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A Claim Pairing Approach to Measuring Superimposed Inflation – A NSW CTP Example

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Synopsis

Many factors influence the amounts that are ultimately paid to claimants as settlement of bodily injury claims. Injury severity and personal circumstances are two such factors. However, because there can be an infinite spectrum within each factor, plus confounding effects of other factors, traditional techniques on aggregate payment experience to understand superimposed inflation have inherent shortcomings. There is not good agreement on what is being measured or how best to measure superimposed inflation.

In this paper, we develop a new approach to measuring superimposed inflation for bodily injury claims that is akin to the methodology used in compiling house price indices, namely a 'claim pairing approach' or pairs of sales index.

The claim pairing approach to developing a superimposed inflation index 'pairs' like claims that have settled in different time periods. Each pair then contributes to the inflation index for the period between their settlement dates. The pairing is based on a scoring system that finds the best possible match for each claim pair based on claim characteristics.

This method brings us back to a pure measure of superimposed inflation; how have settlements changed over time, over and above economic inflation, for like-with-like claims?

We have developed the technique using NSW CTP claim experience. However, the approach can be generalised to other long tail or short tail portfolios.

Keywords:

Superimposed inflation, claim pairing index, CTP, compulsory third party, bodily injury

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1 Introduction

1.1 What is superimposed inflation?

In the 2009 paper by Cutter[i], a definition of superimposed inflation is proposed as follows:

"*superimposed inflation is the tendency for personal injury awards to increase at a rate greater than normal (economic) inflation. The drivers of superimposed inflation include (but are not limited to):*

- *Legal decisions/precedents or general scheme dynamics that –*
  - *Allow a larger group of claimants access to a particular head of damage*
  - *Increase the average award for a particular head of damage*
  - *Create a new area of compensation*
- *An increased level of legal involvement (i.e. a higher proportion of legally represented claimants), which may increase the level of awards to claimants, and will certainly increase legal costs*
- *Better preparation by plaintiff lawyers, so that a claimant may now access a particular head of damage that may not have been available (to a claimant with similar injuries) in the past*
- *Claims handling practices of insurers, for example the weight that claims managers give plaintiff versus defendant evidence in terms of formulating offers.*

Superimposed inflation is not –

- *Legislative reforms that change the level of benefits paid to claimants*
- *Driven by changes in total claim frequency*
- *Related to a change in mix of frequency by injury type/severity.*"

This definition combines a non-exhaustive list of what the drivers of superimposed inflation are, as well as what superimposed inflation is not. In our experience, it is necessary to pin down the definition in this way as superimposed inflation goes by many different definitions within the profession and hopefully heads off one of the key debates about measuring superimposed – just what is it?

For this paper we have gone back to what we believe is a pure measure of superimposed inflation, namely, **how have settlement sizes changed over time for like-with-like claims?**

1.2 Why have we developed this new approach?

The 2009 Cutter paper also discussed the problems typically encountered in measuring superimposed inflation. The two main causes of measurement difficulty are –

- Changes in claim frequency and the resulting impact on the types of claims occurring. This makes simple comparisons of average settlement size for cohorts of claims over time an inappropriate lens with which to view superimposed, Even after normalising for groups of injury severity, the

measured superimposed inflation may not be a true measure due to changes in the composition of claims within the injury severity group

- Changes in the order of claim finalisation – which tends to be exacerbated when claims frequency is changing – confounds any measure of superimposed which treats time variables (accident period, settlement delay, etc.) as having a monotonic effect on claims size in the vector of explanatory variables.

Actuarial models of superimposed inflation do not typically deal well with these features.

Some traditional approaches to measuring superimposed inflation (typically using models that incorporate aggregated data), where superimposed inflation is the residual effect, also beg the question as to what is actually being measured?

We asked ourselves "how could we better measure superimposed inflation that would overcome some of these limitations?" Going back to the definition of what superimposed inflation is, how could we create a measure that compared like-with-like claims over time?

The answer: the claim pairing index.

1.3 What is the claim pairing index?

The claim pairing index approach we have developed is akin to the methodology used in compiling house price indices. Using median sales prices to measure house price inflation is prone to distortion as it does not allow for changes in housing stocks. Transferring this to a claims environment, using average settlement sizes does not allow for changes in composition of claims.

The two most common approaches to account for property characteristics and derive the underlying trend in house prices are:

- The **hedonic method**[ii], which uses regression on the most influential characteristics of a property to normalise for them. Modelled coefficients are applied to a basket of standard properties for each time period to obtain the price index. This method is fairly robust and reliable (see Bourassa, et al, 2004[iii]) and have been in popular use in econometric models for the last two decades.

  In our case, we are interested in being able to use the characteristics we know about individual claims to quantify the pure effect of superimposed inflation. That is, we are normalising for the fact that different sized awards are given to different injury types and claimant circumstances. The premise is that claims with identical observed characteristics will settle for the same cost given the same settlement environment.

- The **repeat sales method**[iv], which analyses price changes for only the properties which have been sold more than once. Repeat sales indices have gained popular acceptance for measuring house price growth. This method controls for differences in the mix or quality of houses sold by only comparing repeat observations of sales of a single dwelling. Compared to the hedonic method, repeat sales is a much simpler method and allows for more accurate matching of properties. However, it does not utilise all of the data available and is prone to "backdating" when new data is added.

We have taken these two concepts and applied them to bodily injury claims. In this work, we take the principles underlying hedonic price estimation to construct claims data that is of a form amenable to repeat sales index creation. Specifically, the entire NSW CTP finalised claims history (under MACA

1999) has been converted so that each claim is part of a pair (or string of pairs). Thus, total claim cost escalation (including both economic inflation and superimposed inflation) can be measured directly on quasi repeat settlement observations without being confounded by effects introduced by mix changes.

With an unambiguous measurement of total claims cost escalation, it becomes a straightforward exercise to back out economic inflation (in our case wages) to identify superimposed inflation.

1.4 Applying the approach to bodily injury claims

The measurement of bodily injury claims escalation does not easily lend itself to either of these two methods. Using NSW CTP as an example, we observe that:

- the injury type and maximum injury severity are crucial determinants of the cost of CTP claims, however the injury coding adopted is very granular. There are over 2,000 different injury codes with each claimant potentially having multiple injuries. A hedonic regression approach would not yield robust results
- the repeat "sales" method is not possible. As individual claimants rarely have repeat claims (and when they do their circumstances will have changed – at a minimum they will have aged), it is rare to find a pair of CTP claims with the exact same claim characteristics.

The approach we have adopted combines these two established methods, with a few adjustments, to apply to the CTP claims context. We aim to pair each claim to one with the closest set of descriptive characteristics. A regression is used to help select the claim characteristics used, and the scoring (weight) given to each characteristic. After determining 'pairs' of like claims that have settled in different time periods, their difference in cost then contributes to the inflation index for the period between their settlement dates.

This approach aims to combine the advantages of the hedonic and repeat sales methods, while lessening their respective drawbacks in the context of bodily injury insurance awards:

- In the context of house prices, the hedonic method applies a high level regression model to estimate the overall inflation rate, recognising different variables will have different impacts on price. However, it does not allow a comparison as direct as repeat sales to be made. Our method is only loosely tied to the concept of the hedonic index as it simply uses results from the regression, to aid in the matching of specific claims. Taken in a different direction, the regression we have performed could be used to measure an hedonic inflation index directly.
- The repeat sales method allows comparable properties' prices to be directly connected, and is therefore easier to understand. However, it only utilises a subset of the sales data and is prone to backdating. Our claims pairing algorithm allows most of the useful data to be included in the analysis, while any new claim settlements will not have a large impact on historical periods.

A drawback of our approach relative to the repeat sales method for house prices is that it does not account as perfectly for all the factors that will influence a claim settlement. The granularity of injury codes remains problematic; often the best matched claim can only be paired using the less precise "body region" as opposed to the detailed injury coding. Moreover, our combined method is more complex than the hedonic method, and much more complex than the repeat sales, both in terms of the procedure itself, preparing the data and computation time required.

2 Application to NSW CTP claims: data preparation

We have applied the claim pairing approach to finalised NSW CTP claims occurring after the introduction of the Motor Accidents Compensation Act 1999. We have used data as at 30 June 2015. Before compiling the superimposed inflation index, we have excluded certain claims from the analysis and also made adjustments to some of the variables which we describe further below.

