A changed labour market – effects on prices and wages, the Phillips curve and the Beveridge curve

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In the period after the global financial crisis 2008–2009, price and nominal wage growth have been relatively weak. In addition, some economic relationships have changed: The Phillips curve, i.e. the correlation between nominal wage growth and unemployment, has become flatter while the Beveridge curve, i.e. the correlation between vacancies and unemployment, has shifted outwards. In this article we examine to what extent changes in the Swedish labour market may have contributed to these developments. We first present empirical evidence of various changes in the Swedish labour market. We then show that – in a macroeconomic model with search and matching frictions – several of these changes may have contributed to lower prices and wages as well as a flatter Phillips curve. We also show that the outward shift in the Beveridge curve can only partly be explained by our estimated reduction in the matching efficiency.

1 Introduction

Ten years ago, in the autumn of 2008, the global financial crisis broke out. It started in the United States, but spread quickly to Europe and other parts of the world. The recovery after the crisis has been unexpectedly slow, even if growth rates in recent years have been picking up. From the Riksbank's perspective, it is primarily the relatively weak price and nominal wage growth that have been the surprising factors. Inflation measured in terms of the CPIF has on average been around 0.3 percentage points lower after the crisis and nominal wage growth around 1.1 percentage points lower.[1] Furthermore, economic relationships with implications for monetary policy have changed: The Phillips curve – the correlation between nominal wage growth and unemployment – has become flatter while the Beveridge curve – the correlation between vacancies and unemployment – has shifted outwards.[2]

The economic development after the financial crisis has to large extent been characterised by increased globalisation and digitalisation, encouraging more international trade and greater labour mobility. The demographic development indicates a population structure with more elderly people and at the same time there are extensive migration flows. In addition, a number of economic policy reforms focusing on the labour market have been implemented. All of these factors affect the labour market in some way, but exactly

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1 The period before the financial crisis refers to 2000–2007 and the period after to 2010–2018.

2 The Phillips curve is named after the economist, William Phillips, who, using British data for the period 1861–1957, estimated a negative correlation between nominal wage growth and unemployment. Subsequently, the Phillips curve has been broadened and can now contain a number of different specifications. In this study, however, we use the original specification from Phillips (1958). The Beveridge curve is named after the British economist, William Beveridge, for his commitment to unemployment and matching issues.

how is difficult to know. Nevertheless, empirical estimates and data suggest a number of changes in the labour market after the financial crisis, among others:

(i) Higher labour force participation

(ii) Reduced matching efficiency

(iii) Lower unemployment benefits

(iv) Weaker bargaining power among employees

The aim of this study is to examine to what extent these changes may have contributed to the weak price and wage growth, the flatter Phillips curve and the shift in the Beveridge curve. To do this, we use a macroeconomic model with search and matching frictions. The model is designed to analyse the labour market and its interaction with the rest of the economy. We can therefore use this model to illustrate and quantify how different changes in the labour market affect prices and wages as well as economic relationships such as the Phillips- and Beveridge curves. The model is calibrated to match basic Swedish labour market data.

According to the model, higher labour force participation, lower unemployment benefits and weaker bargaining power lead to both lower prices and wages while reduced matching efficiency leads to higher prices and wages. We therefore, on balance, consider it likely that the changes in the labour market have contributed to lower price and wage outcomes.

It has been widely recognised that the slope of the Phillips curve has changed after the financial crisis and become flatter. Changes in the labour market can be particularly important for this, since both wages and unemployment are determined there. We show that shocks to the labour force participation rate give rise to a negative slope, but that shocks to the bargaining power, unemployment benefits and matching efficiency all lead to a positive slope. Hence, some of the changes in the labour market that we have observed may have contributed to the flatter Phillips curve.

Finally, we show that the Beveridge curve has become steeper and shifted outwards after the financial crisis. Shifts in the Beveridge curve are often explained by permanent changes in matching efficiency. However, according to the model our estimated reduction in matching efficiency after the financial crisis cannot explain the entire shift. A reduction in matching efficiency in line with our estimates can, at most, explain about a third of the shift in the Beveridge curve.

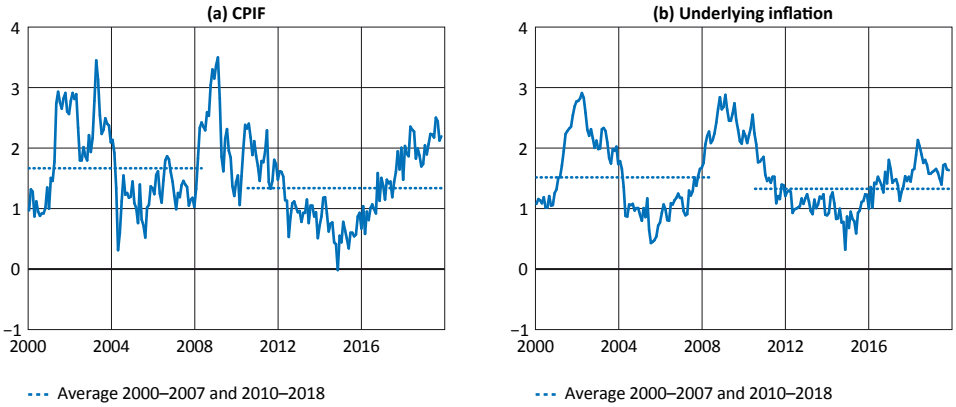
The outline of the article is as follows: Sections 2 and 3 show how prices and wages, the Phillips curve, the Beveridge curve and a number of key labour market variables have changed after the financial crisis. In the fourth and fifth sections, we show how the changes in the labour market may have contributed to lower price and wage growth and a flatter Phillips curve. Section 6 shows that our estimate of the reduction in matching efficiency can only explain a smaller part of the outward shift in the Beveridge curve. The seventh section concludes. A description of the macroeconomic model and the method to estimate the matching efficiency can be found in Appendices A and B.

2 Weak price and wage growth, a flatter Phillips curve and a shift in the Beveridge curve

Price and wage growth have both been weak after the global financial crisis in 2008–2009.[3] Inflation measured in terms of the CPIF has been around 0.3 percentage points lower after the crisis, see Figure 1a. Other measures of inflation also suggest a weak development. Inflation measured as an average of underlying measures has been around 0.2 percentage points lower, see Figure 1b.

3 This is not just a Swedish phenomenon; similar developments have occurred in many other countries, see IMF (2016) and IMF (2017).

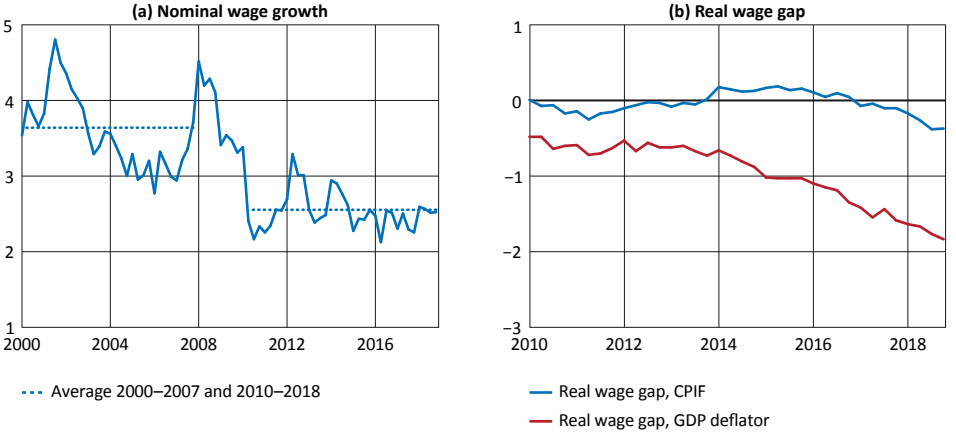
Figure 1. Inflation measured with the CPIF and underlying inflation, before and after the financial crisis
Annual percentage change



Note. Underlying inflation is calculated as an average of the CPIF excluding energy, UND24, Trim85, CPIF excluding energy and perishables, persistence-weighted inflation (CPIFPV), factors from principal component analysis (CPIFPC) and weighted mean inflation (Trim1).
Sources: Statistics Sweden and own calculations

Regarding wages, both nominal and real wages have had a weak development. Figure 2a shows that nominal wage growth has been 1.1 percentage points lower on average after the crisis. The real wage has also been low, but is sensitive to which deflator is used to adjust the nominal wage. We illustrate this by showing two measures in Figure 2b: one where the nominal wage has been adjusted with the CPIF, and one where it has been adjusted with the GDP deflator.[4] Both measures indicate that the real wage has fallen after the financial crisis relative to its trend before the crisis. Adjusted with the CPIF, the real wage has fallen by just under 0.5 per cent while adjusted with the GDP deflator, it has fallen by just under 2 per cent.

