Monetary policy and unemployment: A conceptual review

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The relationship between monetary policy and unemployment is a frequently-discussed topic. This debate uses a number of unemployment concepts that are considered relevant for monetary policy. However, it is not always easy to understand exactly what is meant by these concepts, or what relationship they have to monetary policy. This article therefore discusses which concepts are relevant on the basis of modern theory and how they differ from older academic literature. Based on the main theories on unemployment the article first discusses concepts dealing with long-run unemployment. After that we focus on short-run concepts and here particularly the relationship between short-run variations in unemployment and inflation. An important cause of confusion in the debate, apart from unclear concepts, is that the new and older reasoning regarding the relationship between unemployment and inflation in the short run are not compatible with one another. For example, it is shown in this article that what drives inflation in one reasoning does not do so in the other.

Many different concepts relating to unemployment are used in the debate on monetary policy. Concepts such as "equilibrium unemployment", "non-accelerating inflation rate of unemployment" (abbreviated NAIRU) and "natural unemployment" are but a few examples. Furthermore, a distinction is often made between the concepts at different time horizons. These concepts are often considered relevant to monetary policy, but it is rare that more precise information is given with regard to what they mean.[1] As a result of this, there is widespread confusion regarding the concepts in the general debate.

A number of models have been constructed recently that combine ideas from labour market research with the canonical New Keynesian model for monetary policy analysis. One such model is the Riksbank's own model RAMSES II.[2] However, the introduction of these partial labour market models into modern macro-economic theory has led to further confusion. This confusion has arisen because the unemployment concepts used in the

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1 In the cases where an attempt is made to be more precise, this often merely demonstrates how vague the concept is. A good example of this is given in Rogerson (1997), which points to 12 different varieties of "natural unemployment" in academic research.

2 See Christiano, Trabandt and Walentin (2011).

debate often arise from older theories. For example, it is not clear what role a concept such as NAIRU plays in the modern reasoning on which the New Keynesian models are based.

This article discusses which unemployment concepts are relevant on the basis of modern theory and how they differ from the concepts used in the older academic literature.

We use the main theories on unemployment as a starting point and focus first on unemployment in what is known as *steady state*, that is, the unemployment that prevails when the effects of all of the macroeconomic shocks that can affect unemployment have faded. This discussion also makes it easier to understand the older reasoning on the relationship between unemployment and inflation as presented in Layard, Nickell and Jackman (2005) (LNJ).

In the second part of the article we focus on how the short-run variation in unemployment (around the steady-state level) is related to inflation both on the basis of the older LNJ model from 1991 and on the basis of a New Keynesian model with a labour market block formulated by Blanchard and Galí (2010). We also discuss what are – and are not – relevant concepts of unemployment for monetary policy in the New Keynesian model.

Long-run equilibrium: Unemployment in steady state

An often-used concept in the theoretical analysis of the labour market and of long-run unemployment is "natural unemployment". This was defined by Milton Friedman (1968, p. 8) in his speech as the President of the American Economic Association as follows:

The 'natural rate of unemployment,' in other words, is the level which would be ground out by the Walrasian system of general equilibrium equations, provided there is imbedded in them the actual structural characteristics of the labor and commodity markets, including market imperfections, stochastic variability in demands and supplies, the cost of gathering information about job vacancies and labor availabilities, the costs of mobility, and so on.

The general interpretation of the natural rate of unemployment is that it is a long-run equilibrium that the economy strives to attain over time. This idea has had considerable impact in academic research. However, Friedman's original definition is so comprehensive that it becomes unclear, and there are thus many different examples of how the concept has been defined and used in academic research (see for instance Rogerson, 1997, for a discussion). This has in turn led to confusion over what is actually meant when talking about natural or long-run unemployment.

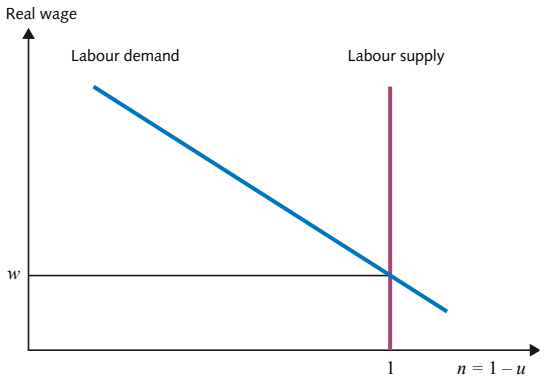
As the concepts in modern theory were not available to Friedman, we cannot know exactly what he thought in relation to them. But this is not really so important. Modern dynamic theory shows that if we let the macro economic shocks in the model fade out, then unemployment moves towards its steady state level. This rate of unemployment is thus the relevant long-run labour market equilibrium in the reasoning that forms the base for modern dynamic analysis.[3]

3 However, some details are unclear, such as whether this concerns a stochastic or non-stochastic equilibrium or whether or not distortions should be included in the long-run equilibrium concept.

Theories on steady-state unemployment

To gain an idea of the determinants of steady-state unemployment and to obtain some background to the older reasoning on which the LNJ model is based, we can study the theories available to explain unemployment. As a frame of reference we can first use the neo-classical (or Walrasian) labour market with perfect competition. Since labour supply will not play a major role in the latter discussion, we assume that the individuals' labour supply is insensitive in relation to real wages. Moreover, we normalise the size of the labour force to unity. Under competition, the firm will employ workers until the marginal product of labour equals the real wages, which gives an (implicit) demand function for labour. With decreasing returns to scale, the marginal product of labour declines with the number of employees and we obtain a demand function where the demanded quantity (labour) falls if the price (real wages) increases. In this case the equilibrium on a Walrasian labour market is illustrated in Figure 1.

