Technical Note:
The wage algorithm

■ Short-term wage statistics, which are included in the official wage statistics, have the principal aim of illustrating the level of employee wages in Sweden and how these develop. Short-term wage statistics are an important source of statistics for the Riksbank's forecasts of the development of wages and labour costs in the Swedish economy.[1] This technical note describes why the outcome of short-term wage statistics is revised. The Riksbank's method for estimating future definitive wage outcomes according to these statistics is also presented. This method, known as the wage algorithm, involves estimations that have been assessed as being exceptionally accurate in forecasting contexts.

Background and purpose

One of the properties of the monthly short-term wage statistics is that the outcomes are revised on an ongoing basis over a period of one year. It thus takes twelve months for the first preliminary outcomes to become definitive. These revisions are due to the fact that retroactive wage payments are regularly incorporated into the statistics. These retroactive wage payments may relate to the difference between the new and the former rates of pay under trade union agreements (often described as central agreements), and are incorporated into the short-term wage statistics retroactively from the date at which the previous collective wage agreement expired. They may also be due to delays in the local wage formation process. Statistics Sweden's own definition of retroactive wages is as follows: "Retroactive wages are wages that have been paid after the completion of local or central collective bargaining and that relate to months prior to the month in which the wages are paid." The retroactive allocation of wage payments results in the strong correlation of the definitive outcome of short-term wage statistics and the National Mediation Office's series for centrally-agreed wage increases.

The revisions include a bias, which is to say that the revision between the first preliminary outcome and the definitive outcome for any specific month will be greater than zero (see Figure 1). This is because information on new retroactive wage payments is continually included in the statistics. The preliminary outcomes are thus (systematically) lower than the definitive outcomes. The recurring preliminary outcomes correct the level error in the first preliminary outcome, which means that the error gradually falls to zero over the course of 12 months. There is also a clear

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[1] Another important source of statistics is the National Accounts, which are used as a base for the Riksbank's forecasts of the development of hourly wages, labour costs per hour and unit labour costs.

pattern to the revisions in the different months of the year (see Figure 1). The revisions are greatest in April and May, and smallest in December. The large revisions in April and May are due to the fact that wages are revised for a large proportion of employees in these months, which is to say that new wage levels are introduced in accordance with the prevailing wage agreements. In December, on the other hand, the proportion of wage revisions on the labour market is comparatively low.

Against this background, the Riksbank has developed a method of estimating future definitive outcomes according to short-term wage statistics, in which, among other data, the first preliminary outcome of the wage bargaining rounds and centrally-agreed wage increases according to the National Mediation Office's statistics are employed. The purpose of the method is to contribute towards increasing the quality of the Riksbank's forecasts of the development of wages in the Swedish economy in the longer term, as the method is hoped to provide accurate estimates of future definitive wage outcomes.

Data and updating

At the end of each month, Statistics Sweden publishes short-term wage statistics in the form of actual hourly wages for workers in the business sector, and agreed monthly salaries for white-collar workers in the business sector and employees in the public sector. The National Mediation Office corrects the statistics in terms of reductions in working hours and one-off payments that replace local wage supplements. It also weighs the change figures (the annual percentage changes) together to obtain more aggregate measures, such as the development of wages in the economy as a whole. A few days after Statistics Sweden's publication, the National Mediation Office publishes its adapted measure of wage development on its website (http://www.mi.se) under the heading "Den senaste lönestatistiken" ("the latest wage statistics").

The first preliminary wage outcomes published by the National Mediation Office have a time-lag of just over two months after the end of the survey month – so the first preliminary wage outcome for March (for example) is published at the start of June. In conjunction with the National Mediation Office's publication, the Riksbank aims to publish on its website an estimate of the future definitive monthly outcome for the development of wages in the Swedish economy. This means that, for example, at the start of June, the Riksbank publishes an estimate of the future definitive wage outcome for March of the same year.

The National Mediation Office usually publishes the first preliminary wage outcomes for January and February together, at the start of May. This is because the selection of companies in the survey of the business sector is changed in January of each year, so the statistics take longer to be processed. In this case, the Riksbank publishes estimates of the future definitive wage outcomes for both January and February simultaneously at the start of May. This means that the Riksbank usually publishes an estimate of the definitive monthly outcome for wage development ten times per year, with two estimates being published simultaneously in May, for a total of eleven publications.

