*	-0.504*	0.944*	-0.782*	-0.092
2110 Iron smelting and steel manufacturing	0.758*	0.863*	0.762*	-0.249	0.820*	-0.696*	-0.365*
2121 Iron and steel casting	-0.333*	-0.219	-0.367*	0.243	-0.300*	0.393*	-0.476*
2132 Aluminium smelting	0.728*	0.616*	0.675*	-0.100	0.635*	-0.724*	0.134
2142 Aluminium rolling, drawing, extruding	0.617*	0.662*	0.663*	-0.124	0.654*	-0.671*	0.218
2221 Structural steel fabricating	0.722*	0.884*	0.777*	-0.346*	0.842*	-0.673*	-0.326*
2299 Other fabricated metal product manufacturing n.e.c.	0.388	0.926*	0.823*	-0.162	0.887*	-0.438*	-0.545*
2311 Motor vehicle manufacturing	0.718*	0.801*	0.873*	-0.692*	0.827*	-0.673*	0.212
2312 Motor vehicle body and trailer manufacturing	0.877*	0.977*	0.915*	-0.475*	0.957*	-0.784*	-0.250
2313 Automotive electrical component manufacturing	0.629*	0.672*	0.673*	-0.732*	0.668*	-0.371*	0.081
2319 Other motor vehicle parts manufacturing	0.842*	0.902*	0.942*	-0.512*	0.929*	-0.834*	0.189
2391 Shipbuilding and repair services	0.867*	0.963*	0.952*	-0.628*	0.966*	-0.771*	0.006

Indexes	ASX All Ords	CPI	Industrial production volume index	Interest rate	Real GDP volume index	Unem-ployment rate	USD AUD
2394 Aircraft manufacturing and repair services	-0.080	0.085	0.173	-0.433*	0.101*	0.018	0.863*
2412 Medical and surgical equipment manufacturing	0.395*	0.348*	0.389*	-0.398*	0.378*	-0.255	0.474*
2419 Other professional and scientific equipment manufacturing	-0.563*	-0.516*	-0.525*	-0.443*	-0.578*	0.703*	0.897*
2422 Communication equipment manufacturing	-0.261	-0.166	-0.240	0.568*	-0.207*	0.036	0.003
2429 Other electronic equipment manufacturing	-0.919*	-0.938*	-0.922*	0.570*	-0.941*	0.754*	0.194
2432 Electric lighting equipment manufacturing	0.840*	0.948*	0.965*	-0.565*	0.966*	-0.826*	0.118
2439 Other electrical equipment manufacturing	0.872*	0.970*	0.945*	-0.518*	0.967*	-0.802*	-0.090
2491 Lifting and material handling equipment manufacturing	0.906*	0.938*	0.883*	0.132	0.921*	-0.736*	-0.266
6931 Legal services	0.634*	0.992*	0.913*	0.132	0.986*	-0.703*	-0.755*
6932 Accounting services	0.731*	0.963*	0.892*	0.239	0.978*	-0.793*	-0.816*
6923 Engineering design and engineering consulting services	0.609*	0.990*	0.924*	0.119	0.978*	-0.671*	-0.719*
7000 Computer system design and related services	0.641*	0.939*	0.917*	0.279	0.942*	-0.768*	-0.700*
Ordinary time hourly rates of pay excluding bonuses ; Australia ; Private ; All industries	0.641*	0.997*	0.917*	0.120	0.991*	-0.696*	-0.766*
Ordinary time hourly rates of pay excluding bonuses ; Australia ; Private ; Manufacturing	0.652*	0.997*	0.921*	0.141	0.994*	-0.712*	-0.778*
Ordinary time hourly rates of pay excluding bonuses ; Australia ; Private ; Professional, scientific and technical services	0.609*	0.995*	0.912*	0.081	0.981*	-0.655*	-0.731*

*Significant at the 0.01 level (i.e. 99%)

In fact, results in Table 6.1.1. showed that all of the ABS indexes analysed were related to at least two macroeconomic variables. In particular, index ABS PPI 2221 Structural Steel Fabricating was strongly linearly related to all seven macroeconomic variables tested.

While the correlation results provide some tentative support for the use of at least some of these seven macroeconomic indicators as explanatory variables in the estimation of multiple regression models to be used to predict the value of the dependent variable (i.e. the index of interest), it is nevertheless important to note that correlation does not equate to causality. A significant correlation coefficient simply indicates that the two variables are linearly related.

The correlation analysis formed the basis for determining appropriate macroeconomic variables to use to estimate a multiple regression model for each index of interest. The regression modelling and interpretation of regression results, however, were not that straightforward. Table 6.1.2 shows the estimated regression results (i.e. coefficient estimates) for two particular indexes–ABS PPI 2110 Iron Smelting and Steel Manufacturing, and ABS PPI 2311 Motor Vehicle Manufacturing–against the seven macroeconomic variables.

Table 6.1.2. Multiple regression results – Steel products and Vehicles perspective

Indexes	ASX All Ords	CPI	Industrial production volume index	Interest rate	Real GDP volume index	Unemploy-ment rate	USD AUD	c	R-squared	Adjusted R-Squared	F-stat	Prob (F-stat)
2110 Iron Smelting and Steel Manufacturing	-0.003	2.215	-2.217	4.835	2.041	8.448	-15.006	-185.649	0.854	0.840	60.238	0
2311 Motor Vehicle Manufacturing	0.0008	0.695*	1.068*	-3.266*	-1.909*	-5.308*	-2.239	151.925	0.922	0.915	122.112	0

*Significant at the 0.01 level (i.e. 99%)

Firstly, Table 6.1.2 showed the regression model of ABS PPI 2311 Motor Vehicle Manufacturing has a coefficient of determination (R–squared) of 0.922, which indicates that the model's fit is very good. In this case 92.2% of the variation in index 2311 could be 'explained' by variations in the seven macroeconomic variables. The F test (F=122.22, p-value = 0) on face value supports this interpretation, especially in view of the significance of most of the explanators.

However, the regression interpretation is not as straightforward for ABS PPI 2110 Iron Smelting and Steel Manufacturing. The results for PPI-2110 indicated that none of the seven macroeconomic variables are significantly different from zero at the 0.01 level of significance. Therefore, interpretation of the impact of individual macroeconomic variables on the dependent variable (PPI-2110) cannot be conducted in a meaningful manner. Furthermore, the regression results contradicted the correlation results as PPI-2110 was found to be strongly correlated to six macroeconomic variables (except interest rate). The regression findings seemed to be flawed. By illustration, the correlation analysis in Table 6.1.1 shows that there was an inverse relationship between index 2110 (Iron Smelting and Steel Manufacturing) and the macroeconomic variable of unemployment–the correlation was -0.696. However, the multiple regression equation (see Table 6.1.2) for PPI-2110 produced a positive coefficient of 8.44 for the independent variable of unemployment. A similar contradiction was also observed for the macroeconomic variable of industrial production. Analysis found a positive correlation between PPI-2110 and the macroeconomic variable of industrial production, but the regression equation produced a negative coefficient.

Likewise, the coefficient for Real GDP under the regression equation for ABS PPI 2311 (Motor Vehicle Manufacturing) was negative. However, the correlation analysis reported a positive relationship between Real GDP and the index of 2311. These phenomena are almost certainly a direct result of multicollinearity, which can be a major problem with multiple regression.

Multicollinearity arises when the assumed independent or explanatory variables are highly correlated with one or more other explanatory variables (Bowerman, O'Connell and Murphree, 2011). Multicollinearity effectively means that it is not possible to separate the effect of one particular macroeconomic variable from another. The correlation matrix at Table 6.1.3 shows correlation among the seven potential independent variables.

Table 6.1.3. Correlation matrix – Australian macroeconomic variables

	ASX All Ords	CPI	Industrial production volume index	Interest rate	Real GDP volume index	Unemploy-ment rate	USD AUD
ASX All Ords	1.000						
CPI	0.900*	1.000					
Industrial production volume index	0.899*	0.968*	1.000				
Interest rate	-0.358*	-0.468*	-0.501*	1.000			
Real GDP volume index	0.914*	0.989*	0.986*	-0.492*	1.000		
Unemployment rate	-0.835*	-0.852*	-0.889*	0.105	-0.883*	1.000	
USD AUD	-0.201	-0.127	0.024	-0.339*	-0.062	0.078	1.000

*Significant at the 0.01 level (i.e. 99%)

The result from Table 6.1.3 indicates the presence of multicollinearity. By illustration, the correlation matrix shows that the correlation between ASX All Ordinaries (ASX All Ords) and CPI is 0.9; ASX All Ords and Real GDP is 0.914, and CPI and Real GDP is 0.989 (all three are significant at the 0.01 level). Given that the stock market (i.e. ASX All Ords), inflation (i.e. CPI), and real GDP in Australia tend to move together, it is not possible to separate the individual impact each of these macroeconomic variables has in a particular price index.

From an international comparison perspective, the correlation analysis on the set of seven macroeconomic variables from the US and the UK also demonstrated that the majority of these macro variables were strongly correlated with each other. The correlation matrices for these non-Australian macro variables are available in Appendix H and I. Therefore the issue of multicollinearity among the macroeconomic variables exist not just in Australia-based data.

Accordingly, as macroeconomic factors intertwine with each other, isolating a few of these macro variables and then interpreting the significance of the regression equation as a way to predict a value of the price index may provide misleading results. This problem was clearly evident with the regression equation of ABS PPI 2110. In the case of ABS PPI 2110, Table 6.1.2 indicated that none of the estimated coefficients in the estimated regression model was found to be significantly different from zero (at the 0.01 level of significance), yet the R-squared was 0.85, indicating a good fit of the model. Such outcomes occur when there is significant multicollinearity occurring between the explanatory variables. This is clearly the case here, as shown by the correlation matrix for the seven macroeconomic variables at Table 6.1.3. While it may be true that multicollinearity may not harm forecasts as long as it continues into the forecast period, it is rather difficult to predict or assess continuance of multicollinearity. Furthermore, it is safe to assume that due to the presence of multicollinearity, one of the regression assumptions has been violated. The difficulties lie in identifying which assumptions were violated. Also, even if a particular explanatory variable was removed as the result of further analysis, extreme caution is necessary as removing a variable can result in specification bias. As a result, multiple regression modelling is unlikely to offer any advantages for the purpose of prediction for the indexes of interest in this research[19].

In addition, even if a number of independent macroeconomic variables could be identified for use in a multiple regression model, or indeed one macroeconomic variable in a single variable regression model, the prediction of the dependent variable from the estimated regression model will be based on predictions of the explanatory variables in the estimated model. As such, additional modelling is required to generate predictions on these explanatory variables. The accuracy of the predicted explanatory variables will, of course, impact on the predicted dependent variable–the index of interest. In sum, the

---

[19] The logically prior question was pursued of whether in fact the macroeconomic factors could have been sensibly viewed as 'explaining' the price indexes or whether the reverse causation might have been true - with macro effects being built up from the more micro-oriented industry specific indexes. An extensive amount of additional analysis was not reported here, as it did not ultimately add additional light to finding the 'best' method in forecasting indexes. This analysis was undertaken by a series of Granger causality tests (conducted in EViews), with attention also being paid to a potential problem of non-stationarity (addressed through differencing the data). Some of the results were counter-intuitive, others were the apparent result of obvious correlation, but could not be confirmed as evidence of causality.

current research takes the view that it is necessary to explore alternatives especially due to the contradictory results presented in the regression modelling.

6.2 Time series forecasting–Holt-Winters method

An alternative technique is time series forecasting. There are many such procedures available, including the extrapolation of trend curves and exponential smoothing. The Holt-Winters multiplicative forecasting procedure is an exponential smoothing technique that has been proven to be useful when dealing with a broad range of different time series data, including time series containing trend and seasonal variation.

This type of forecasting assumes that a time series has four elements. These are trend, seasonal, cyclical, and irregular. Exponential smoothing actually continually revises a forecast based on previous observations. This is achieved by assigning exponentially decreasing weights to earlier observations. Effectively, recent observations are given more weight than past observations. Unlike forecasts generated from regression equations, which use fixed coefficients, forecasts from exponential smoothing actually adjust based upon past forecast errors.

Table 6.2.1 shows the annual forecast inflation together with their 95% confidence interval for each of the shortlisted ABS indexes.

Table 6.2.1. Index forecasts and their respective 95% confidence interval

Indexes	2012			2013			2014		
1811 Industrial gas manufacturing	11.3%	±	3.2%	10.2%	±	3.2%	9.2%	±	3.2%
1813 Basic inorganic chemical manufacturing	2.5%	±	14.4%	2.4%	±	15.5%	2.4%	±	16.6%
1831 Fertiliser manufacturing	12.4%	±	5.6%	11.1%	±	5.5%	10.0%	±	5.4%
1892 Explosive manufacturing	5.1%	±	5.0%	4.9%	±	5.2%	4.6%	±	5.5%
1912 Rigid and semi-rigid polymer product manufacturing	0.7%	±	4.6%	0.7%	±	5.0%	0.7%	±	5.5%
1914 Tyre manufacturing	2.4%	±	4.7%	2.4%	±	5.0%	2.3%	±	5.3%
2110 Iron smelting and steel manufacturing	7.4%	±	6.9%	6.9%	±	7.1%	6.4%	±	7.3%
2121 Iron and steel casting	3.1%	±	4.7%	3.0%	±	4.9%	2.9%	±	5.3%
2132 Aluminium smelting	2.3%	±	29.0%	2.2%	±	31.3%	2.2%	±	33.6%

Indexes	2012			2013			2014		
2142 Aluminium rolling, drawing, extruding	1.1%	±	18.0%	1.1%	±	19.6%	1.1%	±	21.3%
2221 Structural steel fabricating	2.4%	±	7.2%	2.3%	±	7.7%	2.3%	±	8.3%
2299 Other fabricated metal product manufacturing n.e.c.	2.8%	±	3.4%	2.8%	±	3.6%	2.7%	±	3.9%
2311 Motor vehicle manufacturing	-0.9%	±	4.0%	-0.9%	±	4.5%	-0.9%	±	5.0%
2312 Motor vehicle body and trailer manufacturing	2.2%	±	2.6%	2.1%	±	2.8%	2.1%	±	3.1%
2313 Automotive electrical component manufacturing	3.6%	±	5.4%	3.5%	±	5.7%	3.3%	±	6.0%
2319 Other motor vehicle parts manufacturing	1.0%	±	4.7%	1.0%	±	5.1%	1.0%	±	5.5%
2391 Shipbuilding and repair services	5.3%	±	4.0%	5.1%	±	4.2%	4.8%	±	4.4%
2394 Aircraft manufacturing and repair services	2.8%	±	12.5%	2.7%	±	13.3%	2.6%	±	14.2%
2412 Medical and surgical equipment manufacturing	-0.4%	±	8.4%	-0.4%	±	9.3%	-0.4%	±	10.3%
2419 Other professional and scientific equipment manufacturing	-1.61%	±	18.34%	-1.64%	±	22.36%	-1.66%	±	26.57%
2422 Communication equipment manufacturing	1.8%	±	6.2%	1.7%	±	6.7%	1.7%	±	7.3%
2429 Other electronic equipment manufacturing	-5.7%	±	13.5%	-6.1%	±	15.7%	-6.4%	±	18.4%
2432 Electric lighting equipment manufacturing	2.4%	±	4.1%	2.4%	±	4.4%	2.3%	±	4.7%
2439 Other electrical equipment manufacturing	2.4%	±	2.5%	2.3%	±	2.7%	2.3%	±	2.9%
2491 Lifting and material handling equipment manufacturing	0.6%	±	5.4%	0.6%	±	5.9%	0.6%	±	6.4%
6931 Legal services	2.5%	±	2.6%	2.5%	±	2.7%	2.4%	±	2.9%
6932 Accounting services	1.8%	±	3.2%	1.8%	±	3.5%	1.7%	±	3.7%
6923 Engineering design and engineering consulting services	3.2%	±	4.9%	3.1%	±	5.2%	3.0%	±	5.6%
700 Computer system design and related services	2.7%	±	2.5%	2.7%	±	2.6%	2.6%	±	2.8%
Ordinary time hourly rates of pay excluding bonuses ; Australia ; Private ; All industries	3.2%	±	0.8%	3.1%	±	0.9%	3.0%	±	0.9%
Ordinary time hourly rates of pay excluding bonuses ; Australia ; Private ; Manufacturing	2.9%	±	0.9%	2.8%	±	0.9%	2.7%	±	1.0%

Indexes	2012	2013	2014
Ordinary time hourly rates of pay excluding bonuses ; Australia ; Private ; Professional, scientific and technical services	3.7% ± 1.5%	3.6% ± 1.6%	3.5% ± 1.6%

It is interesting to note that for several indexes the expected inflation forecast is one of possible deflation (i.e. negative). In particular, ABS PPI 2429 Other Electronic Equipment Manufacturing, where the (annual) deflation ranges from -5.7 to -6.4%. This is as a result of the forecast technique being based on historical data of the index series of interest. If this index has, in the recent past, been in decline, then this declining trend will be reflected in the predictions. Of course, such forecasts may not be held with very much confidence, as is now discussed.

