

## Unemployment, capital accumulation, and real wages.

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The purpose of this second model is to provide a way of interpreting the joint evolutions of employment and capital, real wages, and real interest rates. It improves upon the first model by introducing capital accumulation, and technological progress. (It is a simpler version of the model developed in my Brookings paper, "The Medium Run". )

The note has three parts. First, the facts that led me to explore such a model. Then the model, and the analysis of the dynamic effects of various shocks. Then, a brief summary of the findings in the "Medium run" paper.

### 1 Some facts

Figure 1 shows the evolution of the unemployment rate in the three major continental European countries, Germany, France and Italy (the picture is the same when looking at continental Europe as a whole). It documents the steady increase in unemployment since the early 1970s.

Figure 2 shows a set of facts that is less well-known, but would appear to be relevant in trying to understand European evolutions. It shows the evolution of the

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\* Prepared for Lecture 3, Econ 2410d

Fig 1

### Unemployment rates in France, Germany, Italy

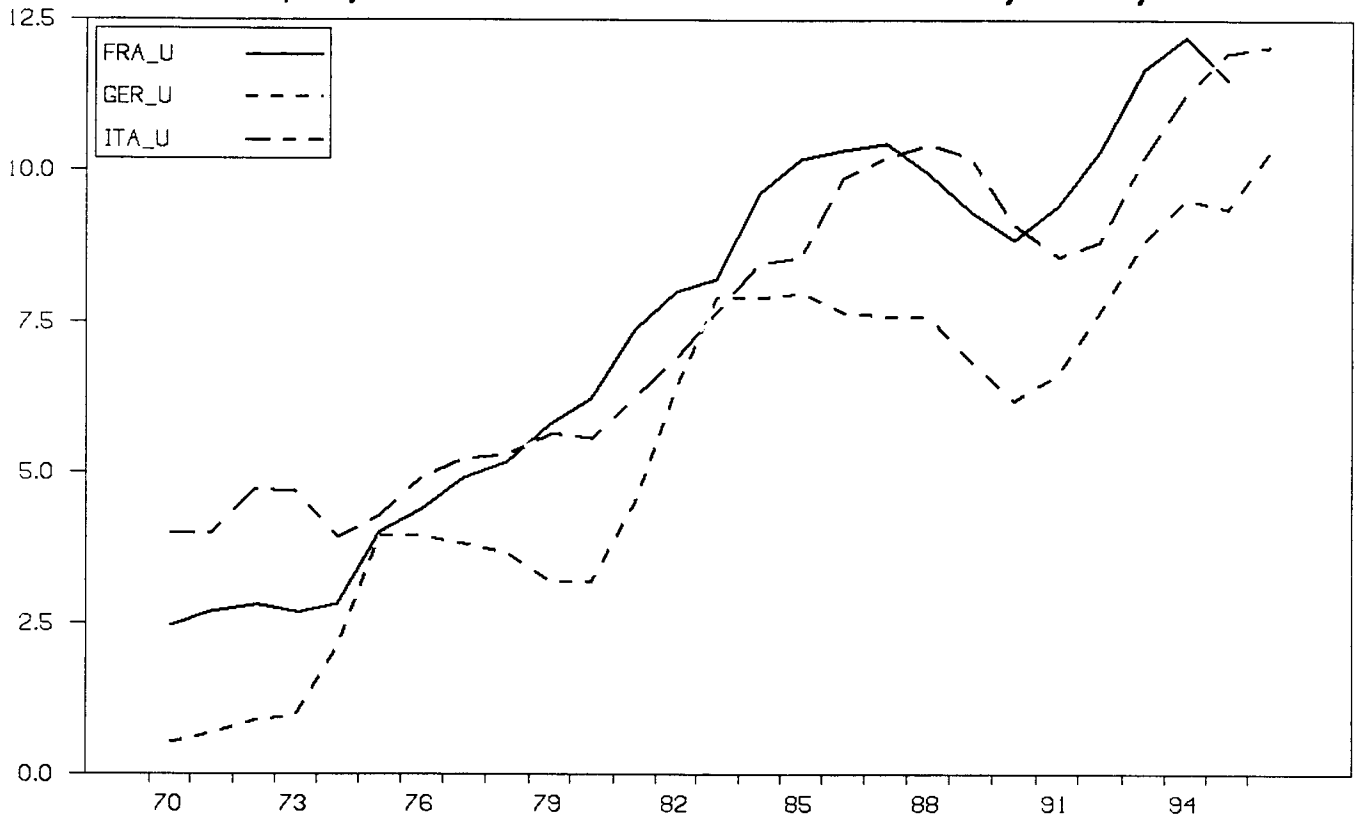


Fig 2

### Profit shares in France, Germany, Italy



capital share in the business sector in the same three countries since the early 1970s. The evolution is largely common and quite striking: a substantial decrease from the mid 1970s to the mid 1980s, but a large increase since. In all four countries, capital shares stand at a much higher level than in 1970.

What is this evolution of capital shares telling us? More generally, how should we interpret the evolution of unemployment, capital, wages and profits? What does it tell us about the types of shocks that have affected these economies. The issue was first tackled by Bruno and Sachs in the early 1980s. Given the evolution of shares since then, it seems worth revisiting it. This is what the model developed in these notes is about.