Method

The Riksbank uses time series models to make estimates of future definitive wage outcomes in the Swedish economy. The models use monthly data from January 2001 onward (see Table 1). At the Riksbank, this method is often designated the wage algorithm. The method uses several variables to estimate the revisions to be made between the first preliminary outcomes and the definitive outcomes for wages in the economy as a whole, according to short-term wage statistics. The models to be estimated are illustrated by equations (1)-(3). All of the models use a constant (designated α in the following equations), autoregressive (AR) terms $\left(\sum_{i=1}^{p} \delta_i r_{t-i}\right)$, moving average (MA) terms $\left(\sum_{m=1}^{n} \varphi_m \hat{\varepsilon}_{t-m}\right)$, seasonal dummies $\left(\sum_{s=1}^{11} \rho_s SD_{s,t}\right)$, a shift dummy (AD_t) and specific time-dummy variables $\left(\sum_{j=1}^{k} \sigma_j D_{j,t}\right)$.[2] Equations (2) and (3) also include the first preliminary wage outcomes (W_t^P). Finally, equation (3) also includes centrally-agreed wage increases according to the National Mediation Office's statistics (A_t). ε_{it} is the residual or error term in the estimation of each equation. The residual is assumed to be normally distributed and to have a constant variance.

(1)
$$r_{1t} = \alpha_1 + \sum_{i=1}^{p} \delta_{1,i} r_{1t-i} + \sum_{s=1}^{11} \rho_s SD_{s,t} + AD_t + \sum_{j=1}^{k} \sigma_j D_{j,t} + \sum_{m=1}^{n} \varphi_{1,m} \hat{\varepsilon}_{1t-m} + \varepsilon_{1t}$$

(2)
$$r_{2t} = \alpha_2 + \beta_2 W_t^P + \sum_{i=1}^{p} \delta_{2,i} r_{2t-i} + \sum_{s=1}^{11} \rho_s SD_{s,t} + AD_t + \sum_{j=1}^{k} \sigma_j D_{j,t} + \sum_{m=1}^{n} \varphi_{2,m} \hat{\varepsilon}_{2t-m} + \varepsilon_{2t}$$

(3)
$$r_{3t} = \alpha_3 + \beta_3 W_t^P + \gamma_3 A_t + \sum_{i=1}^{p} \delta_{3,i} r_{3t-i} + \sum_{s=1}^{11} \rho_s SD_{s,t} + AD_t + \sum_{j=1}^{k} \sigma_j D_{j,t} + \sum_{m=1}^{n} \varphi_{3,m} \hat{\varepsilon}_{3t-m} + \varepsilon_{3t}$$

Using these three models (i), the Riksbank produces forecasts of the magnitude of the revisions $(\hat{r}_{it})$ which, in turn – when added to the first preliminary outcome – provide estimates of the future definitive wage outcome $\left(\widehat{W}_{it}^{D}\right)$, which is to say

(4) $\widehat{W}_{it}^{D} = W_t^P + \hat{r}_{it}$, where $i = $ model 1, 2, 3

The average forecast for the future definitive outcome can be estimated according to the following equation:

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[2] Seasonal dummies are included in the model to capture the systematic pattern of revisions over the year's twelve months (see Figure 1). A shift dummy is included in the models to capture the somewhat lower wage outcome in the third year of the three-year agreements of 2001, 2004 and 2007. Specific time-dummy variables are included to capture extreme values.

■ (5) $$W_{Mt}^D = \left(\widehat{W}_{1t}^D + \widehat{W}_{2t}^D + \widehat{W}_{3t}^D\right)/3$$

The estimate of the definitive wage outcome 12 months ahead published by the Riksbank each month is thus the average forecast (W_{Mt}^D) given by equation (5). Figure 2 shows how the forecast paths for future definitive wage outcomes may look at a specific point in time, in this case at the start of March 2011, when the short-term wage statistics available then were used in the models. In Figure 2, the red, green and grey lines show the three models' different forecast paths for future definitive wage outcomes. The blue line shows the path of the average forecast of future definitive wage outcomes. In Figure 2, the final observation on the blue line is thus the estimate of the future definitive wage outcome for December 2010 that the Riksbank would have published at the start of March 2011.

Analysis and evaluation

Evaluations indicate that the average of the model forecasts demonstrates a strong ability to forecast the future definitive outcomes. One evaluation shows, for example, that about 85 per cent of the model forecasts twelve months ahead fall within a tolerance interval of ±0.10 percentage points around the actual definitive outcome. This high accuracy is exceptional in forecasting contexts, but is, of course, due to the fact that the first preliminary outcomes are available, at the same time as the revisions follow a systematic pattern (as can be seen clearly in Figure 1). Current evaluations are made more difficult by our constant attempts to improve the models' characteristics – that is, to increase the coefficient of determination of the models and to improve their residual characteristics, for example by removing or introducing specific time-dummy variables.

