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**Research Report**

## The Phillips Curve and Beyond - Why Has Wage Growth Been so Low?

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# STAFF MEMO

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NO. 10 | 2018

LEIF BRUBAKK,  
KÅRE HAGELUND AND  
EILERT HUSABØ



NORGES BANK

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# The Phillips curve and beyond - Why has wage growth been so low? \*

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## Abstract

In this paper, we estimate various dynamic wage equations for mainland Norway. Our starting point is a standard Phillips curve. We then expand on our baseline specification by adding explanatory variables suggested by economic theory. In our preferred specification, the labor share plays the role of an error correction term. This means that whenever the wage level is high relative to the value of productivity, there is a tendency for wage growth to slow down. We demonstrate that accounting for this level effect, which has also proven useful in earlier studies on Norwegian data, is particularly helpful in understanding the low wage growth in recent years.

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\*We are grateful to Ida Wolden Bache and André Anundsen for valuable comments and suggestions. All remaining errors are our own. The views expressed in this paper are those of the authors and do not necessarily reflect the views of Norges Bank.

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# 1 Introduction

Understanding the determinants of wage growth developments over time is of first order importance for the conduct of monetary policy. Labor costs account for the largest share of production costs in most sectors, and wage growth is the main factor behind movements in core inflation. Furthermore, labor income drives consumption spending and is thus an important factor in determining aggregate demand.

Wage growth has been subdued in most advanced countries after the Great Recession, and, in general, markedly lower than before the financial crisis. To some extent this reflects cyclical developments. Growth has been sluggish and unemployment has increased significantly in many countries in the aftermath of the financial crisis. However, even in countries where labor market conditions have improved, wage growth has remained low, at least until recently. This has led to a search for explanations beyond what is implied by the standard wage Phillips curve. One candidate is the slow growth in productivity experienced after the financial crisis. Indeed, several studies find that an augmented Phillips curve including productivity growth significantly improves the empirical fit in the post crisis period.<sup>1</sup> Other explanations include reduced bargaining power, the inadequacy of traditional measures of unemployment to capture underemployment and shifts in inflation expectations.

Similar to most advanced economies, wage growth in Norway has been showing a downward trend since the financial crisis. However, relative to labor market developments, the underlying slowdown in wage growth appears to have been more pronounced in Norway than in most other countries. The unemployment rate has been quite stable in historical terms. Taken at face value, this would seem to suggest a steepening of the wage Phillips curve, contrary to what has been found elsewhere.<sup>2</sup> However, we find that this can be attributed to a slowdown in productivity growth and worsening of the terms of trade.

Our augmented Phillips curve suggests that wage growth should be in line with changes in the value of productivity, adjusted for cyclical bargaining power, as mea-

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<sup>1</sup>See e.g. IMF (2017) and Abdih and Danninger (2018).

<sup>2</sup>See e.g. Blanchard (2016) and Leduc and Wilson (2017).

sured by the labor market slack. This implies that workers share of value added should be stable over time, which has been the case in Norway. In many advanced countries, however, the wage share has been on a downward trend since the 1980s. This has attracted considerable attention from both academics and bodies such as the IMF and the OECD. Although no consensus has emerged, potential drivers discussed in the literature are automation, increased power in product markets, import competition and off-shoring, as well as changes in labor market institutions.

Profit sharing has been a prominent feature of the Norwegian wage bargaining framework for decades.<sup>3</sup> The tradable sector starts by negotiating a wage norm based on profitability considerations. This wage norm then forms a basis for wage negotiations in other sectors of the economy. Although actual outcomes might deviate from the norm in some years, the mean reverting behavior of the wage share - both in the tradables industries and mainland Norway as a whole - indicates that profit sharing is a guiding principle in wage determination in Norway. We demonstrate that accounting for this level effect is particularly helpful in understanding the low wage growth in recent years. Our preferred specification shares several similarities with previous studies estimating wage equations on Norwegian data<sup>4</sup>

## 2 Background

### 2.1 International developments

A number of explanations have been put forward to reconcile the apparent disconnect between labor market conditions and wage growth experienced internationally in the aftermath of the financial crisis.<sup>5</sup> Slow trend productivity growth in recent years has reduced the scope for wage increases. This also means that growth in firms' unit labor costs has not fallen to the same extent as wage growth. At the same time, the degree of labor market slack might have been higher than indicated by traditional measures of unemployment. There have been signs of underemployment in a number of countries,

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<sup>3</sup>See NOU (2013) for a thorough discussion of the Norwegian system of wage determination.

<sup>4</sup>See e.g. Bjørnstad and Nymoen (1999), Holden and Nymoen (2002) and Nymoen (2017).

<sup>5</sup>See IMF (2017) and Arsov and Evans (2018).

manifested by for example involuntary part-time employment.<sup>6</sup> In many countries, labor force participation rates have remained low.<sup>7</sup> Finally, lower inflation expectations may have weighed on wage growth.

In addition, reduced bargaining power due to structural changes may have had a dampening effect on wage growth in many countries in recent years. Partly, this is linked to secular trends in unionization rates,<sup>8</sup> union coverage,<sup>9</sup> and easing of employment protection. Additional factors include increased automation and stronger cross-border economic integration, leading to higher import penetration, spill-overs in wage setting, and heightened concerns for job losses. In some countries, slower wage growth may in part also have been due to policy measures to increase competitiveness in the wake of the Great Recession. Within a Phillips curve framework, lower bargaining power would lead to lower wage growth for a given level of labor market slack, i.e. a flattening of the Phillips curve.<sup>10</sup>

IMF (2017) finds that the bulk of the wage slowdown after the financial crisis can be explained by slower growth in trend productivity, labor market slack (including involuntary part-time employment) and inflation expectations. This suggests that an augmented version of the Phillips curve still holds. For commodity exporting countries, the Phillips curve should also take into account terms-of-trade developments.<sup>11</sup> In a closed economy producer inflation moves in line with consumer price inflation. In open commodity exporting economies, like Norway, where commodity producers and related sectors account for a relatively large share of domestic production, producer price inflation will depend more heavily on world market prices. In some of these countries, the decline in fuel and non-fuel commodity prices since 2013 may have reduced the scope for wage growth.

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<sup>6</sup>See e.g. Haldane (2017) and Bell and Blanchflower (2018) for a discussion.