Figure 1. Equilibrium on a Walrasian labour market



In this model the equilibrium wage is thus given at the point where the demand for labour intersects with the labour supply curve. As the labour market clears at this point, that is, all supply finds its demand at the market price, full employment will prevail. This means that if we define an unemployed person as someone who can and wants to accept employment at the current market wage but nevertheless cannot find a job, then the neoclassical theory of clearing markets cannot explain unemployment. Instead, a theory on unemployment must be based on frictions and imperfections.

The theories we have on steady-state unemployment can be divided into two main lines.

The first line is that different factors lead to wage-setting that differs from that on a Walrasian labour market (as in efficiency wage models and bargaining/trade-union models). As wage-setting in these models gives a higher wage than the one that clears the labour market with perfect competition, unemployment will arise in steady state.

The second line is based on the observation that the labour market is characterised by a never-ceasing flow of individuals moving between employment and unemployment. As

the parties on both sides of the labour market (jobseekers and employers with vacancies) differ both with regard to the qualities they have themselves and what they seek from their counterpart, it takes time and resources to fill a job vacancy (search models). If an individual loses his job, it is not likely that he will immediately find a new one. Similarly, an employer cannot expect to immediately fill a job vacancy. This leads to there always being unemployment, even when all of the macroeconomic disruptions have faded and long-run equilibrium prevails.

All of these labour market models (or combinations of them) result in a supply curve, which is known as the wage-setting curve, with a negative relationship between real wages and unemployment.[4] We will return to the question of what lies behind this negative relationship, but if we take this for granted for now we obtain a wage-setting relationship as

$$w^n - p = \gamma_0 - \gamma_1 u,\ \gamma_1 > 0, \qquad (1)$$

where w^n is (the logarithm of) the nominal wages and p is (the logarithm of) the price level that gives (the logarithm of) real wages as $w^n - p = w$. Further, u is unemployment and γ_1 is a parameter determined by the sensitivity of wage-setting in relation to changes in unemployment. Finally, all factors determining the horizontal position of the wage-setting relationship are summarised by γ_0 This means that factors that shift the wage-setting relationship horizontally, and give a higher or lower wage for all levels of unemployment, affect γ_0. As we are interested in steady-state unemployment (with price and wage stability), we assume there that nominal wages (w^n) are set with knowledge of the price (p).

The demand relationship, which is known as the *price-setting relationship*, is usually derived from the firms' optimal pricing decisions in a market with imperfect competition, given the nominal wage.[5] The result is a generally positive relationship between real wages and unemployment. The price-setting relationship can be expressed mathematically as

$$p - w^n = \beta_0 - \beta_1 u,\ \beta_1 \geq 0, \qquad (2)$$

where we assume in the same way as for the wage-setting relationship that the price (p) is set with knowledge of nominal wages (w^n). Here the parameter β_1 is determined by the sensitivity of the price markup that firms want to make on nominal wages is in relation to unemployment. It is also worth noting that unemployment ($u = 1 - n$) affects the marginal product of another employee and thereby the firms' marginal cost and optimal price.[6]

4 Real wages here refers to the real product wage, that is to say the ratio of the nominal wage to the producer price.

5 Note that a price decision on a market with imperfect competition also determines the firm's demand and production and thus its demand for labour.

6 Technically, β_1 is determined by the degree of return to scale (to factors that can be adjusted). The existence of search frictions also affects β_1 (see appendix B).

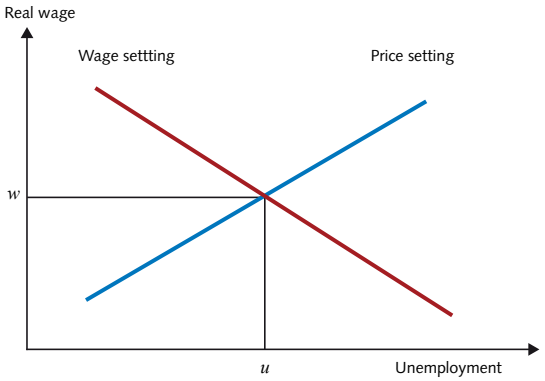
Finally, all factors determining the horizontal position of the price-setting relationship are summarised by β_0. More specifically, β_0 declines (which reduces the price set for all levels of unemployment) with increased productivity or product market competition, and increases with increased capital costs.[7]

We can also write the price-setting curve in terms of real wages as

$$w^n - p = -\beta_0 + \beta_1 u. \qquad (3)$$

Equilibrium unemployment will thus be obtained at the wage at which price-setting and wage-setting decisions are consistent with one another, which is illustrated in Figure 2 (where we have changed the terms on the horizontal axis to focus on unemployment).

Figure 2. Equilibrium unemployment in a general labour market model



What, then, determines the wage-setting relationship, or in other words, why doesn't the labour market clear in steady state? To answer this question, we must go on to analyse the three main models one by one.

