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# **Firms' Subjective Uncertainty and Forecast Errors**

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### Firms' Subjective Uncertainty and Forecast Errors\*

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#### Abstract

Using original survey data linked with the financial statements of Japanese listed firms, this study presents an *ex post* evaluation of firms' *ex ante* subjective uncertainty. *Ex ante* forecast uncertainty in terms of sales and employment growth is derived from firms' subjective confidence interval around their point forecasts. *Ex post* forecast error is calculated as the deviation of the realized figures from the point forecasts. The results indicate that *ex ante* subjective uncertainty has a positive association with realized absolute forecast error. The subjective confidence interval for a firm's own business forecast, in comparison with that for macroeconomic variables, is reliable as a measure of uncertainty. These findings indicate that the subjective probability distribution of business outlook captured by firm surveys contains valuable information for measuring economic uncertainty at the micro-level.

Keywords: uncertainty, confidence interval, probability distribution, forecast error, volatility JEL Classification: D84, E22

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#### Firms' Subjective Uncertainty and Forecast Errors

### 1. Introduction

A large number of studies have indicated that uncertainty shocks regarding economic conditions and policy have negative impacts on firm investment and household consumption. As the uncertainty faced by economic agents is generally unobservable, various proxy measures of uncertainty have been developed and used in empirical studies. This study uses unique firm survey data combined with the financial statements of Japanese listed firms and presents an *ex post* evaluation of firms' *ex ante* subjective uncertainty.

Regarding macroeconomic uncertainty, the implied volatility of stock prices (captured through indexes such as the VIX), cross-sectional disagreement over forecasts by professional economists, the unexplained residuals of macroeconomic variables derived from econometric models, and the frequency of newspaper articles on policy uncertainty have been used in past empirical studies (see Bloom, 2014; Meinen and Roehe, 2017; Kozeniauskas *et al.*, 2018 for recent surveys of uncertainty measures). Micro-level uncertainty faced by firms has been captured, for example, by the volatility in firm performance, *ex post* forecast errors in firms' business outlook, and the volatility of individual firms' stock price. However, uncertainty measures should ideally be constructed from individual firms' point forecasts and probability distributions (Pesaran and Weale, 2006; Manski, 2018).

In the case of forecasts by professional economists, a large number of studies use the subjective probability distribution of forecasted real GDP growth and inflation rates as the measure of uncertainty (e.g., Boero *et al.*, 2008; Clements, 2008, 2014; Engelberg *et al.*, 2009; Rich and Tracy, 2010). In a similar manner, firms' subjective uncertainty can be captured through a survey to determine point forecasts and probability distributions of a firm's own business outlook or macroeconomic variables. Guiso and Parigi (1999), Bontempi *et al.* (2010), Ben-David *et al.* (2013), Morikawa (2016a), Coibion *et al.* (2018), and Altig *et al.* (2019) are examples of such studies.

As part of the Management and Organizational Practices Survey (MOPS), the U.S. Census Bureau recently started to collect information regarding subjective uncertainty over the business forecasts of manufacturing establishments by including a five-point forecast in relation to their shipment, investment, employment, and materials cost (Buffington *et al.*, 2018). In Japan, the Cabinet Office launched a similar survey as part of the JP-MOPS.<sup>1</sup>

<sup>&</sup>lt;sup>1</sup> The Federal Reserve Bank of New York started a monthly survey (the Survey of Consumer Expectations) to determine households' point forecast and their probability distribution regarding

Using an original survey of Japanese listed firms conducted in fiscal year 2012 and linking the data with the financial statements of these firms up to fiscal year 2015, this study compares the *ex ante* subjective uncertainty with the *ex post* forecast error to evaluate the validity of the subjective uncertainty captured by the firm survey.<sup>2</sup> This study analyzes uncertainty regarding firms' own business outlook as well as that regarding the macroeconomic outlook (GDP growth and CPI inflation rates). While the analysis is simple, an *ex post* evaluation of firms' *ex ante* probability distribution is scarce. In addition, the comparison of uncertainty over firms' business outlook and that relating to the macroeconomic outlook is also a unique feature of this study.

In the case of professional economists' macroeconomic forecasts, Clements (2014) analyzes the relationship between *ex ante* and *ex post* uncertainty (realized forecast error) and states that "there is little evidence of a link between individuals' *ex post* forecast accuracy and their *ex ante* subjective assessments."<sup>3</sup> However, as firms' subjective probability distributions of their business and/or macroeconomic forecasts are rarely surveyed, *ex post* evaluation of the probability distribution has been scarce. A recent study by Altig *et al.* (2019) is a rare example that uses the Survey of Business Uncertainty for U.S. firms and indicates that *ex ante* subjective uncertainty and *ex post* absolute forecast error of employment growth are positively correlated.