Table 6.2.1 presents the forecasts and associated 95% confidence intervals. The lower and upper bounds of the forecasts reflect the volatility that the index has experienced. For example, since the labour price movement for the manufacturing industry (as seen in ABS LPI Ordinary time exclude bonus–Manufacturing) has been quite stable in the past, the 95% confidence interval for year 2012 was ±0.9% while the forecast was 2.9%. In comparison over the same period, ABS PPI 1813 Basic Inorganic Chemical Manufacturing has a lower and upper boundary of ±14.4% while the forecasted inflation was 2.5%. This reflects the fact that the series from which the forecasts were estimated fluctuated significantly during the period that was analysed.

It is important to note that all forecast estimates should be treated with caution as there are many uncertainties and assumptions that underlie such estimates. The forecasts and associated 95% confidence intervals for ‘appropriate’ defence contracting indexes from BLS and ONS are available in Appendix J and K.

6.3 Summary on index forecasting

In conclusion, the current research found that one method to aid contract budgeting and management is the use of univariate time series forecasting–the Holt-Winters multiplicative forecasting procedure. This procedure was used to provide a forecast together with a 95% confidence bound for the minimum or maximum likely inflation compensation that would be required if the index was used as part of the contract. Furthermore, since multicollinearity was observed in the multiple regression modelling undertaken as part of the current research, therefore in comparison, univariate time series forecasts appear to be a more appropriate forecasting technique for defence contracting purposes. In the context under consideration, univariate forecasting also made the best use of available data.

Chapter Seven

Illustrative application

In order to propose and develop a framework to calculate the ‘true’ defence-contract-relevant inflation, three coherent stages were discussed in Chapters Four to Chapter Six. These were, (i) selecting an ‘appropriate’ index or indexes, (ii) correcting the bias in the index, and (iii) forecasting the index for inflationary outlook. An additional step presented here is to show the illustrative application of the initiatives recommended by this research.

This illustrative application contains two analyses. It will first conduct a comparative analysis between the two price variation approaches, namely the Single Index and Multiple Indexes approaches. Such a demonstration of the practical application will be completed by using historical, smoothed, and forecast data for the procurement of combat vehicles. In the field of defence verse commercial procurement, vehicles are arguably a closer comparison than many other procurements of defence interest. Nonetheless, while the illustrative example is applied to the procurement of combat vehicles, the procedures are also typical of other specialised combat equipment procurements like combat communications equipment, combat aircraft and so forth.

The second part of the illustrative example is to investigate the relative difference in inflation between the procurement of combat and commercial vehicles. In this analysis, under the Multiple Indexes approach, the issue of difference in cost structure in material and labour for combat and commercial vehicles will become apparent.

All of the inflation measures calculated should be treated with caution due to the assumptions made in conducting this analysis. The geometric mean was used to calculate the inflation and aggregate the composite inflation.

7.1 Calculating the 'true' defence-contract-relevant inflation for the procurement of combat vehicles

Stage 1–Selecting an 'appropriate' index or indexes

For any procurement, officers in DMO and defence contractors can consider using either the Single Index or the Multiple Indexes approach. The current example will contrast the difference in inflation between the two price variation approaches for the procurement of combat vehicles using the Three-Stage Modelling Strategy.

Recall that the first stage in the Three-Stage strategy in calculating the 'true' defence-contract-relevant inflation is to select an 'appropriate' index or indexes. Therefore, under the Single Index or Finished Goods approach, choosing from Appendix E, the 'appropriate' index which matches combat vehicles most closely would be the ABS PPI 2311 Motor Vehicles Manufacturing. It is important to note that if the user was to choose an index at a higher level than what has been recommend by the current research (i.e. the fourth dissection level), for any reason (say due to practicality), then this will contradict the selection principle of 'relevant degree of aggregation'. The current research takes the view that the criterion of 'relevant degree of aggregation' of the index to the contract procurement should be more important than other selection criteria, such as being 'not too volatile'.

Similarity, indexes under the Cost Components approach were chosen from the refined set of ABS indexes presented in Appendix E. The 'basket' of price indexes relevant to the procurement of combat vehicles' cost structure, together with its weights, is presented in Table 7.1.1.

Table 7.1.1. Weighting pattern of combat vehicles - Australian case example

Combat (protected) vehicles	**Weights**	**Average annual inflation between 2003/04-2007/08**
ABS PPI 1914 Tyre manufacturing	0.02	0.72%
ABS PPI 2110 Iron smelting and steel manufacturing	0.09	9.12%
ABS PPI 2221Structural steel fabricating	0.10	5.99%
ABS PPI 2312 Motor vehicle body and trailer manufacturing	0.07	3.27%
ABS PPI 2313 Automotive Electrical component manufacturing	0.07	1.60%
ABS PPI 2319 Other motor vehicle parts manufacturing	0.07	0.20%
ABS PPI 2491 Lifting and material handling equipment manufacturing	0.04	3.69%
ABS PPI 6923 Engineering design and engineering consulting services	0.10	8.09%
ABS LPI Ordinary time hourly rates of pay excluding bonuses; Private; Manufacturing	0.19	2.82%
Non-variable element - Other costs	0.25	-
Total	1.00	

Table 7.1.1 also shows the average annual inflation for the five-year period (between financial years 2003/04 and 2007/08) for this collection of indexes.

In addition to price indexes, a non-variable element can be seen in Table 7.1.1. For illustrative purposes, a weight of 0.25 was assigned to ‘other costs’. This was due to the fundamental principle of price variation, and that its intent was to cater for unexpected fluctuations in material and labour costs experienced by the contractor. Other costs that are non-material or non-labour in nature fall outside the intent of the price variation objective, and were previously discussed under Section 5.2.1.

Since all indexes in this example have been selected from Appendix E, these indexes are deemed by this research to be ‘appropriate’ indexes for defence contracting purposes.

Stage 2–Correcting the biases in the index

The second stage involved in calculating the ‘true’ defence-contract-relevant inflation is to correct the biases in the selected index or indexes. Firstly, from the Single Index or Finished Goods approach since the defence industry is ‘unique’ and as it is quite specialised, many firms may not be able to achieve economies of scale or scope like those in the commercial manufacturing industry. In such situations the publicly available index would understate the 'true' inflation. Therefore, a defence-specific adjustment is required. Figure 7.1.1 shows the application of the rating scale which was recommended in Section 5.2.1.

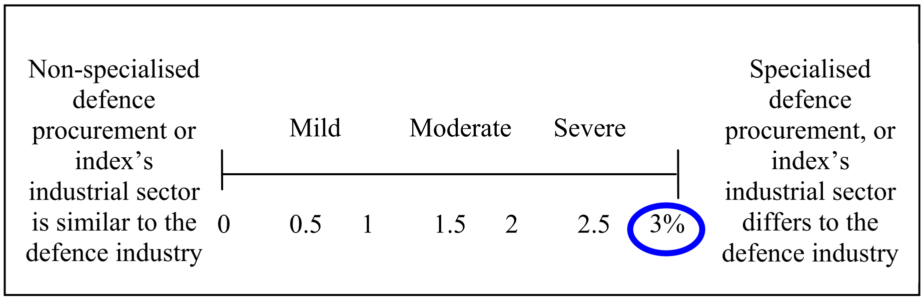


Figure 7.1.1. Application of the defence-specific adjustment – Australian combat vehicles example

For the example of combat vehicles, since such procurements are considered to be 'specialised materiel', and by using the rating scale in Figure 7.1.1, a 3% defence-specific adjustment is applicable. An additional rationale for such a choice is that the industrial sector reflected by the price index, ABS 2311 Motor Vehicle Manufacturing, is dominated by activities in manufacturing commercial items rather than activities related to manufacturing specialised materiel. On these bases and under the Single Index approach, the index ABS 2311 Motor Vehicle Manufacturing would need to be up-scaled by 3% in an attempt to align more with the 'true' defence-contract-relevant inflation, but also be capped at a maximum of 4.5% p.a. if the after up-scale inflation is greater than 4.5%[20].

The analysis will now turn to the bias correcting adjustment under the Multiple Indexes or Cost Components approach. This bias correcting adjustment relates to the appropriate treatment or consideration of productivity in the calculation of the

[20] It is important to note that if for any practical reason a third dissection level index was chosen (which contradicts the selection principle of 'relevant degree of aggregation'), the logic behind the rating scale shown in Figure 7.1.1 would still be valid. This is because the procurement would still be classified as a specialised defence materiel, and despite widening the industrial sector to include more industries at the third dissection, those industries included in the index would still likely to differ from the industry of interest.

composite inflation. It was earlier found (Chapter Five) that the composite inflation would be overstated as the index on labour cost is usually an input index which does not cater for productivity. Additionally, the research also found that the composite inflation most certainly would have been overstated as it fails to cater for the productivity gain generated from the production process.

While precise determination of the productivity achievable and apportioned from the producer to the buyer is a comprehensive and challenging exercise, current research can show the affect of productivity at various rates. For illustrative and comparison purposes the current research will consider three productivity rates, 0.3%, 1% and 2%, to discount the component associated with material and/or capital[21]. In addition, a labour productivity deduction of 1%, which was sourced from the ABS measures of labour productivity, has been applied to the indexes from the series of ABS LPI (this was discussed under Section 5.2)[22].

After correcting the biases associated with each of the price variation approaches, Figure 7.1.2 shows the accumulated inflation movement reflected by the two approaches using historical data. There are five variants applied to the Multiple Indexes approach in order to illustrate the effect of the non-variable element (i.e. 25%) and the various multifactor productivity adjustments (however, the labour productivity for this illustration is fixed at 1% - for an additional illustrative comparison, another analysis which uses the labour productivity of 2% is available at Appendix L. Only minor differences were noted between using 1% and 2% for labour productivity).

---

[21] The first productivity rate of 0.3% is the average of the ABS Multifactor Productivity rate between 1990 and 2009. The second rate of 1% is half of the 2% productivity rate provided by 10 of the top defence contractors in the 2005 survey. This is result of an attempt to discount the survey figure to compensate for what appears to be rather excessive optimism of the contractors surveyed. The 2% productivity was the estimate recorded in the Defence Contractor Survey in 2005.

[22] It is important to note that these four productivity rates (for material/capital and labour) are used for illustrative purposes only. The resulting inflation in any case will almost certainly vary each time if a different productivity deduction is applied to the calculation. However, the determination of the exact productivity achievement and apportionment is specific to each individual contract performance; such a task is beyond the scope of this current research.

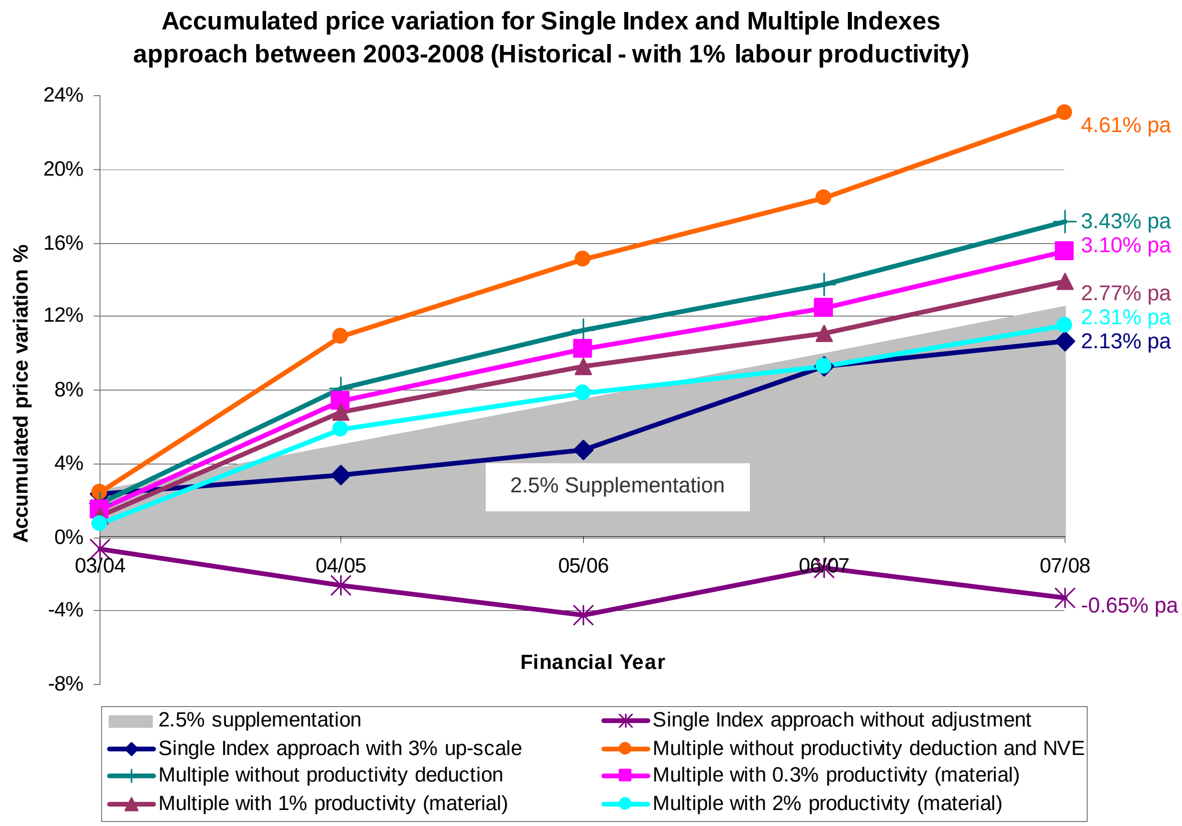


Figure 7.1.2. Comparison of inflation from the two price variation approaches (historical data) – combat vehicles perspective

Figure 7.1.2 shows that the choice of productivity adjustment has a considerable influence on the composite inflation. The differences among the various chosen productivity deductions caused the composite inflation to differ by approximately 1% on an annual average basis. Also Figure 7.1.2 shows the contrast in implication of utilising non-variable element. Simply by including a non-variable element of 25% (and neglecting the effect of productivity), there was an approximately 1.2% p.a. difference in average inflation.

Figure 7.1.2 also shows that, in this example, the inflation under the Single Index approach was the lowest in comparison to the inflation from the three variants of the Multiple Indexes approach. The inflation generated from the Single Index approach was approximately 1% p.a. lower than the composite inflation generated from the Multiple Indexes approach with 0.3% productivity deduction. Yet, if a 2% productivity reduction was applied, then there was little difference between the two price variation approaches.

In that situation, the Multiple Indexes approach with 2% productivity was only slightly higher (i.e. 0.2%) in inflation than the Single Index approach.

Figure 7.1.2 also shows the significance of the application of the defence-specific adjustment. If no adjustment was applied to the index under the Single Index approach in this example, and since deflation occurred, the average yearly deflation for the same period was calculated to be 0.65%. In essence, if a contract used the ABS PPI 2311 Motor Vehicles Manufacturing, the contractor in principle is required to reduce their contractual price according to the deflation observed by the index.

The following part of the analysis compares the difference in inflation between those inflations generated using smoothed data rather than historical data. The advantage of using a smoothed index series for price variation was briefly discussed in Section 5.2.2. Figure 7.1.3 shows the accumulated price variation using smoothed data.