2.1 Excluded claims

The following table shows the claims that have been excluded from the analysis and why.

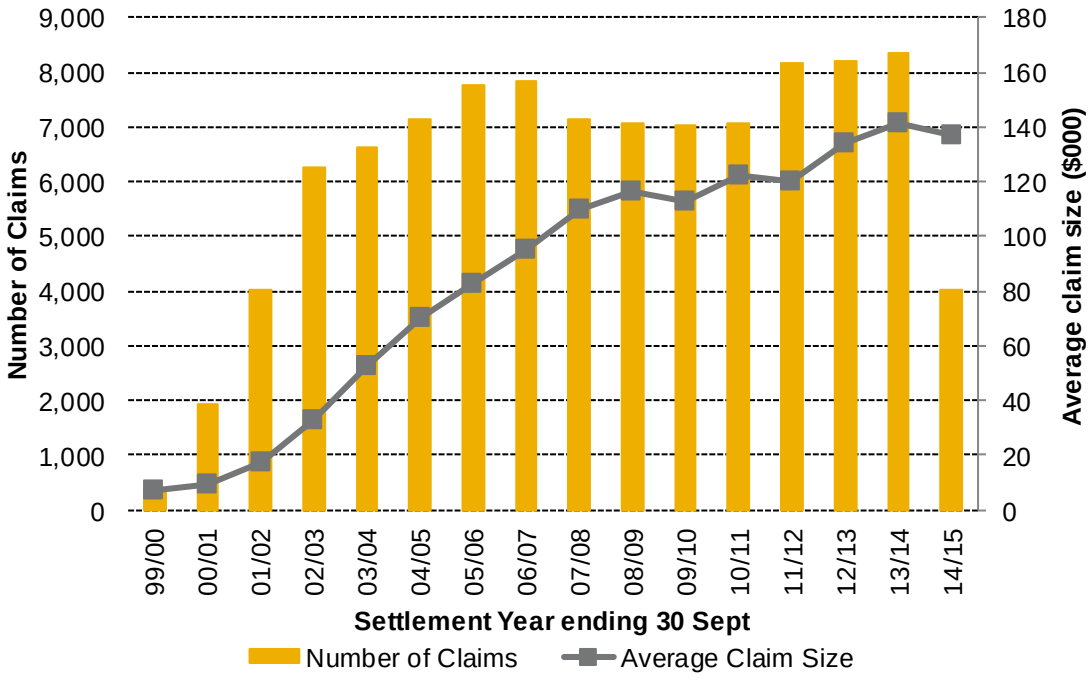
Type of Claim Excluded	Definition	Reason for exclusion	Number of claims	% of claim numbers	% of claims cost
ANFs (including at fault ANFs)	Where claim flag is not Y	Small cost but high volume. Little contribution to total costs and therefore to superimposed inflation. Removes "noise" in the data.	33,000	19%	0.3%
Pre-1 Oct 2008 'MACA 07 ANFs'	Claims finalised within six months of the accident date for less than $5,000 of medicals and past economic loss only	These are claims that we expect would have been settled as ANFs had the MACA 07 legislation been in force. Exclude for same reason as above	5,100	3%	0.0%
Small claims	Finalised cost of less than $1,000	Small cost but high volume. Little contribution to superimposed inflation	18,700	11%	0.0%
LTCS claims	Claims that are in the LTCS scheme, plus pre-LTCS claims that we expect would have been in the scheme had it existed	Large and non-homogeneous claims. While these are low volume they have the potential to introduce random but significant volatility which is not amenable to unpacking by the method we have developed.	1,200	1%	15%
Interstate claims	Where accident postcode or garage location of at fault vehicle is outside NSW	Benefits paid to interstate claims are under different legislation to the NSW scheme hence it is not appropriate to pair interstate claims with non-interstate claims. Superimposed inflation within other jurisdictions should be measured on industry wide experience.	11,200	7%	7%
Settlements in June 2015 quarter	Where settlement date between 1 April and 30 June 2015	Backdating of settlement information impacts on most recent quarter	1,900	1%	2%

Type of Claim Excluded	Definition	Reason for exclusion	Number of claims	% of claim numbers	% of claims cost
Other miscellaneous exclusions		No injury code, gender is unknown, employment status is unknown or occupation is unknown. These claimant characteristics are important in the pairing algorithm.	1,700	1%	1%

Of the total dataset of finalised claims and ANFs (172,000 matters), we have therefore excluded around 40% of matters by number (mainly ANFs, small claims and interstate claims) and around 25% of costs (mainly LTCS claims and interstate claims). We have included a total of 99,000 claims in our matching algorithm.

The following graphs show the number of claims and average claim size by settlement year for these 99,000 claims (noting the 2014/15 year is a six month settlement period only).

Figure 2.1 – Number and Average Size by Settlement Year of Claims Used



2.2 Variables

We made a number of small adjustments to some of the variables to allow for changes in injury codes over time and the like. Specifically we have:

- Mapped the AIS85 injury codes used prior to 1 July 2008 to the AIS05 injury codes used after that data
- Ignored the F430 detailed injury code ("acute stress") as this was a new injury code added after 1 October 2011. We understand that this code indicates that a claimant had a temporary stress reaction that did not go on to manifest into a more severe psychological condition i.e. the claimant fully recovered from the stress injury. No corresponding injury existed prior to 1 October 2011 and

we understand that the vast majority of claims coded “acute stress” would not have been coded with any stress injury prior to October 2011

- Treated all “severe psych” injuries other than post-traumatic stress disorder interchangeably given that a number of new psych injury codes were introduced on 1 July 2008 and then another major revision to the codes was introduced in 1 October 2008
- Treated two claims with the same multiple injuries but coded in a different order as having the same injuries (e.g. a whiplash injury followed by a lumbar strain is treated the same as a lumbar strain followed by whiplash).

We also created some new concatenated variables:

- The combination of the three most severe injury codes
- The combination of the three most severely injured body regions
- The combination of the most severely injured body region and the maximum injury severity score (e.g. head injury of severity 3)
- The combination of whether a claim is above/below the 10% WPI threshold, and if above whether this is due to a physical injury, a psychological injury or both.

We use the three most severe injury codes/body regions as there is a precedent in the accepted “Injury Severity Score” (ISS) which uses the three most severe injuries from three different body regions. There is a body of evidence that supports the validity of ISS as a measure of trauma severity and therefore this should be equally valid to group claims for measuring superimposed inflation. The ISS correlates linearly with mortality, morbidity, hospital stay and other measures of severity[v].

3 What did we do?

This section sets out the process we followed to pair claims and calculate superimposed inflation in past periods.

3.1 Which claim characteristics did we use to pair claims?

In deciding whether or not claims should be paired, the following claim characteristics were compulsory matches (i.e. if two claims differed in any of these criteria, the claims could not be paired):

1. S151z workers compensation recovery claim (Y/N)
2. Compensation to relatives claim (Y/N/B/C/F/O/S)
3. Fatality (Y/N)
4. Contributory negligence claim (Y if liability is partially accepted or contributory negligence flag is Y, otherwise N)
5. Most severely injured body region and maximum injury severity score (e.g. head injury of severity 3).

The first three of these were chosen as compulsory matches due to the quite different nature of the compensation available to these claims relative to other claims. The fourth criterion was chosen as the cost of these claims represents only a portion of the full value of the claim. The last criterion was chosen as the combined body region and injury severity were seen as crucial determinants of describing like-with-like claims.

Other claim characteristics used to pair claims were not compulsory but where they matched elevated the "look-alikeness" of the claim pair:

- The combination of the three most severe injury codes
- The combination of the three most severely injured body regions
- The combination of whether above/below the 10% whole person impairment threshold (Y/N), and whether due to physical, psychological or both injury types
- Legally represented status (Y/N)
- Whether hospitalised or not (Y/N/unknown)
- Employment status at the time of accident (employed, self-employed, not employed for various reasons, children, students, retired)
- Occupation at the time of accident (managers, professionals, tradespersons, labourers, etc)
- Liability status (i.e. fully accepted, rejected, etc)
- Age at time of accident
- Delay from accident date to report date
- Gender (M/F)
- SEIFA score i.e. an indicator of the claimant's socio-economic status based on their home address. This is a score between 0 and 1.0

- Whether the claimant lives in NSW (Y/N).