## 2 The basic mechanisms

The basic approach is the same as in the first model. The specification of “labor demand”, then of “labor supply”, and a characterization of the equilibrium. (Having discussed them in the context of the first model, I shall ignore a number of semantic issues, such as the use of “labor demand” in a potentially imperfectly competitive environment, and so on.)

### Labor demand

Assume that production is characterized by a constant-returns-to-scale production function, and Harrod-neutral technological progress.

$$y = f(k, zn) \tag{2.1}$$

$y$  is output,  $k$  is capital,  $n$  is labor.  $z$  is the level of technology, and technological progress is assumed to be labor augmenting, so that  $z$  multiplies  $n$ .  $zn$  is often called “labor in efficiency units.” You will remember from growth theory that the assumption of Harrod neutral technological progress is the only one that delivers balanced growth. Thus, it seems like the natural benchmark assumption here.

At any point of time, capital is given. Firms decide how much labor to hire. Building on the discussion in the previous model, I extend the usual first order condition that price equals marginal cost to allow for a possibly non zero markup. The first order condition can thus be written as:

$$z f_n(k, zn) = (1 + \mu)w$$

The marginal product of labor must be equal to the gross markup times the real wage. If  $\mu$  is equal to zero, this reduces to the standard first-order condition for perfectly competitive firms.

Denote the ratio of labor in efficiency units to capital,  $zn/k$  (which will be constant in steady state) by  $x$ . Use the constant-returns assumption. The first order condition can be rewritten as:

$$f_n(1, x) = (1 + \mu) \frac{w}{z} \quad (2.2)$$

Given that  $f_{nn} < 0$ , the ratio of labor in efficiency units to capital,  $x \equiv zn/k$ , is a decreasing function of the wage in efficiency units,  $w/z$ . Solving for  $x$  gives:

$$x = x\left((1 + \mu) \frac{w}{z}\right), \quad x' < 0 \quad (2.3)$$

And employment,  $n$ , is itself given by:

$$n = \frac{k}{z} x\left((1 + \mu) \frac{w}{z}\right), \quad x' < 0 \quad (2.4)$$

This short-run labor demand is drawn for a given value of  $k/z$  in Figure 3. Employment,  $n$ , is measured on the horizontal axis, the wage in efficiency units,  $w/z$  on the vertical axis. The curve is downward sloping, and its slope depends on the short-run elasticity of substitution between capital and labor.