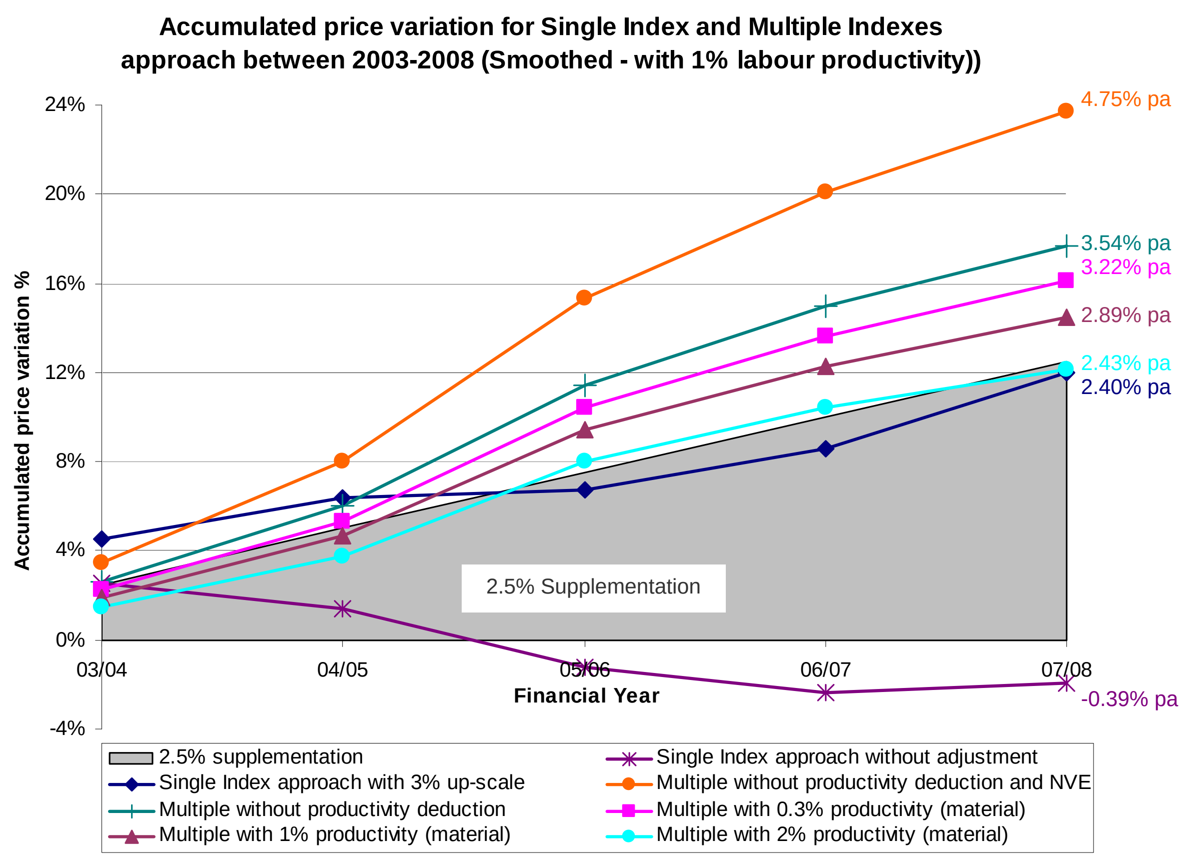


Figure 7.1.3. Comparison of inflation from the two price variation approaches (smoothed data) – combat vehicles perspective

Comparison of Figure 7.1.2 and Figure 7.1.3 shows, in this current example, that there was only a small difference between using historical and smoothed data. At the 2% productivity deduction level, the average annual rate using historical data was 2.31% while using smoothed data showed it to be 2.43% p.a. In fact, not more than 0.3% p.a. separated the inflation calculated using historical and smoothed data at the various conditions (i.e. zero, 0.3%, 1%, and 2% productivity levels).

Stage 3 - Forecasting the selected index or indexes

The third stage in the Three-Stage strategy is to obtain an inflationary outlook of the 'appropriate' index or indexes. Ideally, having these forecasts may aid DMO, and defence contractors, with their contract budgeting and management tasks. It may enable contractors to note in advance and effectively manage, the anticipated inflation compensation they are likely to receive. The forecast analysis in this example will also illustrate the extent to which the different methods (Single Index and Multiple Indexes) lead to diverse consequences. In fact, the analysis will also show the sensitivity of the consequences (i.e. the actual inflation allowed) to the productivity assumption under the Multiple Indexes approach.

It is important to note that all forecast estimates should be treated with caution as there are many uncertainties and assumptions that underlie these results. Using the forecast estimate from Chapter Six, Figure 7.1.4 shows the forecast accumulated price variation using the two price variation methods.

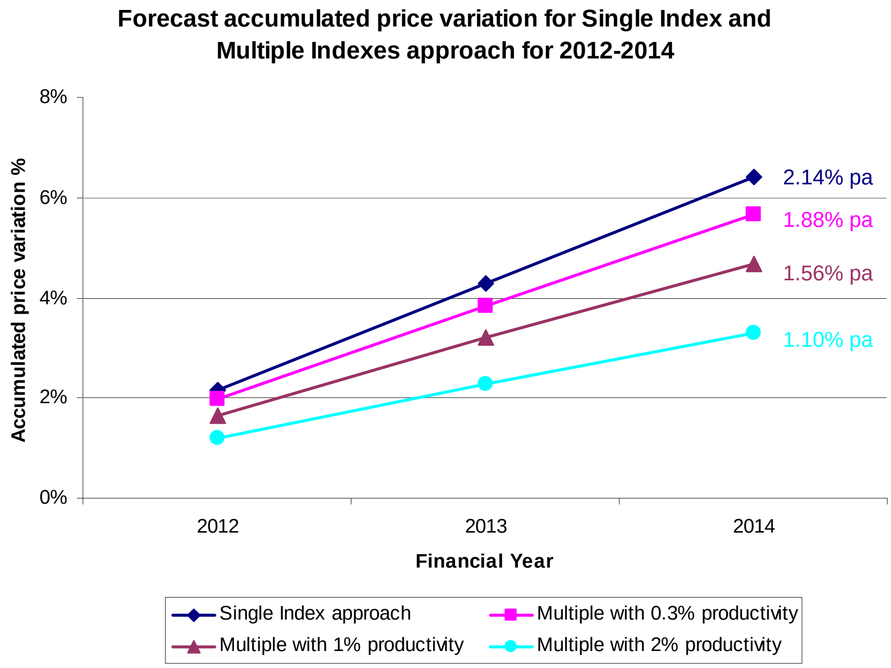


Figure 7.1.4. Comparison of inflation from the two price variation approaches (forecast estimates) – combat vehicles perspective

It is important to note the forecast annual rate of 2.14% under the Single Index approach, seen in Figure 7.1.4, is already inclusive of the 3% defence-specific adjustment. If such an adjustment was not applied on this occasion and as the index was forecasted to deflate, then based on the forecast reported in Chapter Six, the contractor would have been required in principle to lower its contractual price by an average of 0.86% (i.e. 2.14% - 3%) per annum between the years 2012 and 2014.

Figure 7.1.4 also shows the sensitivity of the composite inflation as a consequence of the productivity rate deduction. However, the analysis of forecast estimates produced patterns that are slightly different to the patterns observed while using historical and smoothed data. Instead, if a 2% productivity deduction was applied, there would be a discrepancy of approximately 1% in the inflation between the Single Index and Multiple Indexes approaches. On the other hand, there would only be a 0.46% p.a. discrepancy between the two approaches if a 0.3% productivity deduction was applied to the forecast data. Therefore, the pattern of accumulated price variations when using historical and smoothed data differed to that found when using forecast estimates.

The forecast technique could be a reason why there is a difference in patterns between historical and smoothed data, and forecast estimates. The forecast estimates generated in Chapter Six utilised the Holt-Winters method, which is a weighted exponential time series forecast technique. As previously noted, this forecast technique gives more weight to the most recent observations. As such, forecasts generated in Chapter Six are actually more sensitive to recent conditions. This technique is appropriate theoretically, as in most situations, the economic conditions that were relevant to the industrial sector (say) twenty years ago would not be nearly as relevant as those that occurred for example, five years ago, even for large occasional contracts.

It is also important to note that the differences in patterns between historical and smoothed data to forecast estimates can also be due to the large magnitude of inflation observed by certain indexes during the years analysed in the current example of combat vehicles. By way of illustration, for the financial year 2004/05, the ABS PPI 2110 Iron Smelting and Steel Manufacturing inflated by 32% while the ABS PPI 2221 Structural Steel Fabricating inflated by only 15%. In 2006/07 these two indexes inflated by only 2.86% and 1.46% respectively. The forecast for the year of 2012, with a 95% confidence interval, was 7.4%±6.9% for ABS PPI 2110 Iron Smelting and Steel Manufacturing, and 2.4%±7.2% for ABS PPI 2221 Structural Steel Fabricating. The findings presented in Figure 7.1.4 only used the 7.4% and 2.4% inflation figures. Obviously, the composite inflation would change if the upper bound inflations of 14.3% (7.4+6.6%) and 9.6% (2.4+7.2%) were used instead. Therefore, the current example of combat vehicles illustrates that inflation forecast is not only sensitive to price variation approaches (Single Index or Multiple Indexes) or to the various productivity deductions, but also to the forecast estimates used in the calculation.

Figure 7.1.5 shows the 95% confidence upper and lower bounds for the forecast accumulated price variation under the Single Index approach which included a 3% defence-specific adjustment.

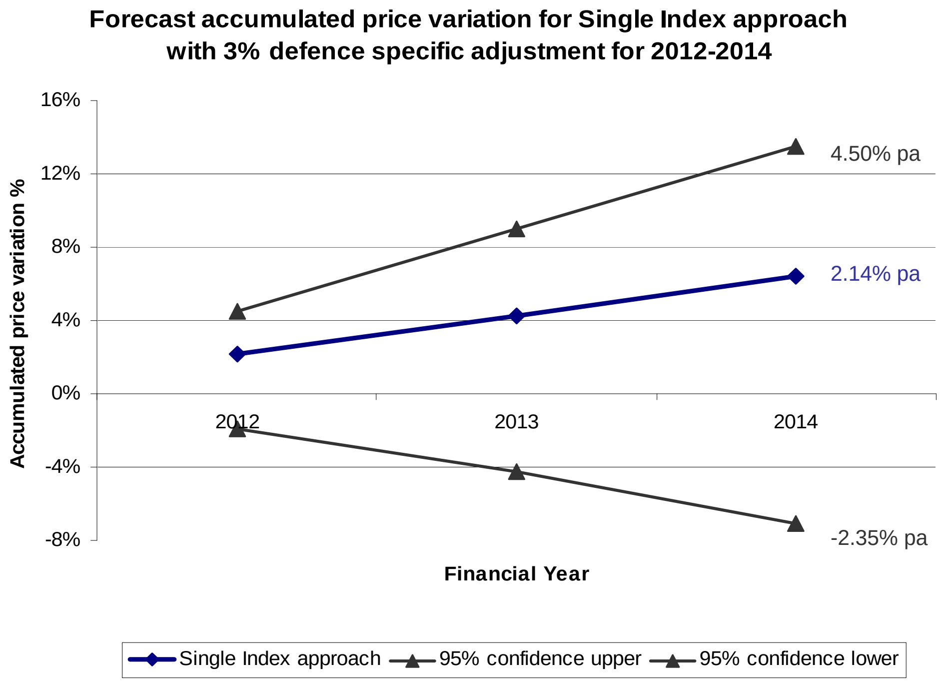


Figure 7.1.5. Forecast estimates of Single Index approach with defence-specific adjustment – combat vehicles perspective

Since using the productivity rate of 0.3% under the Multiple Indexes approach, as in this forecast example, produces a more closely matching inflation to the inflation from the Single Index approach, the following comparison will use the same productivity rate. Figure 7.1.6 shows the 95% confidence upper and lower bounds for the forecast accumulated price variation under the Multiple Indexes approach which had a 0.3% productivity adjustment applied.

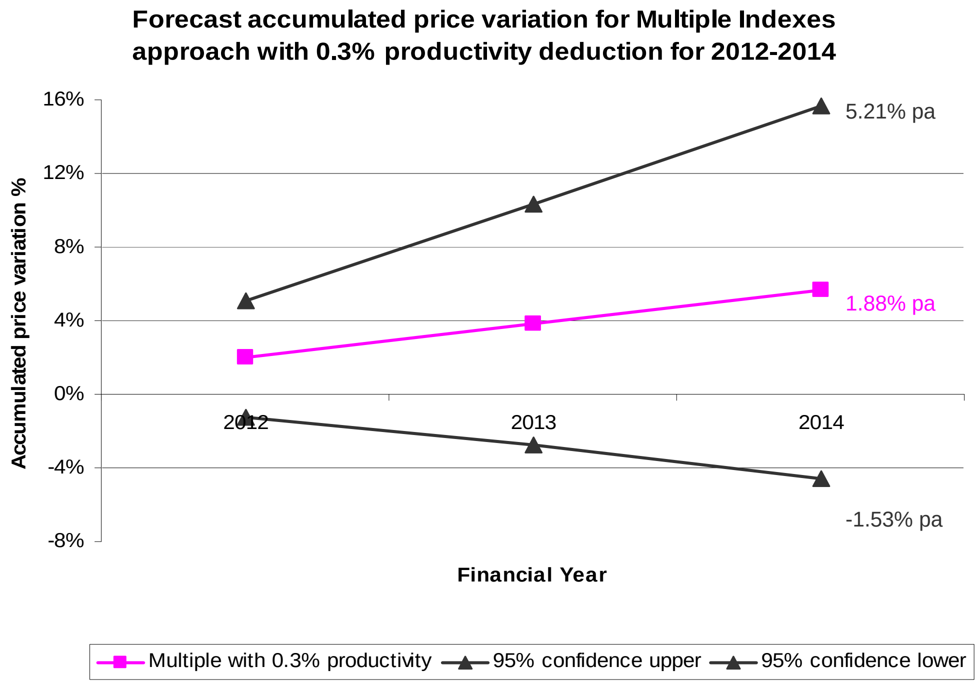


Figure 7.1.6. Forecast estimates of Multiple Indexes approach with 0.3% productivity deduction – combat vehicles perspective

Referring again to Figure 7.1.5, this shows that over a three year period, under the Single Index approach if the upper bound (with 95% confidence) eventuated, then the combat vehicles contractor potentially would receive 4.5% p.a. as compensation for inflation. In comparison, Figure 7.1.6 shows that the upper bound (with 95% confidence) under the Multiple Indexes approach is slightly higher at 5.21% p.a. Furthermore, the lower bound (with 95% confidence) under the Multiple Indexes approach is less (i.e. -1.53% p.a.) than the inflation from the Single Index approach (i.e. -2.35% p.a.). As such, the 95% confidence upper and lower boundaries, as seen in Figures 7.1.5 and 7.1.6, can be a useful tool for both DMO and its contractors for contract management purposes.

7.2 Comparison of the inflation for the procurement of combat and commercial vehicles

Another dimension of this illustrative example is to investigate the difference in inflation for the procurement contract of combat vehicles and commercial vehicles. This can be completed by comparing the inflation calculated under the Multiple Indexes, or Cost Components, approach for both vehicle types. The cost structures and their respective indexes and weight components for combat vehicles was already presented in Table 7.1.1. The specific indexes and their respective weights for commercial vehicle cost component are presented below in Table 7.2.1. These were sourced from the ABS 5206 Input Output Tables.

Table 7.2.1. Weighting pattern of commercial and combat vehicles – Australian case example

	Weights - Commercial (unprotected) vehicles	**Weights – Combat vehicles**	**Average annual inflation between 2003/04-2007/08**
ABS PPI 1813 Basic inorganic chemical manufacturing	0.01	NA	0.64%
ABS PPI 1912 Rigid and semi-rigid polymer product manufacturing	0.04	NA	3.50%
ABS PPI 1914 Tyre manufacturing	NA	0.02	0.72%
ABS PPI 2110 Iron smelting and steel manufacturing	0.06	0.09	9.12%
ABS PPI 2132 Aluminium smelting	0.02	NA	4.12%
ABS PPI 2221 Structural steel fabricating	0.02	0.10	5.99%
ABS PPI 2312 Motor vehicle body and trailer manufacturing	0.20	0.07	3.27%
ABS PPI 2313 Automotive Electrical component manufacturing	NA	0.07	1.60%
ABS PPI 2319 Other motor vehicle parts manufacturing	0.03	0.07	0.20%
ABS PPI 2419 Other professional and scientific equipment manufacturing	0.01	NA	-1.79%
ABS PPI 2491 Lifting and material handling equipment manufacturing	0.01	0.04	3.69%
ABS PPI 6923 Engineering design and engineering consulting services	0.06	0.10	8.09%
ABS LPI Ordinary time hourly rates of pay excluding bonuses ; Australia ; Private ; Manufacturing	0.18	0.19	2.82%
Non variable element - Other costs	0.36	0.25	-
Total	1.00	1.00	

Table 7.2.1 shows that not only is the collection of indexes different for the two vehicle types, but so too are the relative weighting patterns. Analysis using historical data to calculate the inflation for both vehicles types is presented in Figure 7.2.1.