These claim characteristics did not need to match completely; we applied a scoring system to each characteristic (see Section 3.3 below) and then paired claims based on the best match.

The paradigm for selecting these claim characteristics for inclusion in the pairing algorithm was based on the following:

- We started with all claim characteristics available on the Personal Injury Register
- We did not include some claim characteristics are they are either poorly coded or inconsistently coded between insurers (e.g. rehabilitation indication, whether the claimant has had a prior claim or not)
- We did not include some claim characteristics as, while they may be an important determinant of how severely injured a person is, the detailed injury codes used in the matching will better reflect this (e.g. type of at fault vehicle, claimant's role in the accident, whether wearing helmet, whether wearing seatbelt, whether intoxicated or not)
- We did not use any variables that were related to the claims management process (e.g. whether the claim went to CARS, whether litigated or not)
- We ignored some claim characteristics that we felt should not have a bearing on the settlement amount (e.g. whether the claim is shared or not, variables that were related to the at fault driver).

3.2 Other pairing criteria

Pairs were only able to be matched if they had settlement dates that were at least 91 days apart. We added this criterion to avoid pairing claims that were settled in the same settlement/temporal environment. There is no signal associated with two like-with-like claims that settle at the same time, only noise.

3.3 How did we do the scoring?

The pairing algorithm is applied as follows:

- Take the claim characteristics of the most recently settled claim (call this "Claim 1")
- Look at the claim characteristics of every claim with a settlement date more than 91 days prior to this claim that matches on the compulsory criteria (workers compensation recovery, compensation to relatives, fatality, most severe body region & maximum injury severity)
- Calculate the score for each claim based on how many claim characteristics match and which ones. The scores we have applied to each variable are:

Claim characteristic	Score
Three most severe injury codes	18
Three most severely injured body regions	6
10% WPI threshold + injury type	2
Legally represented status	2
Whether hospitalised or not	1
Employment status	1
Occupation	1
Liability status	1
Age at time of accident (<10 years difference)	1
Delay from accident date to report date	0.5
Gender	0.5
SEIFA score (<0.1 difference)	0.5
NSW claimant	0.5

The highest possible score that a pair of claims can receive is 29 points. Note that if a claim has the same three injury codes, then by default it has the same three body regions. These claims attract 18 points, not 24.

Note that if two claims have a 'blank' (i.e. not coded) that creates a same value match, then that characteristic does not get a score. Both hospitalisation status and occupation have a high proportion of claims that are not coded (hospitalisation presumably due to lack of data quality while for occupation those that are not employed or self-employed do not have an occupation coded).

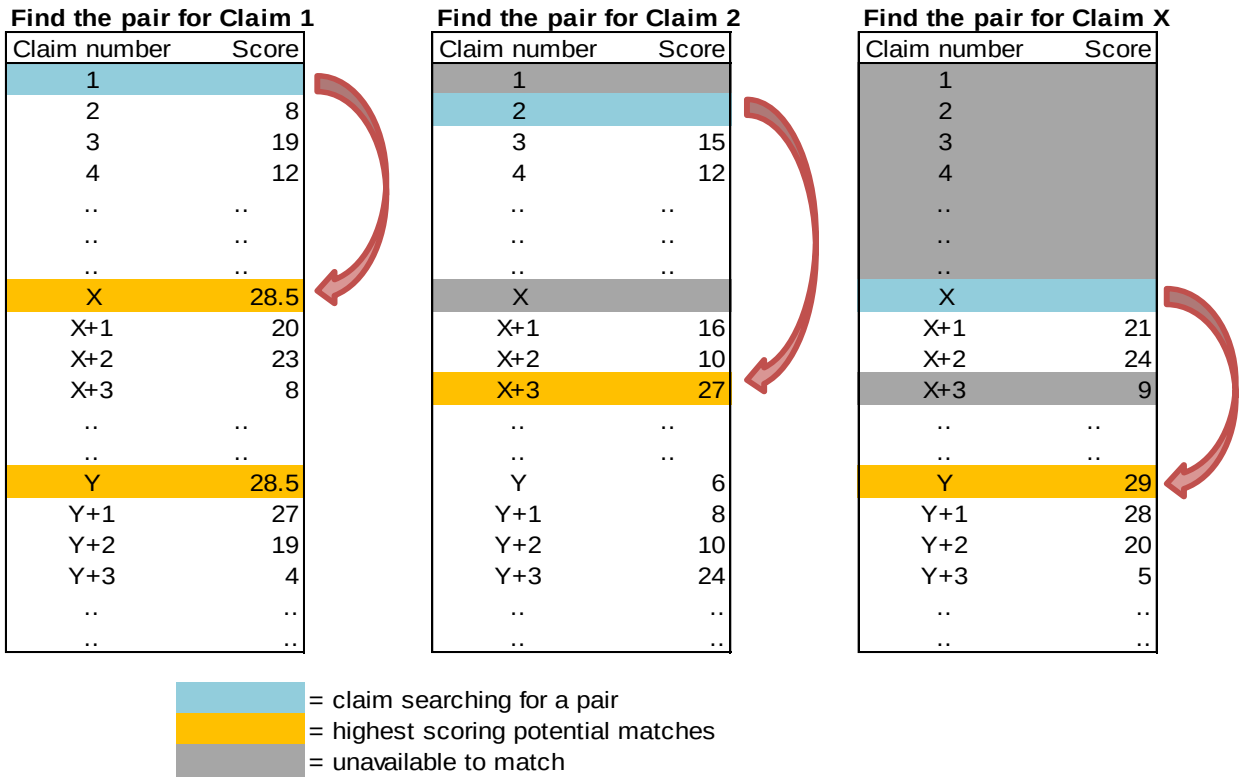
The scoring adopted is linked to the hedonic approach for measuring house price inflation where factors identified as having a discriminating effect on price are modelled. In our methodology, factors identified as having a larger discriminating effect on claims size attract a higher weight. The relativity between the scores is somewhat judgemental. (In section 6 we show the results using alternative scoring. This comparison indicates that so long as the ranking of the weights is maintained, the actual weighting adopted does not materially alter the results.) We have given the same detailed injuries a high score as we observed this was the most important determinant of claims cost. The three most severe body regions also attract a relatively high score. For the remaining claims characteristics, the relative scoring is based on a regression that ranked the significance of each characteristic. Claim characteristics with higher weights were found to be more influential in terms of settlement cost

- Out of all the claims that are now scored against our original claim (Claim 1), we select the claim with the highest score to be the matched claim (call this "Claim X"). If there are two or more claims that have the same score, we select the claim with the settlement date that is closest to Claim 1.

This process is then repeated for each claim, noting that Claim X is unavailable to be paired again, other than when it is its 'turn' i.e. each individual claim can only be paired twice, once with a claim settled before it and once with a claim settled after it.

This process is shown diagrammatically below. Claims have been sorted by date of settlement with the most recent settlement being Claim 1.

Figure 3.1 – Example of Claim Pairing



When finding the pair for Claim 1, Claims X and Y are scored highest and equivalently at 28.5 points. Claim X is paired with Claim 1 as it is the claim that settled most recently to Claim 1 (and the settlement dates are more than 91 days apart).

We then repeat the process to find the pair for Claim 2. Claim X is unavailable for matching as it was paired with Claim 1. Claim X+3 is scored most highly and paired with Claim 2.

The process is repeated for all claims, including claims that have already been paired when is becomes their turn (i.e. Claim X gets paired with Claim Y above and we end up with a string of paired claims including Claim Y, Claim X and Claim 1).

We optimise the pairing by running through this process for each claim before we make any claims unavailable for matching. If two claims are both found to be the best match with a third claim, then the claim that has the closest settlement date is used in the pairing.

Backwards versus forwards pairing

As described above, we started with the claim that was settled most recently and looked backwards in time at all prior settlements for the best match ("backwards pairing"). An alternative to this would be to start with the oldest settlement and look forwards to claims that have settled after it ("forwards pairing").

We have chosen backwards pairing rather than forwards pairing as backwards pairing finds more pairs for recent settlements. Forwards pairing finds more pairs for older settlements. As we are more interested in superimposed inflation in more recent periods, we decided to backwards match.