Figure 2. Nominal wage growth before and after the financial crisis and the real wage gap after the financial crisis
Annual percentage change and per cent respectively



Note. Wages refer to short-term wages. The real wage gap is calculated as the percentage difference between actual real wages and the trend in real wages prior to the financial crisis.
Sources: National Mediation Office, Statistics Sweden and own calculations

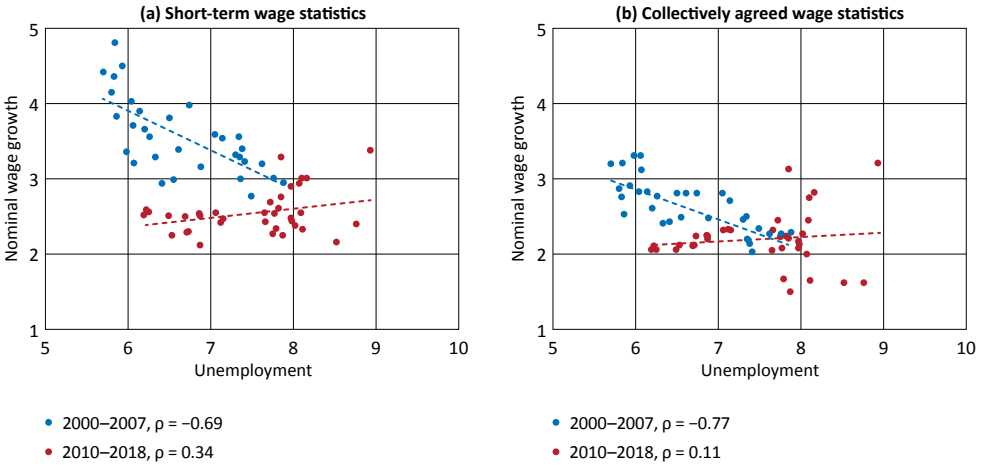
The labour market is of central importance for the Phillips curve, since both wages and unemployment are determined there. A common interpretation of the Phillips curve's negative slope is that falling unemployment leads to a tighter labour market, which makes it more difficult for companies to recruit new employees.[5] This drives up wages and gives

4 The GDP deflator includes prices of domestically produced goods and services. The CPIF includes prices of domestic and imported consumption goods.
5 Labour market tightness is defined as the number of vacancies in relation to the number of unemployed people. On a tighter labour market, it is more difficult for companies to fill their vacancies.

rise to a negative correlation between wages and unemployment, which Phillips (1958) also found in the data. But economic correlations typically vary over time. Several studies have highlighted that the slope of the Phillips curve has changed after the financial crisis.[6] Before the crisis, the slope in most studies was clearly negative, while post crisis it has become flatter and slightly positive.

Figure 3 shows how the slope of the Phillips curve has flattened in Sweden. Prior to the financial crisis, the slope was negative with a slope coefficient of –0.52 and a correlation coefficient of –0.69 when wages are measured by short-term wages. If wages are instead measured by collectively agreed wages, the slope coefficient is –0.40 and the correlation coefficient is –0.77. After the financial crisis, both the slope and the correlation have become slightly positive. The slope coefficient is, depending on the wage measure, 0.14 or 0.06 and the correlation coefficient is 0.34 or 0.11.

Figure 3. The Phillips curve, before and after the financial crisis, estimated with short-term wage statistics and collectively aggreed wage statistics
Annual percentage change and percentage of the labour force



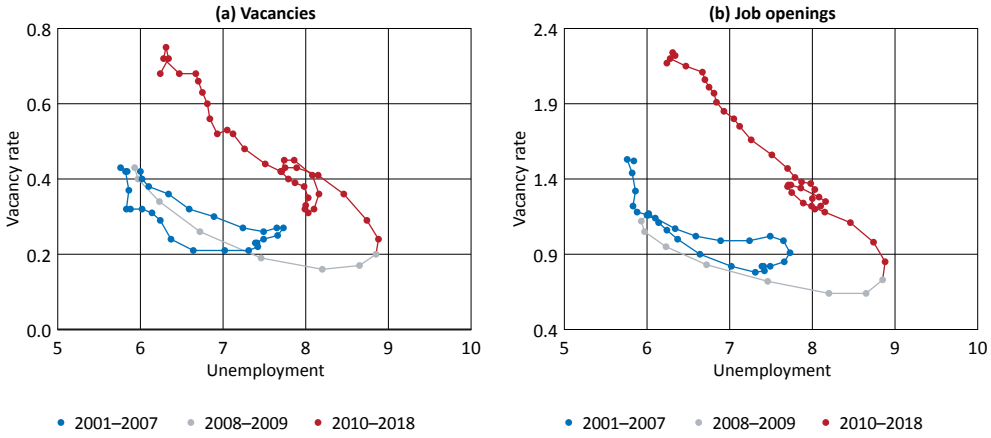
Note. Seasonally adjusted data. Nominal wage growth refers to annual percentage change, unemployment refers to percentage of the labour force, 15–74 years and ρ denotes the correlation coefficient. The blue broken line in Figure 3a shows w = 7.01 – 0.52u and the red broken line w = 1.55 + 0.14u, where w denotes nominal wage growth and u unemployment. In Figure 3b, the blue broken line shows w = 5.31 – 0.40u and the red broken line w = 1.76 + 0.06u.
Sources: National Mediation Office, Statistics Sweden and own calculations

The Beveridge curve shows how well the matching process in the labour market is working. In a labour market where the matching works well, few vacancies are associated with high unemployment and, conversely, many vacancies are associated with low unemployment. This means that the Beveridge curve has a negative slope and that fluctuations in economic activity cause movements along the curve. In economic downturns, the number of vacancies falls while unemployment rises, whereas in economic upturns, the number of vacancies rises while unemployment falls.

The blue line in Figure 4 shows the Beveridge curve before the financial crisis, the grey line shows the curve during the crisis and the red line shows its post-crisis development. In the wake of the financial crisis, there is a clear shift outwards of the Beveridge curve. It is worth noting that the slope of the curve is stable and negative both before and after the financial crisis. Although the slope becomes steeper after the crisis.

6 See for instance Swedish Association of Industrial Employers (2017).

Figure 4. The Beveridge curve, before and after the financial crisis, estimated with vacancies and job openings
Percentage of labour force



Note. Seasonally adjusted data, trend values. The two figures show two different measures of vacancies (labelled 'vacancies' and 'job openings' in the Swedish statistics) as a percentage of the labour force aged 15–74 years. Unemployment refers to the number of unemployed people as a percentage of the labour force aged 15–74 years.
Sources: Statistics Sweden and own calculations

3 The labour market before and after the financial crisis

The development within the information and communication technologies – the digitalisation of the economy – has been rapid in recent years, increasing the scope for automation of more jobs. In the past this has often affected jobs with routine tasks, but nowadays more advanced tasks can also be performed by smart robots.[7] Digitalisation has also accelerated the globalisation process, encouraging increased trade and greater labour mobility as countries become more closely integrated. The Swedish economy is also characterised by a demographic development with a more ageing population as well as extensive migration. In addition, a number of economic policy reforms focusing on the labour market have been implemented. How these developments have affected the labour market is difficult to know, but data and empirical estimates suggest that the labour market has changed in a number of ways after the financial crisis.

