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# Staff memo

Models for forecasting annual wage growth

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# Models for forecasting annual wage growth[1]

This Memo documents a set of VAR models that are part of Norges Bank's model suite for forecasting annual wage growth. The models are used together with more structural models, surveys, and information from wage settlements in Norway. One model is based on developments in mainland Norway and the other on developments in the manufacturing sector, meant to capture distinctive developments in the tradeable sector. The models can also be used to provide wage forecasts that are consistent with Norges Bank's other forecasts and to shed light on how changes in macroeconomic conditions can affect future wage developments.

When forecasting annual wage growth, as with other economic variables, we aim to use all available information and apply models that provide the lowest possible forecast error over time. Expectations from both Norges Bank's Expectations Survey and the Regional Network, as well as current information from wage settlements, among other things, are used to forecast annual wage growth for the current year and for the following year. In addition, smaller empirical models are used. For estimates beyond the current and the following year, the core model (NEMO) is applied,[2] while the empirical models are used as a cross-check.

The empirical models consist of an error correction model[3] and two VAR models estimated using Bayesian methods. The VAR models include variables relevant for wage negotiations but impose fewer predefined relationships between the variables compared to an error correction model. Additionally, the VAR models project all variables included in the system. This simplifies setting up and evaluating the projections from alternative model specifications. We use one VAR model with variables for mainland Norway and one for the manufacturing sector.

When used for forecasting, the VAR models usually condition on the estimated course for the variables we otherwise have forecasts for (e.g., inflation development and the output gap). This can help improve the forecasting

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[2] See Gerdrup, K. R., E. Motzfeldt Kravik, K. Sæterhagen Paulsen, Ø. Robstad (2018) “Documentation of NEMO – Norges Bank’s model for monetary policy analysis and forecasting”. *Staff Memo* 8/2017. Norges Bank.

[3] The error correction model is documented in Brubakk, L., K. Hagelund og E. Husabø (2018): “The Phillips Curve and Beyond – Why has wage growth been so low?”. *Staff Memo* 10/2018. Norges Bank.

properties of the models. It will also increase the usefulness of using the models as a cross-check for the more long-term estimates from NEMO.

**Model specification**

In our forecasting models for wage growth, we aim to use macroeconomic variables that are both theoretically relevant for wage formation in Norway, in addition to having good forecasting properties. The Norwegian system of wage negotiations is set up in such a way that the tradeable manufacturing sector's ability to pay wages provides a norm for total wage growth. Thus, developments within manufacturing are particularly decisive for wage growth, also in other industries, see e.g. description in *NOU 2024:6*.[4] On this basis, we use two different VAR models: one with variables for mainland Norway and one that incorporates variables specific to the manufacturing sector. Both models forecast overall annual wage growth in Norway and can be presented as follows:

$$\boldsymbol{Y}_t^i = \boldsymbol{A}_0 + \boldsymbol{A}_1 \boldsymbol{Y}_{t-1}^i + \boldsymbol{A}_2 \boldsymbol{Y}_{t-2}^i + \boldsymbol{e}_t$$

$$\boldsymbol{Y}_t^{MN} = \begin{pmatrix} w_t \\ Z_t^{MN} \\ \pi_{t+1}^e \\ \hat{y}_t \\ \omega_t^{MN} \end{pmatrix}, \boldsymbol{Y}_t^{mfg} = \begin{pmatrix} w_t \\ Z_t^{mfg} \\ \pi_{t+1}^e \\ \hat{y}_t \\ \omega_t^{mfg} \end{pmatrix}$$

The model for mainland Norway accounts for accrued annual wage growth as measured in the National Accounts ($w_t$), productivity value in mainland Norway ($Z_t^{MN}$), expected inflation ($\pi_{t+1}^e$),[5] Norges Bank's output gap ($\hat{y}_t$), and a measure of the wage share ($\omega_t^{MN}$). Productivity value is defined as gross product at current prices per hour worked. The wage share is a measure of profitability in companies and is defined as labor costs as a share of total factor income.[6] In the model for mainland Norway, we use the wage share for mainland Norway excluding housing services and the public sector, adjusted for self-employment.[7] The model for manufacturing includes the same variables but the figures for productivity value and the wage share are specific to manufacturing. The model therefore incorporates more information about profitability in the tradeable sector. Both models forecast the development of overall wage growth.

The models are estimated on an annual frequency using data from 1980 to 2023 and use two lags.[8] Wages, productivity value, and the wage share are included at log level. The Technical Reporting Committee for Wage Settlements' (TBU) inflation expectations are included as annual growth. The models are estimated using Bayesian methods, and we use the prior from Giannone et al

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4 See particularly chapter 4 «Frontfagsmodellen» in NOU 2024:6 «Grunnlaget for inntektsoppgjørene 2024». *Arbeids- og inkluderingsdepartementet.*

5 Inflation expectations are given by the consumer price inflation forecast from the Technical Reporting Committee on Wage Settlements (TBU), where available.