EFFICIENCY-WAGE MODELS

The central idea in efficiency wage models is that there are also advantages for a firm in paying a higher wage (than the one that clears the labour market). In, for example, Shapiro and Stiglitz (1984) the advantage is that a higher wage means that the employees exert themselves more at work, even when it is difficult for the employer to monitor them. On a labour market with perfect competition, there is no reason for an employee to be afraid of losing his or her job if they are discovered not to be working, as the employee can immediately find another equivalent job. But if the firm pays more than the wage that

7 As we, for instance, take the capital cost for granted, what is discussed here is a partial analysis of the labour market. It may be good for understanding which mechanisms give rise to steady-state unemployment – as long as we bear in mind that important determinants, which are here taken for granted, are determined in an interplay with other parts of the economy.

clears the labour market, the job will be valuable to the employee. If the job has a value and there is at the same time a risk of being detected not working and of being fired, the employee will want to make an effort at work. This gives an incentive for the firm to set wages at a higher level than that which clears the labour market, and as the value of a job (given the wage) rises if it becomes more difficult to find a new one (increased unemployment), the wage-setting relationship will slope downwards.[8]

TRADE-UNION AND BARGAINING MODELS

In trade-union and bargaining models it is no longer the firm that sets the wage one-sidedly; the wage is instead set in a bargaining process, or in an extreme case with a monopoly trade union where the trade union sets the wage one-sidedly.[9]

If we think of a general bargaining model, one normally lets the parties bargain over the total surplus (see Appendix A for a more detailed review of this type of model). The total surplus will in turn stem from the difference between the value to the firm and to the employee (trade union) of an agreement and the value of the respective party's alternative to an agreement (outside option). In these models wages are usually determined by the total surplus being divided according to the respective party's bargaining power.

If the employee's alternative to an agreement is weakened by an increased unemployment, this will lead to a wage-setting relationship that declines in relation to unemployment. One example is a model where higher unemployment makes it more difficult for the employee to find a new firm to bargain with, which leads to a longer expected period of unemployment benefit if one is not finding an agreement in the bargain. Such a relationship can be found, for instance, in the general equilibrium model used by the Riksbank in its forecasting work and for alternative scenarios: RAMSES II.

Some things to note are that a higher bargaining power for the employee pushes up the wage-setting curve and leads to higher wages and higher equilibrium unemployment (compare Figure 2 with an intended wage-setting curve above the one in the figure). Moreover, if the alternative to an agreement for the employee improves by, for instance, better conditions in the remuneration system for the unemployed, this will also push up the wage-setting curve.

Whether taxes and charges affect the negotiated wages and unemployment depends on how they affect the surplus the parties are bargaining over. Taxes and charges that have a proportional effect on the surplus will not affect gross wages and thus not will they affect unemployment. Appendix A contains one such example where an equally large proportion of both wages and unemployment benefit are deducted as tax. Such taxes and charges will only affect net wages and net gains. Similarly, factors that affect the product wage

8 Another idea on this theme is that a higher wage can attract applicants who are better in respects that the firm is unable to observe (Weiss, 1980), can reduce the staff turnover (Eriksson and Gottfries, 2005), or create a loyalty between employer and employee (Akerlof and Yellen, 1990). See, for instance, Romer (2006) for a longer discussion of efficiency wage models.

9 In the latter case the trade union will strive to attain a high wage, but must also take into account the fact that a higher wage will result in higher unemployment among its members.

to consumer real wage ratio will not affect unemployment (for example, changes in the relative price of imported goods) if the surplus is affected proportionally. Note, however, that a tax change that increases the relative value of reaching an agreement and working for the employee (at a given gross wage), for example through the tax deductions for those in work, will push down the wage-setting curve. This in turn reduces unemployment.

The degree of coordination in the bargaining will also affect the labour market outcome; see Calmfors (1993). For one thing, more centralised bargaining will mean that external effects of wage increases on, for instance, unemployment and inflation, can be internalised in the bargaining. For another thing, the degree of centralisation will affect the possibility to shift the wage costs onto the product price as, for instance, the competition is stiffer between firms within the same sector than it is between sectors.

Finally, it is also worth noting that the way in which one formulates the employee's alternative to an agreement in these models will to a large degree affect the sensitivity of the total surplus, and thereby that of the wages, in relation to unemployment. It makes a considerable difference to this sensitivity, for instance, if the alternative to an agreement is a strike (but the employees stay within the firm), or if the alternative is to seek a new bargaining counterpart in the prevailing economic climate; see Hall and Milgrom (2008).

SEARCH AND MATCHING MODELS

The starting point for search and matching models is that resources are required before employers and job applicants can find one another and the firm can begin to produce goods and services.[10, 11] These search frictions mean that the firms' incentives to create job vacancies are affected by the number of unemployed who are looking for work. This is because it is costly to keep a post vacant and to look for someone to employ (for instance, the costs of advertising and recruitment services) and because unemployment affects the time it is expected to take to fill a vacancy. This leads to a form of price-setting relationship that, like the one above, is an upward sloping function of unemployment (see appendix B for a more detailed description of search and matching models).

As search frictions mean that an employee, or job, cannot be exchanged for an equivalent employee, or job, without a period of costly searching, a value is created when an employee and a firm meet and bargain. Similar to the bargaining model we have described, the wage is set by the total surplus being divided according to the respective party's bargaining power. The wage-setting curve will once again be a downward-sloping function of unemployment, as higher unemployment will worsen the employee's alternative to an agreement.

10 See Pissarides (2000) for a detailed description of the search and matching models.

11 There are also search frictions in RAMSES II, but when estimating the model these frictions have proved to have little significance; see Christiano, Trabandt and Walentin (2011). This result is consistent with the findings of Carlsson, Eriksson and Gottfries (2012) in Swedish microdata and with what Yashiv (2000) finds in Israeli macrodata.