3.1 Higher labour force participation after the financial crisis

Labour force participation, i.e. the percentage of the working-age population that is either in work or searching for work, usually varies over the business cycle. However, after the financial crisis labour force participation has shown a more or less steady rising trend, see Figure 5a. The average labour force participation rate has increased from just under 71 per cent prior to the financial crisis to just under 72 per cent afterwards, an increase of around 1.1 per cent. The increase is largely due to high population growth, which, in part, is due to high immigration. A large number of the immigrants have been between 25 and 54 years of age. This is a group with a high labour force participation rate. Other factors that may also have contributed are various economic policy measures that have increased the incentive to work.[8]

7 See for example Roine (2016).
8 The Swedish Fiscal Policy Council (2014) has highlighted the earned income tax credits as an important cause of the increased labour supply as this has incentivised people to look for work. Furthermore, an increased earned income tax credit was introduced for the over-65s, providing them with an incentive to remain in the labour market for longer. See also Swedish Ministry of Finance (2011) and Flodberg and Löf (2017) for a discussion on how various economic policy reforms have affected the labour market.

3.2 Reduced matching efficiency after the financial crisis

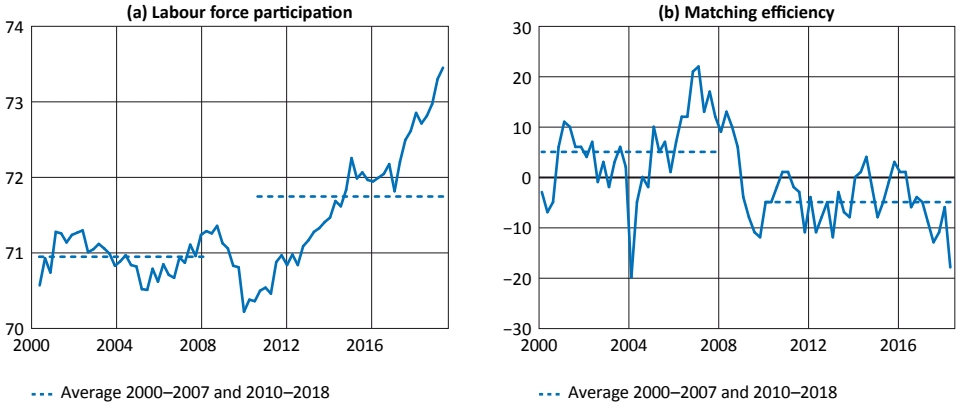
How well the matching between job-seekers and vacancies are working is often measured with what economists call matching efficiency. However, this variable cannot be observed and must therefore be estimated. We use a matching function for this, from which the following expression can be derived,[9]

$$(1) \qquad \ln P_t = \ln \overline{Y} + (1-\alpha)\,\theta_t + \epsilon_t,$$

where P denotes the probability of finding a new job (the job-finding rate), θ the labour market tightness, $\overline{Y}$ the mean of the matching efficiency and ϵ is an independent and normally distributed random variable with zero mean. This variable measures deviations of the matching efficiency from the mean. Figure 5b shows our estimation of the matching efficiency prior to and after the financial crisis. In the wake of the financial crisis, matching efficiency fell sharply and has since become stuck at low levels. On average, it has been just under 10 per cent lower after the financial crisis.

The matching efficiency normally falls in economic downturns. Certain types of skills become outdated while new ones are in demand. For the individual this means that some form of further training is needed. Moreover, a long period of unemployment causes unemployed people to lose their work-related skills, making matching even more difficult. Normally, as the economic activity improves, so too does matching efficiency. But this has not occurred as quickly as expected. Instead, matching efficiency is approximately at the same level as in 2010. One reason for this may be the unusually high immigration numbers in 2015–2016.

Figure 5. Labour force participation and matching efficiency, before and after the financial crisis
Percentage of the population and percentage deviations from the mean



Note. Labour force participation show the number of unemployed and employed as per cent of the population, 15–74 years. Matching efficiency refers to percentage deviations from the mean. A matching efficiency of zero is in line with the historical average.
Sources: Statistics Sweden and own calculations

3.3 Lower unemployment benefits after the financial crisis

The design of tax and benefit systems are important for how well the labour market function, as they affect people's incentive to participate in the labour force and to look for work. The unemployment benefits, measured relative to wages, are an important factor in this context, since it measures the share of income an individual is allowed to maintain if becoming unemployed. From the beginning of the 2000s up until 2018, the unemployment benefits have steadily fallen with the exception of the upturn in 2015–2016, see Figure 6a. On average, the unemployment benefits have been just under 21 per cent lower after the

9 See Appendix B for a derivation and the National Institute of Economic Research (2016) and Håkansson (2014), who use a similar method.

financial crisis. Rising wages are an important factor for this development, although reduced benefit ceilings in the unemployment insurance system and the introduction of earned income tax credits have also played a part, see National Institute of Economic Research (2016). The distinct upturn in 2015–2016 was a result of the government raising the maximum daily allowance and benefit ceiling in the unemployment insurance system.

3.4 Weaker bargaining power after the financial crisis

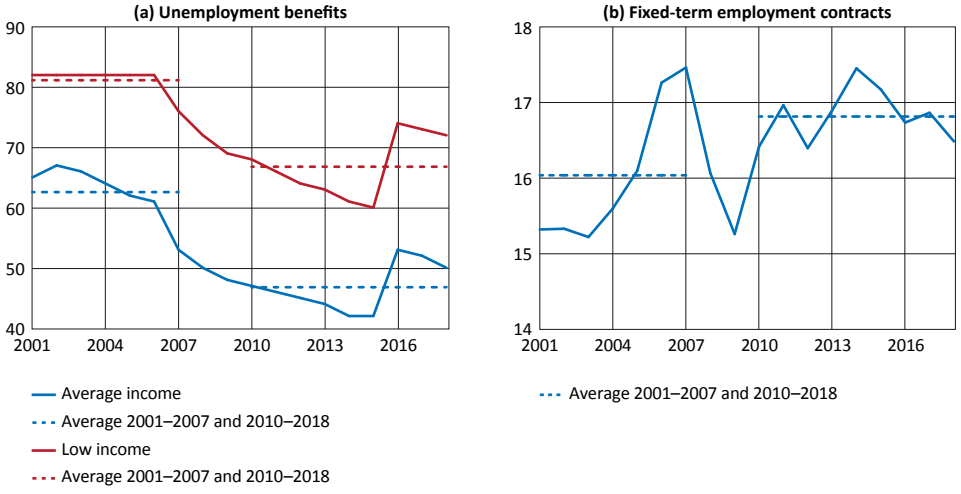
Another important factor regarding the functioning of the labour market is the bargaining power of employees. There are indications that the bargaining power have been weakening for some time. Unionisation has declined by around 15 per cent since the early 2000s.[10] Some of this decline can be explained by the increase of foreign-born people. Employment growth has been strong among those people, but they are joining trade unions in smaller numbers than Swedish-born. It should be noted that a possible problem with using unionisation as an indicator of bargaining power is that the decline does not necessarily lead to a weaker bargaining power of employees, as the proportion of the workforce covered by collective agreements has remained relatively constant.[11]

The proportion of people on fixed-term employment contracts has increased, which can be another indication of weaker bargaining power. People on fixed-term employment contracts often have a weaker foothold in the labour market and probably also a weaker negotiating position. Figure 6b shows that fixed-term employment contracts vary considerably over time, but that they have on average been just under 1 percentage point higher after the financial crisis.

It is difficult to quantify how the bargaining power may have changed. But there are indications that it has weakened as we have argued. In our calculations, we assume a reduction of 1 per cent after the financial crisis.

