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Abstract

This article studies the theoretical foundations of the two main structural wage equations proposed in the literature, namely the Phillips curve and the WS curve. It reinstates to a certain extent the wage Phillips curve by showing that the Phillips curve is preferable to the WS curve from a theoretical point of view. This contradicts the results of previous researches that conclude to the lack of theoretical foundation of the Phillips curve. Moreover, this article shows that the WS curve can be interpreted as a particular case of the Phillips curve: the case of full hysteresis.

Keywords: Phillips curve, WS curve, equilibrium unemployment

JEL-Code: E24

1. Introduction

The specification of the structural macroeconomic wage equation has caused considerable controversy among the proponents of the Phillips (1958) curve which relates the *variation of the nominal* wage to the unemployment rate and those of the Wage Setting (WS) curve which relates the *level of the real* wage to this same rate. This discussion began with a series of theoretical and empirical critics formulated to the Phillips curve.

Following the influential work of Blanchflower and Oswald (1994a&b, 1995), several authors argue that the Phillips curve apparent robustness may come from econometric bias due to macroeconomic data aggregation problems, to incorrect specification, or to measurement errors. Testing both wage relations using microeconomic regional data, they conclude to the rejection of the Phillips curve[1]. However, Card (1995), Blanchard and Katz (1997) and others studies cast serious doubts on this finding pointing out several data and econometric issues. Correcting for these, they reach an opposite conclusion and validate the Phillips curve from microeconomic regional data (see the survey on this literature by Montuenga-Gómez and Ramos-Parreño, 2005). L'Horty and Thibault (1997) claim that the Phillips curve may be a spurious regression as defined by Granger and Newbold (1974). However, this is contradicted by studies which test the Phillips curve in several countries as a cointegration relation (*e.g.* Heyer *et al.* 2000, 2007; Bardsen *et al.* 2005, 2006).

The Phillips curve is also criticized for its lack of theoretical foundations by Layard *et al.*, (1991), Bean (1994) or L'Horty and Thibault (1997). These authors argue that the WS curve has more theoretical foundations because it is compatible with a large variety of wage setting microeconomic models such as bargaining or efficiency models whereas the Phillips curve is not. Several studies contradict this point of view by showing that both curves can be founded by the same theoretical wage setting models (Manning 1993; Blanchard and Katz 1999; Cahuc and Zylberberg 1996, 2004, pp. 482-485). The specification of the wage equation

crucially depends on the specification of the reservation wage. For a Phillips curve, the latter is the past wage whereas it corresponds to a deterministic trend or the labor productivity for a WS curve.

This article does not try to decide between the Phillips and WS curves from an empirical or statistical point of view. The literature quoted above shows how difficult it is to reach affirmative results in this matter. Instead, this article concentrates on the theoretical foundation of each structural wage equation. It reinstates the wage Phillips curve since our main finding is that the Phillips curve appears preferable to the WS curve from a theoretical point of view. This contradicts the results of previous research concluding to the lack of theoretical foundation of the Phillips curve[2].

Section 2 discusses the respective theoretical foundations of the WS and Phillips curves. It contradicts several theoretical criticisms formulated to the Phillips curve and argues that this curve has stronger theoretical foundation than the WS curve. In particular, we show that the Phillips curve's implicit assumption of a reservation wage that corresponds to the past wage seems more realistic.

In addition, Section 3 shows that the Phillips curve can be interpreted as a more general model that the WS curve. On one hand, it is able to synthesize a large range of wage setting behavior. On the other hand the WS curve is a particular case of the Phillips curve, namely the case of full hysteresis. We show that some constraints applied to a general specification of the Phillips curve lead to the main WS curves proposed in the literature. This is a different result compared to previous attempts of reconciliation between the two macroeconomic wage equations where the Phillips curve is viewed (1) either as the dynamic adjustment of a WS curve (Sargan 1964; Sawyer 1982), (2) either as a particular case of the WS curve (Manning 1993; Blanchard and Katz 1999; or Cahuc and Zylberberg 1996, 2004, Chap. 8), (3) either as a reduced form obtained by combining the WS and Price Setting (PS) curves (Whelan 2000).

Section 4 discusses the implications of the specification of the wage equation in terms of equilibrium rate of unemployment. It shows that a temporary shock with a Phillips curve becomes permanent with a WS curve because of the full hysteresis hypothesis. Section 5 concludes.

2. Theoretical foundations of the macroeconomic wage equations

The controversy between the Phillips and WS curves is likely to be due to the complexity of the wage-setting process. Whereas the price setting may be described as the firm's discretionary choice, the question of knowing who sets the wage and on which basis does not have an obvious answer. Does the employee herself set the "price" of her work as a producer sets the price of the goods or services that she sells? Does the firm decide the remuneration of the labor which it needs? Is the wage always negotiated between employers and employees? If it is the case, what are the main objects of the negotiation? In particular, are unemployed people's welfare or the workers' productivity directly taken into account?

These uncertainties may explain the coexistence of several theoretical models of wages formation. Despite very different assumptions concerning the wage-setting process, most of these models deliver the same wage equation (*e.g.* Layard *et al.* 1991; Cahuc and Zylberberg 1996, 2004). Appendix A surveys the main wage setting theoretical models and shows that neoclassical, bargaining or efficiency wage models generally conclude that the real wage is set as a mark-up over a certain reservation wage which represents the income opportunities of an employee outside the firm, *i.e.* unemployment benefits, wages proposed by other firms or revenues from domestic or illegal activities:

$$\tilde{w} = w - p = \tilde{w}^r + m^w - \beta U \qquad (1)$$

Where $\tilde{W}$, W, P, $\tilde{W}^r$, U, M^w are, respectively, the real wage, the nominal wage, the price, the reservation wage, the unemployment rate and the desired mark-up of workers[3].

