Unemployment and real wages. A basic model

Olivier Blanchard *

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The following model of unemployment is as basic as it gets. But it allows to discuss various conceptual and semantic issues, to think about the effects of various shocks, and get a sense of critical assumptions and specifications.

It is the first of three models I want to develop at the beginning of the course. The second one introduces capital, and focuses on dynamics of factor prices and quantities; that model can be taken, with some care, to the data. The focus of the third is on micro foundations, starting from flows and bargaining.

Labor demand

Firms have the following production function:

$$Y = XN^{1-a} \qquad 0 \leq a \leq 1$$

where X is the level of technology, and other factors such as capital are assumed constant and ignored for notational simplicity.

Prices are set as a markup over marginal cost:

$$P = (1+\mu)MC; \qquad MC = W/Y_N$$

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P is the nominal price, equivalently the price level, $(1 + \mu)$ is the gross markup, and MC is marginal cost. Under perfect competition, μ is equal to zero. Marginal cost in turn is equal to the nominal wage, W, divided by the marginal product of labor, Y_N.

A side remark on μ. A natural interpretation is that it comes from imperfect competition in the goods market, leading firms to set price above marginal cost. But it could also come from imperfections in the labor market. More generally, note that we can rewrite the gross markup as:

$$(1 + \mu) = P/MC = Y_N/(W/P)$$

The gross markup $(1 + \mu)$ can be expressed either as the ratio of price to marginal cost, or as the ratio of the marginal product of labor to the real wage. Suppose for example that unions force firms to featherbed, i.e. to have more workers than they need at a given level of output; in that case, the marginal product of labor will exceed the real wage, μ will be negative. The elimination of featherbedding will lead to an increase in μ, from a negative value to zero. This being said, I shall keep the goods market interpretation here.

Denote logarithms of variables by corresponding lower case letters. Then the production function is given by:

$$y = (1 - a)n + x \tag{0.1}$$

Assume that μ is not too far from zero, so that $\log(1 + \mu) \approx \mu$. Ignoring constant terms for notational simplicity, here and below, the price is given by:

$$p = w + an + \mu - x \tag{0.2}$$

Two remarks at this point:

- The second equation is often called the "price setting", or the "price" equation. As well known, when firms set their price and thus do not take the real wage as given, there is no "labor demand" relation. But there is a relation that looks very much like a labor demand relation. Note that equation (0.2) can be rewritten as:

$$n = -(1/a)(w - p) - (1/a)\mu + (1/a)x \tag{0.3}$$

If μ is equal to zero, this is just the competitive labor demand curve. If μ is positive and constant, the relation is parallel to the competitive labor demand curve, but with lower employment at a given real wage. For this reason, I shall refer to (0.2) as the "labor demand equation" even when μ is different from zero.

- Note that the coefficient multiplying technology x is the same, up to a sign change, in the production function and the price equation. An adverse technological shock increases the price given the wage and employment and decreases output given employment in the same proportion. This is not a general result and depends on the form of the production function. Following Bruno and Sachs, think for example of production as depending on both labor and oil. If production is Cobb Douglas in labor and oil, then an increase in the price of oil will have the same effect as a decrease in x here. But, if production is, say, Leontief in labor and oil, then the relation between labor and output will be unaffected, but the price of oil will still enter the price equation: an increase in the price of oil will increase the price of output given the wage. (Work all this out).

Labor supply

It is quite clear —at least to me— that the competitive labor supply will not do as the other equation of the model. My preference for thinking about wage determination runs to models that allow for specificity and bargaining in the determination of wages, and we shall see a number of such formalizations later. Here, I shall adopt a black box specification, namely that the real wage set in bargaining between workers and firms depends on the level of technology, on employment, and other unspecified factors.

More specifically, and going directly to logs, I assume:

$$w = p + bn + Ex + z \tag{0.4}$$

The wage depends, with unit elasticity, on the price level (nominal rigidities will be discussed later). It is increasing in employment, n (equivalently in unemployment). If we conveniently normalize the labor force to be equal to 1, then n is approximately equal to minus the unemployment rate, u.

The wage also depends on the expected level of technology, Ex, with unit elasticity. If one wants to build a model in which there is no trend in unemployment as technology improves, the level of technology must eventually be reflected one for one in the bargaining wage at a given level of employment. In the explicit models we shall see later, the effect comes largely through the reservation wage, and is likely to take place only over time. The specification in (0.4) captures both the fact that an increase in technology is eventually fully reflected in the wage at a given level of employment, and the fact that an unexpected improvement in technology ($x > Ex$) may not be reflected in the wage right away. We shall return to the issue of the right specification at many times in the course; but be warned already: the issue is far from settled, both theoretically and empirically.

Finally, the wage depends on other factors, z that can, for the moment, be generically be refered to as "wage push" (or wage pull) factors. In explicit models, changes in z will be generated by institutional changes, such as changes in the structure of bargaining, in employment protection, in the generosity of unemployment benefits, and so on.