As the wage-setting curve in the search and matching models is based on bargaining, many of the conclusions from the bargaining model carry over. For example, the wage-setting curve is pushed up with improvements in the remunerations system for the unemployed, which leads to both a higher wage and higher unemployment.

Note, however, that as the firm's revenue from having an employee is treated as an exogenous variable (or, in other words, as a variable determined outside of the model), the basic search model should also be regarded as a partial equilibrium analysis.

Short-run equilibrium: Unemployment and inflation

In the previous section we discussed the main theories on steady-state unemployment. The next stage is to move on from a theory on long-run unemployment to a theory on short-run variation in unemployment and inflation. For this we need to introduce the partial labour market analysis into a general equilibrium model, which is done in RAMSES II, for instance. This means that, for instance, the firm's revenue from having an employee in the model is no longer exogenous, but endogenously determined on the basis of the general equilibrium system. This means that RAMSES II is part of a new research programme where one has included the partial labour market models in the New Keynesian model, to be able to study outcomes for the labour market and inflation in general equilibrium in a way that agrees with modern dynamic macro theory.[12]

Theories on short-run variation in unemployment and inflation

THE LAYARD, NICKELL AND JACKMAN MODEL

There is also an aim in the older literature to link together the partial labour market models with general equilibrium, and in this way build a theory on short-run variation in unemployment and inflation. An important example of this is Layard, Nickell and Jackman (2005) (LNJ). Their reasoning on the labour market and macro economy is described in the book *Unemployment: Macroeconomic Performance and the Labor Market,* which was first published in 1991. The book has had a very large impact on how economists think about unemployment in general equilibrium and on the relationship between unemployment and inflation both in labour-market research and in the policy discussions. The LNJ model is based on a price- and wage-setting relationship (shown in Figure 2) but does not specify which of the above-mentioned mechanisms has given rise to the downward-sloping wage-setting curve.

Let us write down the price-setting relationship where firms set the price given the expected wage as

12 Other examples are Danthine and Kurmann (2004) and de la Croix, de Walque and Wouters (2009) who introduce efficiency wages, Erceg, Henderson and Levin (2000) and Carlsson and Westermark (2011) who include a monopoly trade union/bargaining model for wage setting, and Gertler, Sala and Trigari (2008) who introduce labour-market search frictions in a New Keynesian framework.

$$p - E_{-1}(w^n) = \beta_0 - \beta_1 u,\ \beta_1 \geq 0, \tag{4}$$

and the wage-setting relationship where the wage is set given the expected price as

$$w^n - E_{-1}(p) = \gamma_0 - \gamma_1 u,\ \gamma_1 > 0, \tag{5}$$

where E is an expectations operator and the index –1 indicates that expectations were formed earlier. Thus, $E_{-1}(p)$ is yesterday's expectation of today's price. We can then once again describe equilibrium unemployment in a price and wage-setting diagram as shown in Figure 2. Figure 3a shows these relationships once again, with the difference that we are clear that the relationships are based on prices and wages being realised according to expectations. Steady-state unemployment is thus given as the unemployment that makes price and wage-setting decisions compatible, at the same time as prices and wages are realised according to expectations (that is, price and wage stability).

If an expectation is not realised for some reason, a situation may arise in the short run where unemployment deviates from steady-state unemployment. To derive a short-run supply curve, LNJ further assumes that the "surprises" in prices and wages are equal, which gives the following relationship:

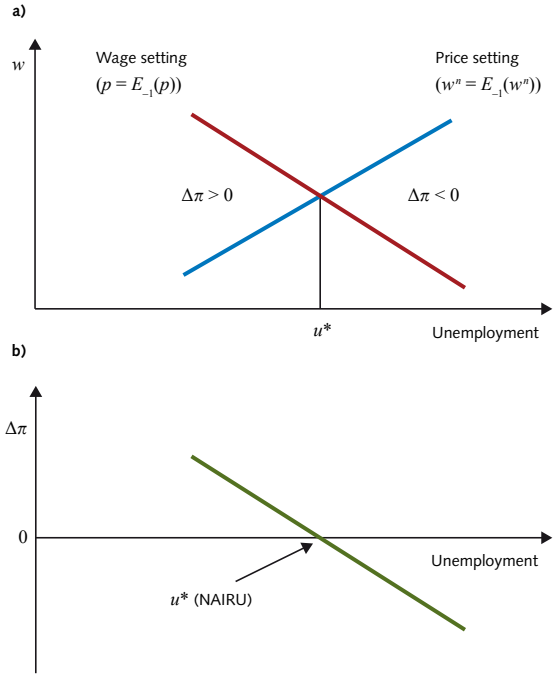
$$u - u^* = -\frac{1}{\vartheta}(p - E_{-1}(p)), \tag{6}$$

where u^* $(=(\beta_0+\gamma_0)/(\beta_1+\gamma_1))$ is steady-state unemployment and ϑ $(=(\beta_1+\gamma_1)/2)$ is a measure of wage and price flexibility, that is, how much prices and wages will adjust to changes in the labour market situation (see appendix C for a derivation of equation (6)). Thus, low unemployment is related to positive price and wage surprises. We can then rewrite (6) by adding and deducting the previous period's price level, p_{-1}, as

$$\pi = E_{-1}(\pi) - \vartheta(u - u^*), \tag{7}$$

where π $(=p-p_{-1})$ is the rate of inflation. We then see that the LNJ model leads to a traditional Phillips curve with an expectations term. However, the difference is that the LNJ model can give an idea of what determines steady-state unemployment.