The desired mark-up of workers may depend on their bargaining power. Applying standard linear approximation and simplifying hypothesis about the appropriate indicator of the labor market tightness, the mark-up is generally assumed to be a decreasing function of the unemployment rate.

2.1. Lack of theoretical foundations of WS curves

Several studies have shown that the specification of the reservation wage is a crucial element of the controversy between the WS and the Phillips curve (Manning 1993; Blanchard and Katz 1999; Cahuc and Zylberberg 1996, 2004, pp. 482-485; Heyer *et al.* 2007). In WS curve *à la* Sargan (1964), the reservation wage follows a determinist trend: $\tilde{w}^r = \tau.t$ (*e.g.* L'Horty and Rault 2003). This trend is supposed to measure either the rise in the standard of living upon which the wage claims of workers would be indexed (Cotis *et al.* 1998) or the rise in the value that workers attribute to leisure. But this specification has several theoretical and empirical drawbacks.

Firstly, there is little realistic theoretical justification to specify the reservation wage as a determinist trend. The evolution of the standard of living is not perceived in absolute terms *via* a deterministic trend, but rather in relative terms since it depends upon the former purchasing power, *i.e*. the past real wage. The value of leisure depends on the standard of living and not on a quasi-physiological law disconnected from any macroeconomic variables.

Secondly, the econometric estimation of a determinist trend is generally unstable. It often varies according to the length of the estimation period and the presence (or the absence) of certain variables. For instance, on French data, the trend estimates of similar WS curves *à la* Sargan are nearly 5 times higher in Cotis *et al.* (1998) for the 1/1974-4/1995 period than in L'Horty and Rault (2003) for the 1/1970-4/1996 period. This instability leads to significant differences in the estimation of the equilibrium rate of unemployment.

Thirdly, this specification leads to a model that does not have a consistent equilibrium growth path since the equilibrium rate of unemployment is affected by an unrealistic permanent up or downward drift when the determinist trend in the wage equation diverges from the trend of labor productivity (see Section 4).

To avoid these theoretical and empirical problems, most studies choose a WS curve *à la* Layard *et al.* (1991), where the reservation wage is the labor productivity: $\tilde{w}^r = p^{rod\,4}$. The fact that the income opportunity outside the firm follows the labor productivity relies on two implicit hypotheses. The first one assumes that unemployment benefits depend on labor productivity (*e. g.* Bean 1994). This hypothesis is false since benefits are generally calculated on the basis of past wages and not according to labor productivity. The second hypothesis formulated by Blanchard and Katz (1999) argues that the productivity of domestic or illegal work follows the productivity of dependant employment. Although this hypothesis is difficult to verify empirically, one can cast doubt that it is actually true. In particular, one may expect some illegal activity to be more productive but some domestic work to be less productive than the productivity of dependant employment.

Job search and matching models inspired by the seminal work of Diamond (1982), Mortensen (1982) and Pissarides (1985) provide another reason to specify the reservation wage as labor productivity. They assume that the firm negotiates the wages with each one of its employees on the basis of their productivity (*e.g.* Mortensen and Pissarides 1994; Pissarides 2000; Cahuc and Zylberberg 2004, Chap. 3). The bargain concerns the share of the value-added created by the worker. Such a mechanism does not seem very realistic to describe the wage setting process at the macroeconomic level. It is representative of an economy where workers own a significant share of their company, as it may be the case in some self-employed professions. Sometimes independent workers such as lawyers or doctors choose to associate and then bargain over the share of the future profits. However, these are not

employees, but joint owners of the company. Their financial responsibility is committed in the event of bankruptcy. Moreover, as self-employed workers do not constitute the majority of the workers, it is not very realistic to want to found the WS curve on such models.

In reality, employees are not entrepreneurs. They often prefer a stable wage enabling them to have a regular consumption rather than a wage reflecting exactly their effective productivity, particularly sensitive to economic shocks. As suggested in implicit contracts models proposed by Baily (1974) and Azariadis (1975), the wage can be seen as an insurance against income losses in the event of an unanticipated shock. Firms are able to provide such insurance because they can more easily protect themselves from economic fluctuations. For instance, they can diversify their business activity and they have an easier access to stock and insurance market. In addition, they have an economic interest in providing such an insurance since it allows them to generate higher profits. In exchange against this implicit insurance, the employee pays a kind of premium corresponding to a wage which is in average lower than her productivity.

Paying each worker at her productivity would also imply that the latter is perfectly observable. This assumption was largely criticized by the theoretical and empirical literature related to wage efficiency models (see Appendix A) but also by sociological studies on remunerations systems (*e.g.* Brown 1962). The latter show that the proportion of piecework is relatively low at least in advanced economies.

The productivity of a particular worker is not precisely known for several reasons. Firstly, it depends on the worker's characteristics which are not always observable. Secondly, it is often influenced by the work of her colleagues because of the complexity of the task to be executed. Thirdly, the average productivity of the workers generally decreases with the number of employees in the firm. As a typical example, the first salesman hired is very productive since without him the store would remain closed. Those hired later increase the

sales thanks to a better customer service, but they generally degrade the average productivity. Paying workers at their productivity would have the consequence of decreases in wages in period of labor force shortage, *i.e.* following a rise of the economic activity. This is generally in contradiction with empirical facts where wages increase more during period of growth than during period of recession.