6 Factor income is defined as the sum of labour costs and operating profits.

7 See more on the wage share in Hagelund, K., E. W. Nordbø og L. Sauvik (2017) «Lønnsandelen», *Aktuell kommentar 9/2017.* Norges Bank.

8 We have tested the models with different lag-specifications. Including 2 lags provides the smallest forecasting error for both VAR models.

(2015), which is a combination of a standard Minnesota prior (Doan et al, 1984), a "sum-of-coefficients" prior, and "dummy-initial-observation".[9]

**Relationships in the models**

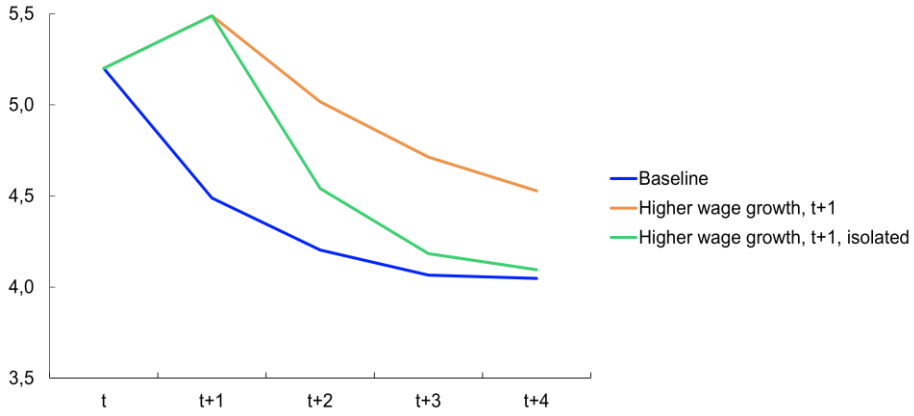
The models estimate the relationships between the variables in reduced form. Hence, the coefficients do not have a causal interpretation. This makes the models more flexible, but it also becomes more challenging to assess which relationships are captured in the model estimates.

To examine the relationships more closely, we perform some simple curve shifting exercises that illustrate the impact of various changes in the explanatory variables. The shifts are not structural shocks but rather illustrations of the correlations captured by the models. Nonetheless the exercises will help indicate whether the relationships captured by the models are consistent with how we normally assess the impact of changes in various macroeconomic variables on future wage growth.

In the shifting exercises, we use historical data up to and including 2023[10] and examine the impact of conditioning on different outcomes one period ahead on the model estimates further out in the projection period. The basis for comparison is the unconditional estimates from the models for period t+1 and further out. We start by illustrating the shifts using the model for mainland Norway. The results using the model for the manufacturing sector are broadly comparable, but some more substantial differences are commented on towards the end of this section.

**Chart 1: Higher wage growth in period t+1**

Annual growth. Percent




Source: Norges Bank

Wage growth is, all else being equal, a slow-moving variable in the model for mainland Norway. This implies that higher wage growth in current year, in isolation, contributes to higher estimated wage growth the following year. Chart

[9] Giannone, D., M. Lenza og G. E. Primiceri (2015) "Prior selection for vector autoregressions". *Review of Economics and Statistics*.

[10] The model estimates here use National Accounts data accessed in 2024-Q3.

1 compares a baseline path with two alternative assumptions for wage growth ahead. The baseline path consists of unconditional estimates from the VAR model for mainland Norway. Both alternative paths assume that wage growth in period t+1 is one percentage point higher than in the baseline. The orange path illustrates estimated wage growth when conditioned on 1 percentage point higher wage growth, while all other variables in the system are allowed to respond freely. Higher wage growth could plausibly be consistent with a different macroeconomic situation, e.g. higher inflation expectations and a tighter labor market. Therefore, higher wage growth in period t+1 could be consistent with higher wage growth ahead, not only due the direct effect of the wage-shift, but also given the alternative developments in the other explanatory variables. The green line attempts to isolate the model's interpretations of how higher wage growth in period t+1 affects wage forecasts in period t+2 and further out, by conditioning on the baseline path for all other explanatory variables in the system. Along this path, wage growth is expected to decline more rapidly but remains higher than the baseline path throughout the forecast period. The difference between the baseline path and the two shifts is summarized in Table 1.