Figures and tables

Figure 1. Definitive outcomes, first preliminary outcomes and revisions of the short-term wage statistics, and centrally-agreed wages during the period January 2001–December 2010.
Annual percentage change and percentage points
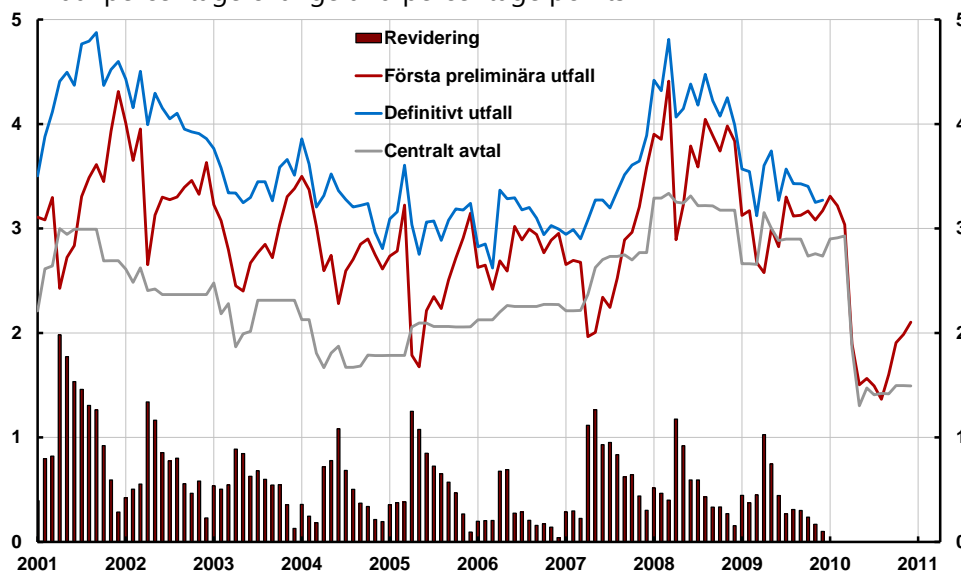
Sources: National Mediation Office, Statistics Sweden and the Riksbank

Figure 2. Estimations of definitive outcomes in short-term wage statistics for the period January 2010–December 2010 made using the wage algorithm.
Annual percentage change
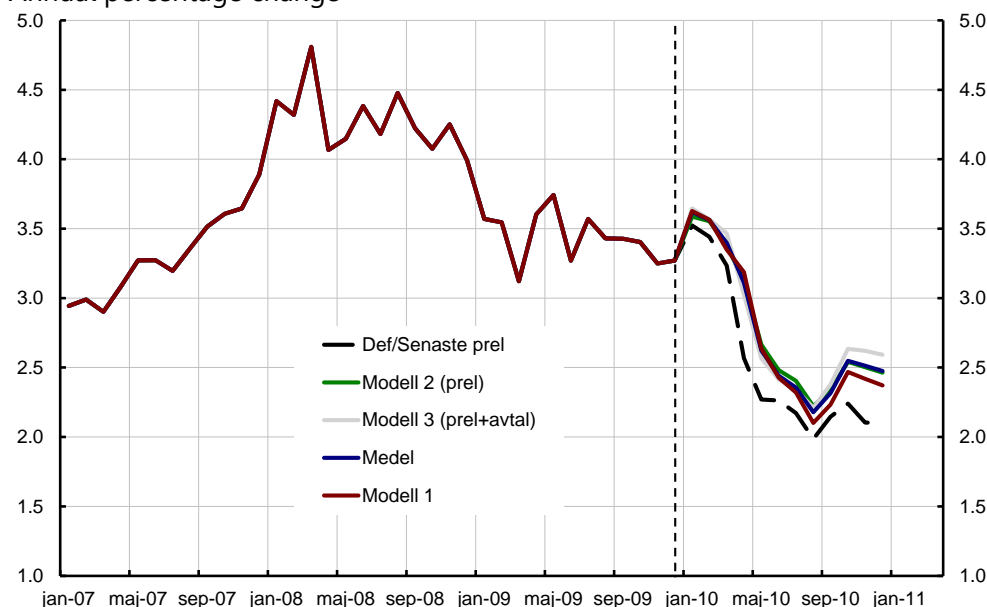
Note. Def/Last prel = Definitive and last preliminary wage outcome (at the start of March 2011). Model 1 includes the inherent dynamic in the revisions and various dummy variables. Model 2 also includes the first preliminary wage outcomes. Model 3 also includes central agreements. Mean = The average forecast of future definitive wage outcomes.