3.4 Calculating the overall inflation

Pairs of settlement contribution, aka the "toothpaste" method

Once we have all of the sets of pairs defined, we are able to combine these in a way to arrive at the overall inflation from one period to the next. We have adopted what we will refer to as the "toothpaste" method to determine successive periods of inflation:

1. For all pairs of claims where the earlier claim is settled in the December 1999 quarter and the latter claim is settled in the March 2000 quarter, we calculate the inflation between the paired claims. The inflation for each pair is then combined using a weighted average approach to determine the overall inflation level between these two quarters (see below for a discussion of the weights used).
2. We then examine all claim pairs where the latter claim is settled in the June 2000 quarter to derive the cumulative inflation over the December 1999 to June 2000 six month period:
   - If the earlier claim is settled in the December 1999 quarter, we calculate the inflation between the paired claims following the same procedure as in Step 1 above
   - The remaining pairs of claims in this group have the earlier settlement date in the March 2000 quarter and the latter settlement date in the June 2000 quarter. We calculate the inflation for these pairs (for the March 2000 to June 2000 period), and then add on the average inflation rate calculated in Step 1 (for the December 1999 to March 2000 period)
   - We now have an estimate of the December 1999 to June 2000 inflation rate for every pair that had the latter claim settled in June 2000. The inflation from these pairs is then combined, again using the weighted average approach to arrive at the total estimated inflation for the six month period
   - We then back out the inflation derived in Step 1 to determine the inflation for the March 2000 to June 2000 quarter.
3. This process is the repeated for each successive settlement quarter, using the inflation derived from the previous steps to back out the latest quarter's inflation.

This approach is loosely analogous to converting zero coupon bond yields to forward yields.

Note that all settlement amounts included in the above process are in original values (not inflated with economic inflation to today's values), hence the resulting measure of inflation includes both economic and superimposed inflation.

Note also that while the measure of economic plus superimposed inflation accounts directly for different settlement mixes between periods, a word of caution; measured claim inflation in the early years of the Scheme relates to the mix of claims actually settled in those years. More generally, the index of total claims inflation in any period is necessarily specific to the mix of the pairs of claims settled during the period in question.

This means that you'll need to think carefully about how to interpret our results before application to future periods. For example, you may want to subset and reweight the historical claim number experience so that it provides a direct measure of claims inflation applicable to an outstanding claims valuation claims mix. Or you may want to apply a different weighting appropriate for a new injury or underwriting year. We provide an example of what we mean here in Section 5.2 below.

Single inflation index adopts weights for each of the pairs

Rather than weight the contribution to the aggregate index by the actual dollar settlement amount, we combined each pair's contribution to an overall inflation rate by adopting different weights depending on each claim's characteristics.

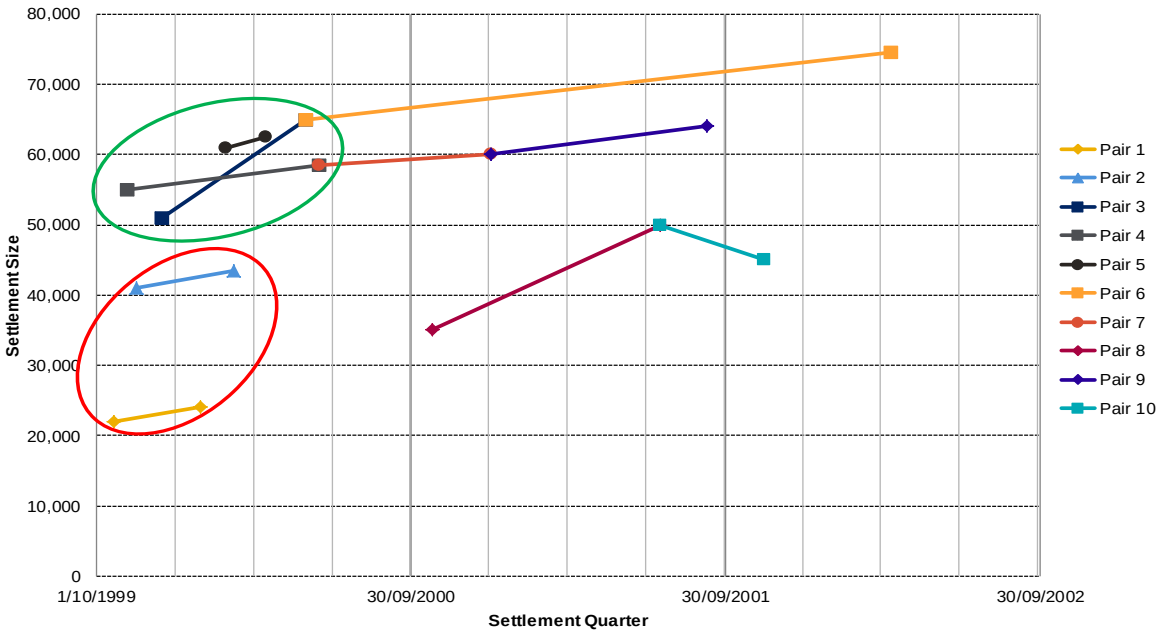
More expensive claims do make a greater contribution to the index relative to less expensive claims. However, the weightings adopted are based on a segmentation exercise that grouped claims into 15 different segments with different expected costs. These expected costs range from $6,000 for the least costly claims to $580,000 for the most expensive claims. Each claim within the pair is assigned the cost for the segment it belongs to, and this is then used to weight the pair's inflation. So a pair of claims that are both in the least costly segment make up around 1% of the contribution compared with a pair of claims in the most costly segment. The actual settlement cost for the individual claims is not used in the weighting. The actual settlement cost is of course used in the measure of inflation between pairs of claims.

The weighting used was chosen to avoid higher cost claims, and in particular where the settlement size differential was also large, being doubly influential on the contribution to inflation. In section 6 we show the results using equal weightings for all pairs, irrespective of their size. This comparison indicates that the weighting adopted is not significant.

Example Calculation

A set of example claims are shown in the diagram below.

Figure 3.2 – Sample Inflation Calculations



We first calculate the inflation between the December 1999 and March 2000 quarters using Pairs 1 and 2 (circled in red), both of which have their first claim settled in the December 1999 quarter and the second claim in the March 2000 quarter. Both claims from Pair 1 are from Segment 2 (with an expected average cost of $25,000) while the claims from Pair 2 are from Segments 5 and 6 (with expected average costs of $38,000 and $42,000 respectively).

The inflation index for the December 1999 to March 2000 quarter is calculated as:

$$\exp\left(\frac{w_1}{w}\times\log\left(\frac{24{,}000}{22{,}000}\right)+\frac{w_2}{w}\times\log\left(\frac{43{,}500}{41{,}000}\right)\right)=1.07$$

Where the weights for pair 1 and pair 2 are given by:

$$w_1 = 0.5\ \times(25{,}000+25{,}000)$$
$$w_2 = 0.5\ \times(38{,}000+42{,}000)$$
$$w = w_1 + w_2$$

These calculations are detailed in Table 3.1 below.

Table 3.1 – Example Calculations

	Pair 1	Pair 2	Combined
Claim 1			
Settlement Quarter	Dec-99	Dec-99	
Settlement Amount	22,000	41,000	
Segment	2	5	
Segment Size	25,000	38,000	
Claim 2			
Settlement Quarter	Mar-00	Mar-00	
Settlement Amount	24,000	43,500	
Segment	2	6	
Segment Size	25,000	42,000	
Avg (Segment Sizes)	25,000	40,000	65,000
Weights	38%	62%	
Log (Size 1/Size 2)	0.09	0.06	0.07
Inflation index from Dec 1999			1.07
Inflation for Quarter			7%

The inflation index for the first quarter is calculated as 1.07 and the total inflation is therefore 7%.

We then use Pairs 3 to 5 (circled in green) to calculate the inflation for the second quarter. Both Pairs 3 and 4 have their first settlement date in the December 1999 quarter and their second claim in the June 2000 quarter, thus providing a measure of inflation over the six month period. Pair 5 has the first claim in settled in the March 2000 quarter and the second in the June 2000 quarter, hence this pair needs to have the inflation from December 1999 to March 2000 added to get the inflation over the six month period. The formula and calculations are shown below.

