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Reading Between the Lines: Objective Function Estimation using RBA Communications

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Jeremy Smith (Head of the Department of Economics, University of Warwick) and Michael Ward (Head of the Department of Economics, Monash University)

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Reading between the lines: Objective function estimation using RBA communications*†

Robert Gao‡

Abstract

We use a dictionary based natural language processing approach to quantify the sentiment of RBA communications. This measure of sentiment is then used as a proxy for loss in the estimation of the RBA's objective function. We find that RBA communications imply a target for average inflation between 2.4% to 2.7% for short run horizons of up to one year ahead, consistent with the RBA's medium term inflation target band of 2-3%. This result is robust to different forms of communication, forecast horizons, and allowing for asymmetric preferences. We also find that the RBA's loss improves with rising output growth, commodity prices and stock market returns, as well as an appreciating exchange rate and falling unemployment.

Keywords: central bank, natural language processing, objective function, Reserve Bank of Australia, text analysis

JEL Codes: E58, E59

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†An online appendix can be found here: `https://drive.google.com/file/d/1MEjvxvqcI-nKe4FR1GdztDxwttlS4qC0/view?usp=sharing`

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1 Introduction

"There are plenty of people who probably think that 'central bank' and 'communication' are not expressions that are normally thought of as belonging together. Yet communication has become steadily more open, and more important, in the central banking world over the years."

- Glenn Stevens, Former Governor of the Reserve Bank of Australia

2007 Address to The Sydney Institute[1]

The 1990s signalled a paradigm shift in the communication strategies and transparency of central banks (Geraats, 2002; Woodford, 2005). Previously labelled as "wise but mysterious institutions" for their secretive nature, central banks moved to embrace open communication with the public as a pillar of successful monetary policy (Mishkin, 2004). For instance, the early 1990s represented a transition period for the Reserve Bank of Australia (RBA) from loosely defined operating frameworks to explicit inflation targeting and public announcements of previously undisclosed cash rate changes (Ahn, 2004). The reliance on communication by central banks has only since expanded, especially in light of the Global Financial Crisis (GFC) and the COVID-19 crisis (Filardo and Hofmann, 2014). Coinciding with this growth, an extensive literature examining central bank communication emerged. One area of research that has recently developed is quantifying the sentiment of this communication. Early studies adopted a 'narrative' approach, whereby researchers personally interpret the sentiment of textual communications (Blinder, Ehrmann, Fratzscher, De Haan and Jansen, 2008). A reliance on human interpretation however exposes this methodology to personal bias and time inefficiency (Hansen and McMahon, 2016). Instead, the growing use of computer automated text analysis within economics and finance has presented an alternative quantification tool suitable to central bank communication.

In this paper, we adopt a natural language processing method proposed by Shapiro and Wilson (2021) to quantify the sentiment of RBA communications. More specifically,

[1] A transcript of his speech, titled 'Central Bank Communication', can be found here: `https://www.rba.gov.au/speeches/2007/sp-gov-111207.html`

we use a computer automated dictionary approach to identify words in communications that express either a positive or negative sentiment, according to Loughran and Mcdonald's (2011) dictionary. Our measure of sentiment, called net negativity, is then defined as the difference between the fraction of total words classified as negative, and the fraction of total words classified as positive. Subsequently, the sentiment measure is used to make inferences on the RBA's objectives. This is plausible, as Woodford (2005) suggests that central bank communications can contain information on the frameworks and objectives underlying monetary policy. On the basis of this assumption, the sentiment expressed within these communications can act as a proxy for unobserved loss in the objective (loss) function. For instance, in times of relative economic prosperity, communication on the state of the economy by the RBA should be fairly positive. In contrast, the expected sentiment of RBA communications in economic downturns would be more negative. We construct a measure of sentiment for three types of RBA communications: the Statement of Monetary Policy (SMP), board meeting minutes, and public speeches delivered by prominent members. Focusing on the measure of net negativity in SMP publications, we show that the loss function and objectives can be directly estimated.[2]

Our first finding is that the RBA's communications imply a point target for average inflation between 2.4% to 2.7% for short run horizons of up to one year ahead, which lies within the target band of "2-3%, on average, over time."[3] The inflation target estimates remain largely consistent across alternative specifications, measures of sentiment, asymmetric preferences and different forms of communication. This result is not trivial, as the RBA's inflation target is defined as a medium term average, meaning it is not immediately obvious that the target band of 2-3% extends to the short run. In particular, communication by the RBA has suggested that their perception of the medium term exceeds the one year horizons we consider; for instance, former Governor Glenn Stevens in his 2016 speech said

[2]Other forms of communication are explored in Appendix C.

[3]A definition and explanation of the RBA's inflation target can be found here: `https://www.rba.gov.au/education/resources/explainers/australias-inflation-target.html`

the following:[4]

"From 1993 to 2016, a period of 23 years, the average rate of inflation has been 2.5 per cent – as measured by the CPI (and adjusting for the introduction of the GST in 2000). When we began to articulate the target in the early 1990s and talked about achieving '2–3 per cent, on average, over the cycle', this is the sort of thing we meant."

Furthermore, the policy flexibility embedded in the RBA's target band introduces additional uncertainty about whether the 2-3% target holds in the short run. That is, the purpose of a medium term target may interpreted as allowing for short run deviations of inflation from the inflation target in pursuit of other objectives, such as output stabilisation (Stevens, 2003; Debelle, 2009).

Our result is also one of few point estimates of the RBA's inflation target. Empirical research on RBA objectives typically assume a point target of 2.5%, the midway of the target band, rather than estimating it.[5] However, Clarida et al. (1998) show that an inflation target can be estimated using the parameter estimates of reaction functions. Ahn (2004) employs this method by estimating a reaction function for the RBA using data from 1990 to 1999, then recovering short run inflation target estimates between 2.42% and 2.78%.[6] Our findings complement this result by finding a similar range of estimates across a sample of 1997 to 2019, and by utilising a text analysis approach rather than a reaction function. In conjunction, the results suggest that the RBA has maintained a short run point inflation target somewhere close to the middle of the target band since the inception of inflation targeting in 1990.

Secondly, we investigate how non-inflation variables affect the RBA's net negativity by

[4] A transcript of his speech, titled 'An Accounting', can be found here: `https://www.rba.gov.au/speeches/2016/sp-gov-2016-08-10.html`

[5] See De Brouwer and Gilbert (2005), Leu and Sheen (2006) and Tawadros (2016). Prior to the inflation targeting period, a variety of methods were adopted to retrieve an inflation target estimate. For example, De Brouwer and Gilbert (2005) assume an inflation target equal to the sample mean. Alternatively, Leu and Sheen (2006) retrieve an estimate via Clarida, Gali and Gertler's (1998) method.

[6] More specifically, Ahn (2004) estimates reaction functions using 1 quarter ahead to 6 quarter ahead realisations of inflation. Several other differences should be noted, besides those in the sample and model. Firstly, Ahn uses future realisations of inflation, whereas we use RBA forecasts of inflation. Secondly, we use an average of future inflation forecasts, whereas Ahn considers a single future value of inflation.

including them into the loss function. Most commonly, some measure of real activity, such as unemployment or GDP, is included when modelling the RBA's objectives.[7] This is an important consideration, as one purpose of the medium term inflation target average is to provide the RBA with flexibility to pursue its other objectives of output and employment stabilisation in the short run (Stevens, 2003; Debelle, 2009). We find that the RBA's loss falls linearly with lower unemployment and higher output growth.

However, typical loss functions include a measure of real activity relative to a natural or target level to capture economic slack (e.g. the unemployment gap).[8] This is because when the unemployment rate is below this level, it may represent an overheating labour market, and upward pressures on wages and inflation.[9] In this situation, higher unemployment may be preferred by the RBA to reduce capacity constraints and price pressures. However, we show that this linear relationship between unemployment and sentiment is consistent with the circumstances of the Australian labour market in our sample, as in periods when unemployment was below its natural level, inflationary pressures were subdued. Notwithstanding, higher output growth and lower unemployment are consistent with the achievement of objectives underlying the RBA's inflation target. The RBA seeks to maintain inflation within its target band in part because it creates an economic environment fostering "sustainable growth in output and employment."[10]

Besides indicators of real activity, there is support for including variables capturing external conditions in the loss function. As a small open economy dependent on resource exports, Australia's domestic economic conditions are dependent on the state of the global economy

[7]For example, see Ahn (2004), De Brouwer and Gilbert (2005), Lubik and Schorfheide (2007), Smales (2012) and Ballantyne et al. (2019).

[8]Output growth is not typically included in the loss function, but Walsh (2003) and Shapiro and Wilson (2021) formulate specifications including it, and find a possible role for output growth in shaping central bank preferences. Shapiro and Wilson (2021) put forth the interpretation that output growth may be an indicator of future economic slack. This interpretation would mean that our finding of declining sentiment as output growth rises is consistent with typical loss functions.

[9]Whilst inflation is already controlled for in our loss function, spare capacity may be an indicator of future inflation beyond the short run horizons accounted for.