Finally, the good implementation of the work often requires a strong co-operation between workers. Paying them differently on the basis of a necessarily subjective estimate of their productivity is likely to poke resentments and thus to degrade the productivity of the whole working group. Thus companies usually prefer more objective rules of remuneration, by conditioning the level of wages to hierarchical criteria or seniority which do not reflect necessarily the labor productivity of each worker.

Consequently, the bargaining power of an individual worker when she is hired is not as important as those suggested by the job search and matching models. As a firm has little interest in remunerating differently employees that work on a same position, there can only be a minor negotiation. The company proposes wages according to the prevailing remuneration scale. Theoretically, it varies according to the work position, the qualification and the professional experience of the candidate. The margin for negotiation is rather small. It may consist in stating that a certain working experience is comparable with a certain qualification. Rather than negotiated, the entry wage is more defined on a “take-it-or-live-it” basis. Negotiations (if any) are at another level, with trade unions. Their goals are generally about the raising of the remuneration scale but according to criteria that are more objective than the productivity of each worker such as inflation, the economic situation of the company or the labor market tightness.

2.2. The link between wage and productivity may not be a wage behavior

Empirical evidence and more precisely the fact that the share of value-added going to labor is relatively stable over time is another common justification put forward to specify the reservation wage as the labor productivity. By definition, the labor share (L^{Share}) is the ratio between the real wage and labor productivity and lies between 0 and 1:

$$L^{Share} = \frac{WL}{PY} = \frac{W}{P.P^{rod}} \qquad (2)$$

Where Y, L, P, $P^{rod} = Y / L$ are, respectively, the production (output), the labor, the output price and the labor productivity.

When the labor share is 0, workers are kind of slaves or forced laborers, whereas they get all the creation of value when the share is 1. In OECD countries for the post World War II period, this share is far from these two theoretical limits. According to various estimates, it would be around 50 % and 70 % depending on the country and the period. Moreover, one often opposes the continental European countries where this share has decreased in the 1980's to Anglo-Saxon countries where it remained almost stable (*e.g.* Blanchard 1997).

Although this share moves over time, it is relatively stable in the sense that it generally never shows a permanent up-ward or down-ward drift. This is the reason why at the macroeconomic level, the labor share has never been observed to reach any of its theoretical limits (0 or 1). On the contrary, the determinants of the labor share, namely prices, wages and the labor productivity, are in most country affected by a trend (*e.g.*, OECD 2009). Unless a link exists between the trends of prices, of wages and of labor productivity, the labor share would have the tendency to converge to 0 or 1. From Equation (2), we readily see that the relative stability of the labor share observed empirically implies that the real wage grows in the long run at the same rate as the labor productivity.

The empirical link between the real wage and the labor productivity is an undeniable fact. But assuming *a priori* that it comes from the wage setting process may lead to erroneous interpretations. The link between the real wage and the labor productivity has at least two other potential causes related to producer maximization program: the price setting process and the labor demand.

In general, it is assumed that the price-setting results from profit maximization in an imperfect competitive market (*e.g.* Layard *et al.* 1991, Chap. 7). The firm set its price level as a mark-up (M^p) over unit labor costs, *i.e.* the ratio between wage and labor productivity. Thus the Price Setting (PS) curve is:

$$p = m^p + w + t^c - p^{rod} \tag{3}$$

Where T^c is the employer social contribution rate.

Inverting this relation gives the specification of the *available wage* (W^a) which corresponds to the wages that firms are able pay to their employees. Written in first difference, it defines the possibilities for wage increase:

$$\Delta w^a = \Delta p + \Delta p^{rod} - \Delta m^p - \Delta t^c \tag{4}$$

The higher inflation or the growth of labor productivity, the higher the possibilities for wage increase. On the contrary the higher the increase in the desired mark-up or in the employer social contribution rate, the lower the possibilities for wage increase. Relation (4) should always be verified in the long run as long as firms can freely set their price. If workers obtain higher rises – resp. lower – than those allowed by the available wage, the firms react by a rise – resp. drops – in inflation.

Because of the price setting process (and regardless the characteristic of the wage setting process), the long run real wage at the macroeconomic level is expected to grow at the same rate as the labor productivity. The unit elasticity between the real wage and the labor

productivity derived from the price equation is justified theoretically by the producer's rationality. This relation is thus expected to hold empirically, otherwise the firm would not be profitable and would be likely to shut down. By imposing without testing an unit elasticity between the real wage and the labor productivity in a wage equation, studies using a WS curve *à la* Layard *et al.* (1991) take the risk of estimating a inversed price equation instead of a wage equation. They may thus formulate erroneous diagnoses about the wage setting process[5].

The link between the real wage and productivity may also come from the firms' labor demand. Let us assume that firms choose their input demand in order to maximize their profit (P^{rofit}):

$$P^{rofit} = PY - (W.T^c L + C^k K) \tag{5}$$

Where Y is the production, K the capital and C^k the capital cost.