<sup>7</sup>See e.g. IMF (2018).

<sup>8</sup>Ratio of non-members relative to total employment.

<sup>9</sup>Share of employers covered by collective agreements.

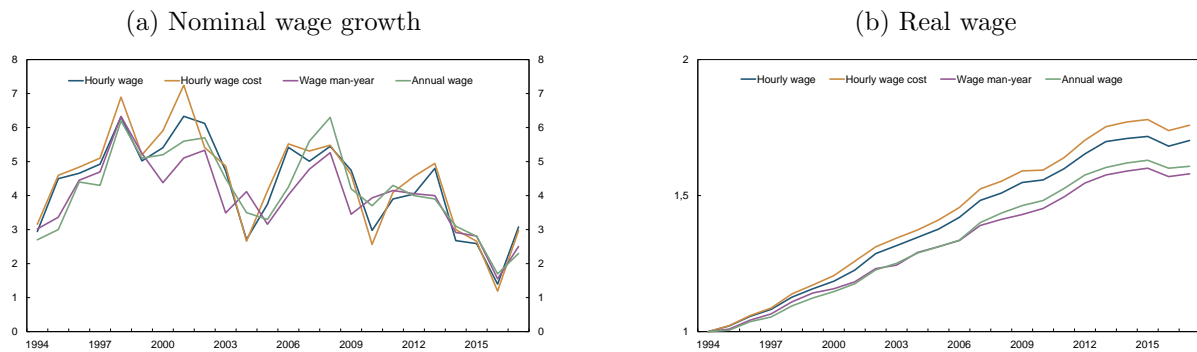
<sup>10</sup>See e.g. Leduc and Wilson (2017).

<sup>11</sup>See e.g. Jacobs and Rush (2015) for a discussion of the Australian experience.

## 2.2 Wage developments in Norway

Figure 1(a), shows wage developments in Norway based on four different measures of labor related costs. Although each measure captures slightly different aspects of wage cost developments, they all reveal the same tendency. Focusing on the period since the financial crisis, there has been a clear downward trend in wage growth, especially since 2013. Measured by real wages, the picture is even starker. In Figure 1(b), we plot real wages in levels. The real wage level was roughly unchanged from 2013 to 2017. In fact, we need to go all the way back to the late '70s and early '80s to find a similar period of weak real wage developments.

Figure 1: Wage developments in Norway



Notes: a) Annual growth. Per cent. 1994-2017 b) Deflated by CPI. Index, 1994 = 1. 1994 – 2017

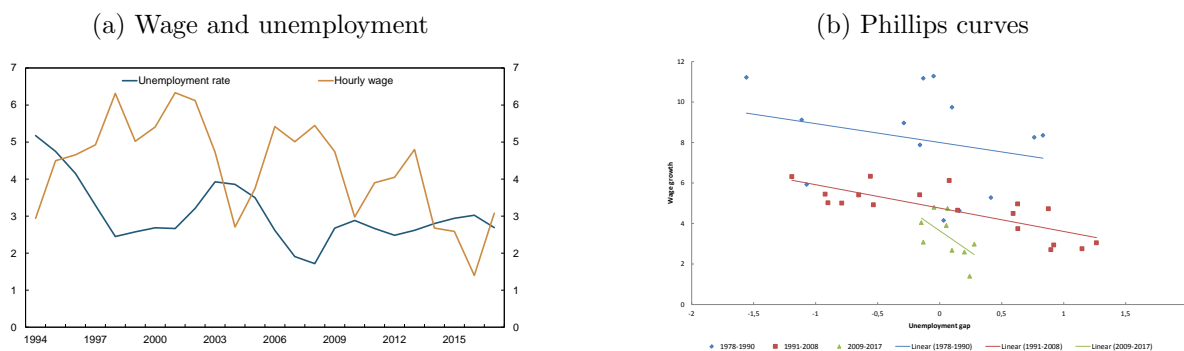
Figure 2(a) depicts wage growth together with the unemployment rate. There is a clear negative correlation between the two variables over the sample period. From 2009 onwards, however, there is a marked variation in wage growth, despite the fact that unemployment has remained fairly stable. This is even clearer if we split the data into different sub-samples. In Figure 2(b), we plot wage growth against the unemployment rate for various periods. The first period stretching from 1978 to 1990 is characterized by years of both high and variable inflation. In the second period, from 1991 to 2008, inflation on average hovered around 2 pct. In the years following the financial crisis, the curve has shifted further inwards, but also seems to have steepened, as alluded to above.

One important factor that could shift the Phillips curve is inflation expectations. Employees ultimately care about the purchasing power of their wage, as measured relative to the consumer price index. To the extent that consumer price inflation is expected to



pick up, unions will try to compensate by demanding higher wages. The downward shift in wage growth from the '70s and '80s is to a large extent driven by lower inflation expectations.

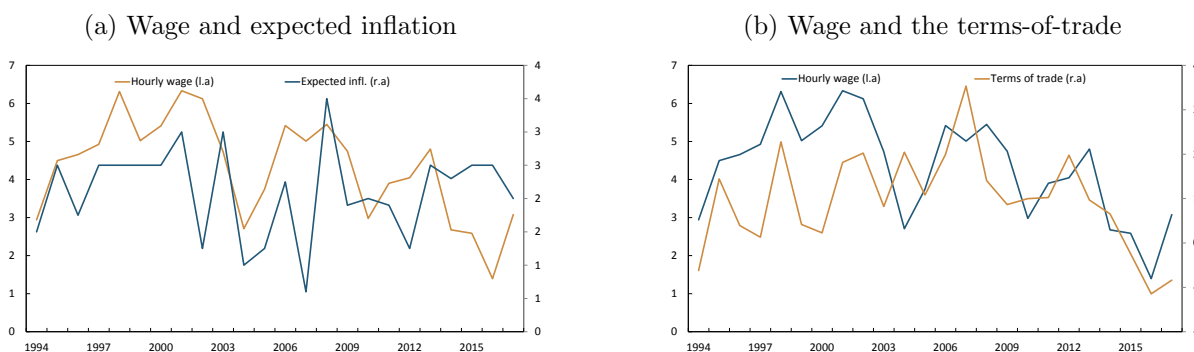
Figure 2: Wage and unemployment



Notes: a) Annual hourly wage growth and registered unemployment. Per cent. 1994 – 2017. b) Annual hourly wage growth and unemployment gap. Per cent. 1978 – 2017.