[10]A definition and explanation of the RBA's inflation target can be found here: `https://www.rba.gov.au/education/resources/explainers/australias-inflation-target.html`

(De Brouwer and Gilbert, 2005; Lubik and Schorfheide, 2007). We find that the RBA's loss is positively affected by an appreciating exchange rate, as measured by the nominal trade weighted index (NTWI), and a rising commodity price index. The most direct interpretation of these results is that the exchange rate and commodity prices appear directly in the loss function. This may be plausible given the RBA's responsibility of maintaining financial stability.[11] Alternatively, movements in the exchange rate and commodity prices may be acting as proxies, or channels, for the effect of global economic conditions on the domestic economy. As Stevens (2008) and Kent (2013) note, the high commodity prices observed in our sample can be attributed to strong global demand, particularly that of an emerging China in the early 2000s. High commodity prices in turn benefit the key resources sector of Australia (Kent, 2013). The RBA's sentiment may also improve with an appreciating exchange rate because of its role in absorbing inflationary pressures during periods of strong external growth.[12] Previous Deputy Governor Ric Battellino makes the following statement in his 2010 speech on the 2000s mining boom:[13]

"In the current episode, with a floating rate, the behaviour of the nominal exchange rate has been very different from the past. It has risen early in the boom and by a large amount. This has been an important factor helping to dissipate inflationary pressures."

Moreoever, our results indicate that the RBA's loss falls with rising stock market returns, as measured by the ASX200 index. Similar to the exchange rate and commodity prices, this result may be interpreted as asset prices for stocks appearing directly in the RBA's loss function. Alternatively, Shapiro and Wilson (2021) suggest that stock market conditions may appear in the loss function, not because central banks care about financial asset returns, but

[11]The RBA's (2020) intervention in the exchange rate market has shifted from reducing initial volatility when the exchange rate was first floated in 1983, to moderating 'overshoots', a situation where the exchange rate is severely misaligned with what is implied by economic fundamentals. In our sample, the only significant intervention due to this reason was during the GFC in 2008. As such, the exchange rate is likely a part of the loss function for other reasons as well.

[12]This interpretation is consistent with De Brouwer and Gilbert (2005).

[13]A transcript of his speech, titled 'Mining Booms and the Australian Economy', can be found here: `https://www.rba.gov.au/speeches/2010/sp-dg-230210.html`

because they are informative as signals for future economic activity. This interpretation is consistent with the work of Valadkhani (2004), who finds that recent ASX200 index returns contain useful information for forecasting future output growth in Australia.

Finally, we find that the RBA does not respond asymmetrically to deviations in inflation below or above target. In other words, the increase in the RBA's net negativity as inflation falls further below target is not significantly different in magnitude to the increase in net negativity as inflation rises further above target. This is consistent with Leu and Sheen (2006), and Karagedikli and Lees (2004), who find only a symmetric response to the inflation gap via Taylor rules.

A direct estimation of the objective function employing text analysis offers an alternative approach to examining central bank objectives, as compared to the indirect methods prevalent within the literature. More specifically, indirect methods commonly adopt interest rate rules, or reaction functions, first introduced by Taylor (1993), and later enriched by Clarida et al. (1998). Interest rate rules connect an observable policy rate to the state of the economy, meaning they can be estimated. In contrast, because loss is unobserved, loss functions cannot typically be estimated. As a result, much of the empirical analysis on the RBA's objectives have utilised interest rate rules.[14]

As Shapiro and Wilson (2021) note however, several drawbacks arise with interest rate rules. In recent times, the zero lower bound for policy rates has constrained their ability to capture the monetary policy stance within reaction functions (Orphanides, 2010). A more fundamental issue stems from the theoretical framework these rules are derived from. Interest rate rules are solutions to a central bank's optimisation problem, whereby they choose a policy rate to minimise their loss function, subject to structural constraints of the economy. Critically, the ability to infer objectives from interest rate rules depends on the assumed structure of the economy (Chevapatrakul and Paez-Farrell, 2014). As Shapiro and Wilson (2021) highlight however, there is no widely agreed upon structure of the economy.

[14]See Ahn (2004), De Brouwer and Gilbert (2005), Tawadros (2016, 2020) and Karagedikli and Lees (2004).

Even within the popular New Keynesian framework, there is no consensus on important structural parameters relating to the Phillips and IS curves. In fact, Blanchard (2018) suggests that the true structure of an economy is too complex to be summarised in any theoretical model. Consequentially, the extent to which interest rate rules can be linked to central bank objectives is constrained. For instance, De Brouwer and Gilbert (2005) find that the weighting on inflation stabilisation relative to output stabilisation has risen over time in their estimation of the RBA's reaction function. However, mixed findings on stability in Australia's economic structure means that they cannot distinguish between a change in the RBA's preferences and a change in the structure of the economy as the reason for their finding. Alternatively, by utilising net negativity as a proxy for loss, the objective function can be directly estimated without assuming a structure for the economy.

The remainder of the paper is structured as follows. In Section 2, we outline specifications of the loss function to be estimated. We also provide details on how an inflation target estimate can be retrieved. In Section 3, we describe how textual data for RBA communications is collected. We also show how our measure of sentiment is extracted from this data. In Section 4, we outline the collection of economic data entering the right hand side of the loss function, including forecasts of macroeconomic variables and indicators of external and financial market conditions. Section 5 presents our main results for the loss function estimation, using sentiment extracted from the Statement of Monetary Policy. We first investigate a symmetric loss function, and then consider an asymmetric specification. Section 6 provides our concluding remarks.

2 Proxying for Loss in the Objective Function

2.1 Baseline Quadratic Loss

The preferences of central banks are typically modelled by a quadratic, or U-shaped loss function, within a New Keynesian framework.[15] Following Shapiro and Wilson (2021), we specify the following short run loss function:[16]

$$L_t = \tilde{\pi}_t^2 + \mathbf{X}_t \Lambda \tag{1}$$

Where L is the central bank's loss, $\tilde{\pi} = \pi - \pi^*$ is the inflation gap, $\mathbf{X}$ is a $1 \times k$ vector of other variables possibly appearing in the loss function, and Λ is the corresponding $k \times 1$ parameter vector. The inflation gap term enters the loss function in quadratic form, as in the case of a U-shaped quadratic, it allows for an optimal level of inflation to exist that minimises the loss function. This would correspond to the central bank's inflation target.

Central banks may also consider non-inflation variables in their loss functions. As discussed in the introduction, this generally includes some measure of economic activity, and in the case of the RBA, possibly external and financial conditions as well. In the non-inflation variable vector $\mathbf{X}$, we examine output growth, unemployment, the exchange rate, commodity prices and ASX200 returns.

The loss function cannot usually be estimated because loss is unobserved. Following Shapiro and Wilson (2021), we derive a measure of net negativity conveyed RBA communications, denoted N, and utilise this as a proxy for loss. More specifically, we assume that $N = \delta L$. For our main analysis, we focus on the Statement of Monetary Policy, in which

[15] For example, see Clarida et al. (1998), Debelle (2001), and Shapiro and Wilson (2021).

[16] Shapiro and Wilson (2021) note that there may be a case of omitted variables in this loss function. The short run is the future horizon in which monetary policy cannot affect the state of economy, due to impact lags of monetary policy. This means that short run loss may be the sum of L_t and L_{t+l}, where l is less than the length of the impact lag. As such, the simple specification in (1) may omit time $t + l$ values of inflation and other relevant variables. However, they show that given the high persistence in macroeconomic variables, this does not affect the interpretation of their results. A further discussion is provided in Section 4.2.

net negativity N_t will vary only over time. We introduce appropriate controls and data transformations for minutes and speeches, as these forms of communication are subject to the underlying tone of board members and speakers. This is discussed further in Appendix C.2. Substituting in net negativity for loss and rearranging, the following specification is produced:

$$N_t = \alpha + \delta \tilde{\pi}_t^2 + \sum_j \omega_j x_{j,t} + \epsilon_t \tag{2}$$

where α is a constant term, $x_{j,t}$ is the j^{th} element of $\mathbf{X}_t$, $\omega_j \equiv \delta\lambda_j$, λ_j is the j^{th} element of Λ, and ϵ_t is an error term. This specification is now estimable via OLS, as both the left hand and right hand side are observed.

To retrieve an estimate for the inflation target π^*, the inflation gap term in (2) can be expanded as follows:

$$N_t = \beta + \delta \pi_t^2 + \theta \pi_t + \sum_j \omega_j x_{j,t} + \epsilon_t \tag{3}$$

Where $\theta = -2\delta\pi^*$ and $\beta = \alpha + \delta\pi^{*2}$. Then, it is clear that $\pi^* = -\frac{\theta}{2\delta}$. And so, estimating (3) via OLS, an estimator for π^* can be retrieved using the estimated coefficients of inflation ($\hat{\delta}$) and its quadratic term ($\hat{\theta}$): $\hat{\pi}^* = -\frac{\hat{\theta}}{2\hat{\delta}}$. This formula is simply the formula for calculating the turning point of a quadratic.

In estimating (3), we produce standard errors that are robust to heteroskedasticity and auto correlation (HAC), as our data consists of time series. We then calculate standard errors and confidence intervals for estimates of the inflation target via the delta method, as our estimate is a function of estimated coefficients.