The first order conditions ($\partial P^{rofit} / \partial L = 0$ and $\partial P^{rofit} / \partial L = 0$ imply that profit are maximum when the marginal productivity of each input equals their real cost :

$$\begin{cases} \partial Y / \partial L = (WT^c) / P \\ \partial Y / \partial K = C^k / P \end{cases} \tag{6}$$

These two relations say that the firm adjusts its labor and its capital stock in order to equalize the input's marginal productivity to its real cost. For an intuitive reasoning, let us assume a decreasing return-to-scale technology, so that the marginal productivity is also decreasing. The company will hire an additional worker as long as the marginal productivity of the latest hired worker is higher than the real wages, in other words as long as the latter brings more than what she costs. Following a rise of the productivity, the company increases its employment in order to bring back the marginal productivity to the level of the real wages. Here productivity adjusts to wages and not the opposite.

2.3. The theoretical foundations of the Phillips curve

In the specification proposed by Manning (1993) or Blanchard and Katz (1999), the reservation wage is the lagged real wage ($\tilde{w}^r = \tilde{w}_{-1}$) and the wage equation (1) is nothing else but the traditional augmented Phillips curve:

$$\Delta w = \Delta p + m^w - \beta U \tag{7}$$

This specification of the reservation wage seems to have more realistic theoretical foundations than the two mentioned above. There are several good reasons to think that income opportunities of employees outside the firm depend on the past wage. Firstly, the unemployment benefits are more or less proportionate to the past wage. Secondly, when a worker loses her job, she can expect to find another job and be paid at the wage prevailing in the economy that can be approximated by the past average wage. Thirdly, if the objective of workers during wage negotiations is to increase their standard of living, the reference is their former purchasing power, *i.e.* the past real wage.

Moreover, the standard believe that the decision of accepting or refusing a job amounts simply to trade off between dependent employment and unemployment (or domestic or illegal work) may not be the most realistic representation of the actual functioning of the labor market. Most workers are likely to accept or refuse a job according to their perception of the "normal" wage level they can expect knowing their professional qualification and experience. The evaluation of this wage level is not directly based on the level of unemployment benefits or of labor productivity. It is more likely to be based on the wage a person with the same qualification and experience was able to get in the past. At the macroeconomic level, it would approximately be the average past wage. Depending on how difficult it is to find a job, *i.e.* depending on the level of unemployment, the worker would accept either a higher or a lower wage than the average wage. On the other hand, firms rarely propose a wage according to the worker's productivity which is hard to evaluate ex-ante. They are more likely to propose a

wage on the basis of the wages already prevailing inside the firm and the wages offered by other firms. The tightness of the labor market certainly has an effect on the wage level proposed by the firm. When the unemployment rate is low, the firm has to offer higher wage than the average one to attract workers, whereas the contrary is likely to be true when the unemployment rate is high. Such considerations about the behavior of workers and firms provide for theoretical support to the specification of the Phillips curve, where the reservation wage is the past wage.

3. The Phillips curve as a synthesis

In order to ease the comparison between the Phillips and WS curves, we imposed three restrictions on the specification of the Phillips curve. Firstly, we assumed that the remuneration is defined in real terms. This assumption is reasonable as long as workers and firms are not subject to money illusion. However, actual remunerations are defined in nominal terms and the indexation of wages on prices is not automatic. In a more general framework, the reservation wage is the past nominal wage instead of the real wage.

Secondly, we assumed that the employee's desired mark-up depends only on the level of the unemployment rate. Two theoretical arguments suggest that it may also depend on the variation of the unemployment rate. The first one was already present in the earliest contributions on the Phillips curve. It argues that wages can be affected not only by the level but also by the evolution of employment (Phillips 1958; Lipsey 1960). When firms proceed to important hiring, wages may rise despite a still high unemployment. On the contrary, a period of low unemployment but where firms start to lay off may discourage wage increases. Relying more on microeconomic foundations, the second argument justifies the effect of the variation of the unemployment rate with the theory of hysteresis. Hysteresis generally occurs when the long-term unemployed workers exert no influence on the wage-setting process (Blanchard and

Summers, 1986; Lindbeck, 1993). This may be due to the actual or perceived skill losses of unemployed people which make them less attractive to employers. The fact that negotiations may be carried out by insiders is another common explanation. Insiders may not defend the interests of unemployed people and take the labor market situation into account only when their own employment is threaten, *e.g.* when they observe that the unemployment increases.

Thirdly, as the available wage is the maximum wage a firm is able to grant to its workers, it may be shared between employers and employees. Consequently, at least part of the increases in the available wage (4) may go into the actual wage. Taking into account these three elements leads to a Phillips curve expressed in nominal terms and including the variations of the unemployment rate and of the available wage:

$$\Delta w = \psi - \beta_0 U - \beta_1 \Delta U + \varphi \Delta w^a \qquad (8)$$

This specification is quite general since it encompasses several wage setting mechanisms and the theoretical models described in Appendix A. This wage equation may thus reflect the outcome of an explicit negotiation between firms and workers, but it may also reflect the cases where wages are unilaterally determined either by the firm or the worker. For instance, a firm may use the increases of the available wage to increase the actual wage in order to attract additional workers or to keep those already hired. This may be the discretionary choice of the firm as suggested by wage efficiency models or an agreement with trade unions as suggested by negotiation models.