Figure 3. Equilibrium in the Layard, Nickell and Jackman model



To move on, a theory is required as to how expectations of inflation are formed. Instead of trying to derive expectations consistent with the model, that is, the expectations that rational agents in the model would form if they knew the properties of the model, LNJ assumes that the agents in the model incorrectly believe that the rate of inflation is what is known as a random walk.[13] Given that this assumption, the rational, and also the adaptive, forecast is $E_{-1}(\pi)=\pi_{-1}$. If we move the inflation forecast back to the left-hand side, we then get the following relationship:

$$\Delta\pi=-\vartheta(u-u^*), \qquad (8)$$

13 That is, a process where a shock today will affect today's inflation and today's expectations of inflation in all future periods in the same way.

which is illustrated in Figure 3b.[14, 15] Thus, the inflation rate rises when unemployment is lower than steady-state unemployment in the LNJ model. Further, the rate of inflation is constant when unemployment coincides with steady-state unemployment; u^* is thus what is usually known as "the non-accelerating inflation rate of unemployment" (NAIRU).[16] What it is important to note prior to the continued discussion is that equation (8) entails there being one, and only one, level of unemployment that is compatible with a constant rate of inflation, that is steady-state unemployment u^*.

From a policy perspective, it is interesting to note that the Phillips curve in equation (8) means that only surprises in the inflation outcome will lead to variation in unemployment. Also note that the LNJ model assumes that systematic, or predictable, monetary policy does not have any effect on today's real economic outcome via its effect on the formation of expectations. This assumption contrasts strongly with the New Keynesian model we will discuss in the next section, where the effects of systematic monetary policy on the formation of expectations is an important part of the monetary policy transmission mechanism.[17]

To then resolve the general equilibrium model, LNJ assumes a demand relation where aggregate demand, measured as unemployment, is given by

$$u=-\frac{1}{\lambda}(m-p), \qquad (9)$$

where m is nominal GDP (adjusted for real trend growth). Exogenous shocks to m thus lead to short-run deviations between the observed and the long-run unemployment and to movements in price and wage inflation. In the long run, however, the economy moves back towards steady-state unemployment.[18]

A NEW KEYNESIAN MODEL OF A LABOUR MARKET

The key difference between the LNJ model and New Keynesian models with a labour market block is the degree of formalisation and the further insights this provides. New

14 Note that the assumption that inflation is perceived as a random walk is rather unusual seen from an inflation-targeting policy perspective and that it entails the agents also believing that deviations between the observed rate of unemployment and steady-state unemployment are white noise (that is, a process where today's outcome does not help to forecast tomorrow's outcome). One reason why the assumption was common in the academic research was that one then did not need to put one's foot down in the 1970s debate on adaptive or rational expectations.

15 Equation (8), extended by an error term, has often been used to estimate equilibrium unemployment (as a function of estimated parameters in the regression); see for example Blanchard and Katz (1997). With an error term one can regard equilibrium unemployment as the level of unemployment that systematically gives a constant rate of inflation. However, the obvious econometric problem is the endogeneity bias. This is because both inflation and unemployment are determined in general equilibrium, and one thus cannot say that unemployment causes inflation but not vice versa.

16 A more correct term is "the non-increasing inflation rate of unemployment", but this is how the term is used in the academic research.

17 For empirical evidence that supports expected monetary policy affecting real economic outcomes, see Mishkin (1982a, 1982b).

18 By taking the time difference of (9) and combining it with (8) we get $u=\frac{1}{\vartheta+\lambda}(\vartheta u^*+\lambda u_{-1}-(\Delta m-\pi_{-1}))$. As discussed by LNJ, u will return to u^* and π_{-1} will tend towards Δm if Δm is constant for long enough.

Keynesian models are based on assumptions of agents' preferences and restrictions (micro foundations) and solutions are based on model consistent expectations instead of ad hoc assumed aggregate relationships and expectations. Further, one can also discuss optimal monetary policy in this model class, that is, the monetary policy that maximises welfare for agents in the model, as the models are derived from the agents' preferences and restrictions. However, this difference in approach can lead to confusion over concepts. A concept that is relevant in modern dynamic theory need not be relevant in the older model without clear micro assumptions (and vice versa).

In a New Keynesian model there are several concepts that are of interest to monetary policy. These include both dynamic concepts and long-run concepts that apply when all of the macro economic shocks have faded:

i. First is the *observed equilibrium* as shown by data or the short-run equilibrium given all frictions and imperfections in the model.

ii. The second concept is the equilibrium that would apply if prices and wages could be adjusted without friction, which is known as the *flexible-price equilibrium*. The difference between the observed equilibrium and the flexible price equilibrium, which is usually called the *flexible-price gap*, is a measure of the imbalance that has arisen as a result of the adjustment of prices and nominal wages to new conditions not being immediate (so-called nominal frictions). The flexible price gap is thus the gap that is relevant for determining the underlying inflationary pressure and for forecasting inflation.

iii. The third concept concerns efficiency – that is, the allocation (or the production and consumption decisions) that a planner would choose if he or she had the task of maximising the welfare of the individual given the resources restrictions and the production technology available. This is called the *efficient allocation*. The deviation between the observed equilibrium and the efficient allocation is the *welfare-relevant gap*, that is, the gap that is relevant when formulating optimal monetary policy and which is included in the central bank's target function in this model.