2.2 Asymmetric inflation preferences

The equation presented in (1) is a loss function that implies the RBA's sentiment is affected symmetrically by deviations of inflation above or below target. Blinder (1997) and Ruge-Murcia (2003) suggest that quadratic formulations are often specified for their analytical convenience, evident in our case from the simplicity of retrieving an inflation target estimate. However, it is possible that central bank preferences are more complex than implied by a simple quadratic loss function. For instance, evidence has suggested central banks may respond asymmetrically to inflation, whereby inflation deviations above target are more heavily weighed than those below target (Ruge-Murcia, 2003; Clarida and Gertler, 2007). However, studies on the degree of asymmetry present in the RBA's preferences have been mixed. Leu and Sheen (2006), and Karagedikli and Lees (2004) estimate reaction functions that imply the RBA responds symmetrically to inflation. In contrast, Chevapatrakul and Paez-Farrell (2014) find an asymmetric relationship between interest rates, output and inflation. To investigate the possibility of asymmetric inflation targeting, we follow a non-linear estimation approach proposed by Shapiro and Wilson (2021). This entails a linear inflation gap specification that allows for different slopes depending on the sign of the inflation gap:

$$N_t = \delta_1(\pi_t - \pi^*) \times \mathbb{1}[\pi_t > \pi^*] + \delta_2(\pi_t - \pi^*) \times \mathbb{1}[\pi_t \leq \pi^*] + \mathbf{X}_t\Lambda \tag{4}$$

where π_t, π^*, $\mathbf{X}_t$ and Λ are defined the same as previously. $\mathbb{1}[]$ is an indicator function equalling to one if the condition in the brackets is satisfied, and zero else wise. δ_1 and δ_2 are slope parameters corresponding to when inflation is above and below target respectively, and are allowed to differ. Following Shapiro and Wilson (2021), we estimate the inflation target π^* and other parameters via a grid search over potential values of π^*. The grid search occurs by searching over an interval from 0 to 4.0, with step sizes of 0.1. For each value of π^* in this interval, we substitute it into (4), and then estimate the equation via OLS. For each estimation, the sum of squared resdiuals (SSR) is recorded. Then, the final parameter estimates $\hat{\pi}^*$, $\hat{\delta_1}$, $\hat{\delta}_2$ and $\hat{\Lambda}$ correspond to the estimation that has the smallest SSR. As $\hat{\pi}^*$ is estimated via a grid search procedure, standard errors are calculated using a moving block bootstrap procedure.[17]

[17] We implement a moving block bootstrap procedure described by Fitzenberger (1998) for regression estimation. This is described in detail in Appendix B.

3 Quantifying Sentiment in RBA Communications

To retrieve a measure of sentiment from RBA communications, we follow Shapiro and Wilson's (2021) text analysis approach. Below, we outline sources from which we collect textual data on communications, the cleaning procedures we perform on this data, and how sentiment is calculated using this cleaned data.

3.1 Collecting Textual Data

Scripts of RBA communications are made readily available on the RBA website in HTML format.[18] Because of this, we utilise Scrapy, a web scraping package in Python, to extract textual data from the website.[19] More specifically, the fact that the HTML format is consistent within each form of communication means that the textual content can be extracted from the appropriate HTML tags. The Statement of Monetary Policy (SMP) is a quarterly publication containing the RBA's general assessment of current and future economic conditions, and is released in February, May, August and November of each year. We scrape text from the initial publication in February 1997 to the most recent publication in August 2021, providing a sample of 99 publications.[20] RBA minutes for board meetings and speeches are also published, with details provided in Appendix C.1.

Textual data is extremely noisy, especially as we are interested in the sentiment expressed within these communications. For example, many common words in the English language, such as 'the' or 'and', are not indicative of sentiment. These are often referred to as stop words. Thus, we pass the text through a data cleaning pipeline. The pipeline is structured as follows. First, each word, punctuation and special character is separated into its own 'token'. Second, tokens that are classified as punctuation, special characters or stop words

[18] For example, all publications of the Statement of Monetary Policy can be found here: `https://www.rba.gov.au/publications/smp/`

[19] A full list of software packages used is provided in Appendix E.

[20] The SMP contains sections relating to various topics such as inflation, foreign economic activity, and financial markets. We aggregate all text from each section of the SMP to produce one set of textual data for any given quarter. The board meeting minutes and speeches are also structured similarly, and we aggregate all sections within each publication as well. Further research could consider each section separately.

are removed, as they are not useful for inferring sentiment. Then, tokens are transformed into lower case and lemmatised. Lemmatisation is the process of transforming words into their roots (e.g. 'growing' and 'grown' would be transformed to 'grow'). Additional cleaning procedures are taken in relation to words that may be interpreted as either positive or negative in different contexts, as well as negation words; these are discussed in the following subsection.

3.2 Quantifying Sentiment

Sentiment can be extracted from text in several ways. Following Shapiro and Wilson's (2021) methodology, we adopt a dictionary based (i.e. 'Bag of Words') approach to classify the sentiment of RBA communications.[21] In this approach, the first step is to choose a pre-defined dictionary that distributes words into categories, according to the sentiment they are associated with. We use Loughran and Mcdonald's (2011) dictionary, which is tailored to the language of economics and finance. In our analysis, the two relevant sentiment categories from their dictionary will be positive and negative.[22] To provide an example, the words 'favourable' and 'rebound' are categorised as expressing a positive sentiment, whilst the word 'sluggish' is categorised as expressing a negative sentiment. Loughran and Mcdonald (2011) show that their dictionary is better suited to sentiment analysis within the context of economics and finance as compared to other dictionaries, such as the Harvard Psychological

[21] Alternatively, a machine learning approach could be adopted. As mentioned in Shapiro and Wilson (2021), further discussion on this approach can be found in Liu (2010) and Shapiro, Sudhof, and Wilson (2020). One example is Gorodnichenko, Pham and Talavera (2021), who employ a machine learning approach to analyse the tone of verbal communication by central banks during press conferences, then investigating the effect of this tone on financial markets. They distinguish the effect of the tone of voice from the effect of sentiment expressed by the word choice.

[22] A dictionary based approach has become increasingly common in the literature. Nyugen and La Cava (2020) develop a measure for news sentiment in Australia using Loughran and Mcdonald's (2011) dictionary, then examining its relationship with the state of the Australian economy. Analogous to our net negativity measure, they develop a net positivity measure for news articles. Alternatively, Correa, Garud, Londono and Mislang (2021) create their own dictionary tailored to financial stability reports of central banks, then using this to extract the sentiment of these reports. Baker, Bloom and Davis (2016) develop a measure of economic policy uncertainty (EPU) by measuring the fraction of news articles in a month containing terms relating to the economy, economic policy and uncertainty. They consider an extensive margin rather than a per article uncertainty measure due to the infrequency of uncertainty words, as noted by Nyugen and La Cava (2020).

Dictionary (HPD). For instance, words such as 'tax', 'costs' and 'depreciation' are associated with a negative sentiment in the HPD, however would be neutral in economic dialogue. We then convert words in the dictionary into lower case and take their stem, and also remove duplicates. The resulting dictionary contains 1208 negative words and 200 positive words.[23] Additionally, we remove positive and negative words that are proceeded by a negation word (e.g. 'not', 'n't'), as recommended by Loughran and Mcdonald (2016), and adopted by Shapiro and Wilson (2021) and Correa et al. (2021).[24]

Then, for each observation of textual data, we identify words categorised as positive or negative by the dictionary. Finally, the net negativity score N_t is calculated by taking the difference between the fraction of text (subsequent to data cleaning) that expresses a negative sentiment, and the fraction of text that expresses a positive sentiment. An example of the text cleaning and sentiment quantification procedure is provided in Appendix A. In Section 5.3, we consider a disaggregation of net negativity into its negative and positive components as alternative measures of sentiment.

Figure 1 plots our resulting measure of net negativity over time for the Statement of Monetary Policy (SMP) from February 1997 to August 2021.[25] To examine how this measure of sentiment for the SMP moves with the business cycle, we define economic downturns as quarters in which the GDP growth rate was in the lowest decile of all growth rates in the sample. These quarters are shaded in grey. A countercyclical pattern emerges, whereby the RBA's net negativity rises during periods of sluggish growth, and falls during economic

[23]Following Shapiro and Wilson (2021), we also remove 'unemploy' from the dictionary because of its ambiguity. For example, depending on whether 'high' or 'low' precedes the word 'unemployment', the sentiment conveyed will differ. Even then, a central bank may prefer higher unemployment when the labour market is overheating. As shown in Table D1 of Appendix D however, including 'unemploy' does not affect our findings.

[24]For example, the phrase 'we are not optimistic' expresses a negative sentiment. Following text cleaning without this step, the phrase would be reduced to 'optimistic'. Then, as the word 'optimistic' expresses a positive sentiment, the sentiment of the phrase would be wrongly classified.

[25]Time series plots for the sentiment of RBA meeting minutes and speeches are provided in Figures D5 and D6 of Appendix D respectively. The relationship between the sentiment of meeting minutes and the business cycle is weaker. This is expected, as quarterly GDP growth is less frequent than the monthly sentiment measure for meeting minutes, and so it may not capture changes in economic conditions within a quarter. The pattern between net negativity in speeches and the business cycle is also not clear. This may relate to the limited ability to infer objectives from speeches, which is discussed further in Appendix C.4.

expansions. For example, net negativity is at its highest in the February 2009 and May 2020 publications of the SMP, which correspond to the GFC and COVID-19 recession respectively. Furthermore, sentiment was most positive in the early to mid 2000s, a period of generally strong economic and employment growth, spearheaded by strong commodity demand from rapidly growing Asian economies (Kearns and Lowe, 2011). A sharp rebound in sentiment following the GFC may reflect Australia's relative resilience to the Great Recession, which Kearns and Lowe (2011) also attribute to a strong resource exports sector. Net negativity lingers at a higher average level post GFC, consistent with the stagnation in real wages and slowdown in economic growth over this period (Bishop and Cassidy, 2017). Finally, there is another sharp recovery in sentiment following the initial COVID-19 shock. One possible explanation is Australia's early success in containing the spread of COVID-19, which Lowe (2021) notes has led to economic and health outcomes "better than elsewhere in the world."