In Figure 3(a), we plot the growth rate of hourly wages and the inflation forecasts reported by the Technical Calculation Committee for Wage Settlements (TBU).<sup>12</sup> The latter forms a basis for the wage negotiations and can be viewed as a measure of inflation expectations as stated by the labor market organizations. The correlation is far from one-to-one, but there seems to be a reasonably close relation between the two series up until 2013. However, price expectations cannot account for the subdued wage growth from 2013 onwards.

Figure 3: Expected inflation and terms-of-trade



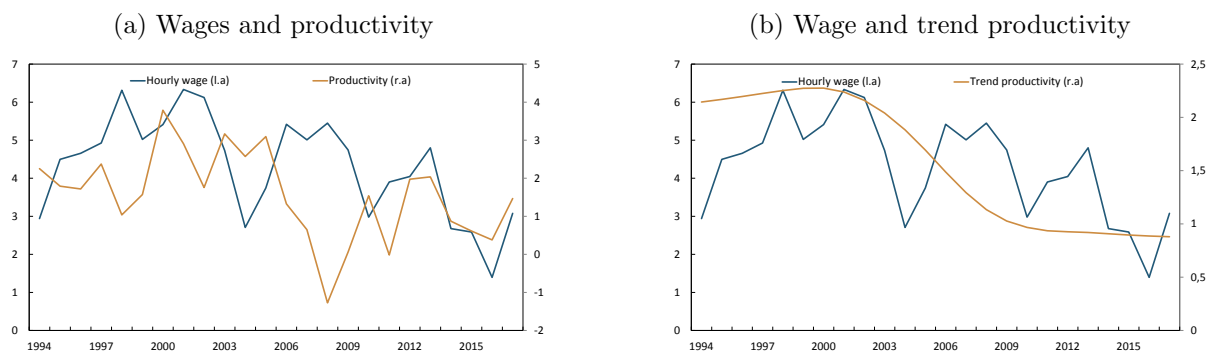
Notes: a) Annual hourly wage growth and current year inflation expectations. Per cent. 1994 – 2017. b) Annual hourly wage growth and the terms-of-trade. Per cent. 1994 – 2017.

In the longer run, economic theory would suggest that real wage growth, measured

<sup>12</sup>TBU is a governmental body set up to facilitate a shared understanding between the social partners regarding the economic situation in Norway, which serves as a reference point in the wage negotiations.

relative to the consumer price index, should follow changes in the terms-of-trade, as measured by producer prices relative to consumer prices, and productivity growth. Norway has experienced large swings in the terms of trade over the last decades, driven both by movements in oil prices and increased imports from low cost countries, e.g. China. In Figure 3(b), we show changes in the terms-of-trade, as proxied by the GDP deflator (mainland Norway) relative to the consumer prices index, and the growth rate of wages. For a large part of the sample period the correlation is quite strong. This is especially true for the period after the financial crisis. Judging from the graph, it would seem that developments in the terms of trade, driven mainly by movements in oil prices, is important for understanding the slowdown in wage growth in the post crisis period.

Figure 4: Wages and productivity



*Notes:* a) Annual hourly wage growth and productivity growth. Per cent. Productivity is mainland GDP divided by total hours worked. 1994 – 2017 b) Annual hourly wage growth and HP-trend of productivity growth. Per cent.

Lower productivity growth will increase wage costs for a given wage rate, leading to lower demand for labor and downward pressure on wages. Productivity growth has fallen in most countries following the financial crisis. Indeed, several studies point to productivity as an important factor in explaining recent wage developments internationally.<sup>13</sup> Several authors have argued for the inclusion of trend, rather than headline, productivity growth alongside cyclical factors.<sup>14</sup> In Figure 4, we therefore plot both actual and trend productivity developments in Norway together with hourly wage growth. Measured by an HP-filter, it seems that productivity growth started on a downward trend long before the financial crisis.

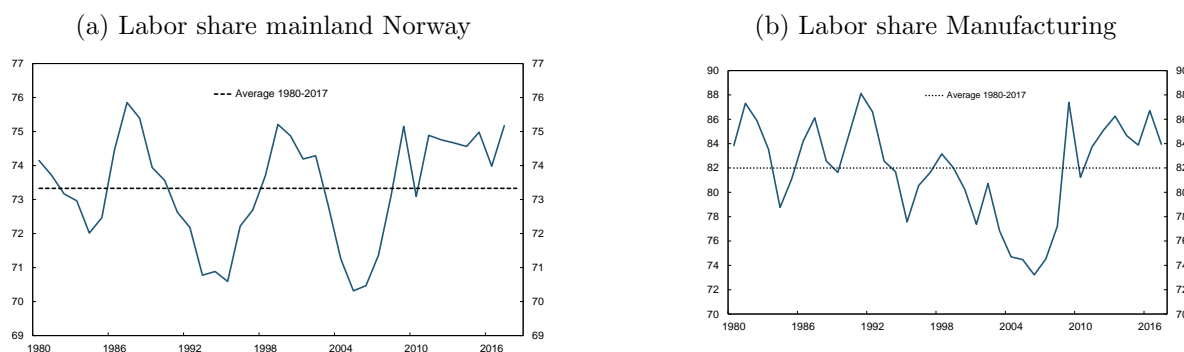
<sup>13</sup>See e.g. IMF (2017).

<sup>14</sup>See e.g. Hall (2005), and Yellen (2005). A theoretical justification for including productivity growth in the wage Phillips curve can be found in e.g. Blanchard and Katz (1997).

## 2.3 The Norwegian system of wage formation

The Norwegian system of wage formation is characterized by highly centralized and coordinated wage negotiations. Another defining feature is the role played by wage developments in the part of the manufacturing industries exposed to international competition. In order to maintain a sufficient share of tradable industries in the economy, it is seen as paramount by both policy makers and labor market organizations to ensure that wage developments over time do not jeopardize competitiveness in these industries. Hence, an important consideration is that wage growth in the tradable industries does not out-pace growth in producer prices and productivity. In order to achieve this, the tradable sector starts by negotiating a wage norm based on profitability considerations. This wage norm in turn forms a basis for consecutive wage negotiations in other sectors of the economy that typically take place after the negotiations in the tradable industries. Although actual outcomes might deviate from the norm in some years, the mean reverting behavior of the wage share, both in the tradable industries and mainland Norway as a whole, indicates that profit sharing is a guiding principle in wage determination in Norway, see Figure 5.