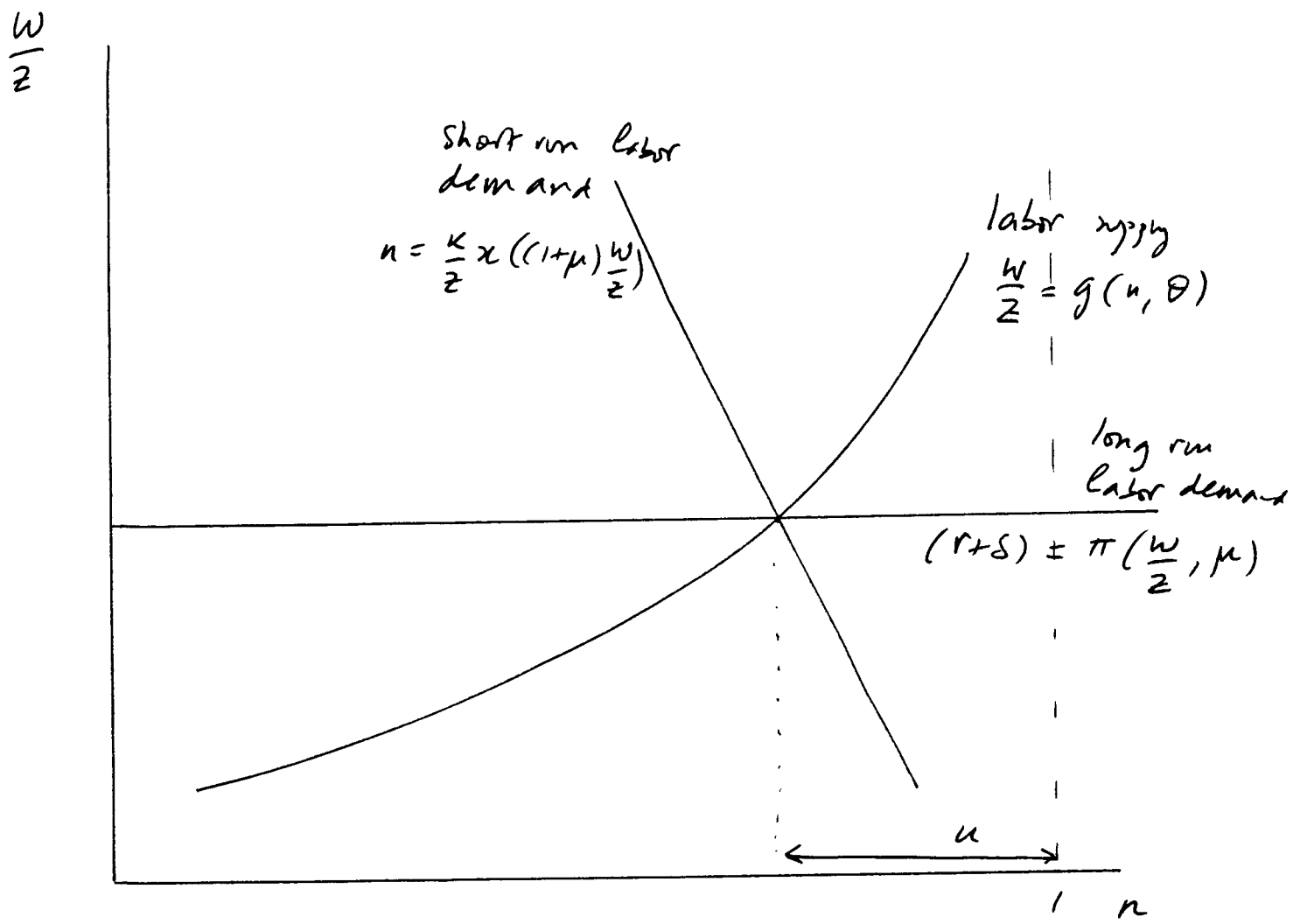


Figure 3.