iv. When all of the macro economic shocks have faded, the economy will return to the *steady state*, the fourth concept, which is the long-run equilibrium.[19]

An article by Blanchard and Galí (2007) shows that in the basic New Keynesian model the flexible price equilibrium and the efficient allocation move together in a "one-to-one" relationship when there are shocks to the economy. In other words, there is no classical

19 If we assume, which is common in monetary policy analysis, that fiscal policy neutralises all remaining inefficiencies in steady state, the long-run equilibrium will be the same regardless of whether the economy is governed by a planner or whether we have a decentralised solution where individual agencies make decisions in the economy. These remaining inefficiencies can, for instance, concern a firm having market power in pricing decisions. One can then use subsidies to get the companies to make efficient production decisions.

conflict between stabilising inflation and stabilising the welfare-relevant gap, a property that Blanchard and Galí (2007) call "the divine coincidence".[20]

However, this coincidence no longer applies if real imperfections, such as real wage rigidities, or inefficient macroeconomic shocks, such as price markup shocks, drive a wedge between the flexible-price equilibrium and the efficient allocation in the model. An example of a model where this coincidence does not occur is Blanchard and Galí (2010) (BG). This model is a New Keynesian model with a simple implementation of a labour market with search frictions. BG shows that the efficient allocation in this model has a constant unemployment rate in all periods. When one introduces wage-setting where the wages are not fully adapted to the variation in productivity (real wage rigidity) we obtain a wedge between the flexible-price gap and the welfare-relevant gap for unemployment, which annuls the "divine coincidence". A key result from BG is that the stabilising of inflation, which in turn means that unemployment is stabilised at the flexible-price equilibrium, does not give rise to a constant unemployment.

What does this mean for a concept such as NAIRU? Here it is important to remember that the LNJ relationship between changes in inflation and the difference between the observed unemployment and steady-state unemployment is given by

$$\Delta\pi = -\vartheta(u - u^*). \qquad (10)$$

This means that LNJ thinks of a world where the stabilisation of unemployment at the steady-state level gives a constant rate of inflation. In the steady state of a New Keynesian model unemployment will be equal to steady-state unemployment and inflation will be constant, but outside of the steady state – when the economy is exposed to shocks – this will no longer apply. BG shows that a monetary policy that completely stabilises unemployment at u^* creates a variation in inflation, and a monetary policy that completely stabilises inflation creates variation in unemployment. The NAIRU idea, where the deviation in unemployment from a constant long-run rate of unemployment drives inflation changes, is thus not relevant in the New Keynesian model world, as it is the flexible-price gap that is related to inflation here. Stabilising unemployment at the flexible-price equilibrium does not mean a constant rate of unemployment. On the contrary, it means that unemployment must vary in response to macroeconomic shocks.[21]

It is worth noting that one could calculate the rate of unemployment that is consistent with constant inflation on the basis of a solution of the New Keynesian general equilibrium model. But once again, this level will not be constant when the economy is subjected to shocks.

What does this mean for the Riksbank's RAMSES II model? As RAMSES II is a New Keynesian model, the overall conclusions also apply to this model, even if the exact

20 Note that as the New Keynesian basic model includes nominal price rigidity, the deviation in inflation from steady-state inflation (the target) will be part of the central bank's target function.

21 The gap in equation (10), that is $(u - u^*)$, is instead related to the deviation from the efficient or welfare-maximising allocation in the BG model.

expressions for the various gaps differ according to the modelling choices for, say the labour market. As in BG, there is no divine coincidence applying in RAMSES II, as there are inefficient macroeconomic shocks that drive a wedge between the flexible-price equilibrium and the efficient allocation in the model. Another property that is model-dependent is whether the efficient allocation is defined by constant unemployment. In BG this result follows on from specific assumptions of preferences, lack of capital formation in the model and a special formulation of the employment adjustment cost function, and it is unlikely that RAMSES II would also have this property. However, determining how much unemployment varies in the efficient allocation in RAMSES II is complicated, and at present unknown.

Concluding comment

It has not always been easy for the various participants in the debate on monetary policy and the labour market to understand one another. The confusion regarding concepts is due to the fact that the debaters rarely describe explicitly the models they base their reasoning on. We have therefore discussed in this article two different lines of reasoning (the LNJ model and the New Keynesian model) on the relationship between inflation and unemployment and shown that these are not compatible with one another. The factors behind inflation in one line of reasoning are not a relevant measure of inflationary pressure in the other. Such differences lead to confusion in the discussion. The debate on economic policy gains new life from the different parties having different views on how the economy functions, but if the message is to get across and if opinions are to be discussed constructively, it is important that the debaters are clear as to which line of reasoning they rely to support their arguments.

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Appendix A: Trade union and bargaining models

This appendix discusses trade union and bargaining models in greater detail. We begin with a monopoly trade union that sets wages one-sidedly. In this case the trade union will strive for a high wage but must also take into account the fact that a higher wage will result in higher unemployment among its members (that is, members who can and want to work for the given wage but where there will not be sufficient demand at the given wage to employ all of them). To illustrate the points in this model more clearly, we imagine that we have a large trade union that covers the whole economy. Moreover the firm in the economy has the right to determine employment given the wage, what is known as the right-to-manage, which is the reasonable empirical case.[22] As the price-setting curve shows optimal combinations between wages and unemployment for the firm, the solution will thus always lie on this curve. The monopoly trade union's problem then is to choose an optimal point on the price-setting curve, given its preferences.