**Table 1: Shift exercises**

Model for mainland Norway. Percentage points

| | | Projected wage growth, change from baseline path | | |
|---|---|---|---|---|
| | | t+1 | t+2 | t+3 |
| 1pp higher wage growth in *t+1* | *(1)* | 1.00 | 0.81 | 0.65 |
| | *(2)* | 1.00 | 0.34 | 0.12 |
| 1pp lower wage share in *t+1* | | - | 0.15 | 0.11 |
| 1pp higher expected inflation in *t+1* | | 0.14 | 0.23 | 0.20 |
| 1pp lower output gap in *t+1* | | -0.21 | -0.41 | -0.31 |
| 1pp higher growth in productivity value in *t+1* | | 0.24 | 0.34 | 0.29 |

We can perform similar exercises for the other variables in the system. For example, it is interesting to consider how changes in the wage share affect wage growth projections. Given the Norwegian model for wage negotiations, the wage share is expected to be stable over time.[11] The wage share can move due to changes in productivity growth, firms' product prices and wages. The model implies that periods with a low wage share will be followed by a period of higher wage growth, which in turn contributes to raising the wage share back towards its historical average. Conversely, when the wage share is high, wage growth is expected to be lower for a period. Such a relationship can be imposed directly in error correction models but appears more indirectly in the VAR models.

[11] In the model, the wage share in the tradeable manufacturing sector is expected to be stable over time. Despite the fact that profitability in the non-tradeable sector does not directly impact wage growth in this model, the non-tradeables' wage share is expected to be stable over time through price adjustments.

Table 1 shows the impact of a one percentage point lower wage share on projected wage growth in the model. Normally, the effects of the wage share in the current year are modelled as impacting wage growth the following year. In the exercise, we impose this by conditioning on wage growth in the baseline path in period t+1, so that the wage share only impacts wage growth in period t+2 and further out. The results indicate that a lower wage share contributes to lifting wage growth ahead. One year ahead, the effect of a one percentage point lower wage share is just under 0.2 percentage point. This is in line with the wage share coefficient in the error correction model in Brubakk, Hagelund and Husabø (2018), which is between 0.2 and 0.3 percentage points. The exercise is consistent with the fact that changes to the wage share affect wage growth with a lag.

The last three lines in Table 1 show individual shifts in the remaining variables in the model for mainland Norway. Here, we allow the forecasts for inflation, output gap and growth in productivity value, respectively, to contribute to changes in all the other variables in the system, also in the current year. One percentage point higher expected inflation is consistent with higher wage growth, but the effect is smaller than in Brubakk, Hagelund and Husabø (2018). A lower output gap supports a scenario where wage growth is lower. Higher growth in productivity value is consistent with higher wage growth. Changes in wage growth resulting from these shifts can both be direct effects on wages or indirect effects via the other variables in the model. The results indicate that changes in all explanatory variables are consistent with lasting changes in the model's projected wage growth.

**Table 2: Shift exercises**

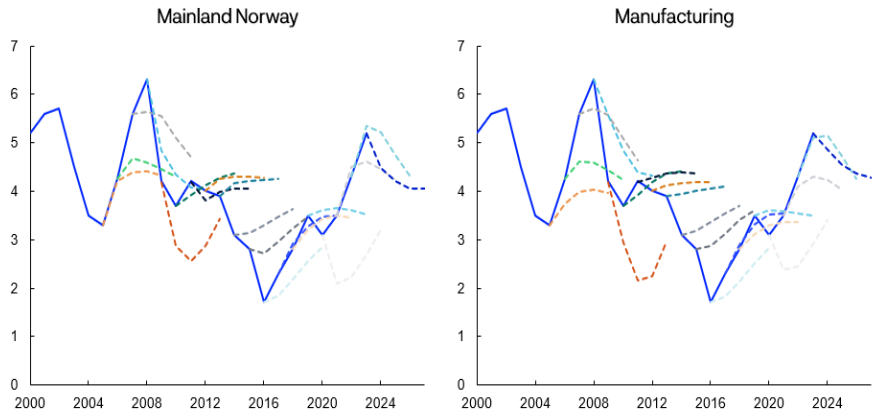
Model for manufacturing. Percentage points

| | | Projected wage growth, change from baseline path | | |
|---|---|---|---|---|
| | | t+1 | t+2 | t+3 |
| 1pp higher wage growth in *t+1* | *(1)* | 1.00 | 0.84 | 0.66 |
| | *(2)* | 1.00 | 0.45 | 0.22 |
| 1pp lower wage share in *t+1* | | - | - | 0.05 |
| 1pp higher expected inflation in *t+1* | | 0.13 | 0.21 | 0.17 |
| 1pp lower output gap in *t+1* | | -0.25 | -0.45 | -0.35 |
| 1pp higher growth in productivity value in *t+1* | | 0.00 | 0.05 | 0.05 |

In the model for the manufacturing sector, similar shift exercises indicate that projected wage growth moves in the same direction as in the results for mainland Norway, see Table 2. Higher wage growth, higher expected price growth, and a lower output gap have broadly similar effects as in the model for mainland Norway. However, changes in the wage share and productivity value result in smaller changes to projected wage growth, compared with the model for mainland Norway. This is likely related to the fact that these variables are more volatile for the manufacturing sector than for mainland Norway as a whole. This volatility may contribute to reducing the short term impact, which is also consistent with lagged and gradual effects on wage growth from shifts in the wage share.