Turn now to the adjustment of capital over time, and the long run labor demand curve. Total profit is given by:

$$\Pi = f(k, nz) - wn$$

The profit rate, i.e. profit per unit of capital,  $\pi = \Pi/K$  is thus given by:

$$\pi = f(1, x) - (w/z)x$$

Using equation (2.3), we can express the profit rate as a function of  $w/z$ . For short, we can write:

$$\pi = \pi\left(\frac{w}{z}, \mu\right), \quad \pi_{w/z} < 0 \quad (2.5)$$

For  $\mu = 0$ , this is simply the “factor price frontier”, which says that the profit rate is inversely related to the wage in efficiency units. Check that, if  $\mu = 0$ , the slope of the factor price frontier is equal to the ratio of labor in efficiency units to capital:  $d\pi/d(w/z) = -x$ . We shall discuss the effects of  $\mu$  later on.

A high profit rate is likely to trigger capital accumulation and entry of new firms, a low profit rate to trigger decumulation. The details depend on the structure of the goods market. An easy way to close the model is to assume that there is free entry in the goods market, that each firm needs one unit of capital, that there is no fixed cost, and that the markup is independent of the number of firms. Thus, firms will enter (exit)—equivalently capital will accumulate (decumulate)—until the profit rate is equal to the user cost of capital.

Assume that the price of capital in terms of goods is equal to 1, that the depreciation rate is equal to  $\delta$  and the interest rate equal to  $r$ . Then, in the long run, it must be that:

$$\pi(w/z, \mu) = r + \delta \quad (2.6)$$

For a given  $r$ , the free entry condition pins down the wage (in efficiency units) in the long run. If the wage is higher, then there is steady capital decumulation, and by implication, a steady decrease in employment; if lower, steady capital accumulation, and a steady increase in employment. In other words, the long run labor demand is horizontal. It is drawn as the horizontal line in Figure 1.

### Labor supply

As in the first model, I shall think of labor supply as a relation between the wage determined in bargaining between firms and workers, labor market conditions, and other factors. (Only in the next model shall I derive such a relation from first principles). Normalize the labor force to be equal to one, so that  $n$  stands for the employment rate, and for one minus the unemployment rate. The simplest specification in this context is the following:

$$w/z = g(n, \theta), \quad g_n > 0, g_\theta > 0 \quad (2.7)$$

The wage (in efficiency units) is assumed to be an increasing function of the employment rate (equivalently, a decreasing function of the unemployment rate), and of other factors, summarized in the variable  $\theta$ . As in the previous model, these factors may come from changes in the bargaining structure, an increase in unemployment benefits, and so on.

The labor supply relation is drawn as the upward sloping curve in Figure 3: the higher the employment rate, the higher the bargained wage. The short and long run labor demand and labor supply relations are drawn so that they all cross at the same point: the economy is initially in the steady state associated with balanced growth. Over time, wages grow in line with technological progress; equivalently, wages in efficiency units are constant. Employment is constant (the labor force is assumed constant here) The unemployment rate, that we can measure starting from the right in the figure, is also constant. Capital grows at the same rate as labor in efficiency units, so that the ratio of labor in efficiency units to capi-