Figure 6. Unemployment benefits and fixed-term employment contracts, before and after the financial crisis

Percentage of wages and percentage of number of contracts



Note. Unemployment benefits refer to percentage of wages after preliminary tax. Fixed-term employment contracts refer to the number of fixed-term employment contracts as a percentage of total number of employment contracts.
Sources: OECD, Statistics Sweden and own calculations

10 See Kjellberg (2018).

11 See, for instance, Kjellberg (2018) and the article 'Strong economic activity but subdued wage increases' in Monetary Policy Report, July 2017.

4 Changes in the labour market may have contributed to low price and wage growth[12]

The low price and wage growth after the financial crisis is most likely due to a number of different factors. In this section, we study specifically to what extent the observed changes in the labour market after the financial crisis may have contributed to lower prices and wages.

The labour force participation rate has shown a rising trend after the financial crisis and has on average been about 1.1 per cent higher. To calculate by how much this may affect prices and wages, we also need to assess the duration of the increase. Naturally, such assessments are difficult. For example, the Riksbank has systematically underestimated the increase in labour force participation after the financial crisis, which is discussed in Hansson et al. (2018). We take a simple approach to assess the duration, i.e. we assume that the labour market participation rate follows an autoregressive process, see Appendix A for details of the methodology.

Figure 7 shows how an increase in labour force participation by 1.1 per cent affects prices and wages. The duration of the increase is about three years, which is in line with the historical pattern. Initially, inflation decreases by just over 0.7 percentage points, real wages by just under 0.8 per cent and nominal wage growth by around 1.2 percentage points. The results can be understood as follows. Companies have costs in terms of wages to employees and recruitment costs. These costs form the basis for how the companies set their prices.[13] The increase in the labour force participation rate means that there are more job-seekers, which makes it easier for companies to find new skilled workers. Vacancies can be quickly filled, reducing recruitment costs. This allows companies to reduce their prices. As far as employees are concerned, more job-seekers mean tougher competition for jobs and more subdued wage demands. Lower wage costs exert further downward pressure on prices.

Figure 7 shows how a reduction in the unemployment benefits with 21 per cent, i.e. in line with the decline after the financial crisis, affects prices and wages. Inflation falls by just under 0.6 percentage points initially, real wages by just under 0.5 per cent and nominal wage growth by just under 1 percentage point. Lower unemployment benefits make it relatively more costly for an employee to be unemployed compared to be employed, or, in other words, it increases the incentive of employees to accept lower wages. This leads to weaker wage growth and reduces companies' costs. Companies therefore reduce prices and inflation falls.

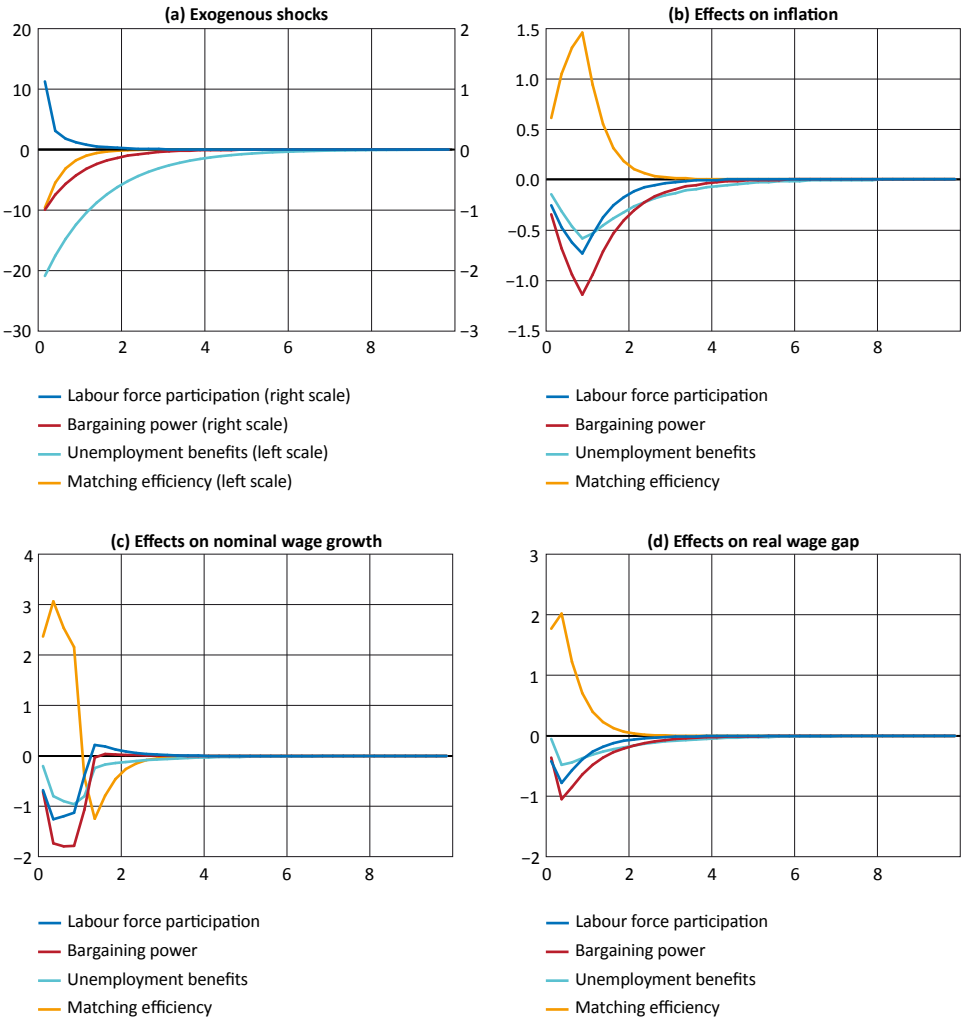
To show how a weakening in employees' bargaining power affects prices and wages, we assume that the bargain power decreases by 1 per cent. Figure 7 shows the results. Initially, inflation falls by just under 1.2 percentage points, real wages by just under 1 per cent and nominal wage growth by around 1.7 percentage points. Hence, a weakening of the bargaining power by 1 per cent, which in percentage terms is relatively small, appears to have relatively large effects on both prices and wages. A weakening in employees' bargaining power reduces the scope for employees to get their wage demands accepted, which leads to lower wages. Companies therefore have lower costs and can adjust their prices downwards.

Three of the four changes in the labour market that we have studied – higher labour force participation, lower unemployment benefits and weaker bargaining power – lead to lower price and wage growth. However, reduced matching efficiency causes prices and wages to rise. If matching efficiency is reduced by 10 per cent, it leads to a rise in inflation of almost 1.5 percentage points, in real wages of around 2 per cent and in nominal wage growth of about 3 percentage points, see Figure 7. Reduced matching efficiency makes it more difficult and costly for companies to employ new staff. Companies therefore increase prices and inflation rises. But despite the fact that reduced matching efficiency drives up prices and wages, the overall assessment is that the changes in the labour market after the financial in total have contributed to the low price and wage outcomes.

12 See Appendix A for a description and calibration of the macroeconomic model.

13 Formally, it is the companies' real marginal cost that affects its pricing, i.e. the cost of producing one more unit of a good.