According to our analysis, *ex ante* subjective uncertainty (standard deviation calculated from the probability distribution of forecast) around a firm's sales and employment growth has a positive correlation with the *ex post* absolute forecast error of these variables. Subjective uncertainty regarding firms' own business outlook is more reliable than that for macroeconomic outlook. These results suggest that the subjective probability distribution obtained from firm surveys contains valuable information for capturing business uncertainty.

The remainder of this paper is organized as follows. Section 2 explains the data used in this study and the method of analysis. Section 3 presents and interprets the results, and section 4 concludes with implications.

### 2. Data and Methodology

The firm survey is the "Survey on the Outlook of the Japanese Economy and Economic Policy" designed by the author of this paper. The survey was conducted by the Research Institute of Economy, Trade, and Industry (RIETI) at the end of fiscal year 2012 (from February to March

personal income growth (Ben-David et al., 2018).

<sup>&</sup>lt;sup>2</sup> The 2012 survey was used in Morikawa (2016a).

<sup>&</sup>lt;sup>3</sup> For example, Giordani and Soderlind (2003) and Kenny *et al.* (2014) evaluate the merit of density forecasts by professional economists.

2013). The survey was sent to managers in charge of drawing up mid-term management plans of listed firms in Japan (2,309 firms) and a total of 294 firms responded to the survey (the response rate was 12.7%). Among the firms that responded, the shares of manufacturing and non-manufacturing firms are 52% and 48%, respectively.

The main survey questionnaires cover the outlook for sales growth, change in the number of regular employees (part-time employees included), real GDP growth, CPI inflation rates for the subsequent fiscal year (fiscal year 2013), and the annualized rates for the subsequent three years (fiscal years 2013 to 2015).<sup>4</sup> Importantly, the survey asked about firms' subjective 90% confidence intervals around their point forecasts (specific figures) for these variables.<sup>5</sup> Specifically, the survey asked firms to choose from ten confidence intervals: 1) less than  $\pm 0.5\%$ , 2)  $\pm 0.5\%$  to 1%, 3)  $\pm 1\%$  to 2%, 4)  $\pm 2\%$  to 3%, 5)  $\pm 3\%$  to 5%, 6)  $\pm 5\%$  to 7%, 7)  $\pm 7\%$  to 10%, 8)  $\pm 10\%$  to 15%, 9)  $\pm 15\%$  to 20%, and 10)  $\pm 20\%$  or over. Based on the responses, the standard deviations ( $\sigma$ ), that is, the *ex ante* subjective uncertainty measure, are calculated under the assumption of a normal distribution.<sup>6</sup> The highest end of the choices is used in this calculation and 40% is assigned to the  $\pm 20\%$  or over category.

To calculate *ex post* forecast errors of sale and employment growth rates, financial statement data for listed firms compiled by the Japan Economic Research Institute are used to measure realized growth rates of sales and employment. Firm-level *ex post* forecast error is calculated as the absolute value of the deviation between the realized growth rate (Yi) and the *ex ante* point forecast (E(Yi)) (see equations (1) and (2)). In the case of GDP and CPI change rates, realized growth rates are taken from the official statistics and the *ex post* absolute forecast errors are calculated in a similar manner.

Forecast error<sub>i</sub> = 
$$Y_i$$
 - E( $Y_i$ ) (1)

Absolute forecast 
$$\operatorname{error}_{i} = |\operatorname{forecast} \operatorname{error}_{i}|$$
 (2)

After constructing these data, we analyze the relationship between *ex ante* uncertainty and *ex post* forecast error. In addition, we analyze the relationship of past volatility of sales/employment with the *ex ante* uncertainty, where volatility of sales and employment is calculated as the standard deviation of these variables during the past five years.

<sup>&</sup>lt;sup>4</sup> The survey questionnaires include perceptions about uncertainty over economic policies, the effects of uncertainty on business operations, and major managerial decisions affected by policy uncertainty, which are used in Morikawa (2016a).

<sup>&</sup>lt;sup>5</sup> The survey asks about the price outlook of the firms' main product/service. However, as realized price cannot be observed from the financial statements, we do not use the price outlook in this study. <sup>6</sup> For example, the standard deviation of the " $\pm$ 7% to 10%" category is 6.08%.