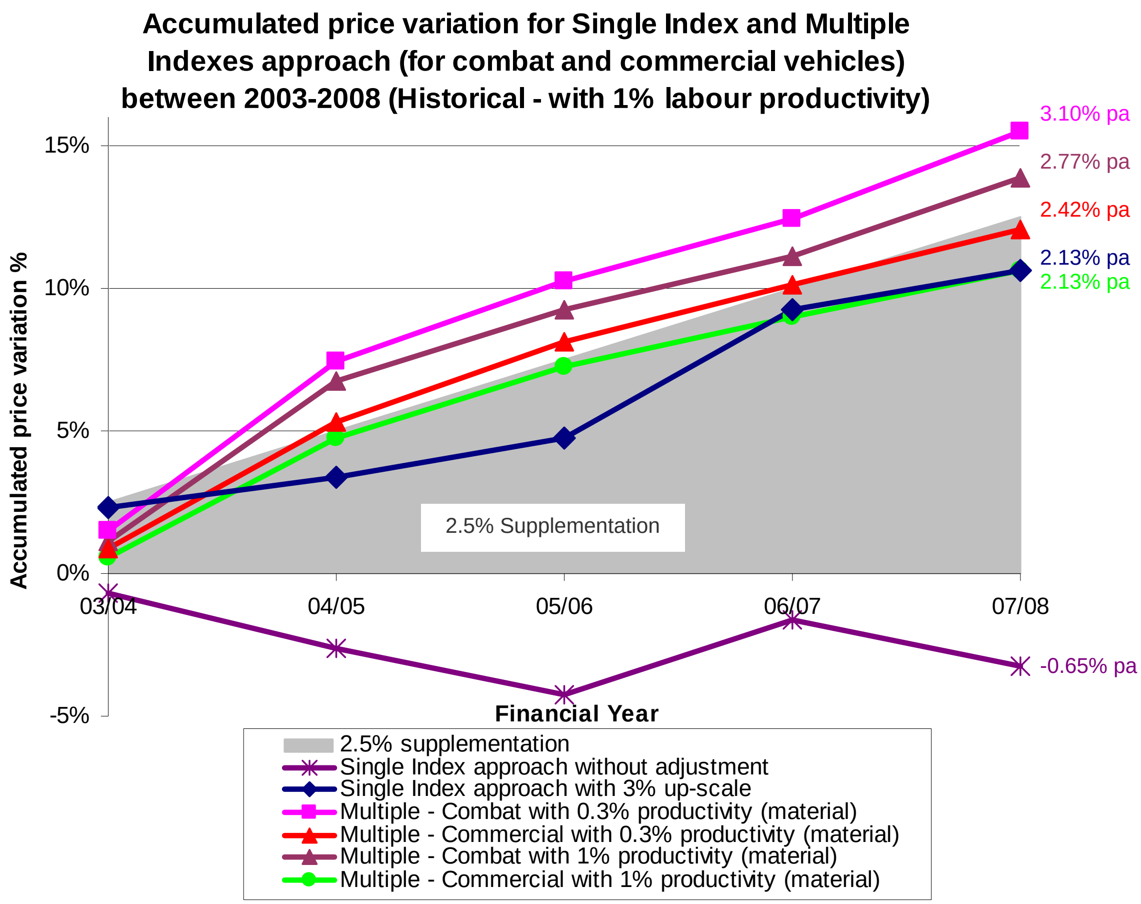


Figure 7.2.1. Comparison of inflation from the two price variation approaches (historical data) – combat and commercial vehicles perspective

The following analysis discusses the three scenarios which were investigated. Each falls under the Multiple Indexes approach. The first scenario is when both manufacturing industries (i.e. commercial vehicles and combat vehicles) achieve the same productivity (i.e. either 0.3% or 1%). Under this scenario, and as shown in Figure 7.2.1, the average annual inflation for combat vehicles is higher, by approximately 0.6% p.a., than commercial vehicles (both at the 0.3% and 1% productivity level). A 0.6% p.a. difference is quite modest. As a result, these findings support the line of argument that, relatively speaking, inflation in commercial and combat vehicles is indeed different.

The second scenario is possible when the contractors in the manufacturing industry of commercial vehicles can achieve productivity higher than those in the industry of combat vehicles. For example, this could be illustrated using the productivity rate of 0.3% for combat vehicles and 1% for commercial vehicles. Figure 7.2.1 shows that the inflation for combat vehicles (with 0.3% productivity) was 3.10% p.a. while the inflation for commercial vehicles (with 1% productivity) was 2.13% per annum. The difference between these two inflationary pressures can be as large as 1% p.a.

The third scenario is the opposite of the second scenario, and such a scenario may exist when contractors in the manufacturing industry of combat vehicles are able to achieve productivity higher than those in the industry of commercial vehicles. In this scenario, Figure 7.2.1 showed that the inflation for combat vehicles (with 1% productivity) was 2.77% p.a. while the inflation for commercial vehicles (with 0.3% productivity) was 2.42% per annum. Once again, the inflation for the procurement of combat vehicles, under this illustrative example, is higher than those applicable to commercial vehicles.

In summary, the current findings indicate that for the Australian case example of combat vehicles, if the Multiple Indexes approach is used, then the inflation for the procurement of specialised materiel will be higher than that of its commercial counterparts. Accordingly, the current findings are mostly in agreement with the persistent argument in the defence literature that inflation for specialised materiel is higher than for non-combat counterparts.

As for the Single Index approach, Figure 7.2.1 revealed that when a productivity deduction of 1% is applied under the Multiple Indexes approach for commercial vehicles, for the five year periods analysed, its average yearly inflation of 2.13% was the same as those calculated under the Single Index approach where a 3% up-scale defence-specific adjustment was applied. All other inflations generated under the Multiple Indexes approach, as seen in Figure 7.2.1, were higher than the inflation from the Single Index approach (with adjustment).

Most importantly though, since deflation occurred, without the application of the defence-specific adjustment, the contractor in principle would have been required to reduce their contractual price according to the deflation observed by the index.

7.3 Summary of the two illustrative applications

Using historical and smoothed data, the illustrative example of combat vehicles showed that composite inflation under the Multiple Indexes or Cost Components approach was higher than the inflation referenced by the Single Index (or Finished Goods) approach– despite the inclusion of a 3% defence-specific adjustment. Furthermore, this gap could be bridged if a 2% productivity deduction was applied. However, the opposite was observed when using forecast estimates. As has already been indicated, a large number of assumptions have been made in applying the Holt-Winters forecasting procedure for the determination of these forecasts. With this caveat, however, the calculation of the potential inflation generated from the forecast's 95% confidence limits, which form the upper and lower bounds, can provide an alternative outlook for inflation budgeting and management purposes.

The illustrative example of combat vehicles showed that productivity deduction can have a considerable effect on the composite measure of inflation under the Multiple Indexes (or Cost Components approach). On these bases, the lesson is that a high-quality and robust determination of productivity that is reflective of each individual contract performance would appear to be essential in order to calculate the 'true' defence-contract-relevant inflation.

Finally, the second dimension of the illustrative application example between combat and commercial vehicles confirmed that since the cost components and their respective weights differ, so too do the corresponding composite inflations on these two types of vehicles (under the Multiple Indexes approach). Under the scenarios examined by this research, its findings provide support that the inflation calculated by a 'basket' of Australian price indexes for the procurement of combat vehicles is in fact higher than for commercial vehicles.

Chapter Eight

Conclusion

8.1 Assessment of research outcomes

The objective of this research was to develop a framework that would allow for the calculation of a 'true' defence-contract-relevant measure of inflation, for price variation purposes in defence contracting. In calculating the 'true' inflation, the intent was to recognise the 'unique' nature of the procurement type and the industrial sector which produces the materiel. The research consisted of four coherent steps, and these are outlined below.

Firstly, the research tested available indexes against nine selection principles in order to refine the set of price indexes appropriate for use in the price variation of defence procurement of specialised materiel.

Secondly, the widely known problem of over or understatement of inflation associated with price indexes, leading to measurement biases was investigated, with reference to two price variation approaches: a Single Index approach, and a Multiple Indexes approach. These are also referenced in this research as the Finished Goods approach and the Cost Components approach, respectively. Biases associated with the specific areas which make defence contracting, and its industrial bases, different to commercial contracting–namely lack of competition, lack of productivity, and the ubiquity of long-term contracts–were also investigated. Bias correcting adjustments, such as a defence-specific adjustment to correct the understatement likely under the use of the Single Index approach, and a productivity adjustment or deduction to correct the likely overstatement in inflation with the Multiple Indexes approach, were presented in Chapter Five.

Forecast estimates of the refined set of 'appropriate' indexes were then presented in Chapter Six. The analysis of forecasts was designed to investigate the feasibility of providing a specific inflation outlook for relevant price indexes in order to improve contract management. The research observed the problem of multicollinearity when applying a multiple regression (i.e. a multivariable) model. Since there could be no means of assurance that the observed multicollinearity would continue in the future, an alternative approach, univariate time series forecasting (Holt-Winters) method, was pursued. In the context under consideration, univariate forecasting also made the best use of available data.

Finally, the first illustrative example–the procurement of combat vehicles–showed that the composite measure of inflation under the Multiple Indexes or Cost Components approach was sensitive to the productivity adjustment. Also the composite measures of inflation, at the three different productivity levels from the Multiple Indexes approach, were all higher than the inflation measure calculated from the Single Index approach. This result was obtained despite the application of a 3% defence-specific adjustment to the index selected under the Single Index approach. Therefore, the use of the Single Index approach needs to be treated with caution as exact calculation of the 'true' defence-contract-relevant inflation for 'unique' procurement from the defence industry may not always be possible–despite using the defence-specific adjustment.

Additionally, the comparative analysis on combat and commercial vehicles in Chapter Seven provided support that inflation between the two vehicles types is indeed different. The current findings on vehicles are mostly consistent with the persistent argument in defence literature that inflation experienced by defence industry, for specialised materiels, is higher than inflation experienced in the commercial industry.

The procedure applied in the illustrative example is also applicable for other specialised materiels procurement. However, the results from the Australian case example of combat vehicles compared to commercial vehicles, whilst being indicative, should not be used to infer specific results for other defence procurements. This is because of the unique nature of specific defence procurements. A generalisation or linkage of the current results to other defence materiel, such as warships or combat aircraft, can only be conducted after an in-depth analysis is applied to these other procurements.

Based on the findings shown in Figures 7.1.2 and 7.2.1 (refer to Chapter Seven), use of the Multiple Indexes, or Cost Components, approach provides a more accurate account of the inflation on materials and labour than using the Single Index or Finished

Goods approach. This is because the Multiple Indexes approach breaks down the principle cost components and then applies the appropriate relative weight to each component–based on its importance to the defence contract. Therefore, under the Multiple Indexes (or Cost Components) approach the collection of indexes used to calculate inflation would be more specific and tailor-made to match the individual defence contract of interest.

However, one of the disadvantages of the Cost Components approach, in comparison to the Finished Goods approach, is that multiple indexes are required. Indeed, a total of nine indexes were used to calculate the inflation in the combat vehicles example. This would obviously add to the workload of both DMO, and its contractor, when applying or reviewing price variation claims. Therefore, on a practical basis, it may be more sensible to reserve the use of the Multiple Indexes approach for only high dollar value contracts (such as those over AUD100 million) and instead use the Single Index approach for contracts under such a threshold.

Regardless of which price variation approach is ultimately chosen for a specific contract, some assessment by DMO and/or its contractor in applying the bias correcting adjustment would still be required. Due to the high degree of uncertainty often associated with long-term defence contracts, the assessments employed on the defence-specific adjustment and productivity deduction could well be subjective, and possibly biased. An example could be under or over estimation of the contractual performance with regards to productivity. Under or over estimation can occur simply due to a contractor's (lack of) previous experience, or their business view being optimistic or pessimistic in their estimation. As such the current research has identified a number of areas in which further research may be necessary to complement the current findings.

Limitation to current research and recommendation for future research

While the current research has sought to provide a framework by which to calculate the 'true' defence-contract-relevant inflation, the plausibility of the findings from this research is dependent on a few elements that have had to be taken at face value. Specifically, a productivity deduction (of 0.3%, 1%, and 2% in the illustration applied to the material components, and 1% (and 2%) to the labour component) in calculating the combat vehicles' inflation; the after defence-specific adjustment inflation cap of 4.5%, and the 3% defence-specific adjustment for product and industry uniqueness, are all elements that would benefit from further research and sensitivity analysis.

The illustrative example of combat vehicles showed that the productivity deduction can have a considerable affect on the composite inflation under the Multiple Indexes or Cost Components approach. The productivity rate of 0.3% on material/capital components and 1% on the labour component (if the labour cost index is an input index) was sourced from ABS data, and is the average productivity rate for the manufacturing division. However, the current research has shown that the defence industry has, to a considerable extent, characteristics that are different from the commercial industry. The other two rates of 1% and 2% were sourced from a DMO Contractor Survey in 2005, the original intent of which was to seek a general productivity estimate. Productivity is a specific matter and the rate applicable will differ for each contract performance. Therefore, a high quality and robust determination of the productivity level and apportionment that would be reflective of each individual contractual performance is necessary in order to calculate an even more accurate 'true' defence-contract-relevant measure of inflation[23].

The current research recommended the application of an inflation cap of 4.5% p.a. if the defence-specific adjustment is to be applied. This inflation rate of 4.5% p.a. originated from the DMO Contractor Survey. However, since the most recent survey was conducted in 2005, an updated survey would be recommended in order to capture more current information. Furthermore, a wider range of respondents, say 50 defence contractors, rather than simply the 10 top contractors, may also be useful in providing a more detailed view of the broader defence industry. Ideally, an annual survey would be another option in order to determine what would be the most appropriate defence-specific adjustment cap.

[23] One simple way this could be achieved is by requiring both the buyer and the contractor to make their assessments against a checklist of issues which can affect the performance of a contract (for example whether the contractor has procedure in place to hedge material risk for long term contracts). In doing so, both parties may determine if productivity is likely to be high or low for the contract performance of interest.

The rating scale shown in Figure 5.2.1.1 (Chapter Five) for the assessment of the defence-specific adjustment has been proposed in the current research to allow for the uniqueness of the defence industry. It was developed in an attempt to account for publicly available indexes failing to capture the inflation pressure stemming from the uniqueness of the defence industry and the specialised materiel. It also serves to recognise that in some unique defence situations, the contractor may not readily be able to achieve economies of scale and scope. However, the actual determination of such a factor can be a challenging exercise and may require an in-depth comparative study of the actual production plants of defence and commercial contractors. Alternatively, one could investigate, for example, an aerospace company which produces both commercial and combat aircraft. However, such a comparative analysis would by its nature be restricted to that single contractor or, at a maximum, to that specific industrial sector and could not be generalised to the entire defence industrial base.

Another way to determine the maximum inflation for the defence-specific adjustment (which is currently set at 3%) could be to use the 'stochastic approach' under the index number theory. By building on the insights of Clements and Izan (1987), and Selvanathan and Selvanathan (2006), it may be possible to generate a confidence band for defence-specific inflation. For example, it may be possible to calculate a general inflation index which has a specific defence inflation component by adding dummy variables in the regression specification to represent 'specialised goods' or a 'unique' industry. This approach would be similar to the weighted country-product-dummy variable method, though with end-user industries replacing countries. As explained by Rao (2005), this method does require a combination of time series and cross-sectional data and would require some time to acquire a suitable database. However, if pursued, the use of the stochastic approach could be an innovative way to calculate inflation for a 'unique product' and 'unique industry' with the added advantage of, for example, being able to assess the reliability of the index from the perspective of the unique industry via the calculation of its own confidence interval.

Another limitation in the current research is the determination of the reliability of forecast estimates. Forecasting can be somewhat problematic, with excessive volatility plaguing the univariate approach. This volatility is reflected in the confidence intervals attached to the forecasts in Chapter Six. One lesson from the research, although it was not possible to pursue it in detail, was that attention to the method of production of price indexes could aid in the subsequent determination of confidence intervals around short-term forecasts. The Cost Components approach requires some decision on the formula in order to aggregate the inflation movement from a group of indexes to generate a composite inflation. Use of the more recently promoted stochastic approach could potentially be valuable here in that it would serve to provide an additional indicator of reliability, which could then feed into the construction of confidence intervals around forecasts.

8.2 Limitations of the indexation method

The intent of this research was to propose and develop a framework in order to calculate the 'true' defence-contract-relevant inflation using publicly available indexes. While the use of price indexes for price variation purposes is common, the basic question is whether adequate indexing can be achieved–especially for long-term contracts. Full protection from inflation is not usually possible as there are a number of limitations associated with the price index itself and the indexation method.

One of the limitations with the price index is the lack of transparency available to users. Statistical agencies like ABS, BLS, and ONS as a rule, protect their respondents by not releasing details such as company name, products and weights of the company in the index value calculation. As a result, users of these indexes have no means of identifying exactly all of the information used in compiling the indexes. When a price index needs to be selected for purposes associated with a very specific contract in a unique industry, this lack of transparency can impact the user in choosing the 'right' index that best matches their 'unique' requirement.

The second limitation associated with indexes relates to measurement biases. Regardless of how many procedures or techniques are used in attempting to identify and even correct the inherent measurement biases, not all biases can be easily identified and eliminated. Therefore, some form of inherent measurement bias will almost certainly exist in the price index, resulting in either over or understatement of the inflation to the user. Furthermore, it is not possible for general users to easily quantify the over or understatement in the inflation as a result of these biases.