Figure 7. Effects on inflation, nominal wage growth and the real wage gap of exogenous shocks in the labour market
Per cent



Note. Labour force participation increases initially by 1.1 per cent, unemployment benefits fall by 21 per cent, bargaining power weakens by 1 per cent and matching efficiency reduces by 10 per cent.
Source: Own calculations

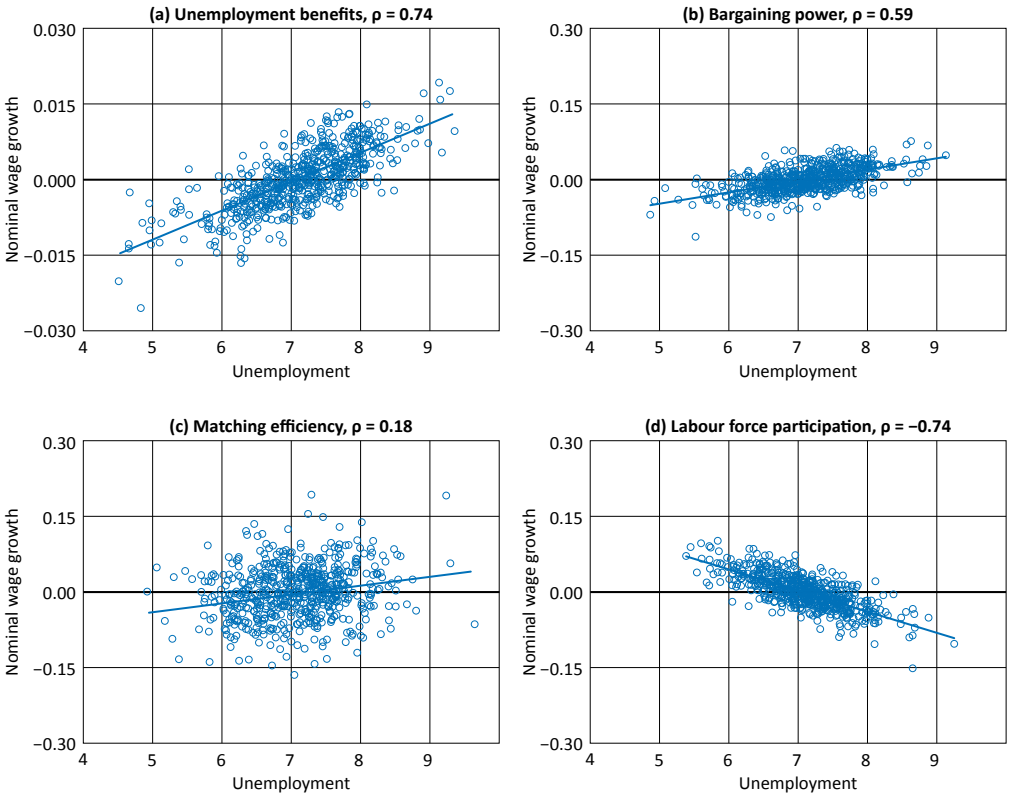
5 Changes in the labour market may also have contributed to a flatter Phillips curve

We have shown in Figure 3 that the slope of the Phillips curve (the correlation between nominal wage growth and unemployment) was clearly negative before the financial crisis, but has become flatter and weakly positive after the crisis. Correlations between economic variables depend in part on the 'exogenous shocks' that an economy is exposed to, by this economists mean unpredictable changes in factors that are unexplained by the model. A possible explanation for the flattening of the Philiips curve may therefore be that the economy has been exposed to shocks that have affected the slope in a flatter direction after the financial crisis. In this context, shocks to the labour market are important, since both wages and unemployment are determined there. In this section we illustrate how shocks to the bargaining power, the unemployment benefits, the matching efficiency and the labour force participation rate may have affected the slope.[14]

14 Exogenous shocks in other parts of the economy can also have contributed to the flatter Phillips curve, but these are not analysed here.

Shocks to the unemployment benefits and the bargaining power affect wages in a similar way. Lower unemployment benefits and weaker bargaining power both lead to a larger surplus for the companies in the wage negotiations. Companies can therefore create more jobs, which leads to lower unemployment while nominal wages decrease. Hence, the correlation between wages and unemployment becomes positive, see Figures 8a and 8b. Shocks to the matching efficiency also lead to a positive correlation, which is illustrated in Figure 8c. When matching efficiency reduces, it becomes more difficult and takes longer to match job-seekers to vacancies, causing unemployment and wages to increase.

Figure 8. The slope of the Phillips curve given various exogenous shocks to the labour market
Annual percentage change and percentage of the labour force



Note. The parameter ρ denotes the correlation between nominal wage growth and unemployment. The blue line represents the following equations (a) $w = -0.04 + 0.01u$, (b) $w = -0.16 + 0.02u$, (c) $w = -0.10 + 0.01u$ and (d) $w = 0.3 - 0.04u$, where w denotes nominal wage growth and u unemployment. Unemployment refers to the percentage of the labour force, 15–74 years.
Source: Own calculations

On the other hand, shocks to the labour force participation lead to a negative correlation between unemployment and nominal wages, see Figure 8d. An increase in labour force participation makes it easier for companies to fill their vacancies. But it nevertheless takes some time to look for and find a new job, which leads to an initial rise in unemployment. At the same time, high labour force participation weakens the bargaining power of employee organisations, which decreases nominal wage growth. The correlation between wages and unemployment therefore becomes negative.

The fact that exogenous shocks affect the correlation between economic variables is a general principle in macroeconomics. One should therefore be cautious to describe correlations between economic variables with rules of thumb. The Phillips curve's negative slope is often interpreted in the following way: Falling unemployment leads to a tighter labour market, which makes it more difficult for companies to recruit new staff. This drives up wages, giving rise to a negative correlation. There is nothing inherently wrong with this reasoning, but it is not a full explanation since it disregards *why* unemployment falls to begin with.

We have shown that the changes in the labour market after the financial crisis can be a factor behind the flatter Phillips curve. The slope can be negative, in line with the common interpretation, when shocks to the labour force participation rate lie behind the fall in unemployment. However, shocks to the unemployment benefits, the bargaining power and the matching efficiency can cause the slope to be positive. Moreover, also technology shocks can imply a positive slope, see Ingves (2019).

6 The reduction in matching efficiency can only explain a smaller part of the outward shift in the Beveridge curve

In this section, we examine to what extent the reduction in matching efficiency after the financial crisis can explain the shift in the Beveridge curve. The Beveridge curve shows how well the matching of job-seekers to vacancies is developing. The more efficient the matching, the faster the outflow from unemployment and the closer to the origin the curve will be. After the financial crisis, the number of vacancies has steadily increased and is currently at historically high levels. At the same time, unemployment has fallen, but not at the same rate as the number of job openings has increased. The weaker correlation between vacancies and unemployment can be interpreted both as a steeper slope of the Beveridge curve, and as a shift outwards. Shifts in the Beveridge curve is often explained by permanent reductions in the matching efficiency.

According to our estimate the matching efficiency has been just under 10 per cent lower after the financial crisis, see Figure 5b. An alternative estimate of the matching efficiency can be based on the relationships in the model. This estimate suggests that the matching efficiency has been just under 14 per cent lower after the financial crisis.[15] In the simulations, we consider both estimates.

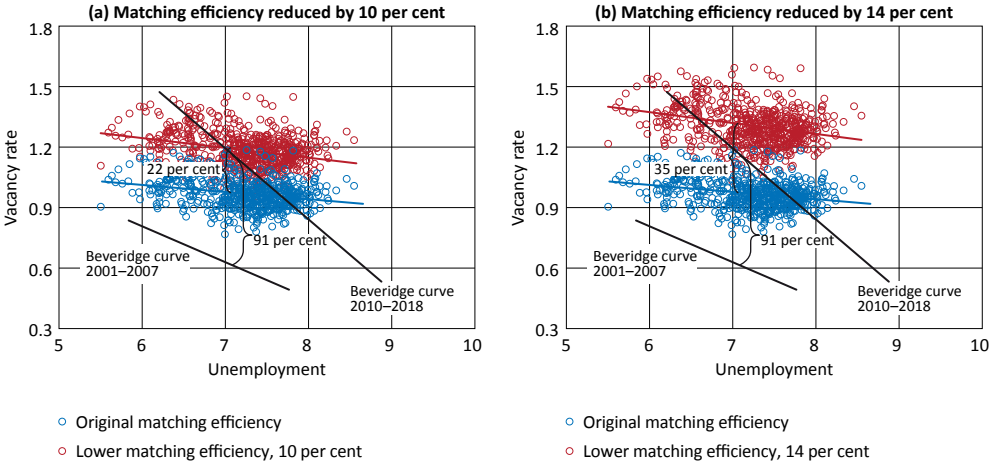
Exogenous shocks are important to explain the slope of the Beveridge curve. However, the focus here is not to explain the steeper slope, but to examine to what extent the outward shift in the Beveridge curve can be explained by our estimates of the matching efficiency. We therefore assume that it is the same demand shocks that have affected the economy before and after the financial crisis.