Moreover, employees or trade unions may not attach the same importance to every component of the available wage. Typically, their main aspiration may be to maintain their purchasing power whereas the repercussion of productivity gains may be a secondary objective. Consequently, the level of indexation on the components of the available wage may not be uniform, which leads to the following more general specification of the Phillips curve:

$$\Delta w = \psi - \beta_0 U - \beta_1 \Delta U + \alpha \Delta p + \delta \Delta p^{rod} - \gamma \Delta m^p - \eta \Delta t^c \qquad (9)$$

The parameter ψ is representative of wage-push factors that may vary with the bargaining power of workers. It may thus depend on institutional characteristics of the labor market such as the trade union membership, the unemployment benefit replacement rate, the minimum wage, etc. Compared to the traditional WS curve *à la* Sargan (1964) or *à la* Layard *et al.* (1991), this general specification of the Phillips curve has the advantage not to postulate *a priori* a unit indexation of wages on prices and labor productivity. Hence, it represents the result of wage bargaining, where employees are not always able to obtain the automatic indexation of their wages on prices and where the reference to labor productivity growth is not necessarily made. Whereas the unit indexation of wages on prices is generally motivated by the absence of nominal illusion of workers and firms, several theoretical arguments go against this proposition of full indexation. As wages are not continuously negotiated, the real wage may decrease with inflation. When inflation is low, workers may not perceive the decrease of their purchasing power (Akerlof *et al.* 2000). But they may not be able to maintain their purchasing power in periods of sustained inflation either, since their bargaining power may be weakened especially if the labor market situation is not favorable (*e.g.* Tobin, 1972). In some countries, trade unions may contribute to the reduction in inflation if they are concerned by macroeconomic performances (Calmfors and Driffill 1988; and Soskice 1990) or if they fear the reaction of the central bank. Such unions may also agree to take into account the evolution of labor productivity in order to limit the negative impact of a productivity slowdown, but this is not always the case since labor productivity growth is a macroeconomic concept difficult to measure accurately at the firm level.

Potentially, any decrease in the profitability of the firm, *i.e.* in the available wage, or decrease in the workers' welfare, *i.e.* in their purchasing power, can lead to a repartition conflict between employer and employee: in order to restore profitability, the employer encourages downward pressures on wages whereas employees push for wage increases in

order to maintain their purchasing power. Employees may wish to increase their standard of living by claiming at least a part of the productivity gains. In order to restore their profitability after an increase in the employer social contribution, Equation (9) shows that employers may want to push wages downward (if $\eta > 0$). They may also want to put down-ward pressures after an increase of their desired mark-up (if $\gamma > 0$). The latter implicitly represents other variables affecting the firm's profitability which could be included in a more general framework such as the capital cost, the capacity-utilization ratio, the competitiveness variable measured by the terms of trade (*i.e.* the gap between the producer and the import prices or between the producer and the export prices), taxes on profit, etc. In order to simplify the presentation, we also deliberately omitted variables affecting the workers' purchasing power and thus potentially being object of conflict such as tax rates on household. Here this effect is implicitly captured by the parameter ψ but all these extra variables could explicitly be included in the Phillips curve as estimated in Chagny *et al.* (2002).

Contrary to what standard WS curves assume, the outcome of these repartition conflicts is not *a priori* known since it depends on the bargaining power and on the objectives of employers and employees. As the bargaining power and objectives vary between countries, it is preferable not to postulate *a priori* indexing rules on prices and productivity as this is the case in the general Phillips curve (9).

In addition to have more relevant theoretical foundations than WS curves in level, the Philips curve has also the advantage to encompass the WS curve. This can be easily shown by rewriting the WS curve (1) in first difference:

$$\Delta w = \Delta p + \Delta \tilde{w}^r + \Delta m^w - \beta \Delta U \qquad (10)$$

With $\Delta \tilde{w}^r = \{\tau; \Delta p^{rod}\}$ for, respectively, a WS curve *à la* Sargan (1964) and *à la* Layard *et al.* (1991).

Comparing Equation (10) with (9), we see that WS curve in level is nothing else but a particular case of the Phillips curve, the case where the level of unemployment does not affect wages: $\beta_0 = 0$ in Equation (9). This case is sometimes referred to as a situation of full hysteresis because (as we shall see in the next section) it has an important implication on the specification of the equilibrium rate of unemployment and thus on the impact of a shock on the unemployment rate.

In addition to the hypothesis full hysteresis, WS curves in level generally impose additional constraints such as a unitary indexation of wage on prices ($\alpha = 1$). Moreover, the Layard *et al.* (1991)'s specification constrains the indexation on productivity at unity ($\delta = 1$) and $\psi = 0$ whereas the Sargan (1964)'s specification assumes no indexation on productivity ($\delta = 0$) and $\psi = \tau$.

Viewing the Phillips curve as a more general framework than the WS curve in level allows reconciliation between the two macroeconomic wage equations. This reconciliation differs from previous attempts of synthesis proposed in the literature. In the line of Sargan (1964) or Sawyer (1982)'s work, the Phillips curve is often interpreted as the adjustment dynamic of a WS curve. Wage is assumed to adjust slowly to its long term target (W^*) according to an error correction model:

$$\begin{cases} \Delta w_t = S_t^{ajust} - \lambda(w_{t-1} - w_{t-1}^*) \\ w_t^* = p_t + \tilde{w}_t^r + m_t^w - \beta U_t \end{cases} \Leftrightarrow \begin{cases} \Delta w_t = S_t^{ajust} + m_t^{w\prime} - \beta' U_t - \lambda(w_{t-1} - p_{t-1} - \tilde{w}_{t-1}^r) \\ m_t^{w\prime} = \lambda m_t^w \text{ and } \beta' = \lambda\beta \end{cases} \quad (11)$$

With $\tilde{w}^r = \{\tau.t; p^{rod}\}$ and S^{ajust} is a term containing all the short-run adjustment variables (first-difference of the lagged wage, of the unemployment rate, of the price, etc). Close versions of (11) are often estimated in the wage empirical literature (see *e.g.* Tyrväinen 1995; OECD 1997). As in a Phillips curve, the variation of wages is related to the level of the unemployment rate, but the long term properties remain those of the presented WS curve. The

reservation wage is a determinist trend or the labor productivity, which as we argued seems to be unrealistic.