The inflation index for the December 1999 to June 2000 six month period is calculated as:

$$\exp\left(\frac{w_1}{w}\times\log\left(\frac{65{,}000}{51{,}000}\right)+\frac{w_2}{w}\times\log\left(\frac{58{,}500}{55{,}000}\right)+\frac{w_3}{w}\times\log\left(1.07\times\frac{62{,}500}{61{,}000}\right)\right)=1.12$$

Where the inflation weights for pairings 1, 2, and 3 are given by:

$$w_1 = 0.5\ \times(42{,}000+42{,}000)$$
$$w_2 = 0.5\ \times(65{,}000+70{,}000)$$
$$w_3 = 0.5\ \times(70{,}000+70{,}000)$$
$$w = w_1 + w_2 + w_3$$

These calculations are detailed in Table 3.2 below.

Table 3.2 – Example Calculations

	Pair 3	Pair 4	Pair 5	Combined
Claim 1				
Settlement Quarter	Dec-99	Dec-99	Mar-00	
Settlement Amount	51,000	55,000	61,000	
Segment	6	8	9	
Segment Size	42,000	65,000	70,000	
Claim 2				
Settlement Quarter	Jun-00	Jun-00	Jun-00	
Settlement Amount	65,000	58,500	62,500	
Segment	6	9	9	
Segment Size	42,000	70,000	70,000	
Avg (Segment Sizes)	42,000	67,500	70,000	179,500
Weights	23%	38%	39%	
Log (Size 1/Size 2)	0.24	0.06	0.02	
Cumulative fom Dec1999	0.24	0.06	**0.09**	0.12
Inflation index from Dec 1999				1.12
Inflation for Quarter				5%

The inflation index for the six months from December 1999 to June 2000 is calculated at 1.12. After backing out the 7% inflation from the first quarter, the inflation for the second quarter is calculated as 5% (1.12/1.07 – 1).

To generalise, the inflation index at quarter *t*, is given by

$$I_t = \exp\left(\sum_{k=1}^{n} \frac{w_k}{w} \times \log\left(i_{k,1} \times \frac{C_{k,2}}{C_{k,1}}\right)\right)$$

Where:

- $C_{k,1}$ and $C_{k,2}$ are respectively the settlement costs of claim 1 and 2 in pairing *k*
- $w_k = \frac{1}{2}(S_{k,1} + S_{k,2})$, where
  - $S_{k,1}$ is the expected average cost of the segment containing claim 1 in pairing *k*
  - $S_{k,2}$ is the expected average cost of the segment containing claim 2 in pairing *k*
- $w = \sum_{k=1}^{n} w_k$
- $i_{k,1}$ is the inflation index to the period containing claim 1 in pairing *k*
- *n* is the total number of claims that settle in period *t*

Conversion to an Annual Index

Following the above methodology, we end up with an inflation index for each settlement quarter. To calculate the inflation index between settlement years, we have taken the average of the four indices from one settlement year divided by the average of the four indices from the previous year.

For the 2014/15 “year”, where we have included only six months of settlement data, we have estimated the indices for the June 2015 and September 2015 quarters assuming the same average inflation as for the December 2014 and March 2015 quarters.

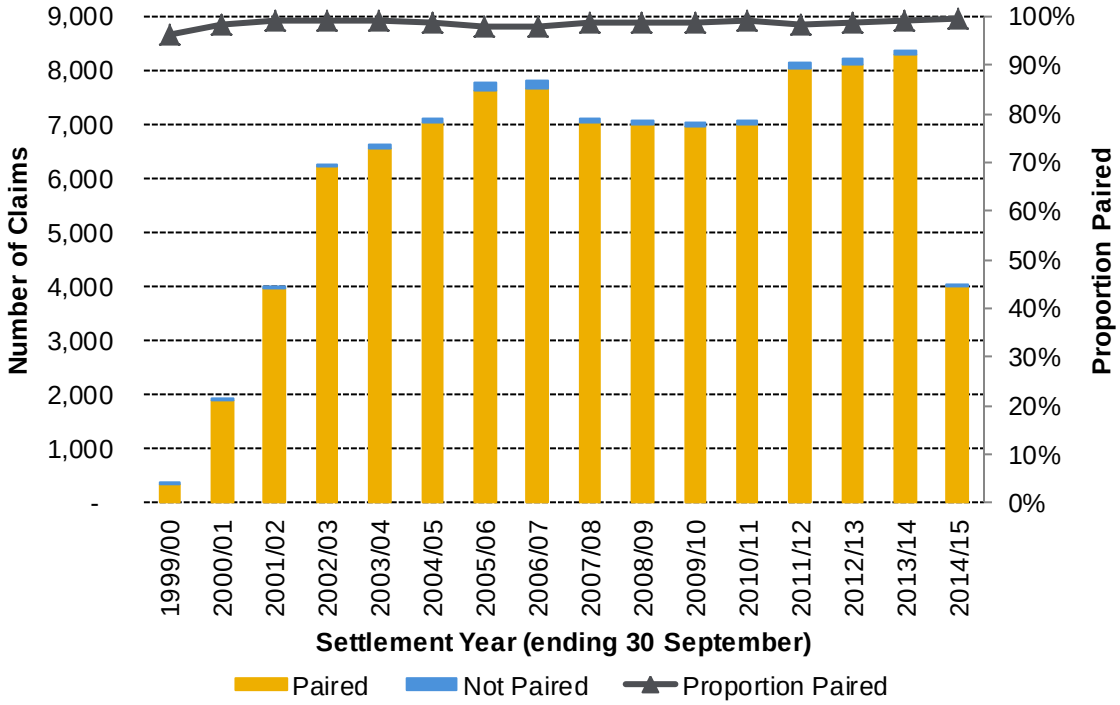
4 Results of the pairing

This section shows some diagnostics resulting from the pairing.

4.1 Number of pairs

Of the 99,000 claims that were fed into the pairing algorithm, we found a pair for 97,800 (99%) of them. The following graph shows the number of claims that were paired by settlement year with the blue bars showing the number of claims where no suitable pair was found (hence the claim was not included in the calculation of the index).

Figure 4.1 – Number of Paired Claims

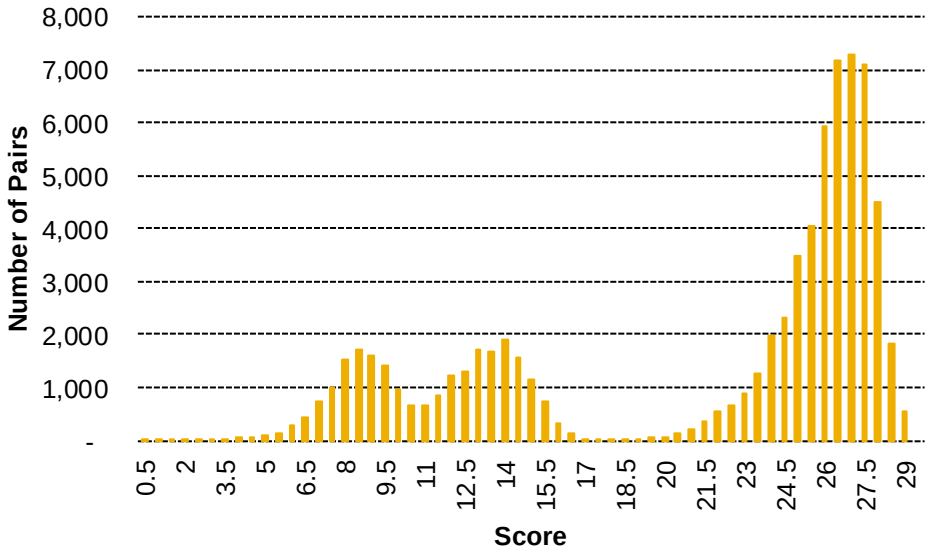


The graph shows that the bulk of claims were included in the calculation of the index.

4.2 Scoring of pairs

The following graph shows the distribution of the scores for the matched pairs.