#### 3. Results

The point forecasts of sales and employment growth rates are presented in panel A of **Table 1**. Mean forecasts of sales growth for the subsequent year and the subsequent three years (annual rate) are 4.8% and 6.0%, respectively. The means for employment growth rates are 1.4% and 0.9%, respectively. As observed from the standard deviation, maximum, and minimum values, growth forecasts are quite heterogeneous among firms.

**Table 2** presents the simple regression results to explain realized growth rates using the point forecasts. The coefficients for point forecasts are all positive, implying that firms expecting higher growth of sales/employment actually grow more. However, the size of the coefficients is far smaller than unity and insignificant for the growth rates for the subsequent year. In the case of forecasts for the subsequent three years, the estimated coefficients are statistically significant at the 5% level for sales growth and at the 10% level for employment growth, but the accuracy of point forecasts is low.

Columns (1) and (2) of **Table 3** summarize the distribution of subjective uncertainty (90% confidence interval) for sales growth rates. In the case of sales growth, the medians are  $\pm 3\%$ -5%, but the subjective uncertainty is heterogeneous. After converting the 90% confidence interval to standard deviation, the sample averages of the subjective uncertainty are 4.1% and 4.4% for 1-year-ahead and 3-years-ahead forecasts (the last row of the table), respectively.

Columns (3) and (4) of **Table 3** are the results for employment growth rates. The medians are  $\pm 1\%$  to 2% and the sample averages of standard deviations are 2.5% and 2.6% for 1-year-ahead and 3-years-ahead forecasts, respectively, which are smaller than the figures for sales growth. The difference between sales and employment growth is unsurprising because the point forecasts for employment growth rates are lower than those for sales growth rates and it takes time to adjust the number of employees.

The *ex ante* uncertainty is higher for 3-years-ahead forecasts than 1-year-ahead forecasts for both sales and employment growth rates, meaning that forecasts are more uncertain for longer time horizons. This result is also expected and similar to previous findings for macroeconomic forecasts by professional economists.

Next, we calculate forecast and absolute forecast errors by comparing forecast and realized growth rates (see row C of **Table 1**). As forecast errors are calculated as the realized growth rates minus the point forecasts (equation (1)), a positive value indicates underprediction (or a positive surprise) and a negative value indicates overprediction (or negative surprise). The mean forecast errors for sales growth rates are 1.7% for 1-year-ahead forecasts and -3.0% for 3-years-ahead

forecasts. In the case of employment growth, the forecast errors are -3.3% and -0.6%, respectively.

**Table 4** shows the percentages of firms with absolute forecast error rates exceeding their *ex ante* confidence interval. For both sales and employment growth rates, the percentages of firms with absolute forecast errors larger than their *ex ante* 90% confidence interval are about 1% to 2% for 1-year-ahead forecasts and about 5% for 3-years-ahead forecasts (panel A of the table). This result indicates that firms' subjective 90% confidence interval is somewhat wider than the realized uncertainty.

Similar calculations are made for forecasts of real GDP growth and CPI inflation rates (panel B of the table).<sup>7</sup> In these macroeconomic variables, the percentage of firms with absolute forecast errors larger than their *ex ante* 90% confidence interval is about 20% to 40%, which is far greater than when forecasting for their own business. This result is similar to the finding from an official business survey that a relatively large number of firms responded as being "unsure" regarding future domestic economic conditions compared with future business conditions (Morikawa, 2018) and is consistent with the literature on rational inattention (e.g., Coibion *et al.*, 2018; Massenot and Pettinicchi, 2018; Morikawa, 2019). The relatively large *ex post* forecast errors for macroeconomic variables suggest that firms may underestimate macroeconomic uncertainty.<sup>8</sup> However, since the timing of the survey (the first quarter of 2013) was just after the start of the Abe administration (or "Abenomics"), macroeconomic forecasting may have been more difficult than under normal circumstances.

**Table 5** presents simple regression results to explain the *ex post* absolute forecast error using the *ex ante* uncertainty, measured as the subjective standard deviation around the point forecast. As previous studies generally indicate that the accuracy of a forecast is positively associated with firm size (e.g., Bachmann and Elstner, 2015; Morikawa, 2016b, 2019; Tanaka *et al.* 2019), firm size (log number of employees) is included as a control variable.