In Manning (1993), Blanchard and Katz (1999) or Cahuc and Zylberberg (1996, 2004, Chap. 8), the term of WS curve refers to the wage Equation (1) directly derived from the theoretical model. The Phillips curve is thus viewed as a constrained version of the WS curve where the reservation wage depends exclusively on the past wage and not on the labor productivity. Our finding does not contradict this view because we do not use the same terminology. As commonly done in the literature, we reserved here the term of WS curve to describe the specification proposed by Sargan (1964) and Layard *et al.* (1991), arguing that there is little theoretical support to specify the reservation wage as a determinist trend or as the labor productivity.

Finally, Whelan (2000) thinks of the Phillips curve not as a structural wage equation but as a reduced form obtained by combining the WS and PS curves. Our analysis on the contrary supports that the Phillips curve is a well founded structural wage equation.

4. Impact on the equilibrium rate of unemployment

The concept of Equilibrium Rate of Unemployment (ERU) is generally defined as the unemployment rate that equalizes the real wage asked by workers to the one which employers are able to pay considering their price setting behavior[6]. Formally, the ERU is equivalent to the concept of *Non-Accelerating Inflation Rate of Unemployment* (NAIRU) formalized by Phelps (1967, 1968)[7] – which is incorrectly used instead as the *Non-Increasing Inflation Rate of Unemployment*. Indeed, inflation stability implies that workers and employers are both satisfied by their respective share of the value-added (see Layard *et al.*, 1991; or Reynès, 2006, Chap. 3). Combining the price Equation (3) rewritten in first differences and the

Phillips curve (9) and solving for U gives the trajectory of the unemployment rate consistent with a stable inflation, i.e. the ERU (U^E):

$$U_t^E = \frac{S_t^{LT}}{\beta_0 + \beta_1} + \frac{S_t^{ST}}{\beta_0 + \beta_1} + \frac{\beta_1}{\beta_0 + \beta_1} U_{t-1}^E \quad (12)$$

$$S_t^{LT} = \psi - (1-\alpha)\Delta p - (1-\delta)\Delta p^{rod} \quad (13)$$

$$S_t^{ST} = (1-\gamma)\Delta m^p + (1-\eta)\Delta t^c \quad (14)$$

The ERU depends on long term and short term shocks (S^{LT} and S^{ST}). The long term shocks embodied the variables such as inflation and productivity growth that may be positive in the long run. Short term shocks regroup the variables with a long run zero-expectation: this is the case of the employer's mark-up and social contribution rate which cannot increase indefinitely. In case of hysteresis ($\beta_1 > 0$), the ERU depends in addition on its past level. Assuming the stability of long term shocks (S^{LT} = constant) and the absence of short term shocks ($S^{ST} = 0$), the ERU may converge toward its long term value as long as the sensitivity of wages to the level of the unemployment rate (β_0) is higher than zero. We define this rate as the long term ERU (ERU^{LT}, U^{LT}). It may depend on inflation and on the labor productivity growth if wages are not fully indexed on prices and productivity (*i.e.* if α and δ are smaller than 1):

$$U_t^{LT} = \left(\psi - (1-\alpha)\Delta p - (1-\delta)\Delta p^{rod}\right) / \beta_0 \quad (15)$$

In case of full hysteresis ($\beta_0 = 0$), that is of a WS curve, the long term ERU (15) is not defined and Equation (12) gives a relation for the ERU in first difference as a function of the long term and short term shocks:

$$\Delta U_t^E = (S_t^{LT} + S_t^{ST}) / \beta_1 \quad (16)$$

Unless long term shocks are set to zero, the ERU as defined by Equation (16) is permanently affected by a trend. Indeed only a permanent increase (or decrease) of the unemployment rate

is consistent with a stable rate of inflation. This is unrealistic in the long run since the unemployment rate should always remain in a finite range (between 0 and 100%). The model does not have a consistent equilibrium growth path.

In order to have a consistent stationary state, the impact of the long term shocks should be constrained to zero ($S^{LT} = 0$) which implies a unit indexation of wages on prices and productivity ($\alpha = \delta = 1$) and $\psi = 0$. These are precisely the constraints imposed by a WS curve *à la* Layard *et al.* (1991). This is not the case of a WS curve *à la* Sargan (1964) which only imposes a unit indexation of wages on prices ($\alpha = 1$) but not on productivity ($\delta = 0$). Moreover Sargan's specification assumes that wages are affected by a determinist trend $\psi = \tau$. Unless the determinist trend estimated in the wage equation is (by chance) equal to the trend of labor productivity, a permanent increase or decrease in the unemployment rate is necessary for inflation stability. This is another weakness of a WS curve *à la* Sargan (1964).