**Chart 2: Recursive forecasts, VAR mainland Norway and manufacturing**

First forecast based on data up to end-2005, last forecast based on data up to end-2023. Annual growth. Percent




Source: Statistics Norway and Norges Bank

## Forecasting properties

It is important that the models we use provide accurate wage growth forecasts. To assess the VAR models' forecasts compared to other wage growth indicators, we evaluate the model forecasts for the period 2005 to 2023. Chart 2 illustrates the recursive forecasts from both VAR models.[12] Table 3 summarizes the forecasting performance of the VAR models, the expectations from the Regional Network, and Norges Bank's Expectations Survey.[13] The evaluation indicates that the VAR model for mainland Norway and the VAR model for the manufacturing sector have an average wage growth forecast error of 0.6-0.7 percentage point in the current year. This is a slightly larger average forecast error than the wage expectations of the social partners in the Expectations Survey and Regional Network contacts.

One year ahead, the models also have a slightly larger forecast error than the surveys. Further ahead, it is not possible to compare the models' performance with the surveys, but the forecast error of both the model for mainland Norway and the manufacturing sector stabilizes at just above 1 percentage point. The forecast errors of the model for mainland Norway have historically been slightly smaller than for the manufacturing model, but the differences are not statistically significant.

Even though the forecasting performance of the VAR models has been slightly poorer on average, it is still valuable to use these models together with other indicators when forecasting. Basing projections on different models and sources will generally be more robust over time. In addition, the model evaluation applies to a relatively short period, as the wage series of interest in on annual frequency. It is only the within-year forecasts for which some of the surveys' outperformance of the VAR models is statistically significant. In practice, one

[12] For recursive estimation, we use data in pseudo real time, meaning revisions of the data are not captured. Data used for estimation was accessed in 2024-Q3.

[13] The error correction model is not included in the evaluation, as it must be conditioned on exogenous forecasts to provide suitable wage projections. The evaluation thus requires recursive forecasts for the explanatory variables, that are not generated by the model itself. Such forecasts are not available for the entire evaluation period.

would normally condition on projections for one or more of the other explanatory variables. This may impact the forecasting performance compared to the unconditional evaluation of the models in Table 3.

**Table 3: Forecasting performance measured by RMSE[14]**

Evaluated 2005-2023

| Model/indicator | Current year | Following year | Two years ahead | Three years ahead |
|---|---|---|---|---|
| VAR, mainland Norway | 0.6 | 1.1 | 1.3 | 1.1 |
| VAR, manufacturing | 0.7 | 1.2 | 1.3 | 1.2 |
| NB Expectations Survey, social partners | 0.5 | 0.9 | - | - |
| NB Expectations Survey, economists | 0.6 | 0.9 | - | - |
| NB Expectations Survey, business leaders | 0.8 | 1.3 | - | - |
| Regional Network[15] | 0.5 | - | - | - |

In addition to accurate forecasts, it is also important to understand what lies behind the expected development of a variable given different indicators and models. Wage expectations in themselves are important for wage formation but tell us little about the factors that contribute to changing expectations over time. Empirical models make it possible to investigate possible drivers of wage growth ahead, beyond movements in expectations. Understanding drivers of wage growth also helps us investigate plausible consequences of various macroeconomic developments on wage growth. This can, among other things, assist in understanding the range of plausible outcomes, given the uncertainty attached to all explanatory variables used in the model.

Finally, it is useful that the models provide projections several years ahead, so they can be used as a cross-check against the forecasts from the core model NEMO. To be used as a cross-check, it is particularly important that it is straightforward to condition on different paths for the different explanatory variables. It is also beneficial to have a model that more directly accounts for the role of profitability and the wage share in the manufacturing sector.

[14] For Norges Bank's Expectations Survey and Regional Network we use expectations reported in Q1 of the current year. This forecast is most closely comparable to the models, for which current year refers to forecasts based on annual data for previous year and TBU projections for current year.

[15] Regional Network contacts are also asked about wage expectations for the following year. The question was added to the survey later than the question on current year expectations. Due to the short time series, it is only current year expectations that can be evaluated along the same premises as the NB Expectations Survey and VAR models.

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