4 Economic Variable Data

4.1 Statement of Monetary Policy Forecasts

The right hand side of Equation (1) should reflect the RBA's perception of the current and future state of the economy which they use to inform their communications (Shapiro and Wilson, 2021). First, we consider the Statement of Monetary Policy (SMP). For this form of communication, we utilise the forecasts accompanying the SMP. These are available from 2000 onwards, and are suitable as they are jointly published with, and discussed in the SMP. Prior to 2000, forecasts were instead prepared by the Joint Economic Forecasting Group (JEFG) in the months of March, June, September and December (Bishop and Tulip, 2017).[26] As they do not directly correspond to the months in which the SMP is published, we assume each publication prior to 2000 utilises the previous round of forecasts (e.g. the

[26] Bishop and Tulip (2017) also note that GDP forecasts were still prepared by the JEFG in these months until 2007. The Beckers (2020) dataset we utilise adjusts accordingly by matching these to the previous round of SMP forecasts.

Statement of Monetary Policy released in August would utilise the June round of forecasts). This assumption follows that of Cloyne and Hürtgen (2016), and Bishop and Tulip (2017). Similar to Cloyne and Hürtgen, we also include changes in other relevant economic variables between the point of forecast and time of publication to control for possible shifts in economic conditions (e.g. stock market movements).

We utilise a dataset created by Beckers (2020), which compiles SMP forecasts from 1991 to 2019, alongside other non-forecasted variables of which the nominal trade weighted index (NTWI) and commodity price index are of interest. Values for these variables are sourced from the RBA, and are taken to be the month-end values prior to the Board meeting and publication of the SMP. For instance, the value of the NTWI at the end of January would be used for the February SMP and meeting minutes. We supplement this dataset with values of the ASX200 stock market index, where monthly observations are generated by taking the monthly average of daily closing prices.[27] Our final dataset for the SMP spans from February 1997 to May 2019.[28] Economic variable data used for RBA meeting minutes and speeches is described in Appendix C.2.

4.2 Short Run Forecasts and Endogeneity

As the SMP forecasts span up to 10 quarters ahead, there is a question of which forecast horizon to use. Following Romer and Romer (2004), and Shapiro and Wilson (2021), we consider only short run forecasts. As the baseline, we take the average of the nowcast and the one quarter ahead forecast from the SMP. The reasoning is as follows. The short run is usually associated with the period in which forecasted inflation, output and unemployment can be treated as exogenous to monetary policy. Romer and Romer (2004) note that beyond this period, central banks are able to endogenously affect the paths of these variables through

[27] We retrieve daily closing prices for the ASX200 index from Yahoo Finance.

[28] Whilst we have not considered anything beyond June 2019 due to data availability, it is also logical to exclude 2020 onwards because of COVID-19. This is because many central banks, including the RBA, have shifted away from a forward looking policy framework based on forecasts, to a 'wait and see' approach. As current Governor Phillip Lowe indicates, this approach involves waiting for sustained changes in actual economic data, rather than forecasted changes (Lowe, 2020).

monetary policy, with the purpose of minimising their loss. Longer run forecasts that do not account for this response would then be endogenous, as the current sentiment of the RBA, being a proxy for loss, would influence current monetary policy decisions. Alternatively, a constant interest rate (CIR) forecast which assumes no endogenous response of the cash rate would be exogenous and could be included into the loss function. To the best of our knowledge however, CIR forecasts for the RBA are not made publicly available.

In not including CIR forecasts however, there is a possibility of omitted variable bias (Shapiro and Wilson, 2021). This is addressed in two ways. Firstly, Romer and Romer (2004) show that there is strong enough serial correlation in short run forecasts for them to approximate the longer run path of the economy. Taking this into account, Shapiro and Wilson (2021) demonstrate that the coefficients on the short run inflation forecasts would also incorporate the persistence of current inflation shocks in the near future if CIR forecasts were omitted. Most importantly, this shift in interpretation does not affect how the estimated inflation target is calculated or interpreted. Secondly, we demonstrate that our results are robust to using longer forecast horizons. We do so by taking the average of forecasts over a successively longer period, up to one year ahead. Similar to Shapiro and Wilson (2021), we do not consider anything longer than one year, as there is a greater probability that the CIR assumption is violated.

5 Results

5.1 Baseline Estimation: Statement of Monetary Policy

We estimate Equation (1) with only the inflation gap term by regressing net negativity on inflation and its quadratic term. We consider the sample of 90 Statement of Monetary Policy publications from February 1997 to May 2019 first, and explore RBA meeting minutes and speeches in Appendices C.3 and C.4 respectively. In Table 1, we present the results for this baseline estimation for a variety of forecast horizons. The standard errors found in parentheses are robust to heteroskedasticity. Column (1) uses the average of current quarter and one quarter ahead SMP inflation forecasts, column (2) uses the average of current quarter to two quarter ahead SMP forecasts, column (3) uses the average of current quarter to three quarter ahead SMP forecasts and column (4) uses the average of current quarter to four quarter ahead SMP forecasts. Beginning with column (1), the positive sign for the quadratic inflation term and negative sign for the linear inflation term imply an inverted U-shape between inflation and net negativity, with this relationship being statistically significant at the 1% level. This estimated relationship is plotted in Figure 2, with actual observations superimposed onto the graph as black dots. The figure makes it clear that net negativity, proxying for loss, is minimised at some optimal level of inflation, π^* (i.e. an inflation target).

As illustrated in Section 2.1, π^* can be estimated as a function of estimated coefficients for the linear and quadratic inflation terms. The specification in column (1) implies a $\hat{\pi}^*$ of 2.59%, with a standard error calculated via the delta method presented in parentheses. Returning to the visualisation in Figure 2, this estimated target is illustrated by the dashed vertical line. The can be interpreted as the RBA's net negativity and loss being minimised when average inflation is approximately equal to 2.59% across this quarter and next quarter. Furthermore, any deviation of inflation above or below this level increases the RBA's loss. This result is robust across different forecast horizons, as illustrated in columns (2) to (4). As the forecast horizon expands, the estimated inflation target falls, and is less precisely estimated. For instance, the estimated inflation target for the one year ahead forecast average specification in column (4) is 2.40%.[29]

Our range of estimates from 2.40% to 2.59% are all consistent with the RBA's inflation target band of 2-3%. As discussed in the introduction, this finding is not trivial, as the RBA's target band is intended as a medium term average, whereas our analysis focuses on shorter run horizons not generally associated with the medium term. Furthermore, our

[29] We also conduct Augmented Dickey Fuller tests for unit roots in the residuals of each estimation, provided in the 'Augmented Dickey Fuller p-value' row of Table 1. In all specifications, the null hypothesis of a unit root in the residuals is rejected at the 5% level. This result is largely consistent across all specifications we consider throughout the rest of the paper.

findings align with previous estimates by Ahn (2004), as well as the widely assumed point target of 2.5% that is prevalent in the literature.

Next, we add in variables representing economic activity, first considering the unemployment rate and then considering output growth. The results are displayed in Table 2, and use 0-1 quarter ahead forecast averages. In column (1), we add a linear unemployment term into our previous specification. The coefficient for unemployment is positive and significant, implying that sentiment worsens as forecasted unemployment rises. However, it is typically the unemployment gap that is included in loss functions, measuring the difference between the unemployment rate and some estimate of the natural or target rate of unemployment. This is because unemployment below the natural or target level may signal a tight labour market, which places upward pressures on inflation and wages (Cusbert, 2017). In these situations, higher unemployment may be preferred to alleviate pressures on capacity and prices. The RBA defines the non-accelerating inflation rate of unemployment (NAIRU) as the benchmark for full employment, representing a minimum level of unemployment that can be sustained without significant inflationary pressures. This would align with the concept of a target for unemployment whereby the RBA's loss is minimised.

As the RBA does not release its forecasts for the NAIRU, we instead attempt to estimate it in a similar fashion to how the inflation target is estimated. That is, we include an additional quadratic term for unemployment, providing us with the results presented in column (2). Both the linear and quadratic term for unemployment are insignificant however, and imply an inverted U-shaped loss function for unemployment where loss is instead maximised at approximately 7.52%. To investigate this insignificance, we visualise the implied concave loss function for unemployment in Figure 3. The dots represent observed forecast averages of unemployment and their corresponding net negativity, conditioned on inflation being at its estimated target level of 2.42%. The blue line represents the estimated relationship between net negativity and unemployment, also conditioned on inflation being equal to 2.42%. The dashed vertical line represents the loss maximising value for unemployment of 7.52%, in which we find that the 0-1 quarter ahead average of forecasted unemployment only exceeds this level 10% of the time in our sample (i.e. 9 observations out of 90). As a result, the quadratic relationship implies a positive relationship between net negativity and unemployment for most of our sample, consistent with the linear representation. The insignificance may possibly arise from the redundancy of introducing an additional parameter in the quadratic specification when fitting a linear term is sufficient.

In spite of the insignificant unemployment gap, the positive linear relationship between unemployment and net negativity would be consistent with typical loss functions if the unemployment rate was above the RBA's estimate of NAIRU for most of the sample. However, the work of Cusbert (2017) suggests that unemployment was below the RBA's perception of NAIRU for a majority of the pre GFC period. This inconsistency with economic intuition can be explained by a weakened relationship between unemployment and inflation over this period. As Borland (2011) finds, falling unemployment in the 2000s coincided with a decline in real unit labour costs, suggesting that an improving labour market did not translate into higher wage pressures. Borland (2011) also finds that the Phillips curve was much flatter during this period.[30] This evidence would suggest that falling unemployment during the 2000s coincided with stronger employment outcomes without threatening the RBA's mandate of price stability, which is consistent with an improving sentiment. Notwithstanding how unemployment enters the loss function, the estimated inflation target is still consistent with our previous findings. A specification with only the linear unemployment term implies an inflation target of 2.41%, as displayed in column (1), whilst including an additional quadratic term in column (2) provides an estimate of 2.42%.