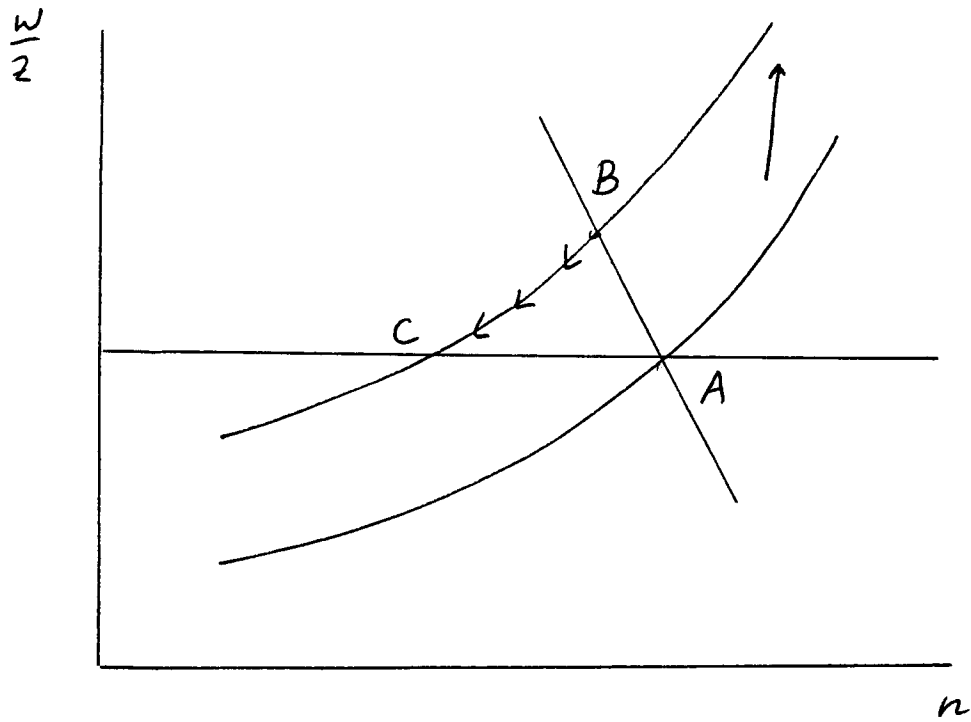


Fig 4.  
Labor supply  
shift

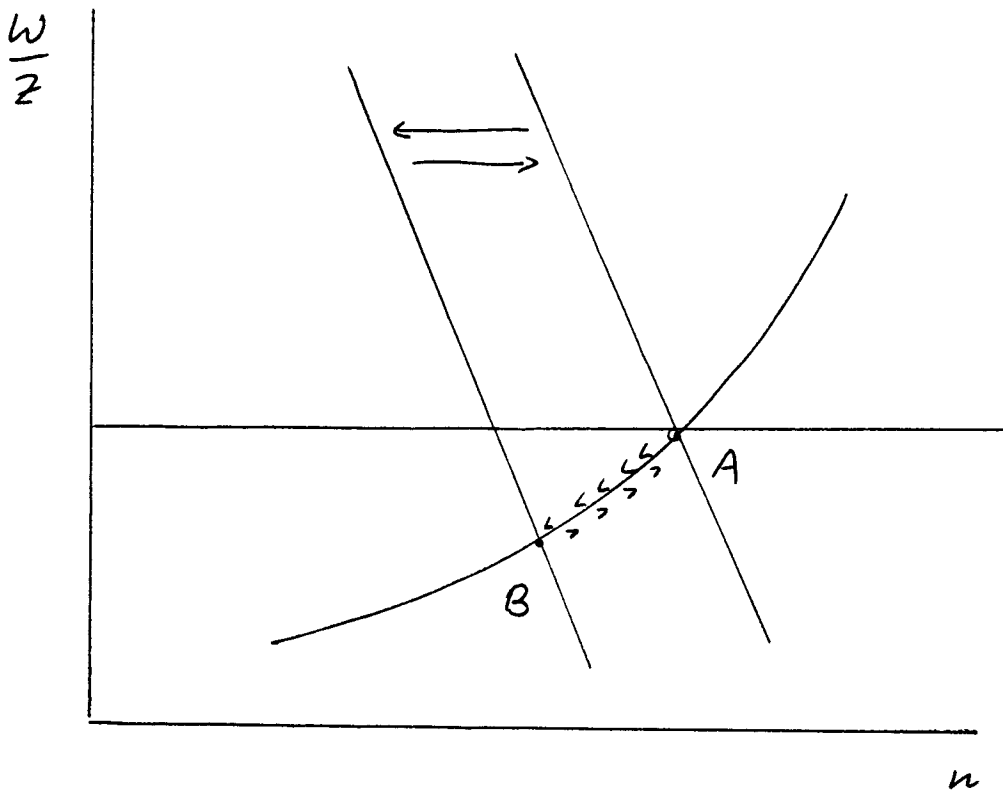


Fig 5.  
Labor demand  
shift.

tal is constant. Absent shifts, technological progress, and changes in the rate of technological progress do not affect unemployment.

We can now look at the dynamic effects of both labor supply and labor demand shocks.