Figure 9 shows how a permanent reduction in matching efficiency by 10 per cent and 14 per cent shifts the Beveridge curve outwards. The blue dots in Figure 9a show the Beveridge curve from the model when matching efficiency is at the level before the financial crisis. The red dots then show how the Beveridge curve shifts outwards if there is a permanent reduction in matching efficiency by 10 per cent. The two black lines show the Beveridge curve in data before and after the financial crisis. The Beveridge curve has shifted outwards by 91 per cent in data given an unemployment rate of about 7 per cent (the average level between 2000 and 2018). This can be compared to 22 per cent, which is the shift according to the model.

Given our second, model based, estimate of the matching efficiency, i.e. a 14 per cent reduction after the financial crisis, the outward shift in the Beveridge curve is slightly larger at 35 per cent, see Figure 9b. It is clear that also this outward shift is smaller than in the data. Therefore, we conclude that, according to the model, the reduction in matching efficiency can only explain a smaller part of the shift in the Beveridge curve after the financial crisis.

15 In formal terms, the difference in the matching efficiency estimate is due to the fact that, given the model's calibrated parameter values, it is not possible to fully link the reduction in matching efficiency of just under 10 per cent with the increase in the tightness of the labour market observed in the data.

Figure 9. The model's Beveridge curve for different estimates of the matching efficiency and the Beveridge curve in the data, before and after the crisis
Percentage of labour force



Note. The blue and red dots refers to the model's Beveridge curve before and after the financial crisis, respectively. The black lines shows the Beveridge curve in the data before and after the crisis. The vacancy rate is calculated as a percentage of the labour force, 15–74 years. Unemployment is calculated as a percentage of the labour force, 15–74 years.
Source: Own calculations

7 Concluding discussion

Hansson et al. (2018) argue that there is a need to better understand the consequences for monetary policy of changes in supply and more trend-like changes. We share this view and have in this study emphasised how a number of changes in the labour market after the financial crisis may have affected price and wage growth, the Phillips curve and the Beveridge curve.

Changes in the labour market may have contributed to lower price and wage growth. After the global financial crisis of 2008–2009, price and wage growth have been lower than expected. Andersson et al. (2015) discuss a number of factors that may lie be behind the low price growth. Among other factors, they point out that increases in labour supply may have held down companies' costs and by extension also prices.[16] Our results confirm this hypothesis. Increased labour supply in the form of a higher labour force participation rate may have had a dampening effect on prices according to our calculations. We have also shown that lower unemployment benefits and weaker bargaining power may have contributed to lower prices.

The Riksbank has in the Monetary Policy Report pointed to a number of factors related to the labour market as possible explanations for the low wage growth: Higher labour force participation, weaker bargaining power and lower unemployment benefits.[17] Our results confirm that changes in these variables may have contributed to lower wages in both nominal and real terms. The results also suggest that the bargaining power of employees can be especially important. Small percentage changes in the bargaining power have a major impact on wages.

A flatter Phillips curve need not necessarily mean less impact from monetary policy. The Phillips curve has changed and become flatter after the financial crisis. We have shown that this may be due to changes in the labour market. Shocks to the unemployment benefits, the bargaining power and the matching efficiency all give rise to a positive correlation between unemployment and nominal wage growth. If such shocks have become more common or larger after the financial crisis, this may have contributed to the flatter Phillips curve. We

16 However, their main explanations for the low price growth are weak international developments coupled with low energy prices that have held back cost increases. Other causes include a stronger krona and companies having squeezed their margins to a greater extent than previously.
17 See Sveriges Riksbank (2017) where it is also pointed out that wage growth has been affected by a number of different factors such as productivity growth and international competitiveness.

have not formally shown that this is the case, though, but merely illustrated that, in a simple model, these shocks give rise to a positive correlation. Whether or not this has been the case requires a more fundamental analysis in order to identify which shocks that have driven the economic fluctuations before and after the financial crisis.

The fact that the correlation between different economic variables varies over time is not in itself surprising. In a functioning market economy, shocks occur all the time; technology progresses, the demographic composition changes over time and there are shocks in the labour market, to name a few examples. This leads to changes in the supply and demand on different markets. Prices and wages are the market mechanisms that allow supply and demand to meet. This means that the strength of the correlation between different economic variables will depend on which exogenous shocks the economy is exposed to. For a central bank, it may nevertheless be somewhat worrying that it is the slope of Phillips curve that has been changing, since it has a prominent role in monetary policy analysis.

It is therefore important for central banks to understand why the Phillips curve has become flatter, since it can have implications for the impact of monetary policy. If the flatter Phillips curve is due to exogenous shocks, it means that the behaviour of the households and companies have not changed. The functioning of the economy and the impact of monetary policy are therefore unchanged. Changes in the policy rate affect inflation and resource utilisation in the same way as before.

However, the flatter Phillips curve could also be due to different behaviour of households and companies, i.e. the functioning of the economy could have changed. There could in principle be many reasons for this, but a good example is companies' wage-setting. Wages are normally 'sluggish', which means that they are not fully adjusted to changes in labour demand. The slope of the Phillips curve can be interpreted as a measure of how much wages are affected by changes in labour demand (measured in terms of unemployment). The flatter the slope of the curve is, the more sluggish are the wages. Hence, the flatter Phillips curve could be due to more sluggish wages. Lindé and Trabandt (2019) show that when an economy is hit by major negative shocks, as was the case during the financial crisis, companies and unions delay price and wage reductions, which leads to a flatter Phillips curve. If the flatter Phillips curve is due to a change in price and wage-setting behaviour, the impact of monetary policy may also have changed. Considering the full period after the financial crisis, more sluggish prices and wages appear to be a less likely explanation for the flatter curve, since the general view is that increasing globalisation and technological development in recent years, if anything, have made prices and wages more flexible.

Another factor that may affect the slope of the Phillips curve is monetary policy. Assume, for example, that monetary policy, somewhat unlikely, is so successful at stabilising inflation that inflation lies constant on two per cent over time. The correlation between prices and unemployment will in this case be zero, regardless of how unemployment develops. This can also affect the correlation between nominal wage growth and unemployment, which would probably be weakened as the variations in nominal wages would be solely due to variations in real wages, see McLeay and Tenreyro (2018) for a discussion.

Reduced matching efficiency can only explain a smaller part of the shift in the Beveridge curve. The Beveridge curve has shifted outwards after the financial crisis. Our estimates of the reduction in matching efficiency can at best explain about a third of the shift. There are several possible explanations for this. The model does not explicitly consider that the composition of the labour force has changed after the financial crisis, with a relatively large proportion of unemployed people with a weaker position in the labour market due to a low level of education and a weak attachment to the labour market. Another explanation may be measurement problems. The statistics on vacancies are unreliable and may have overestimated the increase in recent years. If this is the case, the outward shift in the Beveridge curve would not have been as large.

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Appendix A. The macroeconomic model with search and matching frictions

This appendix gives a short description of the search and matching model. For a more detailed description, see Foroni et al. (2015 and 2018). The appendix also shows how the model is calibrated to fit some salient features of the Swedish economy.

A.1 Households maximise utility and companies maximise profit

The macroeconomic model consists of households, companies and a central bank. A person in a household can be either employed or unemployed. Employed people work and receive a wage bill while unemployed people receive unemployment benefits. The unemployment benefits, i.e. compensation in relation to the wage, have on average been just under 63 per cent since 2000, which is also the value in the model.