Graphically, we can illustrate the monopoly trade union's wage-setting problems as in Figure 4, where the trade union chooses the combination of real wage (w^{MF}) and unemployment (u^{MF}) where its (highest attainable) indifference curve (between the members' wages and the risk of unemployment) meets the price-setting curve.

If we instead imagine that wages are negotiated between the firm and the trade union (under right-to-manage) the standard modelling is for wages to be set by Nash bargaining[23, 24]

$$max_{w}[\Lambda(w)-\Lambda_0]^{\rho}[\Pi(w)-\Pi_0]^{1-\rho}, \qquad \text{(A1)}$$

where $\rho \in [0,1]$ is the trade union's relative bargaining power, $\Lambda(w)$ is the trade union's pay-off function, which depends on the bargained wage and $\Pi(w)$ is the firm's profit. Furthermore, Λ_0 (Π_0) is the trade union's (firm's) alternative to an agreement. The trade union's surplus in the bargain is given by $\Lambda(w)-\Lambda_0$ and in the same way the firm's surplus is given by $\Pi(w)-\Pi_0$.

If we let ρ move towards 1, we reach the monopoly trade union solution discussed above as a special case. If we instead allow ρ to move towards 0, the firm will set wages in line with the reservation wage w^R which is given by the constraint that the employees' surplus $\Lambda(w)-\Lambda_0 \geq 0$.[25] That is, the firm must pay at least a wage that the employees are willing to work for. Note that the latter condition describes a jump in the labour supply. This

22 See Layard, Nickell and Jackman (2005) for a discussion. Further, Basu and Carlsson (2012) show evidence that the right-to-manage assumption is reasonable in Swedish micro data.

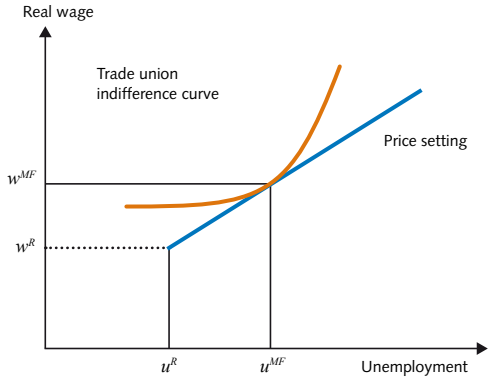
23 For theoretical support for this formula within axiomatic theory, see Nash (1950) and on the basis of non-cooperative bargaining theory, see Rubinstein (1982).

24 The main alternative to a right-to-manage formula is that the trade union and the firm negotiate on both wages and employment (what is known as efficient bargaining). In practice, one can see such a bargaining as first choosing the rate of employment to maximise the surplus in (A1) and that the wages are then determined on the basis of the relative bargaining power between the parties. As wages in this case do not determine employment, the wage is no longer allocative under this formulation of the bargaining.

25 Note that in the second special case with a monopoly trade union ($\rho = 1$) the constraint $\Pi(w)-\Pi_0 \geq 0$ will always be fulfilled as long as the trade union chooses a point on the firm's pricing curve.

is because no one is willing to work for a lower wage than the reservation wage, w^R (which in turn is determined by the unemployment benefit or the value of leisure time), while everyone is willing to work for a wage that is higher than w^R. Thus, unemployment will jump down to 0 for wage levels below w^R.

Figure 4. Equilibrium unemployment in a monopoly trade union model



In a bargaining process, the wage will end up in the interval of $w \in [w^R,\ w^{MF}]$. The exact level for the wages (and unemployment) will, in turn, be determined by the relative bargaining power, ρ.

The point is also made in the main text that taxes and charges that have a proportional effect on the surplus will not have any effect on wages, and thus not on unemployment; they will only affect net wages and net gains. To give an example of this, let us express $\Lambda(w)-\Lambda_0$ in equation (A1) as

$$p(w)\left(\frac{w^{1-\sigma}}{1-\sigma}-\frac{B^{1-\sigma}}{1-\sigma}\right), \qquad \text{(A2)}$$

where $p(w)=N(w)/M$ is the probability of a trade union member being in work (where membership, M, is an exogenous given) and we assume that the trade union's alternative to an agreement Λ_0 is unemployment benefit in real terms (B). If we now introduce a payroll tax we get

$$p(w)\left(\frac{((1-\tau)w)^{1-\sigma}}{1-\sigma}-\frac{((1-\tau)B)^{1-\sigma}}{1-\sigma}\right)=(1-\tau)^{1-\sigma}(\Lambda(w)-\Lambda_0). \qquad \text{(A3)}$$

That is, payroll tax has a proportional effect on the surplus and does not affect the primary conditions for (gross wages) w.