Figure 4.2 – Distribution of Scores

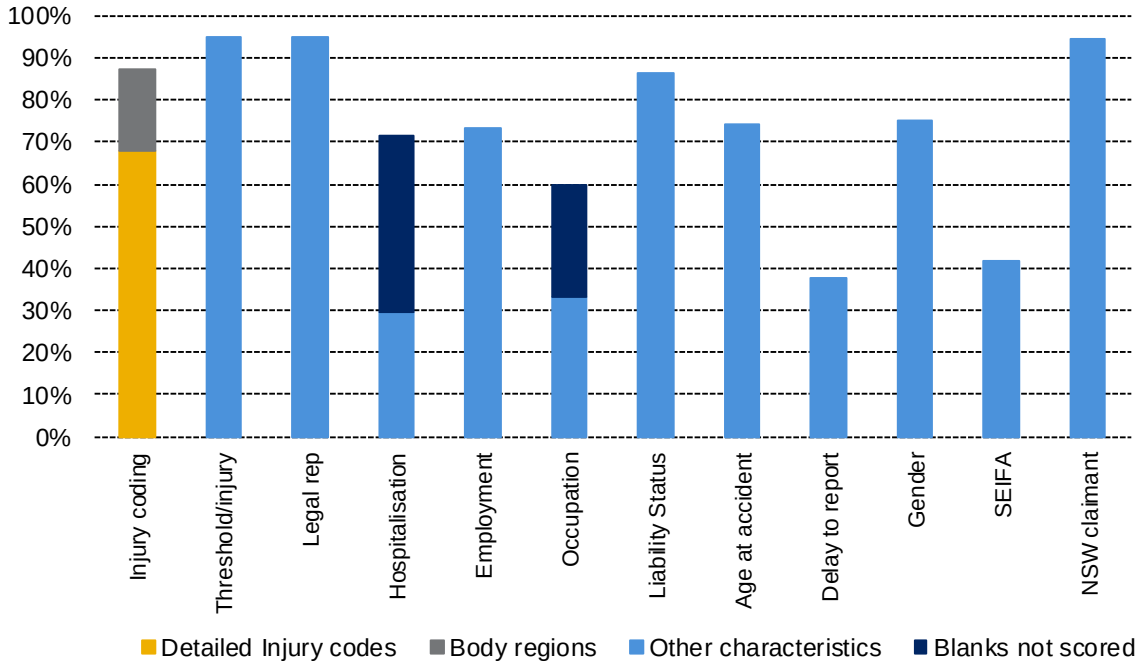


We can see that the scores are clearly clustered around a small number of values:

- At around 26 to 28 points, for those pairs where the detailed injury codes match and most other criteria used in the scoring also match
- At around 13 to 15 points, for those pairs where the body locations match and most other criteria also match
- At around 8 to 10 points, for those pairs where neither the detailed injury codes nor body locations match but most other criteria match (including maximum injury severity which is part of the compulsory matching criteria).

The following graph shows the proportions of pairs that matched on each of the scoring criteria.

Figure 4.3 – Proportion of Pairs by Matching Criteria



Of the matched pairs, almost 70% match on the three detailed injury codes with a further almost 20% matching on the body regions.

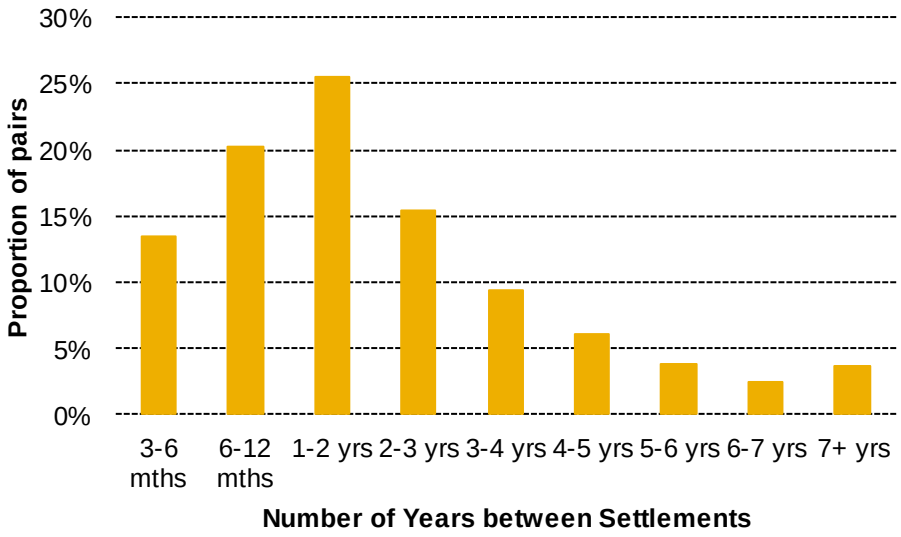
For the other characteristics:

- Around 95% of pairs have the same WPI threshold/injury type codes, same legal representation status, same NSW claimant status
- Around 85% of pairs have the same liability status
- Around 75% of pairs have the same employment status, same age at accident, same gender
- Around 70% have the same hospitalisation status, noting that only 30% score on this criterion due to the high number of blank values
- Around 60% have the same occupation status, noting that only around 35% score on this criterion due to the high number of blank values i.e. around 25% of pairs match on blank occupation status as they are not employed or self-employed but attract no score for this match. Another way to think about this is that of the employed and self-employed claimants that match on employment status, around 60% also match on occupation status
- Around 40% of pairs have the same delay to report, the same SEIFA score.

4.3 Average delay between the pairs

The following shows the average delay between the settlement dates of paired claims.

Figure 4.4 – Time between Paired Settlements



The average delay between the settlement dates of paired claims is 2.25 years. The bulk of paired claims (70%) are settled between six months and four years apart. Around 15% of the pairs are settled more than four years apart.

5 What is the measured superimposed inflation?

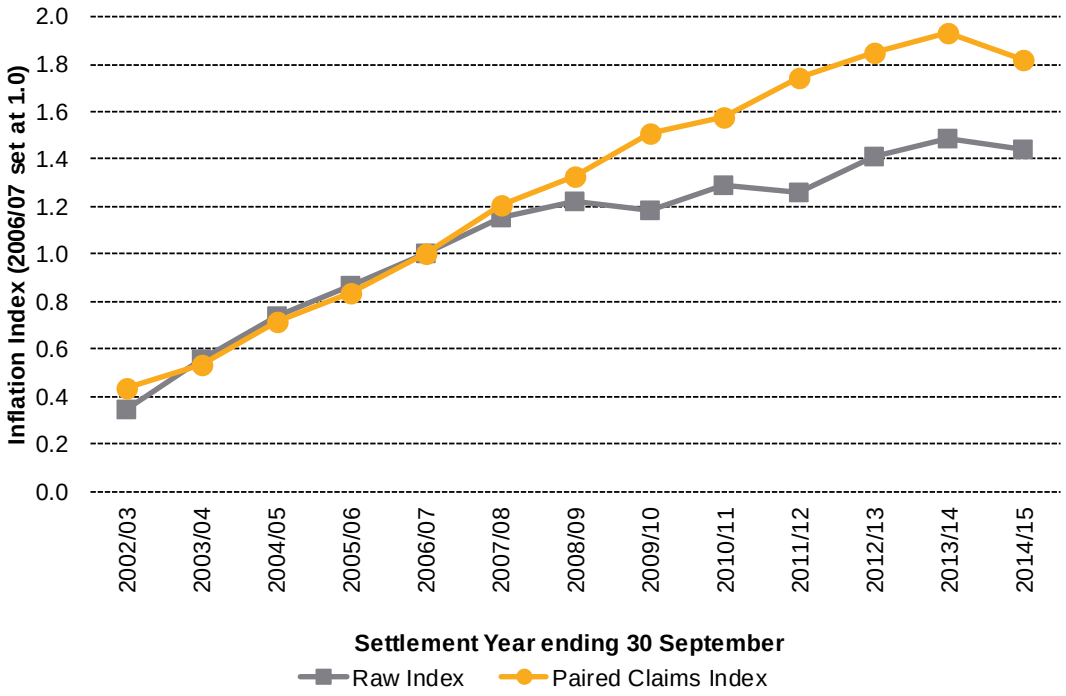
This section shows the overall inflation index derived from our approach and then backs out wage inflation to arrive at a measure of superimposed inflation.

5.1 Overall inflation index

Following the process outlined in Section 3, we have created the overall inflation index, including both wage and superimposed inflation (as all amounts are in original values at the time of settlement). Note that we have set the index to 1.0 for the 2006/07 settlement year. The following graph shows:

- the 'raw' index, derived from the average claim sizes that are fed into the matching process (i.e. the 99,000 claims we feed into the algorithm)
- the 'paired claims index', derived using the process described in the section 3.