Households maximise utility given a budget constraint and a law of motion for employment. Households can choose between participating and not participating in the labour force. If they choose to participate they get disutility. The key factor determining labour force participation is the households' *willingness* to participate in the labour force. This is intended to capture factors that are not explicitly modelled, for example a high inflow of foreign-born people, large cohorts of young people entering the labour market or various income tax reforms.

We assume that companies cannot fully change their prices in response to shifts in demand. The reasons for this are not formally modelled, but may be due to costs involved in changing prices or agreements with customers that extend over longer periods of time. This is an important assumption as it implies that changes in the central bank's policy rate affect the real interest rate, which in turn affects how households allocate consumption over time. It is also an important assumption for how inflation is determined in the short run. The central factor determining prices is companies' real marginal costs, which in part depend on the real wages. We assume prices are changed once a year on average, which is in line with how often companies in Sweden change their prices.[18]

Companies maximise profits and based on their maximisation problem, a condition can be derived that shows how they choose to advertise new vacancies. According to this condition, the costs of advertising a vacancy are equal to the expected revenue from advertise the vacancy, which depends on the probability of filling a vacancy and the expected revenue from employing another person.

A.2 Search and matching frictions are modelled with a matching function

The labour market is characterised by search- and matching frictions, which means that it is costly for companies to hire new staff and for households to search for new jobs. For companies it can be different types of recruitment costs, for example costs for marketing and training, while for households the costs may involve loss of income during unemployment. This is modelled with a matching function. The function is intended to summarise all the sequences of events associated with a recruitment, i.e. how the recruitment is conducted, how the job-seekers search for new jobs, and so on.[19] In other words, the matching function

18 See Apel et al. (2005).

19 The actual sequence of events that leads to a recruitment is thus not explicitly modelled. In other words, the matching function is not explicitly derived from job-seeker behaviour and therefore lacks so-called micro-foundations. This simplification makes the model more tractable.

captures the idea that it takes a certain period of time to find a new job. We assume the following functional form:

$$(2) \qquad M_t = \Upsilon_t S_t^{\alpha} V_t^{1-\alpha},$$

where M denotes matches, S job-seekers, V vacancies, Υ efficiency in the matching process and the parameter α the job-seekers' share of the matchings.[20] Given a constant matching efficiency, more job-seekers and/or more vacancies lead to more people being employed, i.e. matched. Plenty of job-seekers make it easier for companies to find the right skills and plenty of vacancies make it easier for job-seekers to find a suitable job. Matching efficiency also plays an important role in how many matches (recruitments) are realised. A high matching efficiency leads to a smooth recruitment process and more matches.

Based on the matching function, both the probability of finding a new job, the so-called job-finding rate, $P(\cdot)$, and the probability of filling a vacancy, $Q(\cdot)$, can be derived:

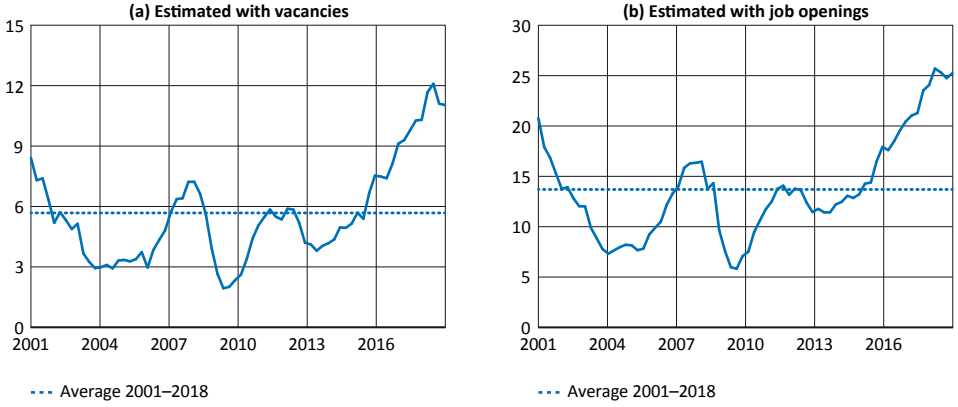
$$(3) \qquad P(\theta_t) = \Upsilon_t \theta_t^{(1-\alpha)}, Q(\theta_t) = \Upsilon_t \theta_t^{(-\alpha)},$$

where θ denotes labour market tightness and is defined as the ratio of vacancies to job-seekers,

$$(4) \qquad \theta_t = \frac{V_t}{S_t}.$$

The labour market tightness plays an important role in search and matching models, since it affects both the job-finding rate and the probability of filling a vacancy. The higher the tightness, the greater the probability of finding a new job and the smaller the probability of filling a vacancy. Tightness in the model is set to the average value of tightness measured by 'vacancies' and 'job openings'. The average since 2001 has been just under 10 per cent, see Figures A1a and A1b.

Figure A1. Labour market tightness calculated with two different estimates of vacancies
Number of vacancies and job openings per unemployed person



Note. Seasonally adjusted data. In Statistics Sweden there are two measures of vacancies, one labelled 'vacancies' and the other 'job openings'. Tightness refers to the ratio of the number of vacancies to the number of unemployed people.
Sources: Statistics Sweden and own calculations

20 In the model there is a distinction between job-seekers and unemployed people, which cannot be observed in the data. Job-seekers in the model include people who, at the beginning of a period, are unemployed and have not yet started to look for a job, while unemployed people are defined as job-seekers minus those who have found a new job (number of new matches). The relevant variable in the matching function is therefore job-seekers.

A.3 Wages are determined through wage bargains

The search and matching frictions imply that there is a surplus to allocate among employees and companies. The surplus consists of the difference between the lowest wage that the employee can accept – which in our model is the compensation received when unemployed – and labour productivity adjusted for the costs of advertising vacancies. The allocation of the surplus is determined in decentralised wage bargains according to the Nash bargaining model, i.e. the surplus is allocated between employees and companies in relation to their bargaining power. Both the employee and the company have an incentive to avoid deadlocked negotiations to save both parties search costs. The Swedish model of employer organisations and employee organisations negotiating new collective agreements is also consistent with the Nash bargaining model.

A.4 The central bank follows a Taylor-rule

The central bank determines the short-term nominal interest rate in the economy, the so-called policy rate. When the central bank sets the policy rate, it follows a simple Taylor-rule.[21] We assume the following rule:

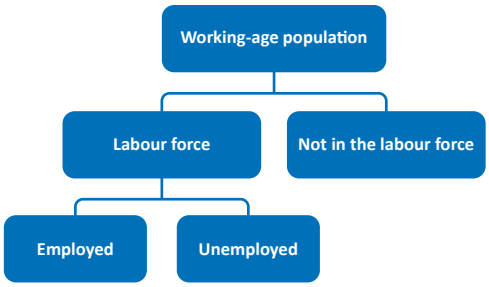
$$R_t = R^* + \alpha\,(\pi_t - \pi^*) + \beta(y_t - y^*), \tag{5}$$

where R denotes the policy rate, R^* the long-run policy rate (an asterisk indicates that it is a long-run steady state value). π inflation, π^* the long-run inflation level, which equals the central bank's inflation target, y resource utilisation and y^* the long-run resource utilisation level. The parameters α and β state by how much the policy rate reacts when inflation deviates from the inflation target and when resource utilisation deviates from its long-run level, respectively. We set these parameters to the standard values from the literature, i.e. $\alpha = 1.5$ and $\beta = 0.125$.

A.5 Employment, unemployment and the labour force in the data and the model

In the Labour Force Survey published by Statistics Sweden, the working-age population, consisting of people aged 15–74 years, is divided into two different groups: those who are in the labour force, and those who are not. Those who are in the labour force are in turn divided into number of employed and number of unemployed people. The various concepts can be described in a tree diagram, see Figure A2.

Figure A2. Description of the notions labour force, employed and unemployed people



21 The Taylor-rule is named after the American economist, John Taylor, see Taylor (1993). It has in practice become a collective term for various monetary policy rules where the central bank determines the short-term nominal interest rate.