### Labor supply shocks

Consider an adverse labor supply shock, an increase in  $\theta$ : for some reason, workers require a higher real wage relative to the level of technology, at a given unemployment rate. The reason may be a change in labor market institutions, such as an increase in unemployment benefits, or the structure of bargaining. Or it may for example reflect a failure of wages to adjust to a slowdown in productivity growth: because we measure the wage in efficiency units on the vertical axis, such a failure of wages to adjust leads to an increase in the bargained wage  $w$  relative to  $z$ , at a given level of employment.

The dynamics are depicted in Figure 4.

The labor supply curve shifts up, leading to a movement along the short run demand curve. The economy moves from A to B. Thus, in the short run, wages increase and so does unemployment. The profit rate unambiguously goes down. What happens to the share of labor depends on the short run elasticity of substitution between capital and labor: if less than one, then the share of labor will increase, the share of capital decrease.

Over time, the lower profit rate leads to capital decumulation, and a further decrease in employment. The economy moves from B to C. The process only ends when the pressure from unemployment on wages leads wages to return to their original value. By then, unemployment is higher; the share of capital is back to its original value. In effect the economy has the same factor prices, the same labor-capital ratio, but is using less labor and less capital. (Note the role of the assumption that the interest rate is constant. How would the dynamics and the long run

effects look like if saving was not fully elastic?)

Even at this crude stage of the analysis, it is clear that adverse labor supply shifts can potentially explain much of the evolution of European unemployment from the mid 1970s on. They naturally explain why the share of capital first went down and then recovered, while unemployment kept increasing.<sup>1</sup> But it is also clear that they do not naturally explain what happened after the mid 1980s, namely the increase in the share above its 1970 level. This motivates looking at other shocks.

### Labor demand shocks

Define a labor demand shock as a shift in the relation between the wage and employment given the level of technology  $z$ , and the capital stock,  $k$ , in equation (2.4). There are two potential sources of such shifts. The first is changes in the markup,  $\mu$ . The second is non-neutral shifts in technology, shifts in  $f(\cdot, \cdot)$  and by implication shifts in  $x(\cdot)$ . Let me discuss each one in turn.

(1) From equation (2.2) or (2.3), an increase in the markup decreases the real wage given employment, or equivalently, decreases employment for a given real wage. The short run labor demand curve shifts down. If we think of the markup as reflecting monopoly power in the goods market, then the first way of thinking makes more sense: at a given level of employment, at a given nominal wage, firms

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1. Much of the focus in the 1970s was on “real wage gaps”, the real wage divided by labor productivity. It was noticed by many researchers that real wage gaps had increased a lot in the 1970s, and real wage gaps were thus blamed for the increase in unemployment. By the mid 1980s, the real wage gaps were largely gone, but unemployment was still high. It was concluded by many that real wage gaps were probably not responsible for the increase in unemployment, and research moved away from gaps. Can you make sense of the evolution of wage gaps in the light of what we just saw? Hint: what is the relation between the evolution of the real wage gap and the evolution of the labor share?

increase their price. Put another way, the real wage decreases. Building on the discussion in the first model, we can also think of the markup as coming from the labor market: recall that featherbedding (firms being forced to employ too many workers at a given real wage) can be thought of as a negative markup. Then, the elimination of featherbedding ( $\mu$  going from negative to zero) will lead firms to employ less workers at a given real wage, again a downward shift in the short run labor demand curve.

(2) Think instead of a non neutral shift in technology, leading firms to want to shift from labor to capital. To make things concrete, think of firms as having a Cobb-Douglas production function:

$$y = k^a (nz)^{1-a}$$

And think of an increase in  $a$ , the coefficient on capital. For given values of  $k$ ,  $n$  and  $z$ , and thus a given value of  $x = zn/k$ , the marginal product of labor will decrease (the marginal product of capital will increase): the short run labor demand will shift down: given the shift in technology, the only way to employ the same number of workers at a given capital stock is if they accept a lower wage.