In following specifications, we include only a linear unemployment term.[31] This does

[30] Kuttner and Robinson (2008) present similar findings on the flattening of the Phillips curve. Borland (2011) suggests that the weakening relationship may be a result of unemployment being an inadequate indicator of labour demand pressures. Instead, they investigate a Phillips curve using inflation and the labour underutilisation rate, in which a significant negative relationship between the two is found.

[31] In column (5) of Table 2, we include both a linear and quadratic unemployment term alongside output growth, in which the two terms are still insignificant. Whilst not presented, this finding is the same after controlling for the exchange rate, commodity prices and stock market returns.

not mean that the unemployment gap does not appear in the RBA's loss function. Most crucially, our attempt to estimate NAIRU assumes that it remains constant over time, which Cusbert (2017) demonstrates is not the perception the RBA holds.[32] For the purpose of our analysis, a linear term is sufficient for modelling the relationship between unemployment and net negativity, as it is consistent with the context of the Australian labour market over our sample.

Additionally, we include forecasted output growth into the specification in column (3). Whilst not a typical variable in the loss function, there has been prior research establishing a possible role for output growth in influencing central bank preferences.[33] The results imply that the RBA's net negativity falls as forecasts of output growth rise. This is consistent with one of the purposes behind the RBA's inflation target, which is to foster an economic environment supportive of output and employment growth. To the extent that output growth improves the living standards of Australians, it is also consistent with the RBA's mandate of contributing to the "the economic prosperity and welfare of the people of Australia."[34] The inflation target estimate of 2.74% is larger than specifications with unemployment, however is still within the target band. In column (4), we include both a linear unemployment and output growth term, where both are significant. This would suggest there is significant information contained in either variable after controlling for the other, even if both are indicators of economic activity. The estimated inflation target of 2.54% remains consistent with prior findings.

There may be a role for variables reflecting external conditions in the RBA's loss function.[35] Asset prices may also be relevant as either an indicator of financial stability or future economic activity. We thus add the exchange rate, commodity prices and stock market

[32]The NAIRU is estimated by Cusbert (2017) via a state space model under a Phillips curve framework, which is a common approach taken by the literature. Ruberl, Ball, Lucas and Williamson (2021) provide further details.

[33]See Walsh (2003), Shapiro and Wilson (2021), and Beckers (2020).

[34]A full description of the RBA's mandate can be found here: `https://www.rba.gov.au/about-rba/boards/rba-board.html`

[35]See De Brouwer and Gilbert (2005), Lubik and Schorfheide (2007), and Ernst and Merola (2018).

returns into the non-inflation variables vector $\mathbf{X}_t$ to investigate. In column (6), we add in the trailing quarterly percentage change in the nominal trade weighted index (NTWI), commodity price index and ASX200 index to the specification in column (4). We find that an increase in all three variables has a significant positive effect on the RBA's sentiment. That is, net negativity of the RBA falls as stock market returns, commodity prices and the exchange rate rise.

Interpreting the exchange rate as a signal for future inflation, our results relating to the exchange rate are consistent with De Brouwer and Gilbert (2005), who find that the RBA tends to increase the cash rate following an exchange rate depreciation. As discussed in the introduction, our findings relating to commodity prices are consistent with the reliance on resource exports in Australia. This also aligns with the results of Ernst and Merola's (2018) examination of central bank communications. In their work, they find that speeches by the RBA imply a greater importance placed on external conditions by the RBA relative to other major central banks. The estimated inflation target for this larger specification is 2.67%, consistent with previously estimated values. This suggests that our findings on the inflation target implied by the SMP are robust to including non-inflation variables besides economic activity.

Finally, we check the robustness of our full specification in column (6) across different forecast horizons, with results presented in Table 3. Column (1) repeats the results of column (6) in Table 2, using averages of current quarter and one quarter ahead SMP forecasts. Column (2) uses the average of current quarter to two quarter ahead SMP forecasts, column (3) uses the average of current quarter to three quarter ahead SMP forecasts and column (4) uses the average of current quarter to four quarter ahead SMP forecasts. Overall, the results for different forecast horizons are robust, as the significance and relationship of non-inflation variables remains similar, whilst inflation target estimates range from 2.62% to 2.67%. As the forecast horizon is increased, the inflation terms become more insignificant. This may be due to longer run forecasts increasingly violating the CIR forecast assumption discussed in Section 4.2.

5.2 Asymmetric Loss Function

As discussed in Section 2.2, there is a possibility that the RBA has asymmetric inflation preferences. We now estimate Equation (4), a piecewise-linear specification that allows for differing slopes of the inflation gap depending on whether inflation is above or below target.[36] First, we impose the constraint that $\delta_1 = -\delta_2$ to investigate whether the estimation of the inflation target is affected by this linear formulation, following Shapiro and Wilson (2021). This restriction would imply a V rather than U shaped loss function that retains symmetric inflation preferences. The results are shown in columns (1), (2) and (3) of Table 4. Column (1) display our baseline specification with only the inflation gap term, whilst column (2) adds in real activity variables of unemployment and output growth in their linear form. Finally, column (3) displays the full specification with all variables. Estimates of the inflation target across these specifications span from 2.47% to 2.48%, in line with previous estimates from the quadratic specifications.

In columns (4), (5), and (6) we repeat this exercise while relaxing the symmetric constraint (i.e. allowing δ_1 and δ_2 to be freely estimated). The results are also consistent with the previous quadratic case. That is, inflation target estimates range from 2.47% to 2.70% across the 3 specifications, and net negativity responds to unemployment, output growth, and the other variables in the same direction as before. Furthermore, the RBA's net negativity rises when inflation is above target and increasing, and falls when inflation is below target and increasing. The magnitudes for the estimated δ_1 and δ_2 in columns (4) and (5) imply that the RBA's net negativity rises faster in response to a deviation of inflation above target than it does following a deviation of inflation below target. However, these differences are not statistically significant. The Symmetric p-value row in Table 4 provides the p-value for the hypothesis test with a null hypothesis of $\delta_1 = -\delta_2$ and an alternative hypothesis of

[36] Estimation is done via the grid search procedure described in Section 2.2.

$\delta_1 \neq -\delta_2$. This is conducted using a t-test based on HAC standard errors.[37] The p-values are all greater than 0.1, implying a failure to reject the null hypothesis at the 10% level. Our finding that the RBA responds symmetrically to inflation deviations above and below target is consistent with Leu and Sheen (2006), and Karagedikli and Lees (2004).[38]

It should be noted that the previous examination of asymmetric preferences is conditional on whether inflation is above or below the estimated inflation target. Alternatively, it may be that the RBA has asymmetric preferences only when inflation is outside of the 2-3% interval. To investigate this possibility, we consider the following specification:

$$N_t = \delta_1|\pi_t - 2| \times \mathbb{1}[\pi_t < 2] + \delta_2|\pi_t - 3| \times \mathbb{1}[\pi_t > 3] + \mathbf{X}_t\mathbf{\Lambda} \tag{5}$$

where net negativity (and loss) is equal to zero for any value of inflation between 2-3%, and is linearly related to inflation outside of the target band. Whilst the results are not presented, we found no change in the finding of symmetric inflation preferences.[39]

5.3 Alternative Sentiment Measures

The analysis in prior sections utilised net negativity, the difference between the fraction of negative text and fraction of positive text subsequent to data cleaning. We now consider the fraction of negative text and fraction of positive text separately as proxies for loss in

[37] The hypothesis tests are conditional on the inflation target being equal to its estimate of $\hat{\pi}^*$.

[38] A caveat of this analysis is that we assume a constant inflation target across our sample. There is a possibility that the RBA has a time varying inflation target, whereby there is an identification issue in distinguishing between the RBA having asymmetric inflation preferences, and the RBA having a time varying inflation target. For instance, suppose there is a period of high inflation, such as prior to the GFC. Then, if the RBA did react more strongly to deviations of inflation above target, we would expect a larger loss relative to an equally sized deviation of inflation below target. However, if the RBA also raised its inflation target in this time period, then the magnitude of the deviation and increase in loss would be smaller, possibly overshadowing the effect of asymmetric preferences. A simple dummy analysis allowing for a different inflation target pre and post GFC however did not show a significant change in the inflation target. Future studies could investigate time variation in the inflation target more rigorously.

[39] The loss function presented in Equation 5 assumes that the RBA is indifferent across values of inflation within the 2-3% target band. This is an alternative way of modelling the RBA's loss function, as it assumes that they target a range of inflation values. Whilst a quadratic loss function somewhat models this through its convexity, Orphanides and Wieland (2000) introduce a zone-generating function into the loss function to allow for a 'zone', rather than point inflation target.

the objective function. The results are provided in Tables 5 and 6 respectively. Column (1) represents a quadratic specification with only the inflation gap term, while column (2) adds in our economic activity variables and other variables. Columns (3) and (4) regress the measure of sentiment on only the inflation gap, however specify a symmetric and asymmetric V shape for the loss function respectively. Columns (5) and (6) repeat this with a specification including all variables. Overall, the disaggregation of sentiment demonstrates that our previous results are robust, and allows us to infer which component of sentiment each variable affects.