While ways to mitigate or rectify any adverse impact from the limitations, such as the ‘right’ choice of an index and the measurement biases, have been presented in this research, other limitations of indexation have not been able to be examined with the same degree of detail. One such limitation is associated with ‘forecasting the present’. This issue can be illustrated using the following example. The prices for a future year, say the year 2012, might be written into the contract using an escalation formula based on the inflation movements from the year 2011. While this may be the most common and best practice available, the inflationary movement in 2011 may not resemble that likely to occur in 2012. Analysis of the actual inflation after the event, in this situation the actual inflation movement in 2012, compared to the previously indexed inflation movement for 2012 (i.e. inflation movement of 2011) is not a common practice. It may only occur when one party requests a review when extreme inflation has arisen. Therefore adequate use of indexing for price variation purposes in practice may not eventuate.

As a practical matter, short-term forecasting is to some extent unavoidable if only to ‘forecast the present’ because there is always some delay in the availability of official statistics when decisions need to be made on the applicability of contract escalation clauses. Indexes such as those from the ABS, which pertain to a given quarter, will generally not be released until the middle of the following quarter. For example, often a contract will require a price variation review to be conducted just prior to the start of the calendar year. However, the problem then is that in practice the index for the December quarter of that year could be excluded in the calculation because it may not be available until February of the following year. As a result, referring to the previous example, the inflation used to escalate the 2012 prices could be based on the average annual difference in inflation for those values observed between the four quarters of Dec-2010 to Sep-2011. Again, this raises the question of how closely inflation from parts of 2010 and 2011 matches inflation in 2012. Consequently, perfect indexing and full protection from unexpected fluctuations seems not possible.

Furthermore, the current DMO practice can worsen this problem. Current DMO practice does not involve averaging the inflation for the year. Under the current DMO practice, and using the previous example, the 2012 prices would have been escalated using two index values, i.e. the ratio of the quarter of Sep-2010 and Sep-2011. Under this method, even if large inflation occurred in the quarter of Mar-2011 and Jun-2011, it would not be reflected in the price variation calculation. On the other hand, if a once-off large inflation movement occurred in the quarter of Sep-2011, the resulting compensation would be affected and to some extent unjustly skewed because the contractor may have been able to hedge its material cost risk. The same reasoning applies for deflation, but the impact would be in a different direction.

The method of averaging the inflation for four quarters using geometric means, which was employed by this research, may be 'better' in reflecting the underlying trend in the applicable inflation (refer to Appendix M for the comparison between the two practices). This method is also consistent with the assertion from Diewert (1997) that geometric means are better for this purpose than arithmetic means. Therefore, use of geometric means to average out the inflation for a yearly basis is not only theoretically sound but also alleviates the effects of once-off inflation, or deflation, which could unjustifiably skew the 'true' defence-contract-relevant inflation.

8.3 Some alternative suggestions

Based on the number of limitations on indexes which have been discussed, compensating a contractor by using historical movements observed in a nominated index or indexes for unexpected movements in materials and labour cost, may not necessarily be the best option. Two alternatives could be useful: (i) indexation based on a smoothed index series, and (ii) a risk sharing arrangement using forecast estimates.

Firstly, a slightly modified alternative to the current indexation method would be to calculate the inflation based on a smoothed index series rather than on historical data. Smoothing via a rolling average is one way to eliminate the unjustifiable skew caused by a once-off inflation or deflation. Another advantage in using a smoothed index series is when the specific index series is particularly volatile, then smoothing could aid in identifying the underlying trend more easily. The illustrative example in Chapter Seven, outlining the procurement of combat vehicles, showed that in that particular situation not more than 0.3% p.a. separated the inflation calculated using historical and smoothed data at the various conditions (i.e. zero, 0.3%, 1%, and 2% productivity levels).

The second alternative can be considered to be an extension to the risk sharing arrangement examined theoretically by Barney (1989). In this type of risk sharing arrangement the contract would specify some inflation rate. As such, regardless of the actual rate of inflation, the amount reimbursed to the contractor for inflation would be in accordance with the contractually agreed inflation rate. To further expand such an arrangement, the forecast estimate from this research (i.e. Chapter Six) could be used in determining the pre-agreed contractual inflation rate. Of course, changing to this practice (i.e. from historical to forecast basis) would require substantial amount of further analysis/consideration.

Nonetheless in some ways, this alternate method is similar to forward pricing contracts where certain rates have been reasonably projected for a specified contractual period. Pre-agreeing the projected labour rates often occurs when the contractors have a significant volume of labour work required under the contract and the contract is for an extended period of time. Contracts could range from engineering design work through to service maintenance work, and many more services.

A possible reaction stemming from such a proposal is that the contractor may only agree to 'sharing the risk of inflation' when compensated by a higher targeted profit (Barney, 1989). This raises another issue as to whether the allowable target profit in defence contracts is currently reasonable. If the allowable target profit is already low, then this may be a reason why contractors would be concerned not being fully protected from inflation. Any slight unexpected fluctuation in the economy, which is beyond the contractor's control, could now consume their rightly earned profits. On the other hand, if the allowable target profit in defence contracts is reasonable, then there may be enough scope to introduce, to some degree, a 'risk sharing' inflation agreement. Therefore, future research on what constitutes as reasonable target profit in order for a risk sharing inflation strategy to be feasible could be useful.

8.4 Benefits of the initiative proposed by this research

In conclusion, the initiative proposed by the current research has considered many issues which has been ignored or have remained dormant in the defence economics literature. Some of the most vital benefits are summarised here. The research has considered the issue of ‘uniqueness’ in the defence procured goods and services in order to provide a framework which facilitate calculating with improved accuracy the ‘true’ defence-contract-relevant inflation. For officers in DMO, and its contractors, the research listed nine fundamental principles to aid in selecting an ‘appropriate’ index for defence contracting purposes. The current research commenced by providing a refined list of indexes from ABS, BLS, and ONS which satisfied these nine principles. The method applied in selecting an ‘appropriate’ index could also be used to select indexes beyond those sourced from the three statistical agencies used in this research.

Another benefit is that the current research found there would almost certainly be an understatement in inflation with indexes under the Finished Goods index approach. This understatement problem is mostly as a result of lack of coverage of defence manufacturing activities in the publicly available indexes. Hence a relatively straightforward defence-specific adjustment was introduced in Figure 5.2.1.1 to counteract this problem.

The research acknowledged that the composite inflation generated by the Cost Components approach would almost undoubtedly be an overstatement if there was no consideration of productivity in the calculation. Hence a productivity adjustment or deduction was recommended.

Another contribution from this research was the forecast estimates for the list of refined ‘appropriate’ indexes. Forecasts generated could aid DMO and its contractors to note in advance, with some degree of confidence, the minimum or maximum likely contractual inflation. Furthermore, the current research also provides support for defence contracting purposes, in using a time series forecast (i.e. univariate method) instead of the more complex option of multiple regression modelling (i.e. multivariate method).

Overall, the current research has provided a framework to aid in calculating the ‘true’ defence-contract-relevant inflation, but it is only the beginning. Accurate defence-contract-relevant inflation is not only a wide area but also one of persistent concern in ensuring both the appropriate use of public funding, and the health of the defence industry.

References

Agapos, A. M. (1971). Competition in the Defense Industry: An Economic Paradox. *Journal of Economic Issues*, 5(2), 41-55.

Arena, M., V., Blickstein, I., Younossim O., & Grammich, C. (2006) *Why Has The Cost of Navy Ships Risen? A Macroscopic Examination of the Trends in U.S. Naval Ship Costs Over the Past Several Decades.* RAND Corporation

Arena, M., Younossi, O., Brancato, K., Blickstein, I., & Grammich, C. (2008). *Why has the cost of fixed-wing aircraft risen?: A macroscopic examination of the trend in U.S Military Aircraft costs over the past several decades*, RAND Corporation.

Australian Bureau of Agricultural and Resource Economics and Sciences, (2010). *Australian commodity statistic 2010,* Canberra.

Australian Bureau of Statistics, (2000). *Australian National Accounts: Concepts, Sources and Methods*. cat.no.5216.0, Canberra.

Australian Bureau of Statistics, (2004). *Labour Price Index: Concepts, Sources and Methods,* cat. no. 351.0.55.001, Canberra

Australian Bureau of Statistic, (2006a). *Australian and New Zealand Standard Industrial Classification (ANZSIC) 2006*, cat.no.1292.0, Canberra.

Australian Bureau of Statistic, (2006b). *Information Paper: Producer and International Trade Price Indexes: Concepts, Sources and Methods*, cat.no.6429.0, Canberra.

Australian Bureau of Statistic, (2007). *Labour Statistics: Concepts, Sources and Methods* cat.no.6102.0.55.001, Canberra.

Australian Bureau of Statistics, (2009). ABS Data Quality Framework, cat. no. 1520.0, Canberra. Website address: http://www.abs.gov.au/AUSSTATS/abs@.nsf/productsbyCatalogue/B0A707C93F279F14CA2575AB008256FE?OpenDocument

Australian Bureau of Statistics (2010a). *Producer Price Indexes*, 'Weighting Patterns for Price Indexes of Articles Produced by Manufacturing Industries', Excel spreadsheet, cat. no. 6427.0, viewed 9 Oct 2010.

Australian Bureau of Statistics (2010b). *Producer Price Indexes*, 'Weighting Patterns for Price Indexes of Materials Used in Manufacturing Industries', Excel spreadsheet, cat. no. 6427.0, viewed 9 Oct 2010.

Australian Bureau of Statistics (2010c). Australian Economic Indicators, ‘International Comparison’, time series spreadsheet, cat. no. 1350.0, viewed 11 Nov 2010.

Australian Bureau of Statistics (2010d). Experimental Estimates of Industry Multifactor Productivity 2009-10, ‘Experimental Estimates of Industry Multifactor Productivity’, Excel spreadsheet, cat. no. 5260.0.55.002, viewed 3 May 2011.

Australian Bureau of Statistics (2010e). Australian National Accounts: Input-Output Tables - Electronic Publication Final release 2006-07 tables, ‘Table 2. Use Table - Input by Industry and Final Use Category and supply by Product Group’, Excel spreadsheet, cat. no. 5209.0.55.001, viewed 3 May 2011.

Australian Bureau of Statistics (2010f*). Information Paper Outcome of the 16th Series Australian Consumer Price Index Review Australia*, cat. no. 6469.0, Canberra.

Barney, L. D., (1989). Inflation and risk in naval shipbuilding contracts, *Atlantic Economic Journal*, 14, 4, 30-36.

Blanchard, O. J. and Fischer, S. (1990). *Lectures on Macroeconomics*, Cambridge, London.

Boskin M. (1996), Advisory Committee to Study the Consumer Price Index, 1996 - *'Toward a More Accurate Measure of the Cost of Living'*, December, Washington.

Bowerman, B. L., O’Connell, R. T. and Murphree, E. S. (2011). *Business Statistics in Practice*, 6th edn, McGraw-Hill/Irwin, New York.

Clements, K. W. & Izan, H. Y. (1987). The Measurement of Inflation: A Stochastic Approach, *Journal of Business and Economic Statistics*, 5(3), 339–50,

Clements, K. W., Izan, H. Y, & Selvanathan, E.A. (2006). Stochastic Index Numbers: A Review, *International Statistical Review*, 74, 2, 235–270,

Cohen, S. I. (2001). *Microeconomic Policy*, Routledge, New York.

Cunningham, A. (1996). Measurement Bias in Price Indices: An Application to the UK's RPI, *Bank of England working papers 47*, Bank of England.

Defense Federal Acquisition Regulations Supplement (2004). *Procedures, Guidance, and Information*, 2004 edn.

Department of Defence – Commonwealth of Australia, (2008). *Australian Standard for Defence Contracting (ASDEFCON) - Complex Materiel*. Canberra.

Department of Defence – Commonwealth of Australia, (2010). *From Building Defence Capability: A Policy for a Smarter and More Agile Defence Industry Base*. Accessed 18/3/2011. http://www.defence.gov.au/dmo/id/dips/dips_2010.pdf

Defence Materiel Organisation (2005). DMO Contractor Survey 2005. – Unofficial publication.

Defence Materiel Organisation (2010). DMO Survey of Indexes 2010. – Unofficial publication.

Diewert, W.E. (1976). Exact and Superlative Index Numbers, *Journal of Econometrics* 4, 114-145.

Diewert, W. E. (1992a). Exact and Superlative Welfare Change Indicators, *Economic Inquiry*, 30, 565–582.

Diewert, W. E., (1992b). Fisher Ideal Output, Input and Productivity Indexes Revisited, *Journal of Productivity Analysis*, 3, 3, 211-248.

Diewert, W. E. (1996). Sources of Bias in Consumer Price Indexes, *Discussion Paper 96/4, School of Economic*, University of New South Wales.

Diewert, W. E. (1997), Commentary on Mathew D. Shapiro and David W. Wilcox: Alternative Strategies for Aggregating Price in the CPI, *The Federal Reserve Bank of St. Louis Review*, 79, 3, 127-137.

Diewert, W. E. (1998). Index Number Issues in the Consumer Price Index, *The Journal of Economic Perspectives*, 12, 1, 47-58

Diewert, W. E. (2004a). Basic Index Number Theory, Chapter 15 in *Producer Price Index Manual: Theory and Practice*, International Monetary Fund, Washington DC, 370-402.

Diewert, W. E. (2004b). The Axiomatic and Stochastic Approaches to Index Number Theory, Chapter 16 in *Producer Price Index Manual: Theory and Practice*, International Monetary Fund, Washington DC, 403-434.

Diewert, W. E. (2004c). Economic Approach, Chapter 17 in *Producer Price Index Manual: Theory and Practice*, International Monetary Fund, Washington DC, 435-462.

Dunne, J. P. (2006). The defence industry sector - what future? *Paper for Cambridge Econometrics and the Commission of the European Communities* (European Foundation for the Improvement of Living and Working Conditions).

Ergas, H. and Menezes, F. (2004). 'The Economics of Buying Complex Weapons', *Agenda,* 11, 3, 247–264.

Ergas, H. and Menezes, F. (2007). The role of competition in Australian defence procurement, *The Melbourne Review*, 3, 1, 41-48.

Greer Jr., W. R. & Liao, S. S. (1986). An Analysis of Risk and Return in the Defense Market: Its Impact on Weapon System Competition, Management Science, 32, 10, 1259-1273

Hall, P., Markowski, S. and Wylie, R. (2009). 'Supply: Defence industry' in Markowski et al, (eds) *Defence Procurement and Industry Policy: Small Country Perspective*, London: Routledge, ch. 3, 82-114.

Hill, P. 1988. Recent developments in index number theory and practice. *OECD Economic Studies,* 10 (spring): 123-48

Hopwood, P. (2005). The new experimental Index of Labour Costs per Hour, Labour *Market Trends*, 113, 8, 345-352

IBISWorld Industry Report – Numerous reports on Australia, the US and the UK industries

Jackson, J. and McIver, R. (2001). *Macroeconomics.* 6th edn, McGraw-Hill, Roseville.

Jenkins, C., Jones, T., and Pegler, K. (2010) Developments in Services Producer Price Indices – 2010, Non-journal articles, 1 - 26. Accessed 15 Aug 2011, http://www.statistics.gov.uk/CCI/article.asp?ID=2394

Kirkpatrick, D. (2008). Is Defence Inflation Really as high as Claimed? *RUSI Defence Systems*, Oct, 66-71.

International Monetary Fund (2010). Australia: Report on the Observance of Standards and Codes (ROSC)—Data Module Volume I, IMF Country Report No. 10/343. http://www.imf.org/external/pubs/ft/scr/2010/cr10343.pdf

Logistic Management Institute (1968). *Wage rate and material price level adjustment provision in DOD Procurement* - Task 67-4 (Rev), AD 677327, Washington.

Lorell, M., Sanders A. and Levaux H., (1995). *Bomber R & D since 1945: The Role of Experience*, RAND, MR-670-AF, 1995.

Morris J. and Green T., (2007). Measuring the quality of the producer price index', *Economic & Labour Market Review* 1(10), 31–5.

Moulton, B. R., (1996). Bias in the Consumer Price Index: What Is the Evidence. *Journal of Economic Perspectives*, 10, 4, 159-177

Office of Inspector General, Department of Defense (2008). *Effect of Payment into Boeing Pension Funds on Economic Price Adjustment Clauses in DoD contracts,* Report No. D-2008-099.

Office of Inspector General, Department of Defense (2009). *Cost Increases Related to the Producer Price Index for Titanium Mill Shapes on DOD Multiyear Contracts.* Report No. D-2010-004

Office of National Statistics, Crown (2009). *UK Standard Industrial Classification of Economic Activities 2007 (SIC 2007) – Structure and explanatory note*.

Pappas, G. (2008). *Audit of the Defence Budget,* Department of Defence, Canberra, 2009, viewed 18 May 2010, http://www.defence.gov.au/publications/DefenceBudgetAudit.pdf

Rao, D.S. Prasada (2005). On the Equivalence of the Weighted Country-Product-Dummy (CPD) Method and the Rao System for Multilateral Price Comparisons. *Review of Income and Wealth*, 51, 571–580.