Figure 5 traces the dynamic effects of such a labor demand shock (due either to a change in the markup, or a technological shift; the source does not matter here). As labor demand shifts down, the economy moves along the labor supply curve, from A to B. Employment decreases, and so do wages. Thus, the labor share unambiguously goes down, the capital share goes up. This combination of both increasing unemployment and increasing capital share fits well what has happened in continental Europe since the mid 1980s. It suggests that such labor demand shifts may well have played a role.

We have looked however only at the initial effects of such shifts, the effects for a given capital stock. What happens over time? At point B, the profit rate is higher. Think for example of firms eliminating featherbedding. As they eliminate

redundant workers (workers whose marginal product is below the wage), their profit rate goes up. This profit rate leads to more capital accumulation, and the short run labor demand now shifts right over time. Thus, after the initial decrease, employment steadily recovers. What happens to the capital share depends on the elasticity of substitution: if less than one, the capital share decreases; if greater than one, it increases further. Where does the economy end up? This depends on the effects of changes in the markup or of shifts in technology on the position of the long run labor demand. The answer is that, to a first approximation, the long run labor demand does not shift.

To see this, take the case of a change in the markup. Note that the wage implied by the long run labor demand (2.6) depends on  $\mu$  only through the effects of  $\mu$  on  $x$ . Differentiating (2.6) with respect to  $w/z$  and  $x$ :

$$(x/z)dw = (f_n - (w/z))dx$$

Thus, starting from  $\mu = 0$ , changes in  $x$  have no effect on  $w$ . By implication, changes in  $\mu$  starting from zero also have no effect on the wage. This result also holds in the case of a change in the coefficient  $a$  in the Cobb Douglas case (Work it out; be careful, when you change  $a$  that this changes relative marginal products, but not output. The easiest way to do this is to assume, by proper normalization, initial  $zn$  and  $k$  to be equal).

To summarize, adverse labor demand shocks lead initially to an increase in unemployment and an increase in the capital share. Eventually, higher investment leads to more capital, more employment, and unemployment returns to its initial level. The capital share remains higher.

The implied increases in the capital share and in unemployment appear to fit quite well the last ten years in Europe. But the implied increase in investment, and the turnaround in unemployment suggested by the model have not yet taken place in continental Europe. This suggests a potential role of yet another type of shock,

*changes in the real interest rate*, affecting the user cost. As you know, real interest rates were low in the 1970s, but have been quite high since. I shall let you work the effects of such a shock out. Make sure to characterize the dynamic effects on capital, employment, real wage and the capital share.

### 3 Taking this model to the data.

What I do in “The Medium Run” is to extend and use this model to interpret the data.

I build a model along the lines allowing for more explicit dynamic choices by firms, as well as for one additional source of dynamics, namely costs of adjusting factor proportions (This implies that, in the very short run, labor demand is nearly inelastic, so that changes in wages lead to very little change in employment, and nearly one-for-one changes in the share.) Thus, there are now two types of decisions taken by firms: whether to accumulate/decumulate capital (enter and exit, if we think of firms as requiring one unit of capital to operate), and whether to adjust factor proportions, how much labor to use with each machine. Decisions are forward looking, taken under rational expectations.

I then use the model to look at the dynamic effects of labor supply and labor demand shifts on factor quantities and factor prices.

I finally use the equations of the model to construct labor supply and labor demand shifts, as well as a user cost series. I do this in a crude but transparent way. I assume specific functional forms, and specific values of the underlying parameters.

This interpretation of the data yields the following broad conclusions:

- The dominance of large adverse labor supply shifts from the mid 1970s on. But the evidence points to a decrease, if not a disappearance of these shifts.
- The appearance of large adverse labor demand shifts from the mid 1980s on, explaining the persistence of high unemployment despite the decrease

in labor supply shifts.

- Low user costs in the 1970s, and higher user costs since, leading to relatively less unemployment in the 1970s, and more unemployment since then.

This is progress. But it leads in turn to another set of questions? Why the shifts. Where do they come from? What is the role of oil shocks, the productivity growth slowdown, downsizing, biased technological progress, high real interest rates on bonds? The next step is to look more closely at wage determination. This is the focus of the next model.