Figure 5: Labor shares in Norway



*Notes:* Labor costs as a percentage of total factor income. 1980 – 2017

The theoretical underpinning for the Norwegian system of wage formation is often referred to as the main-course model, see Aukrust (1977). The framework is based on a two-sector model, separating tradables and non-tradeables, where the tradable sector takes prices as exogenously determined in the world market. Productivity is treated as an exogenous variable in both sectors and labor is the only factor input. In a strict form, the model implies a constant wage share equal to one in both sectors. A more general

formulation is:

$$\frac{W_t}{P_t Z_t} = \frac{\alpha}{\mu_t}$$

where  $W_t$  is the hourly wage rate,  $P_t$  denotes the producer price,  $Z_t$  represents productivity (output per hour) and  $\mu_t$  is a wedge that could be interpreted as the mark-up. The fact that the wage shares in Norway<sup>15</sup> appear to be fairly stationary would suggest that the wedge,  $\mu_t$ , is a stationary variable, typically driven by cyclical factors. Furthermore, this implies that there exists at least one cointegrating relationship between wages, prices and productivity. As a corollary, it follows that at least one of these variables will adjust when wages depart from the value of productivity.<sup>16</sup> In earlier studies of wage equations in Norway, it has been found that there is a tendency of wage growth to slow down whenever wage levels are high relative to the value of productivity, and vice versa.<sup>17</sup>

### 3 Data

We use annual data for the period 1980-2017, during which the labor share is found to be stationary. Our choice of frequency is partly motivated by the fact that the central wage negotiations are undertaken once a year. In addition, quarterly data are quite volatile and do not necessarily reflect the timing of the wage negotiations, nor their fundamental drivers. Modeling quarterly series often results in complicated and opaque short-term dynamics that do not necessarily contribute to the understanding of the wage formation process. As is customary in empirical work on Norwegian data, we use data for mainland Norway, which excludes the direct exposure to the petroleum sector. An overview of the data used in this paper can be found in Table A2.1 (in Appendix A2).

#### **Wages**

In our benchmark set-up, we model hourly wages, defined as wages and salaries paid by employers divided by the total hours worked by employees. However, we also provide results based on wage costs per hour, which includes social security contributions paid

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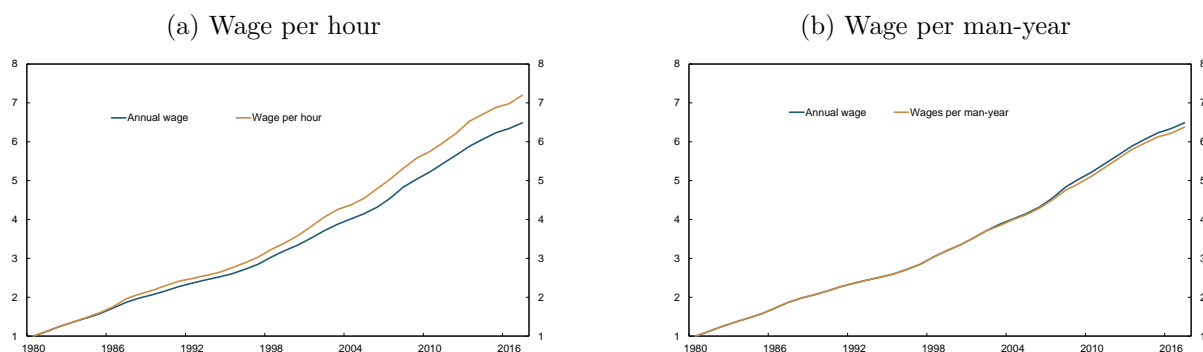
<sup>15</sup>See Hagelund et al. (2017) for a discussion of wage shares in different industries.

<sup>16</sup>See Engle and Granger (1987).

<sup>17</sup>See e.g. Bjørnstad and Nymoene (1999) and Nymoene (2017).

by the employer, and annual wages per man-year, see Figure 1(a). The official forecasts published by Norges Bank are based on annual wages.<sup>18</sup> This is also the variable that all other institutions in Norway, including the Ministry of Finance and Statistics Norway, forecast. Moreover, it serves as the point of reference in negotiations between unions and firms. There are several reasons why we nevertheless primarily focus on the hourly wage. Over time hourly wages have increased more than the annual wage, see Figure 6(a). This reflects that the number of hours per man-year has fallen over time and the actual wage cost of firms is better described by hourly wage. Moreover the hourly wage is more consistent with our preferred measure of productivity - GDP per hour worked. However, as is evident from Figure 1(a), there is a close correspondence between the various wage measures.

Figure 6: Different wage concepts



Notes: Index, 1980 = 1. 1980 – 2017.

### Labor market slack

There are several potential measures of labor market slack. We have chosen to use an unemployment gap based on the registered unemployment rate from the Norwegian labor and welfare administration (NAV). The unemployment gap is calculated using a simple HP-filter with a standard choice of  $\lambda = 100$  for annual data. Thus, in contrast to some of the NAIRU estimates proposed in the literature, the gap is not directly dependent on wage or price growth. We consider this an advantage when the aim of the exercise is to explain wage growth. Moreover, this unemployment gap correlates quite well with Norges Bank's official output gap, which takes into account a number of other indicators of slack. An alternative measure would be the unemployment rate, as reported in the labor force

<sup>18</sup>Annual wage also includes the oil-sector.

survey. This measure is quite volatile in the short term and has lately been at odds with other indicators for the labor markets, including employment from the national accounts.