The working-age population can also be described in terms of the labour force participation rate, employment rate and unemployment rate. Normally, the labour force participation rate and the employment rate are calculated as percentages of the working-age population while the unemployment rate is calculated as a percentage of the labour force. In the model, however, the employment rate is calculated as a percentage of the labour force and not as a percentage of the population, as the population in the model consists of employed and unemployed people.

The long-run level of unemployment is set at the average for 2000–2018, i.e. just over 7 per cent. This means that the employment rate is set at just under 93 per cent in the model. Labour force participation has since 2000 been just over 71 per cent on average, which is also the value in the model, see Table A1.

A.6 Shocks to the labour market are modelled as exogenous AR(1)-processes

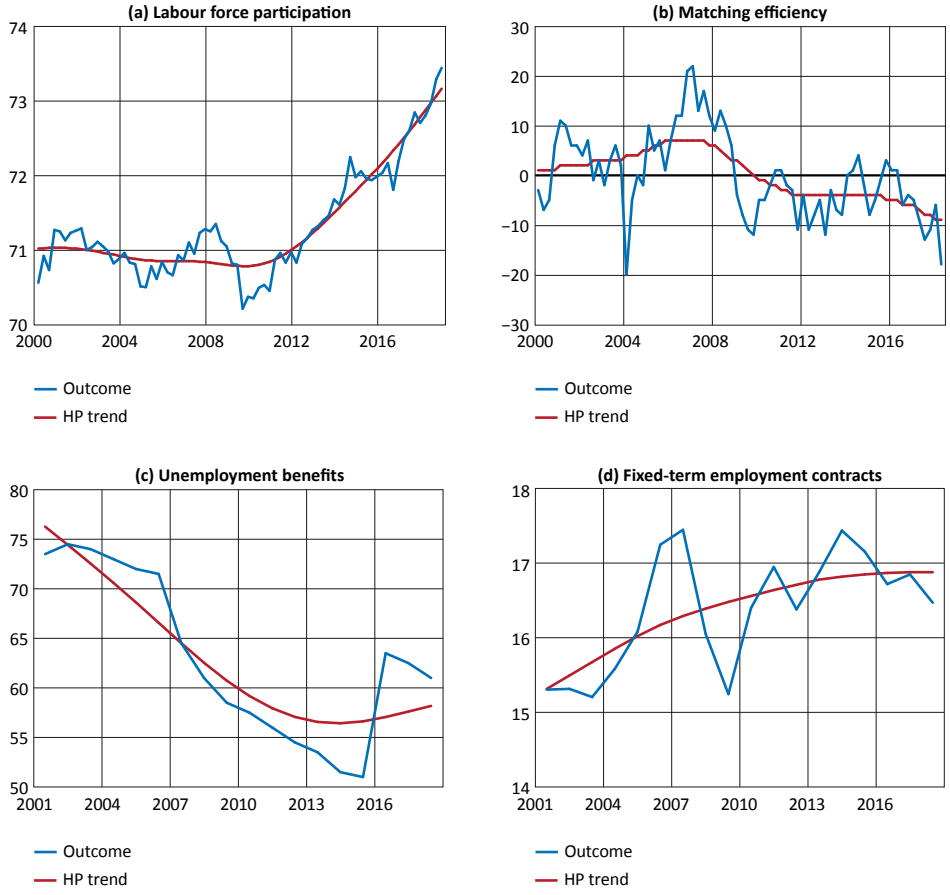
Shocks to the labour market are determined outside the model, i.e. they are exogenous and are not affected by the consumption choices of households, companies' production etc. We assume that labour force participation, matching efficiency, unemployment benefits and bargaining power follow exogenous AR(1)-processes:

$$(6) \qquad ln X_t = \rho \, ln \, X_{t-1} + \epsilon_t^X,$$

where X is a vector containing four variables: labour force participation, matching efficiency, unemployment benefits and bargaining power. The AR(1) coefficient ρ is a vector containing the persistence of each variable and ϵ^X is a vector of independent and identically normal distributed random variables.[22] We estimate the AR(1)-coefficients from trend-adjusted data using an HP-trend, see Figure A3.

22 In formal terms, labour force participation is not an exogenous variable in the model. It is affected to a large extent by the willingness of households to participate in the labour force, which we assume follows an exogenous AR(1) process. To facilitate presentation of the model and description of the mechanisms, we interpret changes in the willingness of households to participate in the labour market as exogenous shocks to labour force participation.

Figure A3. Trends for labour force participation, matching efficiency, unemployment benefits and fixed-term employment contracts
Percentage of the population, percentage deviation from the mean, percentage of wage and percentage of the number of contracts, respectively



Note. Trends are calculated using an HP filter. For the quarterly series (labour force participation and matching efficiency), lambda is equal to 1600, and for the annual series (unemployment benefits and fixed-term employment contracts), lambda is equal to 100.
Sources: OECD, Statistics Sweden and own calculations

Table A1 shows the AR(1)-coefficients and summarises other parameter values calibrated to match Swedish data. Households' preference parameters and job-seekers' share of matches are set in line with Foroni et al. (2015).

Table A1. Calibration of the model's parameters and long-run values

Quantity	Value
Households' time preference (β)	0.99
Households' risk aversion (σ)	1.00
Frisch elasticity (φ)	1.00
Labour force participation ($\bar{L}$)	0.71
Unemployment ($\bar{u}$)	0.07
Unemployment benefits ($b/\bar{w}$)	0.63
Labour market tightness ($\bar{\theta}$)	0.10
Job-finding rate ($\bar{P}$)	0.40
Job-seekers' share of matchings (α)	0.50
Recruitment costs ($K/\bar{q}$)	0.06
Companies' mark-ups ($\epsilon/\epsilon - 1$)	1.20
Price rigidity (δ)	0.75
Interest-rate smoothing in monetary policy rule (ϕ_r)	0.00
Weight on inflation in monetary policy rule (ϕ_π)	1.50
Weight on GDP in monetary policy rule (ϕ_y)	0.12
Public consumption share of GDP	0.20
AR(1) coefficient – labour force participation	0.68
AR(1) coefficient – matching efficiency	0.57
AR(1) coefficient – unemployment benefit	0.84
AR(1) coefficient – bargaining power	0.75

Note. The notations in brackets correspond to those in Foroni et al. (2018).

Appendix B. Estimating matching efficiency

To estimate the matching efficiency, we start from the matching function in Appendix A,

(7) $M_t = \Upsilon_t S_t^{\alpha} V_t^{1-\alpha}$.

By dividing both sides of the function with the number of job-seekers the matching function can be re-written in terms of the job-finding rate, $P(\theta_t)$, and labour market tightness, θ,

(8) $P(\theta_t) = \Upsilon_t \theta_t^{1-\alpha}$.

If we then take the logarithm of the above expression, we obtain the following equation,

(9) $\ln P(\theta_t) = \ln \Upsilon_t + (1-\alpha) \ln \theta_t$.

In equation 9 both the value of α and the matching efficiency, Υ_t, are unknowns. The matching efficiency can therefore not be estimated directly. We estimate the average matching efficiency over the entire period, $\overline{\Upsilon}$, as an intercept and α as a slope coefficient using the method of least squares,

(10) $\ln P(\theta_t) = \ln \overline{\Upsilon} + (1-\alpha) \ln \theta_t + \epsilon_t$,

where ϵ is an error term. By substituting the expression $P(\theta_t)$ for from equation 9 we obtain the following expression,

(11) $\ln \Upsilon_t + (1-\alpha) \ln \theta_t = \ln \overline{\Upsilon} + (1-\alpha) \ln \theta_t + \epsilon_t$,

i.e.,

(12) $\epsilon_t = \ln \Upsilon_t - \ln \overline{\Upsilon}$.

The error term thus measures the (percentage) deviation of the matching efficiency from the average level.