Selvanathan, E.A. and Selvanathan, S. (2006). Measurement of Inflation: An Alternative approach, *Journal of Applied Economics,* 9, 2, 403-408

Silver, M. (2004). Errors and Bias in the PPI, Chapter 11 in *Producer Price Index Manual: Theory and Practice*, International Monetary Fund, Washington DC, (2004), 295-304.

Sköns, E. and P. Dunne (2009). Economics of arms production, in Lester Kurz (ed), Encyclopedia of Violence, *Peace and Conflict*, vol. 1., Elsevier: Oxford.

Smiroff, J. P. and Hicks M. J. (2008). The impact of economic factors and acquisition reforms on the cost of defense weapon systems, *Review of Financial Economics*, 17, 1, 3-13.

Solomon, B. (2003). Defence specific inflation: A Canadian Perspective. *Defence and Peace Economic*, 2003, 14(1), 19-36.

UK MoD - Directorate of Economic Statistics and Advice*, (2009*). *The Commercial Toolkit.*

U.S. Bureau of Labor Statistics (2006), Escalation Guide for Contracting Parties. http://www.bls.gov/ppi/ppiescalation.htm

U.S. Bureau of Labor Statistics (2011a), *BLS Handbook of Methods* - Chapter 8. National compensation measures, http://www.bls.gov/opub/hom/pdf/homch8.pdf

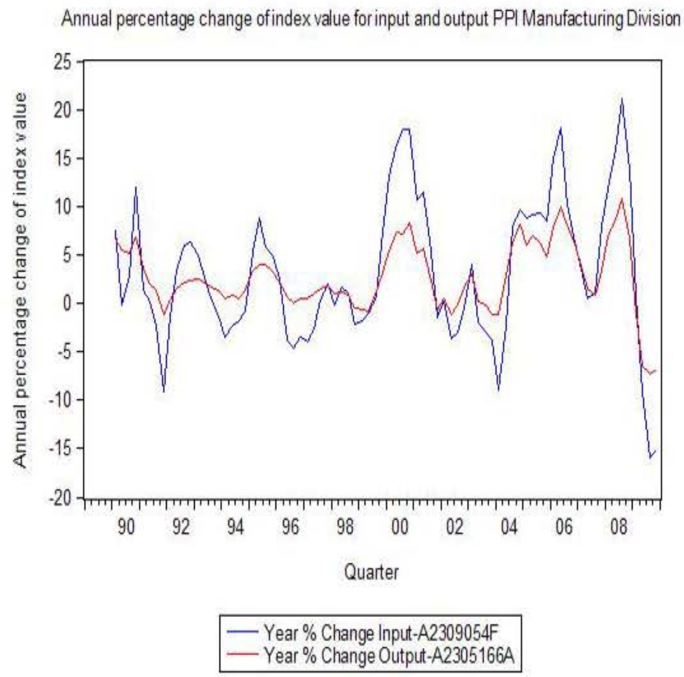
U.S. Bureau of Labor Statistics (2011b), *BLS Handbook of Methods* - Chapter 14. Producer prices, http://www.bls.gov/opub/hom/pdf/homch14.pdf

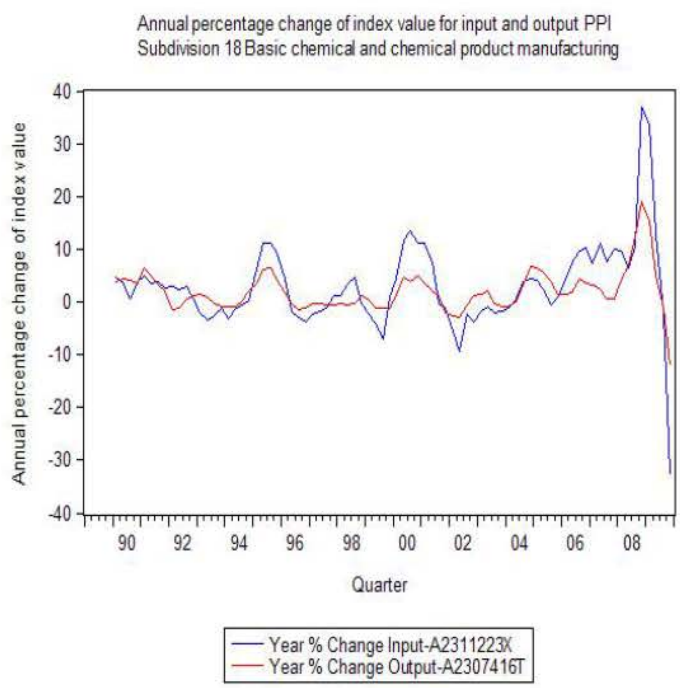
U.S. Census Bureau (no date). Viewed 4 Apr 2011. http://www.census.gov/eos/www/naics/2007NAICS/2007_Definition_File.pdf

Wolf C., Jr. (1993). *Developing Improved Defense Deflators for Defense R&D Programs*, RAND, USA.

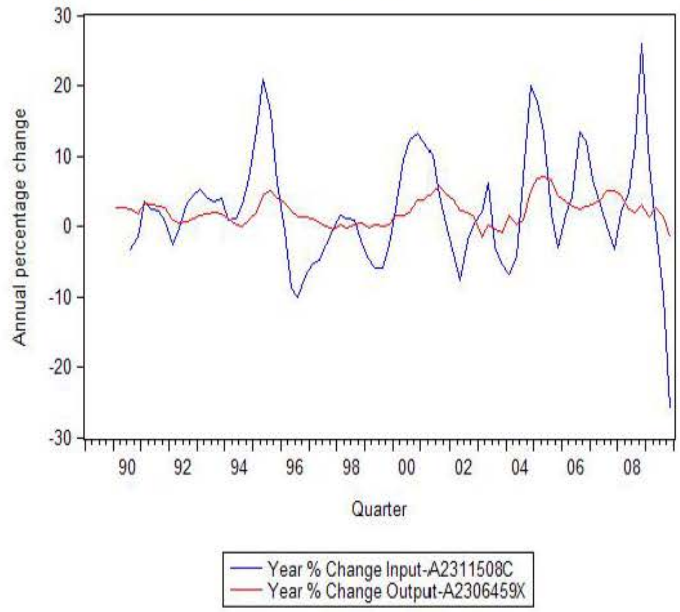
Woods, J. (2008). Measuring the quality of the producer price index – an update, *Economic & Labour Market Review, 2 (*8), 45-48.

Appendix A – Comparison analysis of ABS Input and Output PPI

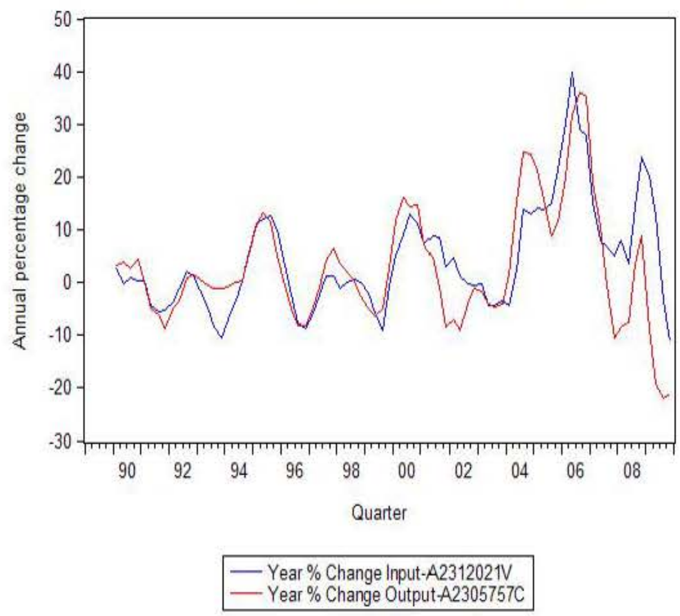


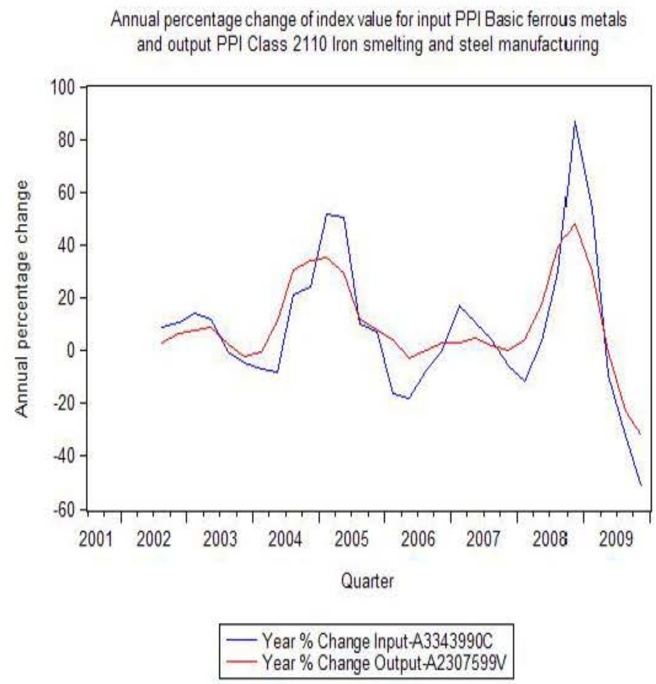


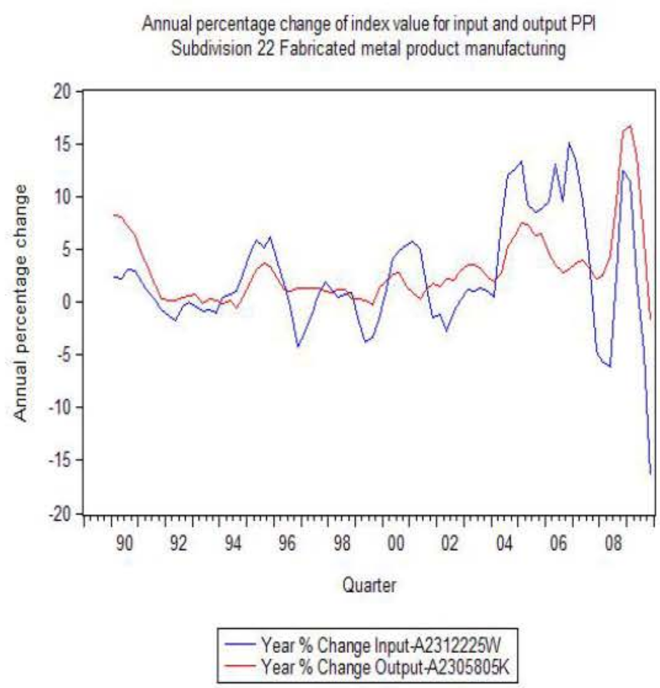
Annual percentage change of index value for input PPI Subdivision 19
Polymer product and rubber product manufacturing

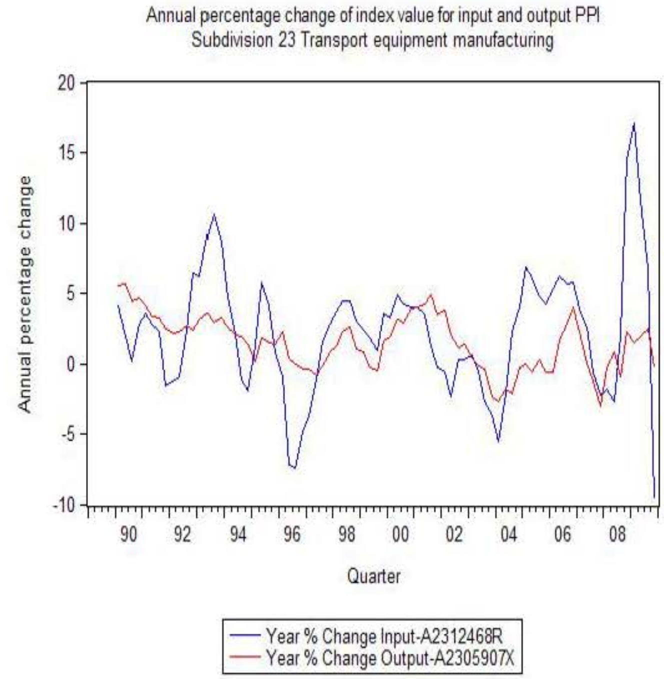


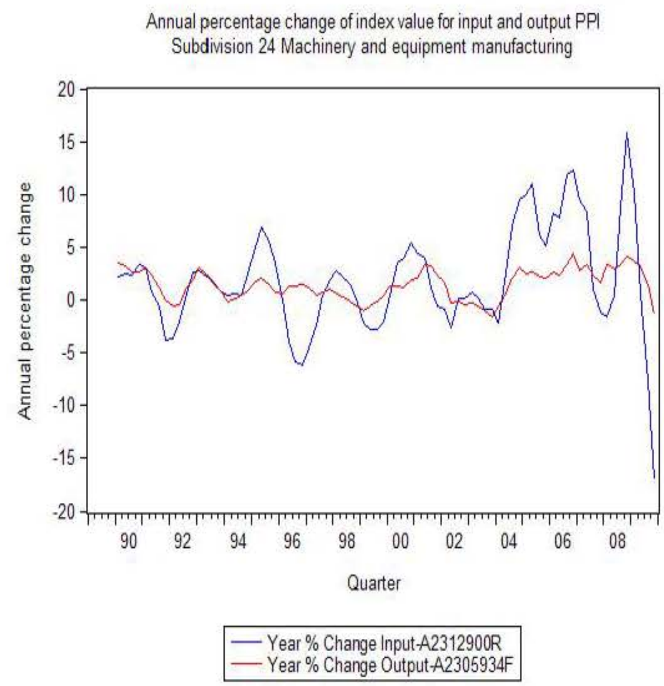
Annual percentage change of index value for input and output PPI
Subdivision 21 Primary metal and metal product manufacturing



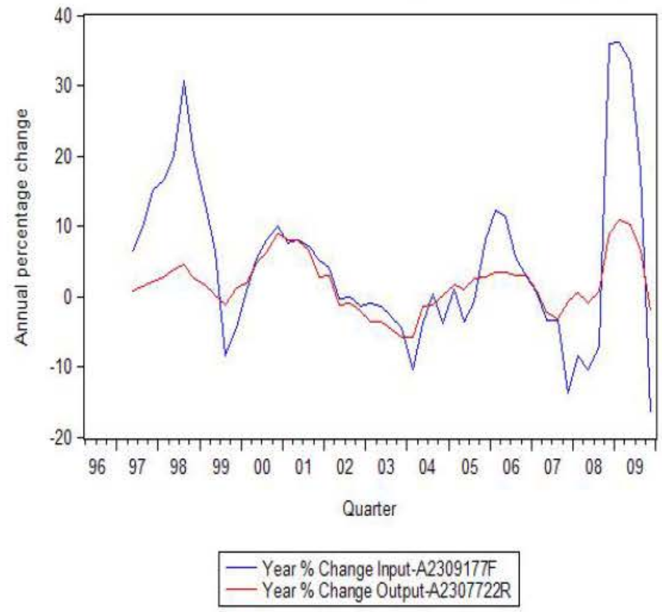

Annual percentage change of index value for input PPI Basic ferrous metals
and output PPI Class 2110 Iron smelting and steel manufacturing
Annual percentage change
100
80
60
40
20
0
-20
-40
-60
2001
2002
2003
2004
2005
2006
2007
2008
2009
Quarter
Year % Change Input-A3343990C
Year % Change Output-A2307599V


Annual percentage change of index value for input and output PPI
Subdivision 22 Fabricated metal product manufacturing
Annual percentage change
20
15
10
5
0
-5
-10
-15
-20
90
92
94
96
98
00
02
04
06
08
Quarter
Year % Change Input-A2312225W
Year % Change Output-A2305805K

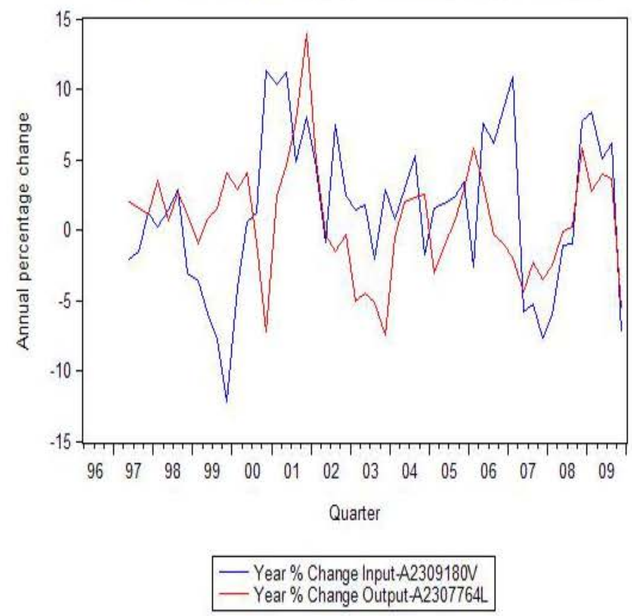

Annual percentage change of index value for input and output PPI
Subdivision 23 Transport equipment manufacturing
20
15
10
5
0
-5
-10
Annual percentage change
90
92
94
96
98
00
02
04
06
08
Quarter
Year % Change Input-A2312468R
Year % Change Output-A2305907X