Appendix B: Search and matching models

This appendix gives a more detailed review of the basic search and matching model. To make it simple, we here look at a model with constant and exogenous search intensity. Thus, we assume that an unemployed person always looks for work. Further, we specify a matching function as $H=x(u\bar{L},v\bar{L})$, where H is the number of new hires (during a period of time), $\bar{L}$ is the exogenous given labour force and u and v are the rate of unemployment and vacancy rate respectively.[26]

In the search models the relevant labour market variable is not unemployment, but the demand pressure for labour (relative to supply), often known as "tightness", which is defined as the ratio of vacancies to unemployed persons seeking work, $\theta(=v/u)$. Further, the probability of a firm filling a vacancy within a period of time $q\theta=\frac{H}{v\bar{L}}$ where we assume that $q'(\theta)<0$. The probability of an unemployed person finding a job during a period of time is given as $p(\theta)=\frac{H}{u\bar{L}}=\theta q(\theta)$ where we assume that $p'(\theta)>0$. Firms with vacancies thus find workers more easily when there are more job-seekers relative to the number of job vacancies and job-seekers find a job more easily when there are more job vacancies relative to to the number of job-seekers.

The labour market is in flow equilibrium when the inflow to unemployment is as large as the outflow. As we assume that the probability of a worker leaving his or her job during a period of time, s, is constant, we have in the flow equilibrium that $s(1-u)=p(\theta)u$ or that the inflow into unemployment is as great as the outflow from unemployment. We can write this equivalently as

$$u=\frac{s}{s+p(\theta)}. \qquad \text{(B1)}$$

The equation (B1) gives us an expression of equilibrium unemployment for a given labour market tightness (θ). Given what we have assumed about the matching function's properties, we can represent equation (B1) in the vacancy/unemployment space as a downward sloping curve that is convex towards origo (see Figure 5 bottom left-hand corner). This type of curve is usually called a Beveridge curve, which is also observed as an empirical relationship in data. Note that changes in the matching process affect the $p(\theta)$ expression, and shift the Beveridge curve closer to or further from origo. That is to say, when the matching efficiency changes, more or fewer vacancies are needed to uphold the same unemployment rate.

To determine labour market tightness (θ) we then turn to the labour-demand side/wage formation in the model. The first relationship is the wage-setting curve. As the search frictions mean that one cannot find a new bargaining partner cost-free, a value is created when the employer and employee meet. In the model, the wage is set by dividing the total surplus in a bargain in accordance with equation (A1) above. The wage-setting

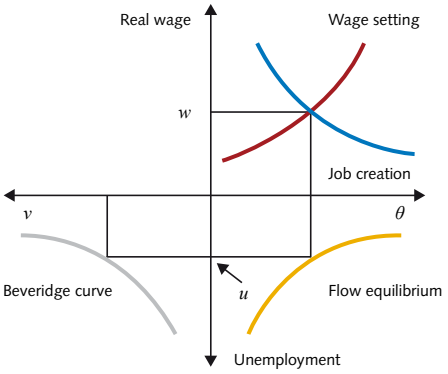
26 In accordance with empirical results, we assume that H is homogenous of degree 1 and concave $(H_{11}<0,\ H_{21}<0)$.

curve will be an upward-sloping function of θ, as more vacancies per job-seeker mean that the competition for workers increases, which strengthens the workers' alternative to an agreement.

The other relationship used to determine labour market tightness (θ), the job-creation curve, comes from the firms' incentives to create vacancies. A vacancy has a value as one can expect to recruit a worker and generate revenues in the future. If the value of the vacancies (net from the cost of holding a vacancy) is positive, the firm can create gains by posting more vacancies, but if the net value is negative, the firm will close the vacancy. Thus, the number of vacancies in equilibrium can be determined by a zero profit condition for them. This zero profit condition gives a negative relationship between wages and θ, as higher labour-demand pressure means that the firm expects it will take longer to fill a vacancy $(q'(\theta)<0)$, which reduces the value of the vacancy. To restore the equilibrium value of a vacancy to zero, the wages must thus fall. One of the key implications from the search model is thus that not only wage-setting, but also incentives for job-seeking are affected directly by the labour market situation (θ) via the expected cost of filling a vacancy.

If we combine these relationships, the equilibrium in a search model can be illustrated as in Figure 5. Alternatively, one can represent the equilibrium as a price-setting and wage-setting equilibrium as in Figure 2 in the main text, by combining both the job-creation curve and the wage-setting curve with the flow-equilibrium condition.

Figure 5. Equilibrium unemployment in a search model



Appendix C: Derivation of the short-run supply curve in LNJ

By writing equations (4) and (5) as deviations from the expectation, we write the price-setting and wage-setting relationship as

$$p-w^n=\beta_0-\beta_1 u-(w^n-E_{-1}(w^n)), \tag{C1}$$

and

$$w^n-p=\gamma_0-\gamma_1 u-(p-E_{-1}(p)). \tag{C2}$$

That is, a situation with a surprisingly high price and wage inflation shifts these curves and gives a short-run equilibrium with lower unemployment. This can also be shown by combining (C1) and (C2), and solving for unemployment which gives

$$u=u^*-\frac{(p-E_{-1}(p))+(w^n-E_{-1}(w^n))}{\beta_1+\gamma_1}, \tag{C3}$$

where u^* is defined as $(\beta_0+\gamma_0)/(\beta_1+\gamma_1)$, that is, equilibrium unemployment with price and wage stability or, in other words, steady-state unemployment. This level can be calculated by setting price and wage surprises to zero in equations (C1) and (C2) and then substituting for real wages in (C2) and solving for unemployment.

To derive a short-run supply curve we then assume (as in LNJ) that $(p-E_{-1}(p))=(w^n-E_{-1}(w^n))$ which gives

$$u-u^*=-\frac{2}{(\beta_1+\gamma_1)}(p-E_{-1}(p)), \tag{C4}$$

which corresponds to equation (6) in the main text.