The coefficients for *ex ante* uncertainty are positive in all regressions and statistically significant for 3-years-ahead forecasts at the 1% level for sales (column (2)) and at the 5% level for employment (column (4)). Firms with higher subjective uncertainty regarding their sales and employment growth rates show larger *ex post* absolute forecast errors. The result is similar to a recent study in the U.S. (Altig *et al.*, 2019). The coefficients for firm size are negative and

<sup>&</sup>lt;sup>7</sup> In the case of real GDP growth and CPI inflation rates, the survey asked firms to choose from ten confidence intervals: 1) less than  $\pm 0.1\%$ , 2)  $\pm 0.1\%$  to 0.3%, 3)  $\pm 0.3\%$  to 0.5%, 4)  $\pm 0.5\%$  to 0.7%, 5)  $\pm 0.7\%$  to 1.0%, 6)  $\pm 1.0\%$  to 1.5%, 7)  $\pm 1.5\%$  to 2.0%, 8)  $\pm 2$  to 3%, 9)  $\pm 3\%$  to 5%, 10)  $\pm 5\%$  or over. The largest end of the choices is used in this calculation and 10% is assigned to the  $\pm 5\%$  or over category. The realized GDP growth rates are 2.0% for the fiscal year 2013 and 1.2% for the fiscal years 2013-2015. The realized CPI inflation rates are 0.4% and 1.3%, respectively.

<sup>&</sup>lt;sup>8</sup> Giordani and Soderlind (2003) analyzed the performance of the U.S. macroeconomic forecasts made by professional economists and reveal that a relatively small number of realized figures falls inside the *ex ante* confidence interval.

statistically significant at the 1% level with the exception of those for 1-year-ahead employment growth, confirming the finding in previous studies that larger firms tend to exhibit smaller forecast errors.

In contrast to the firms' own business outlook, in the cases of GDP and CPI forecasts (not reported in the table), we do not find a systematic relationship between the *ex ante* subjective uncertainty and *ex post* absolute forecast errors. Firms may have difficulty in providing meaningful subjective confidence intervals for the macroeconomic variables.

Finally, we analyze the relationship between past volatility of sales/employment and *ex ante* subjective uncertainty. **Table 6** presents regression results in which past volatility of sales/employment (standard deviation during the past five years) is the explanatory variable and subjective forecast uncertainty is the dependent variable. Both for sales and employment, the coefficients for past volatility are positive, suggesting that firms experiencing volatile sales/employment tend to have higher subjective uncertainty regarding the future, although in most cases the coefficients are statistically insignificant.

#### 4. Conclusion

This study used original survey data on Japanese listed firms' point forecasts and subjective probability distributions (confidence intervals) for the growth rates of sales and employment to evaluate the validity of the survey-based *ex ante* uncertainty measure.

According to the analysis, first, *ex ante* subjective uncertainty for the firms' sales and employment growth is heterogeneous and positively correlated with the *ex post* absolute forecast errors. Firms with higher subjective uncertainty are those with larger realized forecast errors. Second, in the case of business outlook, the percentage of firms with absolute forecast errors larger than their *ex ante* 90% confidence interval is very small, but the percentage is far larger for macroeconomic outlook. Third, the larger the volatility in the past, the larger the subjective uncertainty over future business growth, although the relationship is statistically weak.

These results suggest that subjective probability distribution obtained from firm survey contains valuable information for capturing business uncertainty. However, it should be noted that the analysis in this study depends only on a cross-sectional survey and the number of sample firms is limited.

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		Nobs.	Mean	Std. Dev.	Min	Max
A. Forecast	Sales growth (1 year)	241	0.048	0.081	-0.250	0.600
	Sales growth (3 years)	221	0.060	0.071	-0.250	0.500
	Employment growth (1year)	244	0.014	0.088	-0.500	1.050
	Employment growth (3 years)	224	0.009	0.057	-0.500	0.333
	Sales growth (1 year)	277	0.053	0.329	-1.818	2.932
<b>B D</b> oalization	Sales growth (3 years)	263	0.031	0.083	-0.289	0.627
D. Realization	Employment growth (1year)	277	0.000	0.367	-3.349	3.317
	Employment growth (3 years)	265	0.006	0.093	-0.646	0.625
C. Forecast error	Sales growth forecast error (1 year)	237	0.017	0.320	-1.823	2.982
	Sales growth forecast error (3 years)	208	-0.030	0.103	-0.518	0.477
	Sales growth absolute forecast error (1 year)	237	0.122	0.297	0.000	2.982
	Sales growth absolute forecast error (3 years)	208	0.072	0.079	0.001	0.518
	Employment growth forecast error (1 year)	240	-0.033	0.323	-3.399	0.928
	Employment growth forecast error (3 years)	211	-0.006	0.087	-0.596	0.478
	Employment growth absolute forecast error (1 year)	240	0.084	0.314	0.000	3.399
	Employment growth absolute forecast error (3 years)	211	0.042	0.076	0.000	0.596

Table 1. Summary statistics for point forecasts and forecast errors.