This equation comes under a number of names in the literature, such as the "wage setting" or "wage" equation. Again, just as the price equation can be rewritten as a labor demand equation, the wage equation can be rewritten as a labor supply relation giving employment as an increasing a function of the real wage, adjusted for the technological level, and of other factors:

$$n = (1/b)(w - p - Ex) - (1/b)z \tag{0.5}$$

Equilibrium

Continuing to ignore nominal rigidities, the equilibrium is then given by the equality of labor demand and labor supply (or equivalently, by the condition that the wage consistent with the decisions of firms be equal to the wage consistent with bargaining. Or again equivalently, the condition that the demand wage must be equal to the supply wage. Various researchers have their prefered way of stating the same condition.) This gives:

$$\begin{aligned} n &= (1/(a+b))[(x - Ex) - z - \mu] \\ w - p &= (1/(a+b))[bx + aEx + az - b\mu] \end{aligned}$$

And, with the labor force normalized to one, $u \approx -n$, where u is the unemployment rate.

Figure 1 draws the price and the wage equation (equivalently labor demand and labor supply) in the log real wage-log employment space. The unemployment rate can be read off starting from the right. So long as a is positive, the price equation (labor demand) is downward sloping. The wage equation (labor supply) is upward sloping.

Higher unemployment may then come from one of three sets of causes:

- It may come from an adverse shock to technology, or, more informally, from a slowdown in the rate of technological progress which is not reflected right

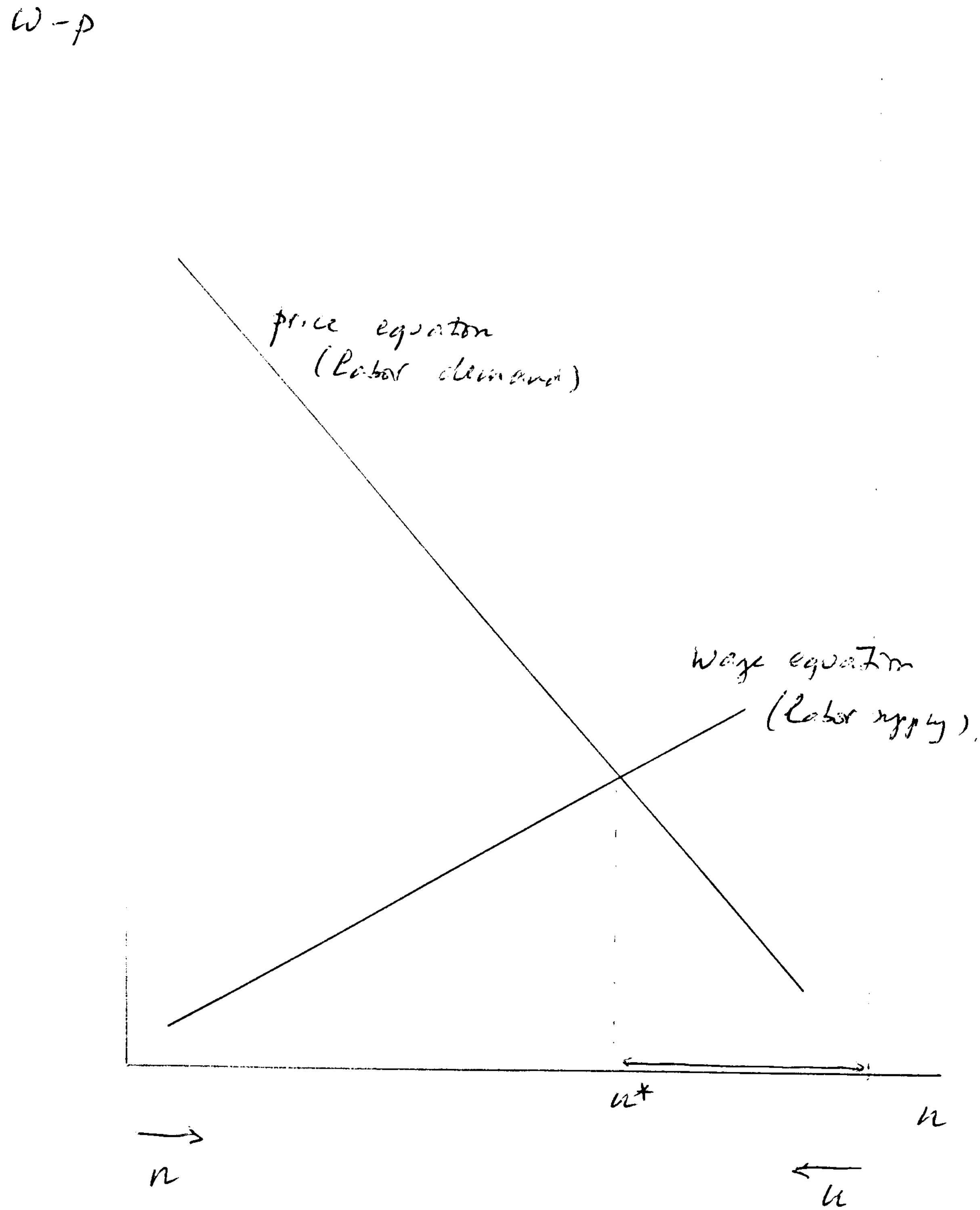
w - p
price equation
(labor demand)
wage equation
(labor supply)
u*
u
u
u

Figure 1.

away in wage setting. If for example, $0 < x < Ex$, labor demand shifts up by x, but labor supply shifts by more, namely Ex. Wages are higher (wages relative to the technological level, $w - x$ are lower), but so is unemployment.