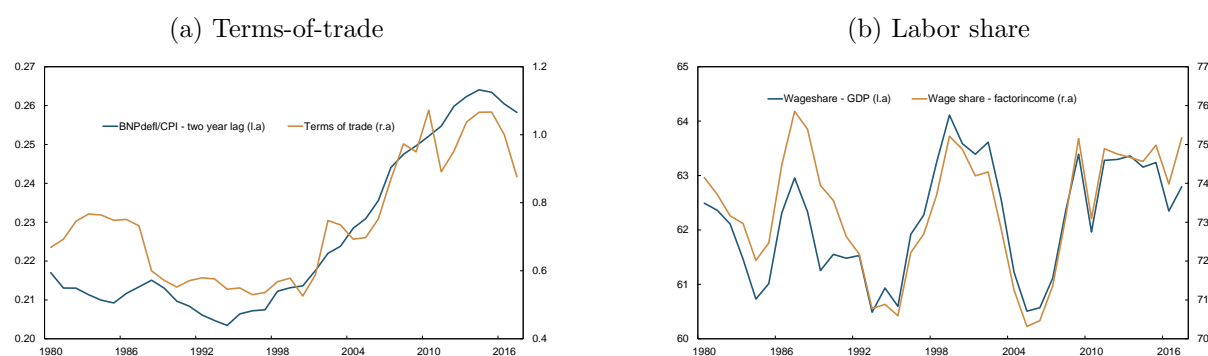
### Productivity

Our productivity measure is calculated as GDP for Mainland-Norway divided by total hours worked. A more consistent approach would be to split GDP into contributions from employees and self-employed persons as the latter group does not receive wages. However, given the available data, such a split would be quite arbitrary and probably would not add much to the analysis.

### Terms of trade

As our measure of the terms-of-trade, we use the ratio between the mainland GDP-deflator and CPI. This measure also represents the wedge between consumer real wages and producer real wages. Whenever producer prices increase relative to consumer prices, there will be scope for both higher consumer real wages and increased profits. Our chosen measure of terms-of-trade for mainland Norway correlates closely with the overall measure, see graph Figure 7(a).

Figure 7: Measures of profitability



*Notes:* a) Terms of trade measured as the exports deflator divided by imports deflator (including the oil sector) and as the mainland GDP deflator divided by CPI, respectively. b) The labor share based on (1): factor income and (2): a proxy calculated using total wage costs divided by GDP for mainland Norway in current prices (nominal GDP). 1980 – 2017.

### Wage share

We define the wage share for mainland Norway as the ratio between compensation of employees in the mainland economy and mainland GDP in current prices. Alternatively, the wage share can be defined as the ratio between the wage compensation of employees and factor income. However, it is not trivial to split factor income into productivity (per

hour) and a GDP-deflator. Hence, we have chosen to use mainland GDP as the income measure. However, the two measures of the labor share for mainland Norway correspond fairly well over the sample period, see 7(b).

## 4 Estimation results

In this section, we test the empirical relevance of the explanatory factors discussed above in explaining wage growth. We proceed in three steps. First, we estimate a fairly standard version of the wage Phillips curve that also includes inflation expectations to account for years where inflation was high and volatile. Next, we augment the standard Phillips curve to take into account changes in productivity and the terms of trade. Finally, we test to what extent firm profitability, as measured by the wage share, impact wage growth.

### 4.1 A standard Phillips curve

Our starting point is a fairly standard expectations augmented Phillips curve, similar to i.e. Galí (2011):

$$\Delta w_t = \alpha + \beta_1 \pi_t^e + \beta_2 \Delta \hat{u}_t + \beta_3 \hat{u}_t + \epsilon_t \quad (1)$$

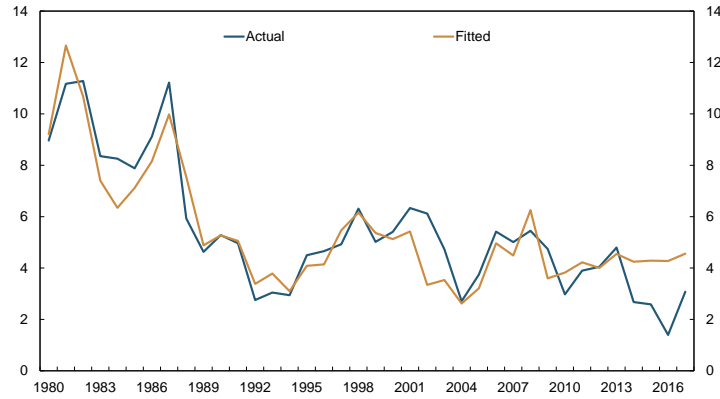
where  $\alpha$  is a constant,  $w_t$  denotes the wage rate (log),  $\pi_t^e$  represents consumer price inflation expectations and  $\hat{u}_t$  is the unemployment gap. One concern might be that the inclusion of inflation expectations for the current year (year  $t$ ) could introduce an endogeneity bias when using OLS. The fact that our measure of inflation expectations is based on the social partners stated expectation at the start of the year, should to some extent alleviate these concerns.<sup>19</sup>

The estimation results are given in Table 1. Both the change and level of the unemployment gap and expected inflation significantly affects wage growth. The model provides a reasonable fit for most of the sample period. However, it is not able to explain

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<sup>19</sup>The existence of a potential endogeneity problem could in principle be checked by comparing the OLS estimates with estimates obtained from running an Instrumental Variable (IV) regression. However, it turned out to be hard finding valid instruments. In small samples, the loss of precision due to weak instruments potentially out-weights the gain from using a consistent estimator.

Figure 8: Actual and fitted values (Model1)



Notes: Annual hourly wage growth. Per cent. Actual and fitted values from Model 1. 1980 – 2017.

the low wage growth in recent years. This is clear from investigating Figure 8, where we plot both the actual wage growth and the corresponding fitted values. Furthermore, judging from the reported AR-test, there seems to be an issue with autocorrelation in the residuals, which points to misspecification. This suggests that there might be a problem of omitted variables or, possibly, a break in the estimated relation over the sample period.

Table 1: A standard Phillips curve

<b>Model 1</b>				
	Const	$\pi_t^e$	$\hat{u}_{t-1}$	$\Delta\hat{u}_t$
$\Delta w_t$	2.94***	0.64***	-1.07***	-1.57***
	[0.30]	[0.06]	[0.29]	[0.40]
	<i>Nobs</i>		38	
	$\bar{R}^2$		0.79	
	$F_{AR}(2, 32)$		4.74**	
	$\chi^2_{Norm}(2)$		2.93	
	$F_{Het}(6, 31)$		0.45	

Notes: Regression results from estimating Equation (1). \*, \*\*, \*\*\* denote significance at 10%, 5%, and 1%, respectively. Standard errors are given in brackets.