Figure 5.1 – Inflation Indices



We can see that the paired claims index gives similar results to the raw index for the 2002/03 to 2007/08 settlement years. Beyond 2007/08 however, the indices vary widely, with the paired claims index implying a much greater level of inflation than the raw averages.

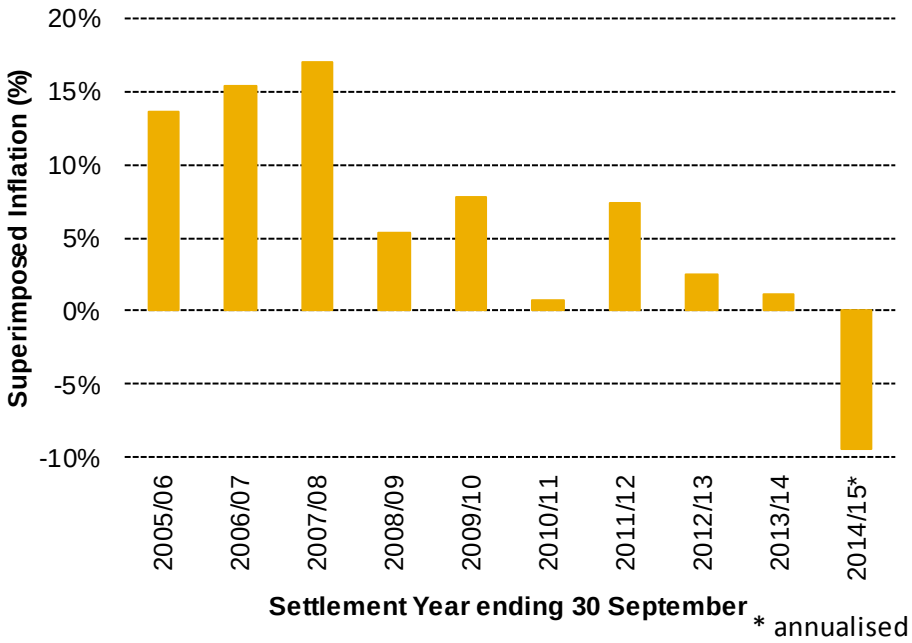
The following table shows the implied superimposed inflation once we have stripped out normal economic (wage) inflation. (We have used the NSW Persons - Full-time adult total earnings (original) series for wage inflation). Figure 5.2 shows the superimposed inflation graphically.

Table 5.1 – Paired Claims Superimposed Inflation

	Total inflation			
	Raw Index	Paired Claims Index	Wage inflation	Paired Claims Superimposed Inflation Index
2002/03				
2003/04	60%	24%	4%	19%
2004/05	33%	34%	5%	27%
2005/06	18%	17%	3%	14%
2006/07	15%	19%	3%	15%
2007/08	16%	21%	3%	17%
2008/09	6%	10%	4%	5%
2009/10	-3%	14%	5%	8%
2010/11	9%	5%	4%	1%
2011/12	-2%	11%	3%	7%
2012/13	12%	6%	4%	3%
2013/14	6%	4%	3%	1%
2014/15*	-3%	-6%	4%	-9%

* annualised

Figure 5.2 – Paired Claims Superimposed Inflation



Our index estimates:

- Superimposed inflation was very high (15% or more) up until 2007/08. This is consistent with generally accepted views that superimposed inflation was high over this period due to the Economic Loss and Care heads of damage.[vi]
- Between 2008/09 and 2013/14, superimposed inflation has been lower, varying between 1% and 8% (average of 4% over these six years).
- For 2014/15, our index estimates that superimposed inflation has been negative at -9%. We investigate the types of claims contributing to this result below.

Our claim pairing approach indicates superimposed inflation has averaged around 4% per annum in the recent past. Other measures of superimposed inflation for the NSW CTP industry have been quoted to be close to zero in recent years[vii]. The difference in results may be that traditional methods have not adequately picked up the changes in claim mix to the extent that our claim pairing approach does.

On the other hand, our measured superimposed inflation does not mean that around 4% per annum superimposed inflation is appropriate for a prospective assumption. Depending on the purpose, the historical rates observed require "unpacking" and "repacking" the individual paired claims inflation in different ways.

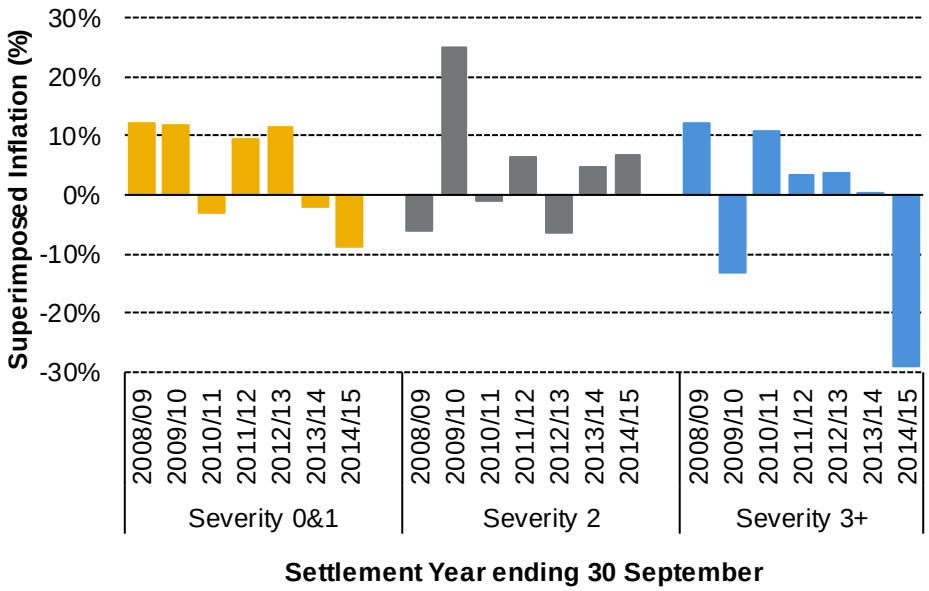
As a simplistic example, a pricing basis requires a basket of claims that mirrors the pricing basis to be assessed. Contrast this with the outstanding claims mix for a valuation basis which may be quite different. The advantage of our approach is that it is straightforward for historical experience to be segmented in these and other ways.

5.2 Superimposed inflation by claim type (unpacking)

Our approach lends itself to examination of the types of claims contributing to superimposed inflation. We have examined superimposed inflation within each maximum injury severity group (excluding workers compensation claims).

The following graph shows the superimposed inflation, as measured using our pairing approach, from 2008/09 for each injury severity group (maximum AIS).

Figure 5.3 – Superimposed Inflation by Injury Severity



Not surprisingly, we observe that severity 0&1 claims have the highest superimposed inflation, averaging 4.5% per annum over the period shown, or 6.5% per annum if we exclude the 2014/15 six month period.

Severity 2 claims tend to have a lower measured level of superimposed inflation compared with severity 0&1 claims. Excluding the high 2009/10 year, superimposed inflation has averaged 1% per annum over the period.

Severity 3+ claims have a more variable level of superimposed inflation.

How might we use the above in thinking about future superimposed?

5.3 How to determine a suitable pricing assumption (repacking)

Individual Severity Contributions

If we disaggregate the historical experience and measure the superimposed separately for each severity group, the average annual superimposed inflation *within* the severity might look like 5.5% p.a., 2.0% p.a. and 1.0% p.a. for severities 0&1, 2 and 3+ respectively.

Note that we are not advocating that this severity mix is appropriate for pricing NSW CTP. This section presents an approach using a simplified example claim mix.

What proportion of the risk premium comes from each severity?

For this example, let's assume that 50% of the claims cost before superimposed inflation relates to severity 0&1 claims, and 25% each from severity 2 and severity 3+ claims. Let's also pretend that the total claims cost per vehicle is $100 on average.

What about the duration to settlement?

The overall mean term to settlement might be around 4.5 years. The mean term for each severity group might be 3 years (severity 0&1), 5 years (severity 2) and 7 years (severity 3+).

Implied future superimposed inflation under the above assumptions

The table below shows how to repack overall superimposed inflation suitable for this example pricing basis.