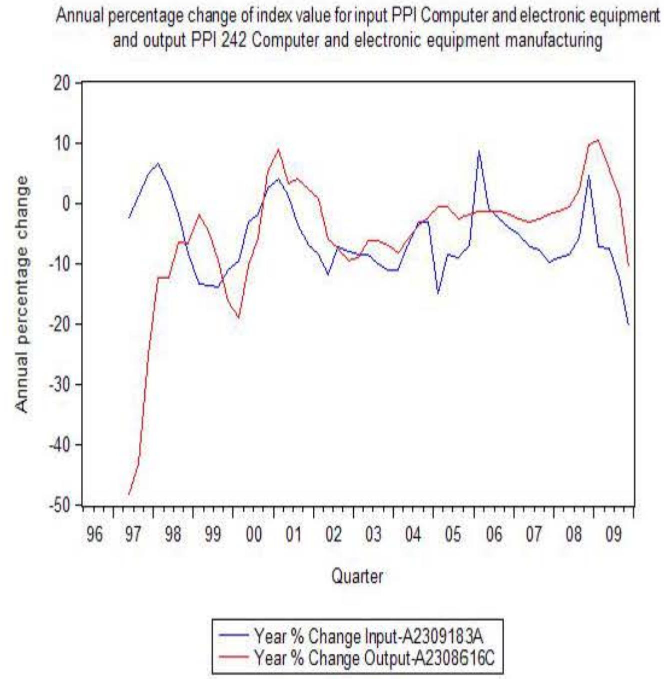

Annual percentage change of index value for input and output PPI
Subdivision 24 Machinery and equipment manufacturing
20
15
10
5
0
-5
-10
-15
-20
Annual percentage change
90
92
94
96
98
00
02
04
06
08
Quarter
Year % Change Input-A2312900R
Year % Change Output-A2305934F

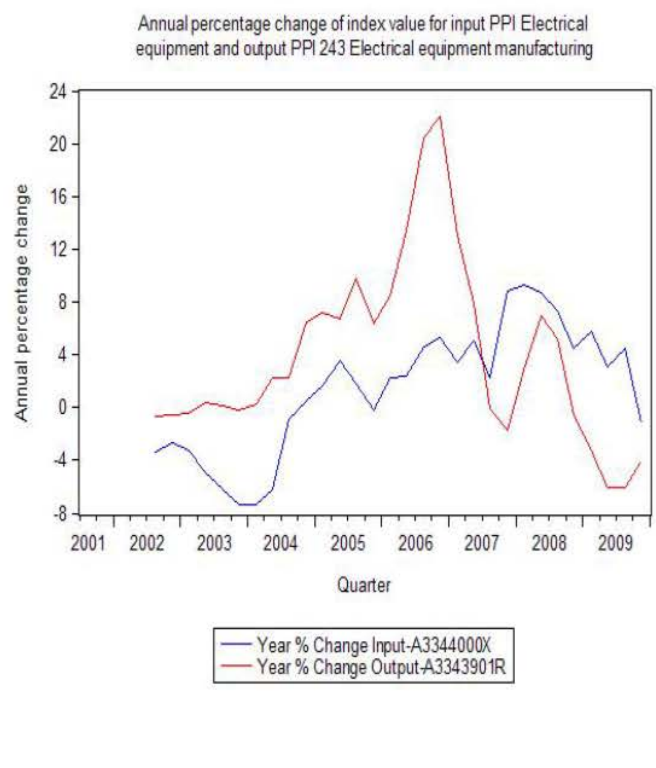
Annual percentage change of index value for input PPI Other transport equipment and output PPI 239 Other transport equipment manufacturing



Annual percentage change of index value for input PPI Professional and scientific equipment and output PPI 241 Professional and scientific equipment manufacturing




Annual percentage change of index value for input PPI Computer and electronic equipment and output PPI 242 Computer and electronic equipment manufacturing
Annual percentage change
20
10
0
-10
-20
-30
-40
-50
96
97
98
99
00
01
02
03
04
05
06
07
08
09
Quarter
Year % Change Input-A2309183A
Year % Change Output-A2308616C


Annual percentage change of index value for input PPI Electrical equipment and output PPI 243 Electrical equipment manufacturing
Annual percentage change
24
20
16
12
8
4
0
-4
-8
2001
2002
2003
2004
2005
2006
2007
2008
2009
Quarter
Year % Change Input-A3344000X
Year % Change Output-A3343901R

Appendix B - Table of Standard Deviation – Australian indexes

Index	**Std. Dev.**
LPI – Ordinary Time - Private - All industries	0.47
LPI – Ordinary Time - Private - Manufacturing	0.52
LPI – Ordinary Time - Private - Professional, Scientific and Technical Services	0.89
2439 Other electrical equipment manufacturing	1.99
2312 Motor vehicle body and trailer manufacturing	2.29
2391 Shipbuilding and repair services	3.00
2432 Electric lighting equipment manufacturing	3.02
1811 Industrial gas manufacturing	3.04
2491 Lifting and material handling equipment manufacturing	3.29
2121 Iron and steel casting	3.36
1912 Rigid and semi-rigid polymer product manufacturing	3.40
2311 Motor vehicle manufacturing	3.48
2313 Automotive electrical component manufacturing	3.67
1914 Tyre manufacturing	3.87
2412 Medical and surgical equipment manufacturing	4.04
2299 Other fabricated metal product manufacturing n.e.c.	4.06
1892 Explosive manufacturing	4.40
2319 Other motor vehicle parts manufacturing	4.48
2429 Other electronic equipment manufacturing	4.72
2422 Communication equipment manufacturing	5.97
2419 Other professional and scientific equipment manufacturing	6.87
2394 Aircraft manufacturing and repair services	7.19
2221 Structural steel fabricating	7.62
2142 Aluminium rolling, drawing, extruding	9.94
2110 Iron smelting and steel manufacturing	11.48
1831 Fertiliser manufacturing	17.15
1813 Basic inorganic chemical manufacturing	19.48
2132 Aluminium smelting	20.62

Appendix C - Table of Standard Deviation – US indexes

Index	**Std. Dev.**
33451 Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	0.26
ECI - Wages and salaries - Manufacturing	0.49
33636 Motor Vehicle Seating and Interior Trim Manufacturing	0.69
33632 Motor Vehicle Electrical and Electronic Equipment Manufacturing	0.88
33699 Other Transportation Equipment Manufacturing	0.93
33661 Ship and Boat Building	0.95
33422 Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing	0.99
81131 Commercial machinery repair and maintenance	1.00
54111 Offices of Lawyers	1.13
32721 Glass and Glass Product Manufacturing	1.17
33641 Aerospace Product and Parts Manufacturing	1.23
33421 Telephone Apparatus Manufacturing	1.33
51711 Wired Telecommunications Carriers	1.39
ECI - Wages and salaries -Professional, scientific, and technical services	1.46
54133 Engineering Services	1.56
33635 Motor Vehicle Transmission and Power Train Parts Manufacturing	1.59
33637 Motor Vehicle Metal Stamping	1.68
32622 Rubber and Plastics Hoses and Belting Manufacturing	2.04
33531 Electrical Equipment Manufacturing	2.07
33634 Motor Vehicle Brake System Manufacturing	2.07
33633 Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing	2.23
33441 Semiconductor and Other Electronic Component Manufacturing	2.23
33251 Hardware Manufacturing	2.29
33299 All Other Fabricated Metal Product Manufacturing	2.33
33361 Engine, Turbine, and Power Transmission Equipment Manufacturing	2.34
32551 Paint and Coating Manufacturing	2.38
33611 Automobile and Light Duty Motor Vehicle Manufacturing	2.59
33411 Computer and Peripheral Equipment Manufacturing	2.59
32621 Tire Manufacturing	3.24
33152 Nonferrous Metal Foundries	3.89
33631 Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	7.36
33231 Plate Work and Fabricated Structural Product Manufacturing	9.24
32512 Industrial Gas Manufacturing	9.73
32612 Plastics Pipe, Pipe Fitting, and Unlaminated Profile Shape Manufacturing	11.11
32592 Explosives Manufacturing	11.13
33131 Alumina and Aluminium Production and Processing	13.83
33122 Rolling and Drawing of Purchased Steel	17.74
33121 Iron and Steel Pipe and Tube Manufacturing from Purchased Steel	19.34
33111 Iron and Steel Mills and Ferroalloy Manufacturing	19.72
33142 Copper Rolling, Drawing, Extruding, and Alloying	29.70
32531 Fertilizer Manufacturing	43.34
33612 Heavy Duty Truck Manufacturing	NA*

* Insufficient data observation to generate appropriate test.

Appendix D - Table of Standard Deviation – UK indexes

Index	**Std. Dev.**
Computer Services (SPPI) - K8UK	1.54
29.32 Manufacture of other parts and accessories for motor vehicles -K33S	1.99
29.20 Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers -K33Q	2.25
30.30 Manufacture of air and spacecraft and related machinery -K33V	2.29
20.30 Manufacture of paints, varnishes and similar coatings, printing ink and mastics -JUI2	2.39
29.10 Manufacture of motor vehicles -JVH7	2.80
33.15 Repair and maintenance of ships and boats -K34H	2.94
26.30 Manufacture of communication equipment -JV5J	3.15
33.16 Repair and maintenance of aircraft and spacecraft -JVU7	3.26
22.21 Manufacture of plastic plates, sheets, tubes and profiles -JUO9	3.33
25.50 Forging, pressing, stamping and roll-forming of metal; powder metallurgy -JV3U	3.44
33.17 Repair and maintenance of other transport equipment -JVU9	3.94
29.31 Manufacture of electrical and electronic equipment for motor vehicles -JVJ4	4.19
20.51 Manufacture of explosives -JUK4	4.29
24.45 Other non-ferrous metal production -K2Z9	6.01
20.16 Manufacture of plastics in primary forms -JUG6	7.96
26.20 Manufacture of computers and peripheral equipment -JV5A	9.26
24.10 Manufacture of basic iron and steel and of ferro-alloys -K2YZ	15.55
25.11 Manufacture of metal structures and parts of structures -JV3D	16.96
20.15 Manufacture of fertilisers and nitrogen compounds -JUF3	NA*
24.42 Aluminium production -JV2H	NA*
25.40 Manufacture of weapons and ammunition -K2ZG	NA*
30.11 Building of ships and floating structures -K3B3	NA*

* Insufficient data observation to generate appropriate test.

Appendix E – Refined list of 'appropriate' indexes for the two approaches - Australian indexes

Single index (Finished goods) approach

Types	Cat. no.	ANZSIC	Index Titles
PPI	6427	1892	Explosive manufacturing
PPI	6427	2299	Other fabricated metal product manufacturing n.e.c.
PPI	6427	2311	Motor vehicle manufacturing
PPI	6427	2312	Motor vehicle body and trailer manufacturing
PPI	6427	2391	Shipbuilding and repair services
PPI	6427	2394	Aircraft manufacturing and repair services
PPI	6427	2419	Other professional and scientific equipment manufacturing
PPI	6427	2422	Communication equipment manufacturing
PPI	6427	7000	Computer System Design and Related Services
PPI	6427	6923	Engineering Design and Engineering Consulting Services
PPI	6427	6931	Legal Services
PPI	6427	6932	Accounting Services
LPI	6345	C	Private - Manufacturing
LPI	6345	M	Private - Professional, Scientific and Technical Services
LPI	6345	-	Private - All industries

Multiple indexes approach

Types	Cat. no	ANZSIC	Index Titles
PPI	6427	1811	Industrial gas manufacturing
PPI	6427	1813	Basic inorganic chemical manufacturing
PPI	6427	1831	Fertiliser manufacturing
PPI	6427	1912	Rigid and semi-rigid polymer product manufacturing
PPI	6427	1914	Tyre manufacturing
PPI	6427	2110	Iron smelting and steel manufacturing
PPI	6427	2121	Iron and steel casting
PPI	6427	2132	Aluminium smelting
PPI	6427	2142	Aluminium rolling, drawing, extruding
PPI	6427	2221	Structural steel fabricating
PPI	6427	2299	Other fabricated metal product manufacturing n.e.c.
PPI	6427	2312	Motor vehicle body and trailer manufacturing

PPI	6427	2313	Automotive electrical component manufacturing
PPI	6427	2319	Other motor vehicle parts manufacturing
PPI	6427	2412	Medical and surgical equipment manufacturing
PPI	6427	2419	Other professional and scientific equipment manufacturing
PPI	6427	2422	Communication equipment manufacturing
PPI	6427	2429	Other electronic equipment manufacturing
PPI	6427	2432	Electric lighting equipment manufacturing
PPI	6427	2439	Other electrical equipment manufacturing
PPI	6427	2491	Lifting and material handling equipment manufacturing
PPI	6427	7000	Computer System Design and Related Services
PPI	6427	6923	Engineering Design and Engineering Consulting Services
PPI	6427	6931	Legal Services
PPI	6427	6932	Accounting Services
LPI	6345	C	Private - Manufacturing
LPI	6345	M	Private - Professional, Scientific and Technical Services
LPI	6345	-	Private - All industries

Appendix F – Refined list of 'appropriate' indexes for the two approaches - US indexes

Single Index approach

Types	NAICS	Index Titles
PPI	32592	Explosives Manufacturing
PPI	33411	Computer and Peripheral Equipment Manufacturing
PPI	33451	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing
PPI	33611	Automobile and Light Duty Motor Vehicle Manufacturing
PPI	33612	Heavy Duty Truck Manufacturing
PPI	33641	Aerospace Product and Parts Manufacturing
PPI	33661	Ship and Boat Building
PPI	33699	Other Transportation Equipment Manufacturing
PPI	54111	Offices of Lawyers
PPI	54133	Engineering Services
PPI	51711	Wired Telecommunications Carriers
ECI -Wages and salaries		Manufacturing
ECI -Wages and salaries		Professional, scientific, and technical services

Multiple Indexes approach

Types	NAICS	Index Titles
PPI	32512	Industrial Gas Manufacturing
PPI	32531	Fertilizer Manufacturing
PPI	32551	Paint and Coating Manufacturing
PPI	32592	Explosives Manufacturing
PPI	32612	Plastics Pipe, Pipe Fitting, and Unlaminated Profile Shape Manufacturing
PPI	32621	Tire Manufacturing
PPI	32622	Rubber and Plastics Hoses and Belting Manufacturing
PPI	32721	Glass and Glass Product Manufacturing
PPI	33111	Iron and Steel Mills and Ferroalloy Manufacturing

PPI	33121	Iron and Steel Pipe and Tube Manufacturing from Purchased Steel
PPI	33122	Rolling and Drawing of Purchased Steel
PPI	33131	Alumina and Aluminium Production and Processing
PPI	33142	Copper Rolling, Drawing, Extruding, and Alloying
PPI	33152	Nonferrous Metal Foundries
PPI	33231	Plate Work and Fabricated Structural Product Manufacturing
PPI	33251	Hardware Manufacturing
PPI	33272	Turned Product and Screw, Nut, and Bolt Manufacturing
PPI	33299	All Other Fabricated Metal Product Manufacturing
PPI	33361	Engine, Turbine, and Power Transmission Equipment Manufacturing
PPI	33411	Computer and Peripheral Equipment Manufacturing
PPI	33421	Telephone Apparatus Manufacturing
PPI	33422	Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing
PPI	33441	Semiconductor and Other Electronic Component Manufacturing
PPI	33451	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing
PPI	33531	Electrical Equipment Manufacturing
PPI	33591	Battery Manufacturing
PPI	33631	Motor Vehicle Gasoline Engine and Engine Parts Manufacturing
PPI	33632	Motor Vehicle Electrical and Electronic Equipment Manufacturing
PPI	33633	Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing
PPI	33634	Motor Vehicle Brake System Manufacturing
PPI	33635	Motor Vehicle Transmission and Power Train Parts Manufacturing
PPI	33636	Motor Vehicle Seating and Interior Trim Manufacturing
PPI	33637	Motor Vehicle Metal Stamping
PPI	54111	Offices of Lawyers

PPI	54133	Engineering Services
ECI -Wages and salaries		Manufacturing
ECI -Wages and salaries		Professional, scientific, and technical services

Appendix G – Refined list of 'appropriate' indexes for the two approaches - UK indexes