## 4.2 An augmented Phillips curve

As alluded to above, both productivity growth and changes in the terms of trade could help improve the fit of the model. Hence, we augment the standard Phillips curve

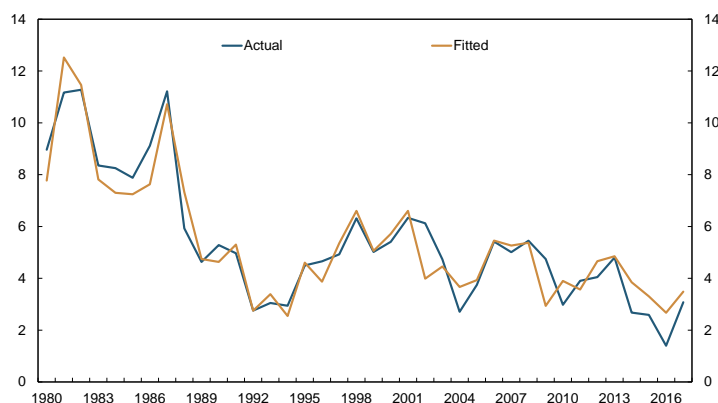


in Equation (1) to include measures of productivity and the terms of trade, respectively:

$$\Delta w_t = \alpha + \beta_1 \pi_t^e + \beta_2 \Delta \hat{u}_t + \beta_3 \hat{u}_t + \beta_2 \Delta z_t + \beta_3 \Delta \tau_t + \epsilon_t \quad (2)$$

where  $\Delta z_t$  represents productivity growth and  $\Delta \tau_t$  is a measure of the changes to the terms of trade. As can be judged from Table 2, both variables are highly significant and have the expected signs. Stronger productivity growth and improvements in the terms-of-trade unambiguously lead to higher wage growth, beyond what is captured by labor market slack.

Figure 9: Actual and fitted values (Model2)



Notes: Annual hourly wage growth. Per cent. Actual and fitted values from Model 2. 1980 – 2017.

Several studies have suggested employing a measure of trend productivity growth rather than the actual growth rate. The rationale behind this could be related to wage rigidities and that both employers and employees see through what is perceived as temporary changes in productivity. Hence, it can be argued that it is the underlying productivity growth that should matter. The same argument also apply to changes in the terms of trade, and we therefore also ran regressions where we replaced the growth rates in productivity and terms-of-trade with their trend equivalents. However, regressions using trend variables were slightly inferior to the model reported in Table 2 (as measured by the R-squared).

The in-sample fit of Model 2 is shown in Figure 9. Overall, the preferred equation seems to give a reasonable account of actual developments. However, it is worth noting that there still appears to be some negative residuals toward the end of the sample period.

Table 2: An augmented Phillips curve

<b>Model 2</b>						
	Const	$\pi_t^e$	$\hat{u}_{t-1}$	$\Delta\hat{u}_t$	$\Delta z_t$	$\Delta\tau_t$
$\Delta w_t$	1.45***	0.78***	-0.95***	-1.42***	0.44***	0.57***
	[0.38]	[0.06]	[0.27]	[0.35]	[0.14]	[0.15]
	<i>Nobs</i>			38		
	$\bar{R}^2$			0.88		
	$F_{AR}(2, 30)$			0.05		
	$\chi^2_{Norm}(2)$			2.40		
	$F_{Het}(10, 27)$			0.91		

*Notes:* Regression results from estimating Equation (2). \*, \*\*, \*\*\* denote significance at 10%, 5%, and 1%, respectively. Standard errors are given in brackets.

Indeed, performing a one-step forecast test for the period 2014-2017 indicates that there might be an issue of parameter instability (not reported). Still, we conclude that a standard Phillips curve augmented with measures accounting for productivity growth and the terms of trade explain wage growth over the sample period fairly well.

### 4.3 Including the labor share

As mentioned above, the wage share for mainland Norway has been fairly stable over the last 40 years. In periods where the wage level has been high relative to the average level of productivity (in value terms), there has been a tendency of mean reversion in subsequent periods. Hence, a reasonable hypothesis is that there is an error correction mechanism at work ensuring that wage levels do not drift too far away from the (value) level of productivity. This is also consistent with what the main-course model would predict. If this is the case, regressions based exclusively on differenced variables risk losing valuable information. Hence, in the following we investigate the importance of the labor share in explaining historical movements in wage growth. To this end we add a measure of the labor share for Mainland Norway to Equation (2):

$$\Delta w_t = \alpha + \beta_1 \pi_t^e + \beta_2 \Delta \hat{u}_t + \beta_3 \hat{u}_t + \beta_2 \Delta z_t + \beta_3 \Delta \tau_t + \alpha \omega_{t-1} + \epsilon_t \quad (3)$$

where  $\omega_t$  denotes the labor share.<sup>20</sup>

<sup>20</sup>On log-form we have that  $\omega_t = w_t - p_t - z_t + tax_t$ , where  $tax_t$  represents social security contributions paid by the employers (all variables are in log levels).

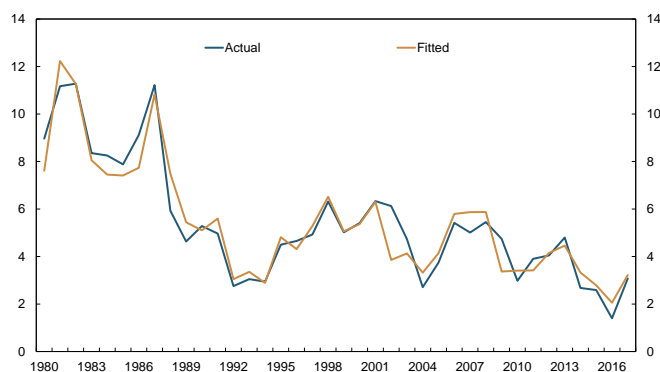
The estimation results can be found in Table 3. All coefficients have the expected signs. The estimated model includes all the explanatory variables that appeared in the augmented Phillips curve. In addition, the wage share, i.e. the error correction term, is found to be significant. With an adjusted R-squared of roughly 0.9, the estimated model explains most of the variation in wage growth over the sample period. Furthermore, the model is economically meaningful. Wage growth is driven by expected inflation, both the level and changes in the unemployment rate, changes in producer prices relative to consumer prices, which is a reasonable proxy for changes in the terms of trade, and changes in productivity. Finally, wage growth also depends on the level of wages relative to the value of productivity. This reflects the profit sharing aspect which seems to be an inherent feature of wage formation in Norway.