With a WS curve à la Layard *et al.* (1991), it is possible to define a constant long run ERU. Integrating Equation (16) with respect to time and calibrating for convenience the constant of integration to m^w gives:

$$U_t^E = \left(m^w + (1-\gamma) m^p + (1-\eta) t^c \right) / \beta_1 \qquad (17)$$

Comparing Equation (12) and (17) allows to stress the fundamental differences in term of ERU between a Phillips curve and a WS curve (*i.e.* a Phillips curve with full hysteresis). As the WS curve *à la* Layard *et al.* (1991) imposes a unit indexation on prices and productivity, a variation in the trend inflation or a shock in the labor productivity would have no impact on the ERU_{LT}. Because of the full hysteresis hypothesis, an increase in the social contribution rate or any shock increasing the desired mark-up of workers and firms (such as increases in the capital cost, in the capacity-utilization ratio, etc.) would permanently raise the ERU_{LT} (Equation (17)). With a Phillips curve (without full hysteresis), a slowdown of the labor productivity or a decrease in inflation would permanently raise the ERU_{LT} (if indexation is

lower than 1), but rises in the social contribution rate or in the desired mark-up of firms (following an increase in the capital cost or in the capacity-utilization ratio) would only have a transitory effect on the ERU (see Equation (12)). To sum up, temporary shocks in the case of a Phillips curve (without full hysteresis) become permanent in the case of a WS curve (*i.e.* a Phillips curve with full hysteresis)[8] whereas permanent shocks in the case of a Phillips curve generate inconsistent explosive shocks in the case of a WS curve.

5. Conclusion

This article analyzed and compared the theoretical foundations of the two main macroeconomic wage equation proposed in the literature: the Phillips and WS curves. We argued that the Phillips curve is a theoretically relevant structural wage equation by reaching two important conclusions that contradict the results of previous research concluding to the lack of theoretical foundation of the Phillips curve. Firstly, the Phillips curve embodies a wide range of theoretical models (neoclassical, efficiency wage and bargaining models) where the wage may be determined unilaterally by the worker or by the firm, or may be the outcome of a negotiation between both of them. Secondly, we showed that the Phillips curve could be viewed as a more general framework than the WS curve. Compared to the latter, the Phillips curve does impose *a priori* a unit indexation of wages on prices and productivity. In addition, the WS curve is formally nothing else but a Phillips curve in the particular case of full hysteresis. This has important implications on the specification of the ERU.

Appendix A. Theoretical wage setting models

This appendix shows that most theoretical wage setting models proposed in the literature lead to a macroeconomic wage equation in the form of Equation (1) despite very different underlying assumptions. These models can generally be classified according to their representation of the stationary state on the labor market. Traditionally the labor market equilibrium (or disequilibrium) is represented by the confrontation of a supply and a demand curve. The labor supply – resp. demand – increases – resp. decreases – with the real wage ($\tilde{W}$) because of substitution effects between labor and leisure – resp. between production factors[9]. Applying standard linear approximation, the unemployment rate (U) equals the gap between the labor supply (L^s) and the labor demand (L^d)[10]:

$$U = l^s - l^d \qquad \text{with } l^s = f(\tilde{w}^{+}) \text{ and } l^d = f(\tilde{w}^{-}) \tag{18}$$

It is common to oppose the market clearing models to non market clearing models. In the latter, the actual real wage ($\tilde{w}_0$) is set above the equilibrium real wage ($\tilde{w}^*$) that equalizes labor supply to labor demand. Neoclassical wage setting models are market clearing types of model (Section A.1). They lead to situations of labor force shortage or of equilibrium between supply and demand (Figure I). As they have the disadvantage to rule out the possibilities of involuntary unemployment (*i.e.* unemployed people willing to work for the current wage), other models propose mechanisms where the real wage may stay permanently above its equilibrium level (Figure II). In efficiency wage models, firms deliberately set the real wage above its equilibrium level because productivity is assumed to increase with the real wage and the unemployment rate levels (Section A.2). In bargaining models, the real wage does not clear the labor market because of the bargaining power of workers (Section A.3).

Figure I. Labor force shortage

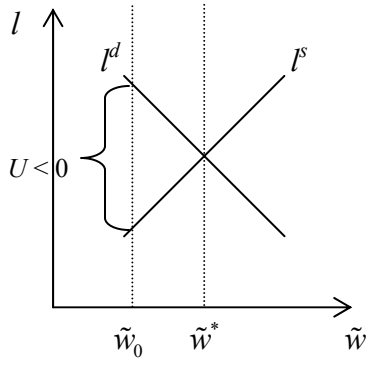
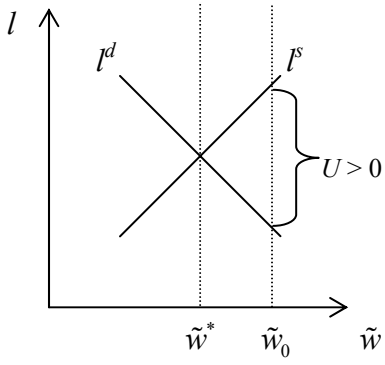