Specifications in Table 5 with the fraction of negative text as the dependent variable still imply a significant relationship between inflation and sentiment, where negativity is minimised at some target level of inflation. Inflation target estimates across different specifications range from 2.47% to 2.65%, consistent with previous estimations and the RBA's target band. When using the fraction of positive text, the findings relating to inflation are only robust in the most parsimonious specifications. In this case, the target level of inflation should maximise positivity, rather than minimise it. Specifications with only inflation in columns (1), (3) and (4) of Table 6 imply such as relationship, and estimated inflation targets are consistent with previous estimations. Introducing non-inflation variables in columns (2), (5) and (6) causes inflation to become largely insignificant and estimated inflation targets to lie outside the target band. This could be interpreted as the RBA primarily relaying its preferences for inflation through the negative component of their communication.

A similar disaggregation can be considered for non-inflation variables. For instance, results in columns (2), (5) and (6) of Table 5 imply that the RBA's negativity rises as unemployment rises. However, negativity seems to be little affected by output growth. In contrast, Table 6 shows that higher output growth increases the degree of positivity in RBA communications, whilst unemployment has no significant effect. Finally, higher commodity prices and stock market returns improve the RBA's sentiment through both a fall in negativity and rise in positivity, whilst an appreciating exchange rate only improves the RBA's sentiment via a rise in positivity.

Next, we depart from Loughran and Mcdonald's (2011) dictionary to measure sentiment using a Python package called VADER (Valence Aware Dictionary and sEntiment Reasoner) (Hutto and Gilbert, 2014). As Shapiro and Wilson (2021) describe, VADER relies on a dictionary approach to classify the sentiment of words, but also takes into consideration the context in which these words appear. The contextual rules relate to negation words (e.g. 'not', 'n't'), punctuation, capitalisation and adverb intensifies (e.g. 'very', ''extremely'), thus introducing additional nuance to the sentiment classification process. However, the dictionary from which words and their associated sentiments are drawn from is not specific to economics and finance. Instead, the dictionary is based on social media language, making this approach prone to misclassification of sentiment similar to the HPD described in Section 3.2.

VADER sorts text into 3 categories of positive, negative and neutral. To form a comparable sentiment measure, we take the difference between the fraction of text that is negative, and the fraction of text that is positive. We call this measure VADER net negativity. Table 7 provides estimation results with VADER net negativity as the dependent variable, whereby the specifications provided in each column align with those of Table 5 and 6. For quadratic specifications in columns (1) and (2), the inflation terms are not significant, and estimated inflation targets are not close to the RBA's target band. In column (2) however, the relationship of other variables with net negativity remains consistent with previous estimations. Allowing instead for a V-shaped loss function in columns (3)-(6), the inflation gap becomes significant and the estimated inflation target falls just below the target band. Overall, is surprising to see that the results are somewhat robust to the use of a more general dictionary.

6 Conclusion

In this paper, we apply Shapiro and Wilson's (2021) dictionary approach to extract net negativity, a measure of sentiment, from RBA communications. We examine the Statement of Monetary Policy, meeting minutes and speeches. These measures are used as a proxy for loss, allowing for a direct estimation of the RBA's loss function and inference to be conducted on the RBA's objectives. Using the sample of quarterly Statement of Monetary Policy publications from February 1997 to May 2019, we find that the RBA's short run inflation target was between 2.41% to 2.74% over this period. This result is robust to alternative forecast horizons, and use of sentiment from RBA meeting minutes. Our findings suggest that the RBA's medium term inflation target interval of 2-3% holds for shorter run horizons of up to one year ahead.

Adding in non-inflation variables, we find that the RBA's sentiment improves as unemployment falls. This result is consistent with economic intuition when taking into account the subdued inflationary pressures that coincided with spans of negative unemployment gaps throughout the sample. Net negativity also falls with rising output growth, a finding that is consistent with the RBA's stated objectives. Our results also show that an appreciating exchange rate and rising commodity prices improve the RBA's sentiment, which is consistent with work by De Brouwer and Gilbert (2005). In this case, communication by the RBA suggests that the exchange rate may appear in the loss function as a signal for future inflationary pressures. Finally, we find that higher stock market returns are associated with higher sentiment. Future research could consider other economic variables, such as housing prices, which have been a contentious issue in recent media coverage. Wage growth, economic conditions in major trade partners such as China, and uncertainty measures are other interesting considerations.

We also explore the possibility of asymmetric inflation preferences, with results suggesting that the RBA targets inflation symmetrically. However, this result is conditional on both the estimated inflation target, and the assumption that the inflation target remained constant.

Further studies could introduce more complex loss functions, for instance to allow for a time varying inflation target or to introduce asymmetry in alternative ways. This could more accurately capture the true preferences of the RBA. Finally, our measure of sentiment is constructed using a dictionary approach, which is automated, objective and transparent. It is however simple, and does not consider the linguistic context of words. Alternatively, a machine learning approach could be adopted to better capture nuances in central bank communication. This would be interesting, as language used by central banks could also be considered to be distinct from language used in the broader economics and finance context.

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Table 1. Baseline estimation of U-shaped loss function across different forecast horizons
Statement of Monetary Policy: 1997m2 - 2019m5, Quarterly

	(1)	(2)	(3)	(4)
	0-1 qtr ahead avg	0-2 qtr ahead avg	0-3 qtr ahead avg	0-4 qtr ahead avg
π_t, SMP	-3.332***	-2.993***	-2.787**	-2.629*
	(1.035)	(1.125)	(1.250)	(1.363)
π_t^2, SMP	0.643***	0.593***	0.568***	0.547**
	(0.166)	(0.178)	(0.199)	(0.222)
(Constant)	4.968***	4.481***	4.161**	3.926**
	(1.408)	(1.559)	(1.745)	(1.888)
Adjusted R^2	0.152	0.110	0.078	0.055
$\hat{\pi}$*	2.591	2.524	2.454	2.404
SE	(0.183)	(0.236)	(0.285)	(0.319)
95% Confidence Interval	[2.232 - 2.950]	[2.063 - 2.986]	[1.896 - 3.012]	[1.779 - 3.029]
Augmented Dickey Fuller p-value	0.039	0.040	0.042	0.043

*** p<0.01, ** p<0.05, * p<0.1; Standard errors (in parentheses) are robust to heterskedasticity and autocorrelation; 90 observations in sample

Table 2. Estimation of U-shaped loss function with non-inflation variables
Statement of Monetary Policy: 1997m2 - 2019m5, Quarterly

	(1)	(2)	(3)	(4)	(5)	(6)
π_t, SMP	-2.910^{***}	-3.453^{***}	-3.171^{**}	-2.671^{***}	-2.905^{***}	-2.654^{***}
	(0.795)	(0.866)	(1.260)	(0.884)	(1.043)	(0.964)
π_t^2, SMP	0.604^{***}	0.714^{***}	0.578^{***}	0.527^{***}	0.576^{***}	0.496^{***}
	(0.136)	(0.153)	(0.201)	(0.147)	(0.185)	(0.150)
u_t, SMP	0.272^{**}	2.031		0.310^{**}	1.007	0.235^{*}
	(0.129)	(1.229)		(0.136)	(1.281)	(0.128)
u_t^2, SMP		-0.135			-0.054	
		(0.093)			(0.098)	
Δy_t, SMP			-0.322^{***}	-0.360^{***}	-0.333^{**}	-0.319^{***}
			(0.115)	(0.098)	(0.129)	(0.084)
ΔNTWI (Quarterly)						-0.039^{*}
						(0.020)
$\pi_{t,\text{Commodity price index}}$ (Quarterly)						-0.038^{***}
						(0.014)
ΔASX200 (Quarterly)						-0.038^{***}
						(0.010)
(Constant)	2.562^{**}	-2.347	5.928^{***}	3.296^{**}	1.289	3.865^{**}
	(1.289)	(3.556)	(1.841)	(1.533)	(3.822)	(1.908)
Adjusted R^2	0.206	0.231	0.234	0.318	0.315	0.421
$\hat{\pi}^*$	2.408	2.420	2.741	2.536	2.522	2.674
SE	(0.180)	(0.136)	(0.192)	(0.192)	(0.174)	(0.211)
95% Confidence Interval	[2.056 - 2.760]	[2.154 - 2.686]	[2.365 - 3.117]	[2.159 - 2.913]	[2.181 - 2.863]	[2.260 - 3.088]
Augmented Dickey Fuller p-value	0.010	0.010	0.086	0.034	0.026	0.015

*** p<0.01, ** p<0.05, * p<0.1; Standard errors (in parentheses) are robust to herterskedasticity and autocorrelation; 90 observations in sample

Table 3. Estimation of U-shaped loss function with non-inflation variables across different forecast horizons
Statement of Monetary Policy: 1997m2 - 2019m5, Quarterly

	(1) 0-1 qtr ahead avg	(2) 0-2 qtr ahead avg	(3) 0-3 qtr ahead avg	(4) 0-4 qtr ahead avg
π_t, SMP	-2.654^{***}	-2.293^{**}	-1.952	-1.611
	(0.964)	(1.063)	(1.188)	(1.304)
π_t^2, SMP	0.496^{***}	0.433^{**}	0.370^{*}	0.308
	(0.150)	(0.170)	(0.194)	(0.217)
u_t, SMP	0.235^{*}	0.254^{*}	0.258^{**}	0.265^{**}
	(0.128)	(0.129)	(0.126)	(0.124)
Δy_t, SMP	-0.319^{***}	-0.385^{***}	-0.469^{***}	-0.532^{***}
	(0.084)	(0.088)	(0.101)	(0.114)
ΔNTWI (Quarterly)	-0.039^{*}	-0.037^{*}	-0.034^{*}	-0.031
	(0.020)	(0.020)	(0.020)	(0.019)
$\pi_{t,\text{Commodity price index}}$ (Quarterly)	-0.038^{***}	-0.032^{**}	-0.026^{**}	-0.021^{*}
	(0.014)	(0.014)	(0.013)	(0.013)
ΔASX200 (Quarterly)	-0.038^{***}	-0.040^{***}	-0.042^{***}	-0.043^{***}
	(0.010)	(0.011)	(0.011)	(0.011)
(Constant)	3.865^{**}	3.482^{*}	3.305	3.045
	(1.908)	(1.964)	(2.039)	(2.118)
Adjusted R^2	0.421	0.422	0.436	0.439
$\hat{\pi}*$	2.674	2.646	2.639	2.619
SE	(0.211)	(0.247)	(0.294)	(0.372)
95% Confidence Interval	[2.260 - 3.088]	[2.161 - 3.131]	[2.061 - 3.216]	[1.891 - 3.347]
Augmented Dickey Fuller p-value	0.015	0.021	0.032	0.033