Note: Figures for 3 years are annualized growth rates.

**Table 2.** Relationship between point forecasts and realized growth rates.

	(1) Sales (1 year)	(2) Sales (3 years)	(3) Employment (1 year)	(4) Employment (3 years)
Point forecast	0.0794	0.1761 **	0.1812	0.2577 *
	(0.2870)	(0.0880)	(0.1954)	(0.1360)
Observations	237	208	240	211
R-squared	0.0004	0.0230	0.0026	0.0382

Notes: OLS estimations with robust standard errors in parentheses. \*\*: p<0.05, \*: p<0.1.

	(1) Salas (1 year)	(2) Sales (3 years)	(3) Employment	(4) Employment
	(1) Sales (1 year)		(1 year)	(3 years)
<b>~</b> ±0.5%	4.5%	5.0%	18.1%	13.9%
±0.5~1%	6.8%	4.0%	18.1%	18.9%
±1~2%	13.6%	9.4%	19.0%	18.4%
±2~3%	14.0%	12.4%	12.7%	14.4%
±3 <b>~</b> 5%	21.7%	23.3%	14.9%	15.4%
±5 <b>~</b> 7%	16.3%	19.8%	7.7%	6.5%
±7 <b>~</b> 10%	10.4%	9.4%	2.3%	5.5%
$\pm 10 \sim 15\%$	7.2%	10.9%	5.0%	4.0%
$\pm 15 \sim 20\%$	2.7%	4.5%	0.5%	1.5%
±20% ~	2.7%	1.5%	1.8%	1.5%
Mean SD	4.11%	4.40%	2.50%	2.63%

Table 3. Distribution of the 90% confidence intervals for sales and employment growth rates.

Note: The last row contains the averages of *ex ante* uncertainty after converting the subjective 90% confidence intervals to standard deviations.

Table 4. The percentages of firms underestimating uncertainty.

		Firms with absolute forecast error exceed ex ante 90% confidence interval	Nobs.
	Sales growth (1 year)	1.4%	218
A. Business	Sales growth (3 years)	5.2%	192
forecasts	Employment growth (1year)	2.3%	218
	Employment growth (3 years)	5.2%	191
	GDP growth (1 year)	39.9%	233
B. Macroeconomic	GDP growth (3 years)	19.2%	213
forecasts	CPI inflation rate (1 year)	34.5%	235
	CPI inflation rate (3 years)	34.2%	225

Note: The percentages are the share of firms with absolute forecast error exceeding their *ex ante* 90% confidence interval.

	(1) Sales	(2) Sales	(3) Employment	(4) Employment
	(1 year)	(3 years)	(1 year)	(3 years)
Uncertainty	0.0005	0.0057 ***	0.0044	0.0075 **
	(0.0016)	(0.0021)	(0.0046)	(0.0033)
Firm size	-0.0460 ***	-0.0142 ***	-0.0118	-0.0122 ***
	(0.0117)	(0.0039)	(0.0073)	(0.0043)
Observations	218	192	218	191
R-squared	0.0507	0.1236	0.0058	0.1882

Table 5. Relationship between subjective uncertainty and absolute forecast error.

Notes: OLS estimations with robust standard errors are in parentheses. \*\*\*: p < 0.01, \*\*: p < 0.05.

The dependent variable is the absolute forecast error of sales/employment growth rate.

		•	•	•
	(1) Sales	(2) Sales	(3) Employment	(4) Employment
	(1 year)	(3 years)	(1 year)	(3 years)
Volatility	0.9425 *	0.1311	1.3139	1.1313
	(0.5160)	(0.6240)	(1.6280)	(1.6863)
Firm size	0.1952	0.1831	-0.0844	-0.3311
	(0.1895)	(0.2035)	(0.2590)	(0.2922)
Observations	211	194	210	192
R-squared	0.0088	0.0034	0.0214	0.0391

Table 6. Relationship between past volatility and subjective uncertainty.

Notes: OLS estimations with robust standard errors are in parentheses. \*: p<0.1. The dependent variable is the subjective uncertainty. Past volatility is the standard deviation of sales/employment during the past 5 years.