Table 3: The full model

<b>Model 3</b>							
	Const	$\pi_t^e$	$\hat{u}_{t-1}$	$\Delta\hat{u}_t$	$\Delta z_t$	$\Delta\tau_t$	$\omega_{t-1}$
$\Delta w_t$	-12.17**	0.76***	-1.28***	-1.12***	0.51***	0.57***	-0.29**
	[5.16]	[0.05]	[0.28]	[0.34]	[0.13]	[0.14]	[0.11]
	<i>Nobs</i>			38			
	$\bar{R}^2$			0.90			
	$F_{AR}(2, 29)$			0.19			
	$\chi^2_{Norm}(2)$			5.30			
	$F_{Het}(12, 25)$			0.91			

*Notes:* Regression results from estimating Equation (3). \*, \*\*, \*\*\* denote significance at 10%, 5%, and 1%, respectively. Standard errors are given in brackets.

Figure 10: Actual and fitted values (Model3)

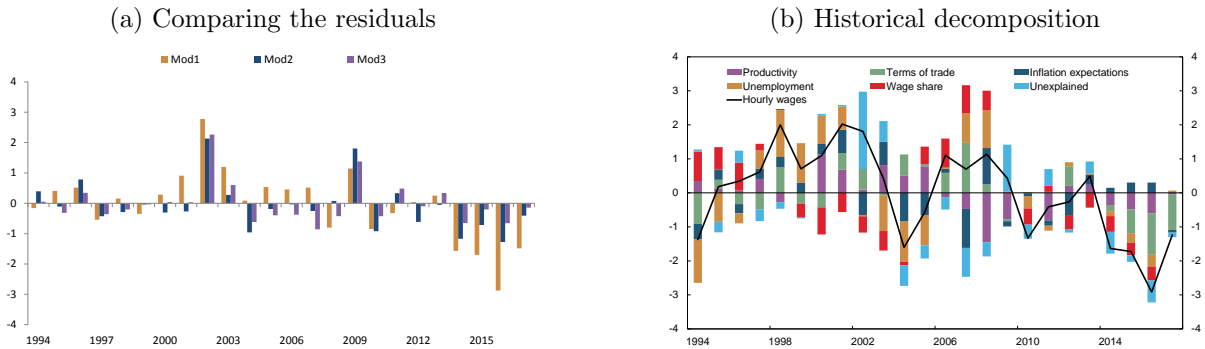


*Notes:* Annual hourly wage growth. Per cent. Actual and fitted values from Model 3. 1980 – 2017.

## 5 Model comparison

In order to assess the additional gain from expanding the standard Phillips curve specification introduced in Equation (1), we compare the residuals from Model 1 to the residuals obtained in Model 2 and Model 3, respectively. The three residual series' are shown in Figure 11(a). Given the fact that each successive extension of the benchmark model has increased the overall fit, the sum of the squared residuals will of course be smaller in the fully augmented model (Model 3). Still, there are periods where Model 3 have larger residuals than Model 2. However, the full model clearly does a better job in explaining recent developments. Hence, taking into account the level information included in the labor share helps explaining wage growth in particular in recent years.

Figure 11: Residuals and contributions



*Notes:* a) Difference between actual wage growth and fitted values. 1994 – 2017 b) All variables measured as deviation from mean. 1994-2017.

To shed some light on the relative importance of the explanatory factors, we decompose the historical wage growth into the marginal contributions from each factor as implied by Model 3, see Figure 11(b). Focusing on the recent history, we observe that the below average wage growth in recent years can be explained by sluggish productivity growth and a deterioration in the terms-of-trade. In addition, a historically high labor share, or equivalently, low profitability has weighted on wage growth.

Although the residuals are small, and well within the realms of statistical normality, it is still true that, even in the full model, the fitted values overstate actual outcomes in recent years. This serves as a reminder that wage growth since 2013 has been on the low side in an historical perspective. While our preferred model does pass all standard stability tests, we cannot exclude the possibility that there have been structural changes

at play. Some commentators have pointed to changes in the wage negotiation system that followed the recommendations put forward by the Holden committee (see NOU, 2013). We agree that the strengthened focus on the tradable industries as wage leader in the central negotiations might have had some disciplinary effect. However, to what extent this has more permanently reduced wage growth for a given level of labor market slack, or even reduced the NAIRU, remains to be seen.

## 6 Conclusion

In this paper, we augment the standard closed economy Phillips curve to take into account changes in productivity and the terms of trade. In line with earlier findings based on Norwegian wage data, we find evidence that not only the growth rate of the value of productivity, but also the wage level relative to the value of productivity, i.e. the wage share, matters for wage growth. High wage levels relative to revenues significantly dampens future wage growth, and vice versa. This effect seems to have been relatively pronounced in recent years. According to the preferred model, the subdued wage growth since 2013 can be attributed to a deterioration in the terms of trade (a drop in oil prices), low productivity growth and, despite the decline in wage growth, a consistently high labor share.

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# Appendix

## A1. Robustness issues

As a robustness check, we have tested for the significance of alternative explanatory variables and experimented with various lag specifications. Regarding the latter, we started out with a more general lag structure before arriving at the final specification reported in Table 3 by successively removing insignificant regressors. Turning to additional variables we also tested for the significance of labor immigration, union participation and changes in taxes. However, none of them turned out to be significant when added to equation 3. Most previous studies have used CPI as a measure of price expectations (lagged) or to account for wage indexation. However, we found the inflation expectations variable reported by TBU to be superior in our specifications.