- It may come from an increase in the markup, which shifts labor demand down, leading to lower wages and higher unemployment. For example, Phelps has suggested that higher interest rates may lead firms to increase markups, increasing unemployment. (Higher interest rates also reduce capital accumulation, and shift labor demand. But we do not have this effect here, as capital is assumed fixed. Wait for model 2). But recall the labor market interpretation above. The elimination of featherbedding also leads to an increase in the markup, and thus higher unemployment (you may, at this stage, ask: will not this increase profits of firms, leading to more investment and perhaps more employment in due time? If so, you are right, but we need a model with capital accumulation to explore those dynamics. This will again be done in model 2.)
- It may come from wage push factors, that shift labor supply up, leading to higher wages. A number of such factors have been suggested in the context of European unemployment. By making unemployment less painful, an increase in unemployment benefits is likely to increase the wage set in bargaining. Employment protection can reinforce the hand of workers in bargaining. And so on.

This model suggests a first pass at the data, looking at the correlation of real wages and unemployment, perhaps the estimation of rough labor supply and labor demand curves. But this runs into a major problem, the presence and the implications of nominal rigidities.

Nominal rigidities

In the absence of nominal rigidities, the two equations above determine employment and real wages. The production function gives us output. And aggregate demand then determines the price level. Working directly in logs, let me assume the simplest form for this aggregate demand equation:

$$y = c(m - p) \tag{0.6}$$

where m is the nominal money stock.

In the presence of nominal rigidities however, variations in nominal money (or more generally movements in aggregate demand) lead to variations in unemployment and in wages. Can we still say something about correlations between real wages and unemployment?

The initial formalization of nominal rigidities, dating back to Keynes and the early formalizations of the Keynesian model, was to assume that wages were set in nominal terms, and prices were free to adjust. This is the approach taken for example in Fischer (1977). Assume, following Fischer (1977) that nominal wages are set equal to their expected value (based on the information available at the beginning of the period; I do not need to be more specific here), so that the wage equation (0.4) becomes:

$$w = Ep + bEn + Ex + Ez \tag{0.7}$$

The model then consists of this new wage equation, together with the price, the production function, and the aggregate demand equations. Assume, by convenient and innocuous normalization, that $Ex = Ez = E\mu = 0$. Then, solving this model yields:

$$Ey = En = 0, \qquad w = Ep = Em$$

and:

$$\begin{aligned} n &= (m - Em) - \mu \\ w - p &= -a(m - Em) - (1 - a)\mu + x \end{aligned}$$

Consider the effects of an unexpected change in money. An unexpected increase in nominal money leads to higher output and employment –lower unemployment– and to a decrease in the real wage, at least as long as a is positive: this is because firms move down their labor demand curve (or equivalently increase their price in response to the increase in marginal cost as they respond to demand). Whether real wages exhibit this countercyclical behavior was the subject of the Dunlop-Tarshis debate and has been studied at length. The evidence, summarized in the Abraham-Haltiwanger paper, suggests that they do not, at least in the United States. If anything, wages are slightly pro-cyclical.

The more recent work on nominal rigidities has emphasized however that both prices and wages are often set in advance. And even if each price is set for a short period of time, interactions between price decisions can lead to substantial price rigidity. In that case, real wages may be pro- or counter-cyclical depending on the exact form of nominal rigidities. Rather trivially: if, for example, both nominal wages and prices are set in advance, then the real wage will be predetermined, and thus, in this model, acyclical. Output and employment will be simply given by:

$$
\begin{aligned}
y &= m - Em \\
n &= (1/(1-a))(m - Em - x)
\end{aligned}
$$

An increase in nominal money will still increase output and employment but will have no effect on the real wage. If price rigidity plays a more important role than wage rigidity, then real wages may then be pro-cyclical.

I have focused on the effects of aggregate demand/nominal money. But the effects of the other shocks are also quite different in the presence of nominal rigidities.

Recall that, absent nominal rigidities, an unexpected increase in productivity led to an increase in employment. Note how, when wages are predetermined, the same unexpected increase in productivity now has no effect on employment, and that when both wages and prices are predetermined, the same increase leads to a decrease in employment! (Make sure you understand why, in each of the two cases, and ask yourself how robust these results are. On this topic, you may want to look at Gali (1997), who discusses these effects at more length.)

The model I have sketched can be used to think about a variety of issues. But the conclusion I want to draw at this point is that the presence of nominal rigidities complicates very much the relation between real wages and unemployment. In the short run, we cannot expect much relation between the two, and we cannot interpret the correlation between the two, if present, to reflect the dominance of labor supply or labor demand shocks. But, over the medium run, that is over a run long enough that nominal rigidities play less of a role, we may be able to. This leads to the second model, and its application to the data.