Source: The Riksbank

Table 1. First preliminary outcomes, definitive outcomes and revisions (between definitive outcomes and first preliminary outcomes) for wages in the economy as a whole according to short-term wage statistics, and centrally-agreed wage increases according to the National Mediation Office's statistics.
Annual percentage change and percentage points

Month	First preliminary outcome	Definitive outcome	Revision	Central agreements
Jan 01	3.1091	3.5032	0.3941	2.2107
Feb 01	3.0823	3.8788	0.7965	2.6138
March 01	3.2965	4.1174	0.8209	2.6410
April 01	2.4268	4.4080	1.9812	2.9981
May 01	2.7232	4.4958	1.7726	2.9445
June 01	2.8368	4.3704	1.5336	2.9927
July 01	3.3063	4.7656	1.4593	2.9927
Aug 01	3.4874	4.7935	1.3061	2.9927
Sept 01	3.6118	4.8759	1.2641	2.9927
Oct 01	3.4483	4.3689	0.9206	2.6897
Nov 01	3.9290	4.5214	0.5924	2.6920
Dec 01	4.3119	4.5981	0.2862	2.6920
Jan 02	4.0080	4.4305	0.4225	2.6111
Feb 02	3.6513	4.1565	0.5052	2.4854
March 02	3.9519	4.5046	0.5527	2.6236
April 02	2.6534	3.9932	1.3398	2.4053
May 02	3.1288	4.2942	1.1654	2.4216
June 02	3.2994	4.1533	0.8539	2.3670
July 02	3.2749	4.0499	0.7750	2.3670
Aug 02	3.3020	4.1037	0.8017	2.3670
Sept 02	3.3945	3.9513	0.5568	2.3670
Oct 02	3.4604	3.9258	0.4654	2.3670
Nov 02	3.3273	3.9091	0.5818	2.3670
Dec 02	3.6315	3.8601	0.2286	2.3670
Jan 03	3.2288	3.7660	0.5372	2.4781
Feb 03	3.0752	3.5804	0.5052	2.1839
March 03	2.7960	3.3410	0.5450	2.2809
April 03	2.4510	3.3393	0.8883	1.8671
May 03	2.4011	3.2471	0.8460	1.9919
June 03	2.6704	3.2976	0.6272	2.0147
July 03	2.7673	3.4480	0.6807	2.3124
Aug 03	2.8487	3.4470	0.5983	2.3124
Sept 03	2.7211	3.2650	0.5439	2.3124
Oct 03	3.0389	3.5853	0.5464	2.3124
Nov 03	3.3046	3.6600	0.3554	2.3122
Dec 03	3.3823	3.5105	0.1282	2.3122
Jan 04	3.4995	3.8585	0.3590	2.1269
Feb 04	3.3711	3.6169	0.2458	2.1269
March 04	3.0223	3.2064	0.1841	1.8062
April 04	2.5958	3.3150	0.7192	1.6674
May 04	2.7441	3.5225	0.7784	1.8076
June 04	2.2812	3.3631	1.0819	1.8739
July 04	2.5936	3.2774	0.6838	1.6711