We have also estimated the model over the sub-sample 1994 to 2017, which has been a period characterized by stable inflation. The results are given in Table 4. With the exception of the change in the unemployment rate, all variables are significant. Furthermore, the coefficients appear to be rather similar. As mentioned in Section 3, the relevant

Table 4: The full model - shorter sample

	Const	$\pi_t^e$	$\hat{u}_{t-1}$	$\Delta\hat{u}_t$	$\Delta z_t$	$\Delta\tau_t$	$\omega_{t-1}$
$\Delta w_t$	-18.92*** [5.10]	0.58** [0.21]	-1.58*** [0.29]	-0.001 [0.37]	0.60*** [0.13]	0.55*** [0.12]	-0.44*** [0.11]
<i>Nobs</i>	24						
			$\bar{R}^2$	0.80			
			$F_{AR}(2, 15)$	0.16			
			$\chi_{Norm}^2(2)$	3.92			
			$F_{Het}(12, 11)$	0.66			

*Notes:* Estimation results from estimating Equation (3). Sample period: 1994-2017. \*, \*\*, \*\*\* denote significance at 10%, 5%, and 1%, respectively. Standard errors are given in brackets.

wage concept will depend on the purpose at hand. In line with earlier empirical studies based on Norwegian data, we have employed the growth rate in wages per hour worked, received by employees. In empirical models of inflation, total wage costs including indirect wage costs borne by employers, would be a more appropriate measure. Another wage concept is wages per man-year, which is closely related to the definition (annual wage) used by both the social partners and professional forecasters in Norway, including Norges



Bank. Even though the definitions differ, they share a high degree of overlap, which is also clear from 1(a). Hence, all variables explaining hourly wages should also be relevant for explaining both wage costs and wages per man-year. In order to investigate this, we have estimated two additional wage equations based on these concepts. The results are shown in Table 5 and Table 6, respectively.

Table 5: Wages per man-year

	Const	$\pi_t^e$	$\hat{u}_{t-1}$	$\Delta\hat{u}_t$	$\Delta z_t$	$\Delta\tau_t$	$\Delta hn_t$	$\omega_{t-1}$
$\Delta w_t^n$	-9.93**	0.75***	-1.05***	-1.01***	0.39***	0.52***	0.58***	-0.24**
	[5.05]	[0.05]	[0.28]	[0.34]	[0.14]	[0.14]	0.21]	[0.11]
	<i>Nobs</i>				38			
	$\bar{R}^2$				0.90			
	$F_{AR}(2, 28)$				0.23			
	$\chi_{Norm}^2(2)$				5.40*			
	$F_{Het}(14, 23)$				0.73			

*Notes:* Estimation results from regressing  $\Delta w_t^n$  on the same set of regressors as in Equation (3). Sample period: 1980-2017. The labor share is now defined as  $\omega_t = w_t^n - p_t - z_t + tax_t - nh_t$ , where  $nh_t$  is total hours relative to standard man-year hours. \*, \*\*, \*\*\* denote significance at 10%, 5%, and 1%, respectively. Standard errors are given in brackets.

Table 6: Wage costs

	Const	$\pi_t^e$	$\hat{u}_{t-1}$	$\Delta\hat{u}_t$	$\Delta z_t$	$\Delta\tau_t$	$\omega_{t-1}$	
$\Delta w_t^c$	-11.79**	0.76***	-1.60***	-1.45***	0.61***	0.62***	-0.28**	
	[5.12]	[0.05]	[0.28]	[0.34]	[0.13]	[0.14]	[0.11]	
	<i>Nobs</i>				38			
	$\bar{R}^2$				0.89			
	$F_{AR}(2, 29)$				0.15			
	$\chi_{Norm}^2(2)$				0.43			
	$F_{Het}(12, 25)$				1.95*			

*Notes:* Estimation results from regressing  $\Delta w_t^c$  on the same set of regressors as in Equation (3). Sample period: 1980-2017. The labor share is now defined as  $\omega_t = w_t^c - p_t - z_t$ . \*, \*\*, \*\*\* denote significance at 10%, 5%, and 1%, respectively. Standard errors are given in brackets.

Not surprisingly, the variables that explain hourly wage growth also significantly affects both growth in wage costs and wages per man-year. Overall the parameter estimates are also quite similar. In the equation for wage per man-year, we also included changes in the ratio of total hours to hours per standard man-year which turned out to be significant. This accounts for the included number of working hours, variation in overtime and calendar related effects.

Table A2.1: Variable definitions and data descriptions

Variables	Data description	Source
Wage per hour ( $w$ )	Wages and salaries per hour worked. Wages and Salaries are total wages paid to employees in Mainland-Norway. It includes bonuses and overtime. Hours worked is the total actual hours worked by employees in Mainland Norway. Hours worked exclude time off for holidays and sickness, but include overtime.	Statistics Norway and Norges Bank
Wage cost per hour ( $w^c$ )	Compensation of employees per hour worked. Compensation of employees includes wages and salaries paid to employees and employers' social security contributions.	Statistics Norway and Norges Bank
Wage per man-year ( $w^c$ )	Wages and salaries per man year. A man-year is the sum of full time employees and part time employees where the latter is recalculated into full-time equivalents.	Statistics Norway and Norges Bank
Unemployment gap ( $\hat{u}$ )	The difference between the actual unemployment rate and a trend from a HP-filter with $\lambda = 100$ . The unemployment measure is the unemployment ratio reported by the Norwegian labor and welfare administration (NAV)	Norges Bank and NAV
Inflation expectations ( $\pi^e$ )	Current year projection for CPI from the Technical Calculations Committee for Wage Settlements (TBU) in the report prior to the central wage negotiation	Statistics Norway
Terms of trade ( $\tau$ )	The ratio of the GDP-deflator (for Mainland-Norway) and the CPI. The GDP-deflator is calculated as the ratio of GDP Mainland Norway, basic values, current prices and GDP Mainland Norway, basic values, fixed 2005 prices	Statistics Norway and Norges Bank
Productivity ( $z$ )	The ratio of GDP Mainland Norway, basic values, fixed 2005-prices and total hours worked (including the self-employed)	Statistics Norway and Norges Bank
Labor share ( $\omega$ )	The ratio of compensation of employees and GDP Mainland Norway, basic values, current prices. In the equations the wage share is written in logs as the hourly wage costs minus productivity and GDP deflator	Statistics Norway and Norges Bank
Total hours per standard man-year ( $nh$ )	Total hours worked divided by the number of hours constituting a standard man-year, excluding self-employed.	Statistics Norway and Norges Bank