Table 5.2 – Calculating Superimposed Inflation on a 'basket' of new policy year claims

Severity	Claims Cost (before superimposed inflation)	Assumed superimposed inflation per annum	Mean Term (years)	Claims Cost (after superimposed inflation)
Severity 0&1	50	5.5%	3	58.7
Severity 2	25	2.0%	5	27.6
Severity 3+	25	1.0%	7	26.8
Total	100	Implied 2.8%	4.5	113.1

So while our measured average superimposed inflation is 4% per annum, a pricing assumption might be more like 3% per annum (on non-LTCS claims as these were excluded from our claims pairing approach).

6 Sensitivity Testing Key Assumptions

This section shows a comparison of our results to those obtained is we vary some of our key assumptions, namely using alternative scoring or alternative weightings.

6.1 Scoring

We have tested our approach using different scoring to find best matched pairs. The scoring used and our alternative scoring are shown in the table below.

Table 6.1 – Alternative Scoring

Claim characteristic	Adopted Scores	Alternative Scores
Three most severe injury codes	18	18
Three most severely injured body regions	6	6
10% WPI threshold + injury type	2	4
Legally represented status	2	4
Whether hospitalised or not	1	2
Employment status	1	2
Occupation	1	2
Liability status	1	2
Age at time of accident (<10 years difference)	1	2
Delay from accident date to report date	0.5	1
Gender	0.5	1
SEIFA score (<0.1 difference)	0.5	1
NSW claimant	0.5	1

The alternative scoring gives more weight to the claim characteristics that are not related to the injury codes. Note however that the relative importance of the non-injury code characteristics have been left unchanged.

6.2 Weighting

We have tested the sensitivity of the results to the weightings used by adopting no weight i.e. each pair contributes equally to the index, irrespective of the size of the settlements.

6.3 Results

The indices derived from the alternative assumptions we have tested are shown in Figure 6.1 below while Figure 6.2 shows the superimposed inflation on each different basis.

Figure 6.1 – Index Using Alternative Assumptions

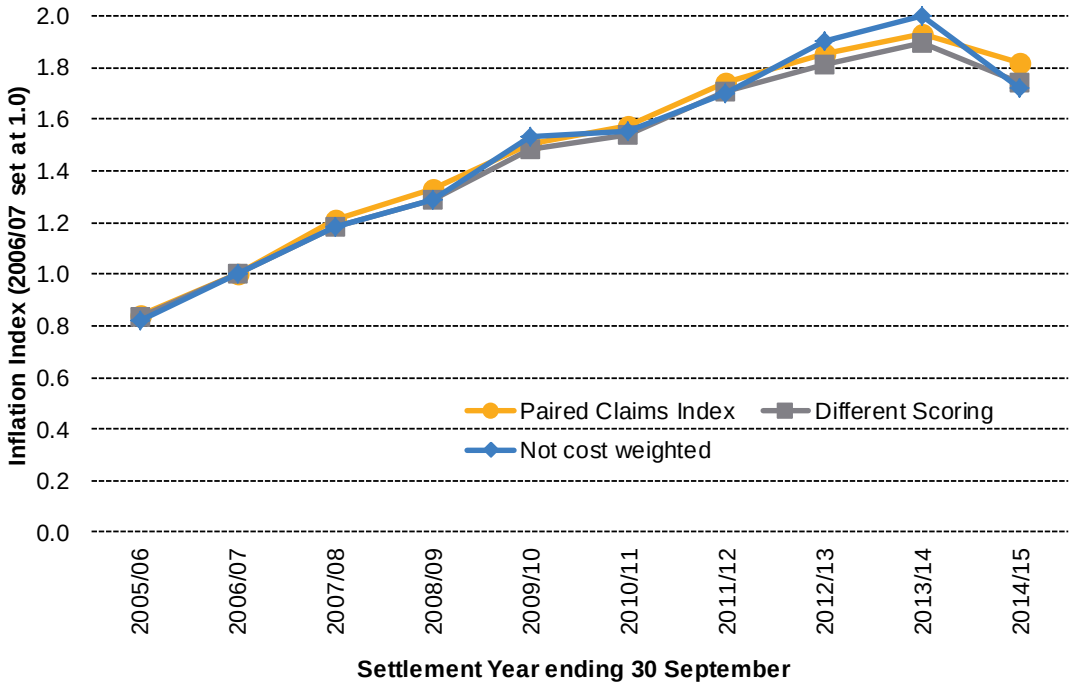
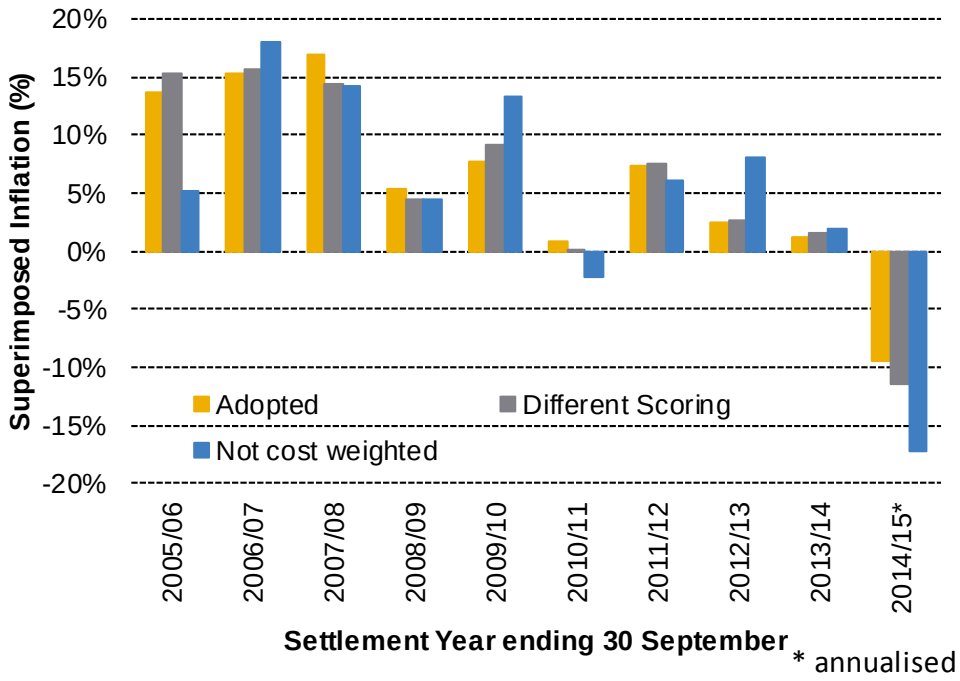


Figure 6.2 – Superimposed Inflation



Broadly, the methodology is not sensitive to the different assumptions with the overall inflation across the period shown being similar irrespective of the assumptions. When we examine the results by year however, we conclude that:

- The different scoring makes very little difference to the results
- If we do not weight the results by cost, the superimposed inflation tends to be exaggerated i.e. in years where our adopted method produces high superimposed inflation, the different weighting produces even higher superimposed; in years where our adopted method produces low superimposed inflation, the different weighting produces even lower superimposed.

7 Where to from here?

Our claim pairing approach to measuring total claims inflation and hence superimposed inflation between like claims can form the foundation for understanding and setting prospective claims inflation assumptions.

However, care needs to be taken in order to segment the historical experience in such a way that it is fit for the purpose you have in mind.

In Section 5.3 we created a simplified example of how to unpack and repack the historical experience in a way appropriate for setting a superimposed inflation assumption for a new underwriting year. Clearly the segmentation could get more granular and sophisticated.

Our next challenge is to use the information on settlements that we have gleaned from our superimposed inflation approach to forecast a mix of claims and starting average size assumptions appropriate for a future policy year to *then* apply prospective superimposed inflation.

We have created the framework for a new method for measuring superimposed inflation and would welcome feedback from the profession on the appetite to accept our approach in practice.

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[ii] Rambaldi, A and Roa, D, 2011, "Hedonic Predicted House Price Indices Using Time-Varying Hedonic Models with Spatial Autocorrelation", School of Economics, University of Queensland

[iii] Bourassa, S, Hoesli, M and Sun, J, 2004, "A Simple Alternative House Price Index Method", Pacific Rim Real Estate Society Conference 2005

[iv] Grimes, A and Young, C, 2010, "A Simple Repeat Sales House Price Index: Comparative Properties Under Alternative Data Generation Processes", Motu Economic and Public Policy Research

[v] http://www.trauma.org/index.php/main/article/383/

[vi] See Cutter, 2009

[vii] Motor Accidents Authority of NSW, Annual Report 2013-14