Aug 04	2.7037	3.2060	0.5023	1.6711
Sept 04	2.8503	3.2208	0.3705	1.6826
Oct 04	2.8997	3.2390	0.3393	1.7884
Nov 04	2.7478	2.9622	0.2144	1.7840
Dec 04	2.6132	2.8071	0.1939	1.7840
Jan 05	2.7358	3.0917	0.3559	1.7851
Feb 05	2.7845	3.1600	0.3755	1.7851
March 05	3.2236	3.6058	0.3822	1.7851
April 05	1.7873	3.0370	1.2497	2.0581
May 05	1.6762	2.7525	1.0763	2.0957
June 05	2.2137	3.0612	0.8475	2.0945
July 05	2.3474	3.0722	0.7248	2.0623
Aug 05	2.2338	2.8866	0.6528	2.0623
Sept 05	2.5079	3.0792	0.5713	2.0623
Oct 05	2.7174	3.1876	0.4702	2.0581
Nov 05	2.9096	3.1768	0.2672	2.0581
Dec 05	3.1467	3.2405	0.0938	2.0585
Jan 06	2.6284	2.8259	0.1975	2.1260
Feb 06	2.6488	2.8517	0.2029	2.1260
March 06	2.4174	2.6219	0.2045	2.1260
April 06	2.6906	3.3667	0.6761	2.1999
May 06	2.5933	3.2845	0.6912	2.2626
June 06	3.0200	3.2944	0.2744	2.2540
July 06	2.8913	3.1787	0.2874	2.2540
Aug 06	2.9945	3.2013	0.2068	2.2540
Sept 06	2.9421	3.0999	0.1578	2.2540
Oct 06	2.7682	2.9405	0.1723	2.2730
Nov 06	2.8881	3.0285	0.1404	2.2730
Dec 06	2.9537	2.9947	0.0410	2.2726
Jan 07	2.6559	2.9436	0.2877	2.2132
Feb 07	2.6943	2.9899	0.2956	2.2132
March 07	2.6767	2.9009	0.2242	2.2150
April 07	1.9653	3.0807	1.1154	2.3676
May 07	2.0063	3.2720	1.2657	2.6264
June 07	2.3423	3.2729	0.9306	2.7022
July 07	2.2438	3.1962	0.9524	2.7330
Aug 07	2.5244	3.3584	0.8340	2.7330
Sept 07	2.8916	3.5142	0.6226	2.7483
Oct 07	2.9637	3.6073	0.6436	2.6997
Nov 07	3.2065	3.6452	0.4387	2.7699
Dec 07	3.5877	3.8900	0.3023	2.7699
Jan 08	3.9016	4.4190	0.5174	3.2902
Feb 08	3.8540	4.3193	0.4653	3.2902
March 08	4.4107	4.8099	0.3992	3.3363
April 08	2.8920	4.0669	1.1749	3.2534
May 08	3.2268	4.1468	0.9200	3.2423
June 08	3.7901	4.3829	0.5928	3.3124
July 08	3.5883	4.1813	0.5930	3.2178
Aug 08	4.0447	4.4761	0.4314	3.2190
Sept 08	3.8902	4.2232	0.3330	3.2159

Oct 08	3.7405	4.0752	0.3347	3.1747
Nov 08	3.9813	4.2514	0.2701	3.1747
Dec 08	3.8374	3.9917	0.1543	3.1759
Jan 09	3.1250	3.5699	0.4449	2.7644
Feb 09	3.1710	3.5454	0.3744	2.7644
March 09	2.6730	3.1221	0.4491	2.7582
April 09	2.5770	3.6027	1.0257	3.2566
May 09	2.9970	3.7429	0.7459	3.0987
June 09	2.8250	3.2692	0.4442	2.9820
July 09	3.3010	3.5698	0.2688	2.9959
Aug 09	3.1190	3.4294	0.3104	2.9959
Sept 09	3.1260	3.4272	0.3012	2.9957
Oct 09	3.1670	3.4035	0.2365	2.8321
Nov 09	3.0810	3.2496	0.1686	2.8558
Dec 09	3.1710	3.2706	0.0996	2.8321
Jan 10	3.3090			2.9913
Feb 10	3.2180			3.0019
March 10	3.0363			3.0221
April 10	1.8943			1.9027
May 10	1.5041			1.3502
June 10	1.5644			1.4645
July 10	1.4930			1.4220
Aug 10	1.3647			1.4381
Sept 10	1.6027			1.4314
Oct 10	1.9062			1.4314
Nov 10	1.9858			1.4314
Dec 10	2.1033			1.4279

Sources: National Mediation Office, Statistics Sweden and the Riksbank.

References

Aranki, T. and K. Friberg (2010), "Analysis of revisions in short-term wage statistics", *Economic Commentaries* no. 3, Sveriges Riksbank.

National Mediation Office (2011), *Avtalsrörelsen och lönebildningen 2010 – Medlingsinstitutets årsrapport*, pp. 88-89 and pp. 92-98.

Statistics Sweden (2011), *AM 49 Short-term statistics, salaries, in the municipalities*, pp. 11-14.

Statistics Sweden (2011), *AM 38 Short-term statistics, wages and salaries in the private sector*, pp. 16-20.

Statistics Sweden (2011), *AM 17 Short-term statistics, salaries in the governmental sector*, pp. 12-14.