*** p<0.01, ** p<0.05, * p<0.1; Standard errors (in parentheses) are robust to heterskedasticity and autocorrelation; 90 observations in sample

Table 4. Estimation of V-shaped loss function, allowing for symmetry and asymmetry
Statement of Monetary Policy: 1997m2 - 2019m5, Quarterly

	(1) Symmetric V	(2) Symmetric V	(3) Symmetric V	(4) Asymmetric V	(5) Asymmetric V	(6) Asymmetric V
$\|\pi_t - \pi^*\|$, SMP	1.029***	0.832***	0.700***			
	(0.253)	(0.231)	(0.181)			
$(\pi_t - \pi^*) * \mathbb{1}[\pi_t > \pi^*]$				1.219***	1.071***	0.665***
				(0.263)	(0.242)	(0.179)
$(\pi_t - \pi^*) * \mathbb{1}[\pi_t \leq \pi^*]$				−0.766*	−0.477	−0.794*
				(0.412)	(0.308)	(0.408)
u_t, SMP		0.283**	0.241**		0.303**	0.229*
		(0.124)	(0.106)		(0.133)	(0.127)
Δy_t, SMP		−0.361***	−0.311***		−0.339***	−0.318***
		(0.101)	(0.084)		(0.103)	(0.084)
ΔNTWI (Quarterly)			−0.043**			−0.043**
			(0.021)			(0.021)
$\pi_{t,\text{Commodity price index}}$ (Quarterly)			−0.035***			−0.035***
			(0.013)			(0.013)
ΔASX200 (Quarterly)			−0.039***			−0.040***
			(0.010)			(0.010)
(Constant)	0.437*	−0.100	0.151	0.446	−0.248	0.228
	(0.250)	(0.828)	(0.696)	(0.290)	(0.860)	(0.816)
Adjusted R^2	0.176	0.321	0.425	0.175	0.319	0.419
$\hat{\pi}^*$	2.48	2.47	2.48	2.65	2.70	2.47
SE	(0.074)	(0.175)	(0.158)	(0.145)	(0.306)	(0.360)
95% Confidence Interval	[2.334 - 2.626]	[2.126 - 2.824]	[2.171 - 2.789]	[2.366 - 2.934]	[2.100 - 3.300]	[1.764 - 3.176]
Symmetric p-value	-	-	-	0.306	0.204	0.623
Augmented Dickey Fuller p-value	0.041	0.036	0.017	0.042	0.034	0.018

*** p<0.01, ** p<0.05, * p<0.1; Standard errors (in parentheses) are robust to heterskedasticity and autocorrelation; 90 observations in sample

Table 5. Estimated V/U-shaped loss function
Statement of Monetary Policy: 1997m2 - 2019m5, Quarterly
Loughran and Mcdonald (2011): Fraction Negative

	(1) Quadratic U	(2) Quadratic U	(3) Symmetric V	(4) Asymmetric V	(5) Symmetric V	(6) Asymmetric V
π_t, SMP	-2.397^{***}	-2.083^{***}				
	(0.838)	(0.603)				
π_t^2, SMP	0.460^{***}	0.418^{***}				
	(0.130)	(0.096)				
$\|\pi_t - \pi^*\|$, SMP			0.741^{***}		0.666^{***}	
			(0.124)		(0.131)	
$(\pi_t - \pi^*) * \mathbb{1}[\pi_t > \pi^*]$				0.869^{***}		0.852^{***}
				(0.104)		(0.137)
$(\pi_t - \pi^*) * \mathbb{1}[\pi_t \leq \pi^*]$				-0.579^{*}		-0.379^{*}
				(0.338)		(0.228)
u_t, SMP		0.230^{***}			0.204^{***}	0.227^{***}
		(0.087)			(0.073)	(0.085)
Δy_t, SMP		-0.072			-0.081	-0.061
		(0.057)			(0.057)	(0.059)
ΔNTWI (Quarterly)		-0.003			-0.006	-0.004
		(0.010)			(0.010)	(0.010)
$\pi_{t,\text{Commodity price index}}$ (Quarterly)		-0.015^{**}			-0.014^{**}	-0.013^{*}
		(0.007)			(0.006)	(0.007)
ΔASX200 (Quarterly)		-0.014^{*}			-0.017^{**}	-0.015^{*}
		(0.008)			(0.008)	(0.007)
(Constant)	6.665^{***}	5.035^{***}	3.383^{***}	3.382^{***}	2.479^{***}	2.313^{***}
	(1.251)	(1.182)	(0.103)	(0.149)	(0.473)	(0.548)
Adjusted R^2	0.211	0.403	0.242	0.244	0.403	0.412
$\hat{\pi}^*$	2.608	2.491	2.49	2.65	2.47	2.65
SE	(0.198)	(0.184)	(0.040)	(0.083)	(0.061)	(0.155)
95% Confidence Interval	[2.220 - 2.996]	[2.130 - 2.852]	[2.412 - 2.568]	[2.487 - 2.813]	[2.350 - 2.590]	[2.346 - 2.954]
Augmented Dickey Fuller p-value	0.021	0.010	0.022	0.021	0.010	0.010

*** p<0.01, ** p<0.05, * p<0.1; Standard errors (in parentheses) are robust to heterskedasticity and autocorrelation; 90 observations in sample

Table 6. Estimated V/U-shaped loss function
Statement of Monetary Policy: 1997m2 - 2019m5, Quarterly
Loughran and Mcdonald (2011): Fraction Positive

	(1) Quadratic U	(2) Quadratic U	(3) Symmetric V	(4) Asymmetric V	(5) Symmetric V	(6) Asymmetric V
π_t, SMP	0.934*	0.571				
	(0.544)	(0.453)				
π_t^2, SMP	−0.183**	−0.078				
	(0.090)	(0.073)				
$\|\pi_t - \pi^*\|$, SMP			−0.290*		0.136	
			(0.168)		(0.102)	
$(\pi_t - \pi^*) * \mathbb{1}[\pi_t > \pi^*]$				−0.435***		0.073
				(0.156)		(0.094)
$(\pi_t - \pi^*) * \mathbb{1}[\pi_t \leq \pi^*]$				0.144		2.280**
				(0.175)		(1.001)
u_t, SMP		−0.005			−0.014	0.012
		(0.058)			(0.059)	(0.054)
Δy_t, SMP		0.247***			0.258***	0.253***
		(0.055)			(0.054)	(0.050)
ΔNTWI (Quarterly)		0.036**			0.036**	0.043***
		(0.015)			(0.015)	(0.014)
$\pi_{t,\text{Commodity price index}}$ (Quarterly)		0.022**			0.020**	0.025***
		(0.010)			(0.010)	(0.009)
ΔASX200 (Quarterly)		0.024***			0.026***	0.025***
		(0.005)			(0.007)	(0.006)
(Constant)	1.697**	1.171	2.948***	2.939***	1.757***	1.929***
	(0.729)	(0.828)	(0.176)	(0.175)	(0.612)	(0.444)
Adjusted R^2	0.033	0.392	0.042	0.037	0.393	0.429
$\hat{\pi}^*$	2.547	3.649	2.44	2.87	3.81	1.81
SE	(0.347)	(0.802)	(0.437)	(0.401)	(1.013)	(0.213)
95% Confidence Interval	[1.867 - 3.228]	[2.076 - 5.221]	[1.753 - 3.467]	[1.914 - 3.486]	[1.825 - 5.795]	[2.052 - 2.888]
Augmented Dickey Fuller p-value	0.030	0.075	0.032	0.026	0.073	0.083

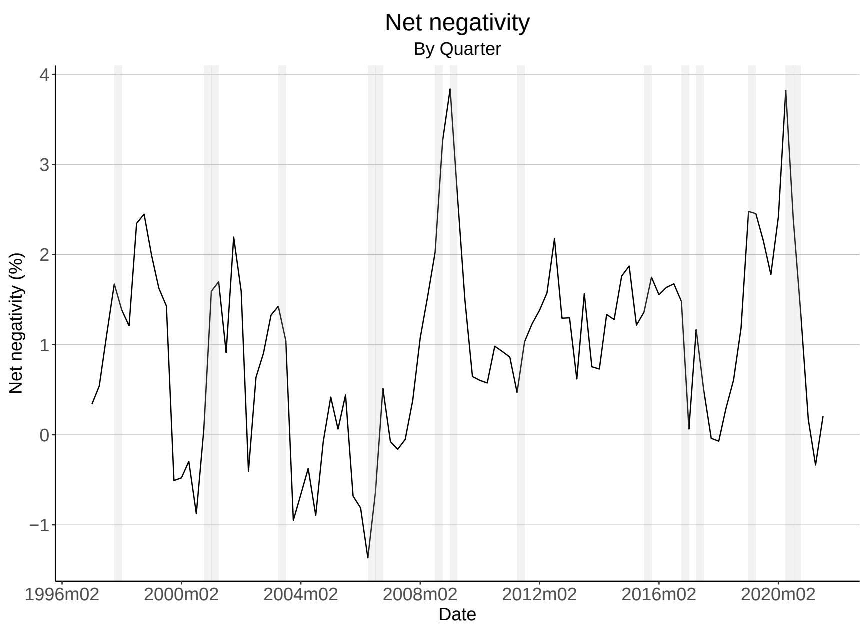
*** p<0.01, ** p<0.05, * p<0.1; Standard errors (in parentheses) are robust to heterskedasticity and autocorrelation; 90 observations in sample