Single index approach

Types	Pub no.	UK SIC	Index Titles
PPI	MM22-Table 4	20.51	Manufacture of explosives
PPI	MM22-Table 4	26.20	Manufacture of computers and peripheral equipment
PPI	MM22-Table 4	26.30	Manufacture of communication equipment
PPI	MM22-Table 4	29.10	Manufacture of motor vehicles
PPI	MM22-Table 4	30.11	Building of ships and floating structures
PPI	MM22-Table 4	30.30	Manufacture of air and spacecraft and related machinery
PPI	MM22-Table 4	33.15	Repair and maintenance of ships and boats
PPI	MM22-Table 4	33.16	Repair and maintenance of aircraft and spacecraft
SPPI			Computer Services

Multiple index approach

Types	Pub no.	UK SIC	Index Titles
PPI	MM22-Table 4	20.15	Manufacture of fertilisers and nitrogen compounds
PPI	MM22-Table 4	20.16	Manufacture of plastics in primary forms
PPI	MM22-Table 4	20.30	Manufacture of paints, varnishes and similar coatings, printing ink and mastics
PPI	MM22-Table 4	20.51	Manufacture of explosives
PPI	MM22-Table 4	22.21	Manufacture of plastic plates, sheets, tubes and profiles
PPI	MM22-Table 4	24.10	Manufacture of basic iron and steel and of ferro-alloys
PPI	MM22-Table 4	24.42	Aluminium production
PPI	MM22-Table 4	24.45	Other non-ferrous metal production
PPI	MM22-Table 4	25.11	Manufacture of metal structures and parts of structures
PPI	MM22-Table 4	25.40	Manufacture of weapons and ammunition
PPI	MM22-Table 4	25.50	Forging, pressing, stamping and roll-forming of metal; powder metallurgy
PPI	MM22-Table 4	26.20	Manufacture of computers and peripheral equipment
PPI	MM22-Table 4	26.30	Manufacture of communication equipment

PPI	MM22-Table 4	29.20	Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers
PPI	MM22-Table 4	29.31	Manufacture of electrical and electronic equipment for motor vehicles
PPI	MM22-Table 4	29.32	Manufacture of other parts and accessories for motor vehicles
SPPI			Computer Services

Appendix H – Correlation matrix – US macroeconomic variables

	NASDAQ (stock market)	**CPI**	**Industrial production volume index**	**Interest rate**	**Real GDP volume index**	**Unemploy-ment rate**	**USD/AUD**
NASDAQ (stock market)	1.000						
CPI	0.655*	1.000					
Industrial production volume index	0.837*	0.904*	1.000				
Interest rate	-0.078	-0.560*	-0.351*	1.000			
Real GDP volume index	0.733*	0.982*	0.960*	-0.503*	1.000		
Unemployment rate	-0.526*	-0.053	-0.432*	-0.536*	-0.195	1.000	
USD/AUD	0.220	-0.088	0.142	-0.077	0.008	-0.297*	1.000

*Significant at the 0.01 level (i.e. 99%)

Appendix I – Correlation matrix – UK macroeconomic variables

	FTSE 100 (stock market)	**CPI**	**Industrial production volume index**	**Interest rate**	**Real GDP volume index**	**Unemploy-ment rate**	**AUD/ GBP**
FTSE 100 (stock market)	1.000						
CPI	0.713*	1.000					
Industrial production volume index	0.722*	0.372*	1.000				
Interest rate	-0.524*	-0.821*	-0.342*	1.000			
Real GDP volume index	0.726*	0.946*	0.483*	-0.683*	1.000		
Unemployment rate	-0.711*	0.618	-0.761*	0.338*	-0.794*	1.000	
AUD/GBP	-0.357*	-0.057	-0.548	-0.029	-0.222	0.577*	1.000

*Significant at the 0.01 level (i.e. 99%)

Appendix J – Index forecasts and their respective 95% confidence interval – US indexes

	2012			2013			2014		
32512 Industrial Gas Manufacturing	5.5%	±	11.9%	5.2%	±	12.4%	4.9%	±	13.0%
32531 Fertilizer Manufacturing	14.8%	±	19.1%	12.9%	±	18.3%	11.4%	±	17.8%
32551 Paint and Coating Manufacturing	3.1%	±	2.6%	3.0%	±	2.8%	2.9%	±	3.0%
32592 Explosives Manufacturing*		NA			NA			NA	
32612 Plastics Pipe, Pipe Fitting, and Unlaminated Profile Shape Manufacturing	1.1%	±	11.7%	1.1%	±	12.6%	1.1%	±	13.8%
32621 Tire Manufacturing	4.2%	±	2.9%	4.0%	±	3.0%	3.9%	±	3.2%
32622 Rubber and Plastics Hoses and Belting Manufacturing	3.7%	±	3.1%	3.5%	±	3.3%	3.4%	±	3.5%
32721 Glass and Glass Product Manufacturing	0.8%	±	2.6%	0.8%	±	2.8%	0.7%	±	3.1%
33111 Iron and Steel Mills and Ferroalloy Manufacturing	7.5%	±	20.9%	7.0%	±	21.4%	6.6%	±	21.9%
33121 Iron and Steel Pipe and Tube Manufacturing from Purchased Steel	5.2%	±	40.7%	4.9%	±	42.5%	4.7%	±	44.5%
33122 Rolling and Drawing of Purchased Steel	7.0%	±	25.0%	6.6%	±	25.8%	6.2%	±	26.5%
33131 Alumina and Aluminium Production and Processing	4.7%	±	10.3%	4.5%	±	10.9%	4.3%	±	11.4%
33142 Copper Rolling, Drawing, Extruding, and Alloying	8.2%	±	19.7%	7.6%	±	20.0%	7.1%	±	20.4%
33152 Nonferrous Metal Foundries	1.5%	±	4.1%	1.5%	±	4.4%	1.4%	±	4.8%
33231 Plate Work and Fabricated Structural Product Manufacturing	5.6%	±	14.0%	5.3%	±	14.6%	5.0%	±	15.2%
33251 Hardware Manufacturing	2.2%	±	3.5%	2.1%	±	3.8%	2.1%	±	4.0%
33299 All Other Fabricated Metal Product Manufacturing	3.5%	±	3.5%	3.4%	±	3.7%	3.3%	±	3.9%
33361 Engine, Turbine, and Power Transmission Equipment Manufacturing	3.4%	±	2.1%	3.3%	±	2.2%	3.2%	±	2.4%
33411 Computer and Peripheral Equipment Manufacturing	-7.6%	±	15.8%	-8.2%	±	18.8%	-9.0%	±	22.5%
33421 Telephone Apparatus Manufacturing	-0.5%	±	2.8%	-0.5%	±	3.1%	-0.5%	±	3.4%
33422 Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing	0.7%	±	1.5%	0.7%	±	1.6%	0.7%	±	1.8%
33441 Semiconductor and Other Electronic Component Manufacturing	-3.1%	±	4.7%	-3.2%	±	5.4%	-3.3%	±	6.1%

	2012			2013			2014		
33451 Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	1.1%	±	1.0%	1.1%	±	1.1%	1.1%	±	1.2%
33531 Electrical Equipment Manufacturing	2.6%	±	3.2%	2.6%	±	3.4%	2.5%	±	3.6%
33611 Automobile and Light Duty Motor Vehicle Manufacturing	1.2%	±	4.6%	1.2%	±	5.0%	1.2%	±	5.4%
33612 Heavy Duty Truck Manufacturing	2.6%	±	1.1%	2.5%	±	1.2%	2.5%	±	1.3%
33631 Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	2.9%	±	6.2%	2.8%	±	6.7%	2.7%	±	7.1%
33632 Motor Vehicle Electrical and Electronic Equipment Manufacturing	0.2%	±	2.2%	0.2%	±	2.4%	0.2%	±	2.6%
33633 Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing	0.2%	±	4.8%	0.2%	±	5.3%	0.2%	±	5.8%
33634 Motor Vehicle Brake System Manufacturing	0.6%	±	2.4%	0.6%	±	2.7%	0.5%	±	2.9%
33635 Motor Vehicle Transmission and Power Train Parts Manufacturing	2.2%	±	2.7%	2.2%	±	2.9%	2.1%	±	3.1%
33636 Motor Vehicle Seating and Interior Trim Manufacturing	-0.2%	±	1.1%	-0.2%	±	1.2%	-0.2%	±	1.3%
33637 Motor Vehicle Metal Stamping	0.8%	±	3.4%	0.8%	±	3.7%	0.8%	±	4.1%
33641 Aerospace Product and Parts Manufacturing	2.0%	±	1.6%	2.0%	±	1.7%	1.9%	±	1.8%
33661 Ship and Boat Building	2.3%	±	1.2%	2.2%	±	1.3%	2.2%	±	1.4%
33699 Other Transportation Equipment Manufacturing	0.4%	±	1.2%	0.4%	±	1.3%	0.4%	±	1.4%
51711 Wired Telecommunications Carriers	1.0%	±	2.9%	1.0%	±	3.1%	0.9%	±	3.4%
54111 Offices of Lawyers	3.3%	±	1.6%	3.2%	±	1.7%	3.1%	±	1.8%
54133 Engineering Services	1.0%	±	2.8%	1.0%	±	3.1%	1.0%	±	3.3%
81131 Commercial machinery repair and maintenance	2.2%	±	1.7%	2.1%	±	1.8%	2.1%	±	2.0%
ECI - Wages and salaries - Manufacturing	1.6%	±	0.9%	1.6%	±	0.9%	1.6%	±	1.0%
ECI - Wages and salaries - Professional, scientific, and technical services	2.1%	±	2.4%	2.1%	±	2.6%	2.0%	±	2.8%

* Insufficient data observation to generate appropriate forecast.

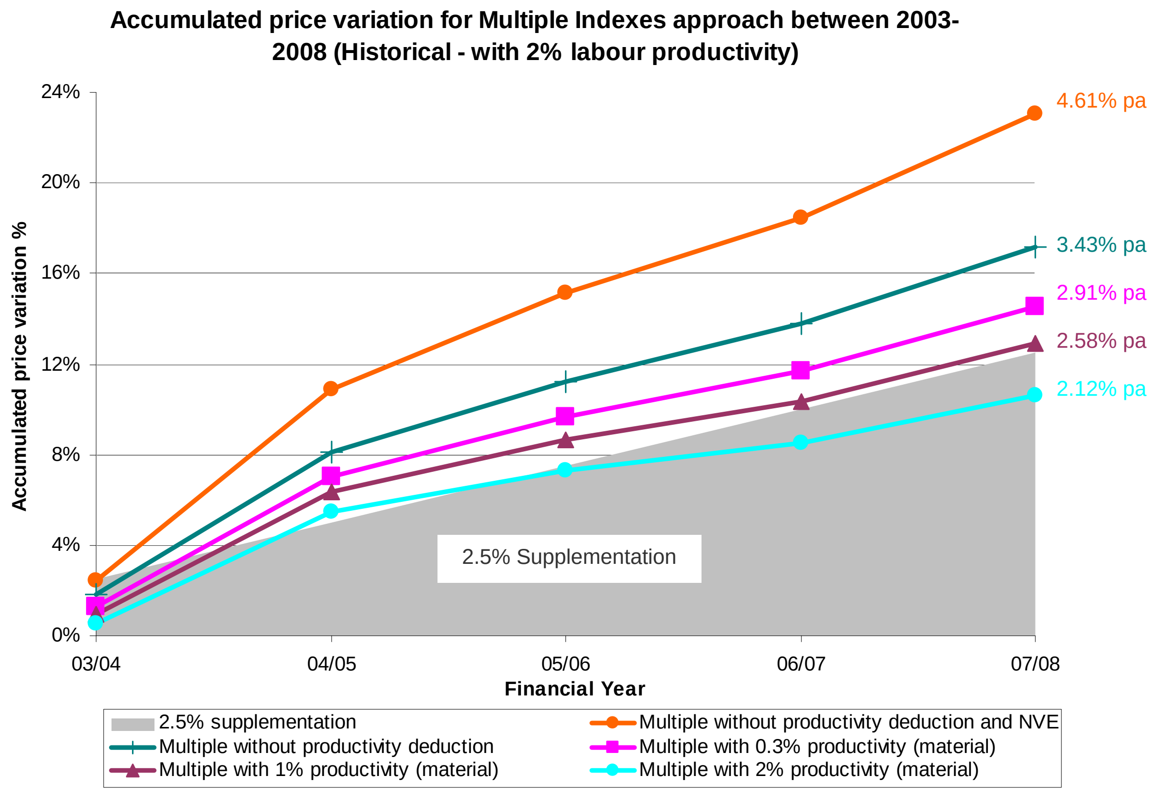
Appendix K – Index forecasts and their respective 95% confidence interval – UK indexes

	2012			2013			2014		
20.15 Manufacture of fertilisers and nitrogen compounds -JUF3*		NA			NA			NA	
20.16 Manufacture of plastics in primary forms -JUG6	6.4%	±	8.4%	6.0%	±	8.6%	5.7%	±	8.9%
20.30 Manufacture of paints, varnishes and similar coatings, printing ink and mastics -JUI2	2.9%	±	3.0%	2.8%	±	3.2%	2.7%	±	3.4%
20.51 Manufacture of explosives -JUK4	5.5%	±	4.8%	5.3%	±	4.9%	5.0%	±	5.2%
22.21 Manufacture of plastic plates, sheets, tubes and profiles -JUO9	3.6%	±	3.5%	3.4%	±	3.7%	3.3%	±	3.9%
24.10 Manufacture of basic iron and steel and of ferro-alloys -K2YZ	7.6%	±	11.8%	7.0%	±	12.0%	6.6%	±	12.3%
24.42 Aluminium production -JV2H*		NA			NA			NA	
24.45 Other non-ferrous metal production -K2Z9	3.5%	±	14.7%	3.4%	±	15.6%	3.3%	±	16.6%
25.11 Manufacture of metal structures and parts of structures -JV3D	5.7%	±	4.3%	5.4%	±	4.5%	5.1%	±	4.6%
25.40 Manufacture of weapons and ammunition -K2ZG*		NA			NA			NA	
25.50 Forging, pressing, stamping and roll-forming of metal; powder metallurgy -JV3U	2.0%	±	4.1%	1.9%	±	4.4%	1.9%	±	4.8%
26.20 Manufacture of computers and peripheral equipment -JV5A	-6.6%	±	24.6%	-7.0%	±	29.0%	-7.6%	±	34.3%
26.30 Manufacture of communication equipment -JV5J	3.2%	±	5.1%	3.1%	±	5.4%	3.0%	±	5.8%
29.10 Manufacture of motor vehicles -JVH7	3.2%	±	3.7%	3.1%	±	3.9%	3.0%	±	4.2%
29.20 Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers -K33Q	3.3%	±	2.7%	3.2%	±	2.9%	3.1%	±	3.1%
29.31 Manufacture of electrical and electronic equipment for motor vehicles -JVJ4	1.4%	±	6.7%	1.4%	±	7.2%	1.3%	±	7.8%
29.32 Manufacture of other parts and accessories for motor vehicles -K33S	2.0%	±	2.6%	2.0%	±	2.8%	2.0%	±	3.0%
30.11 Building of ships and floating structures -K3B3*		NA			NA			NA	

	2012			2013			2014		
30.30 Manufacture of air and spacecraft and related machinery - K33V	2.4%	±	3.1%	2.3%	±	3.3%	2.3%	±	3.6%
33.15 Repair and maintenance of ships and boats -K34H	2.0%	±	3.0%	1.9%	±	3.3%	1.9%	±	3.5%
33.16 Repair and maintenance of aircraft and spacecraft -JVU7	6.8%	±	4.8%	6.4%	±	5.0%	6.0%	±	5.1%
33.17 Repair and maintenance of other transport equipment -JVU9	10.3%	±	5.0%	9.3%	±	5.0%	8.5%	±	5.0%
Computer Services (SPPI) - K8UK	0.9%	±	2.7%	0.9%	±	2.9%	0.9%	±	3.2%

* Insufficient data observation to generate appropriate forecast.

Appendix L – Inflation under the Multiple Indexes approach using a 2% labour productivity



Appendix M – Inflation comparison of current DMO practice and method used in this research - Combat vehicles perspective

	Current DMO practice (per annum)	**Academic research recommended practice (p.a.)**	**Difference**
Single Index approach without adjustment	-1.70%	-0.65%	-1.05%
Single Index approach with 3% up-scale adjustment	1.30%	2.13%	-0.83%
Multiple without productivity deduction and NVE	5.11%	4.61%	0.50%
Multiple without productivity deduction	3.83%	3.43%	0.40%
Multiple with 0.3% productivity	3.50%	3.10%	0.40%
Multiple with 1% productivity	3.18%	2.77%	0.41%
Multiple with 2% productivity	2.72%	2.31%	0.41%