Table 7. Estimated V/U-shaped loss function
Statement of Monetary Policy: 1997m2 - 2019m5, Quarterly
VADER Net Negativity

	(1) Quadratic U	(2) Quadratic U	(3) Symmetric V	(4) Asymmetric V	(5) Symmetric V	(6) Asymmetric V
π_t, SMP	0.874	2.188				
	(2.672)	(1.883)				
π_t^2, SMP	-0.009	-0.270				
	(0.428)	(0.291)				
$\lvert\pi_t - \pi^*\rvert$, SMP			0.915**		0.790*	
			(0.397)		(0.452)	
$(\pi_t - \pi^*) * \mathbb{1}[\pi_t > \pi^*]$				0.956**		0.796*
				(0.402)		(0.455)
$(\pi_t - \pi^*) * \mathbb{1}[\pi_t \leq \pi^*]$				-5.947**		-5.188**
				(2.912)		(2.223)
u_t, SMP		0.505*			0.467*	0.430
		(0.276)			(0.271)	(0.277)
Δy_t, SMP		-0.330*			-0.277	-0.293
		(0.178)			(0.189)	(0.191)
ΔNTWI (Quarterly)		-0.012			-0.018	-0.025
		(0.043)			(0.040)	(0.039)
$\pi_{t,\text{Commodity price index}}$ (Quarterly)		-0.061*			-0.071**	-0.075**
		(0.032)			(0.031)	(0.030)
ΔASX200 (Quarterly)		-0.102***			-0.092***	-0.092***
		(0.021)			(0.020)	(0.020)
(Constant)	-9.512**	-12.918***	-8.052***	-8.168***	-9.745***	-9.556***
	(3.728)	(3.908)	(0.436)	(0.471)	(1.966)	(2.036)
Adjusted R^2	0.064	0.343	0.084	0.084	0.354	0.355
$\hat{\pi}^*$	46.123	4.046	3.99	1.74	1.82	1.76
SE	(1942.701)	(1.118)	(0.874)	(0.798)	(0.691)	(0.286)
95% Confidence Interval	[-3761.571 - 3853.817]	[1.854 - 6.238]	[2.277 - 5.703]	[1.135 - 4.265]	[1.276 - 3.984]	[1.910 - 3.030]
Augmented Dickey Fuller p-value	0.035	0.059	0.040	0.046	0.063	0.063

*** p<0.01, ** p<0.05, * p<0.1; Standard errors (in parentheses) are robust to heterskedasticity and autocorrelation; 90 observations in sample

Figure 1: Statement of Monetary Policy



A higher net negativity value implies that sentiment worsens.
Statement of Monetary Policy data is a quarterly publication released in February, May, August and November.
Shaded bars represent quarters where GDP growth was in the lowest 10% of growth rates across the sample.
The Spearman's rank correlation is −0.23, and is significantly different from zero at the 5% significance level.

Figure 2: Estimated U Shaped Loss Function, Inflation only

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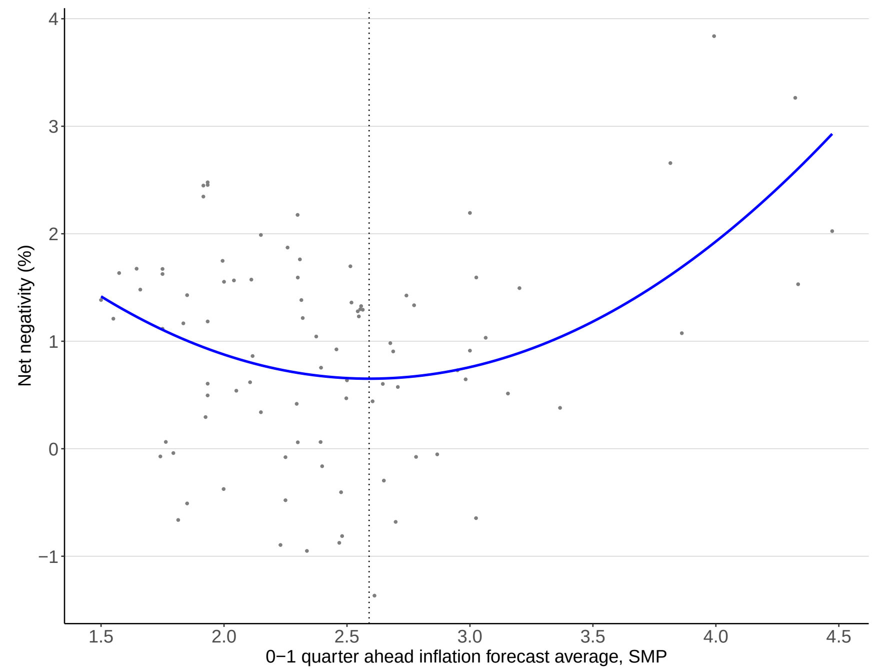

Net negativity is measured using Loughran and Mcdonald's (2011) dictionary.

Figure 3: Estimated U Shaped Loss Function, Unemployment

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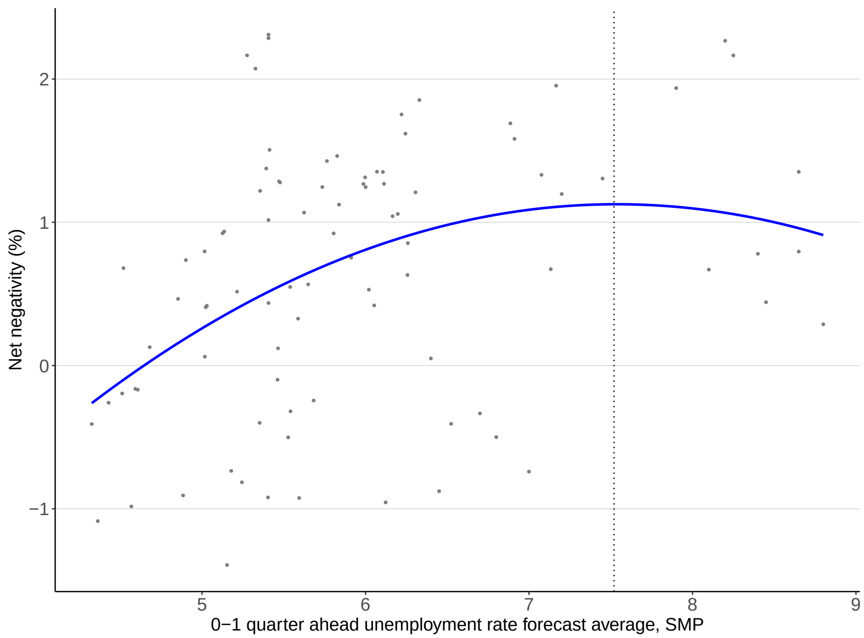

Net negativity is measured using Loughran and Mcdonald's (2011) dictionary.
The estimated specification includes both an inflation and unemployment gap term.
Inflation is assumed to equal its estimated target of 2.42%.

Figure 4: Estimated Symmetric V Shaped Loss Function, Inflation only

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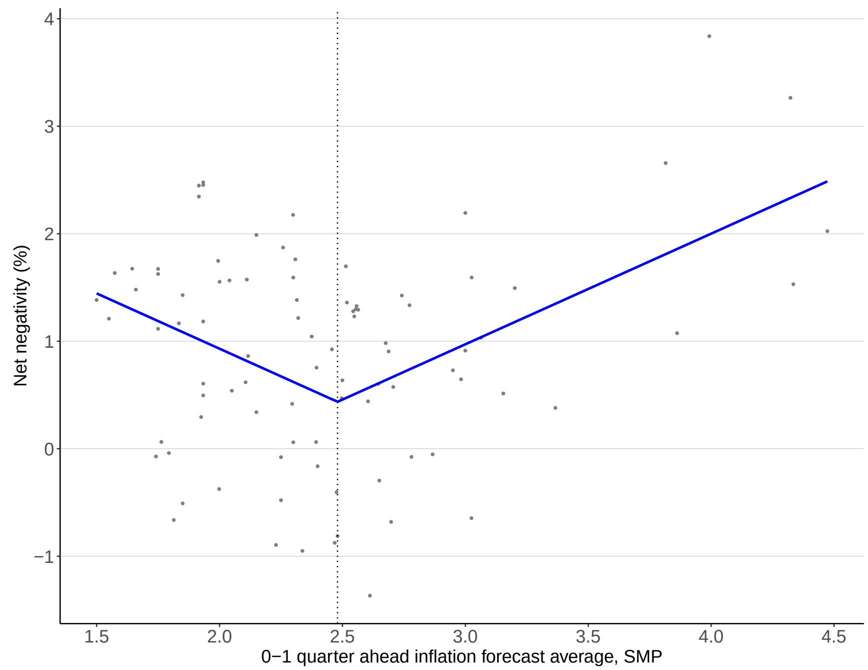

Net negativity is measured using Loughran and Mcdonald's (2011) dictionary.