Figure II. Involuntary unemployment



A.1. Neoclassical wage setting models

Many neoclassical models assume that the reservation wage ($\tilde{w}^r$) is the marginal labor productivity and that the mark-up over the reservation wage is zero ($m^w = \beta = 0$ in Equation (1)). These models surveyed by Romer (2006) are the neoclassical models of growth proposed by Ramsey (1928), Koopmans (1963) and Cass (1965), the overlapping generations model of Diamond (1965), the human capital model developed by Becker (1964), or Real Business Cycle models initiated by Lucas et Rapping (1969). The fact that the real wage always equals the marginal productivity is generally justified by the assumption of perfect competition on the labor market. To be profitable, a firm cannot pay its employees above their marginal productivity. The firm makes a profit when it pays them below this level. Other firms can attract these workers by offering a slightly higher wages and still making a profit. Alternatively, these workers can choose to be self employed workers in order to be remunerated to their own productivity. If agents are rational and if there is perfect information, the sets of remuneration converges towards a Nash (1950, 1953) equilibrium, where profits are null since each employee is paid at her marginal productivity. In all these models, there is no involuntary unemployment. After an unfavorable supply or demand shock, wages drop as much as the marginal productivity does and workers adapt their labor supply to their new productivity according to the (inter-temporal) degree of substitution between

consumption and leisure. Unemployed people are treated as voluntary inactive since they are waiting for a rise of their productivity to go back to work. This strong conclusion of real business cycles models, which has been subject to many empirical criticisms (*e.g.* Mankiw, 1989; Romer, 2006), is based on the assumption of pure and perfect competition. This assumption is not very satisfactory to describe the actual functioning of the labor market. In practice, employees cannot change of work or create their own company at any moment, since working positions are not perfectly interchangeable. The marginal productivity of workers is not perfectly observable, either by themselves or by the firms.

As these models also have the inconvenience not to formally describe the wage-setting process, other neoclassical models explicitly describe the behavior of agents involved in the wage-setting process. In Erceg *et al.* (2000) or in Huang and Liu (2002), the worker sets her wage in the same way a producer sets her price in standard monopolistic competition models (*e.g.* Blanchard and Fischer, 1989, Chap. 8). Producing work (instead of goods), she determines the wage that maximizes her welfare. As the disutility of labor is similar to a cost, the analytical resolution is close to the determination of a price by profit maximization.

Because of the disutility of labor, the labor supply of worker $j = [1; J]$ is expected to increase with the real wage:

$$l_j^s = \psi.\tilde{w}_j + \lambda \Leftrightarrow l^s = \psi.\tilde{w} + \lambda \qquad \text{with } \psi > 0 \qquad (19)$$

Where $\tilde{w} = \frac{1}{J}\sum_{j=1}^{j} \tilde{w}_j$ is the average real wage and λ a constant parameter.

Assuming that firms buy the work they need from the different workers, the labor demand addressed to each worker may be derived from a microeconomic problem of labor costs minimization. Assuming that the substitutability between workers can be represented by a CES (Constant Elasticity of Substitution) production function, the labor demand addressed to

worker *j* is higher the lower the wage asked by the worker relatively to the average wage (see *e.g.* Erceg *et al.*, 2000 or Huang and Liu, 2002):

$$l_j^d = l^d - \eta(\tilde{w}_j - \tilde{w}) \qquad \text{with } \eta > 0 \qquad (20)$$

Where $l^d = \frac{1}{J}\sum_{j=1}^{J} l_j^d$ is the average demand and η the elasticity of substitution between workers.

The worker determines her wage so that her labor supply matches her address labor demand ($l_j^s = l_j^d$). Equalizing (19) to (20) and using the unemployment definition (18) lead to:

$$\tilde{w}_j = \tilde{w} - \beta U \qquad \text{with } \beta = (\psi + \eta)^{-1} \qquad (21)$$

Under the hypothesis of perfect information and no cooperation between workers, there is an instantaneous convergence to a Nash equilibrium where the average wage is perfectly anticipated and where there is no unemployment ($U = 0$). Under a more realistic assumption of imperfect information, each worker chooses her wage on the bases of her anticipation of the average wage. The latter is likely to be the past average wage ($\tilde{w}_{-1}$). In such a case, the aggregate Equation (21) becomes a particular case of Equation (1) where the reservation wage is the past average wage ($\tilde{w}^r = \tilde{w}_{-1}$) and the mark-up depends only on the labor market tightness ($m^w = 0$ and $\beta \neq 0$):

$$\Delta\tilde{w} = -\beta U \qquad (22)$$

In case of positive unemployment ($U > 0$), wages decrease. This reduces unemployment because the labor supply – resp. demand – is by assumption an increasing – resp. decreasing – function of the real wage. A situation of labor shortage ($U < 0$) logically leads to the opposite dynamic. The model thus still converges to a Nash equilibrium with no unemployment but does not do so instantaneously anymore.

The hypothesis that a worker determines her own wage seems reasonable in the case of a self employed worker such as a consultant, a lawyer, etc. It may not be very realistic in the case of dependant employment where the wage is often determined by the firm. In this case, the remuneration is defined on a take-it or leave-it bases. Paraphrasing the old saying, one could say that "the firm proposes, the worker disposes": the firm submits a wage to its workers who have the freedom to accept or refuse it. This is the approach taken in the model proposed by Phelps (1968) to originally provide theoretical foundation to the Phillips curve. Assuming that workers are perfectly interchangeable at no cost, the firm determines the wage relatively to the one proposed by its competitors taking into account the disequilibrium between demand and supply on the labor market. For the sake of conciseness, we will not derive it formally but it is relatively easy to understand why this model reaches the same aggregated wage Equation (22).

In case of unemployment ($U > 0$), the company offers a salary lower than the average wage. If workers refuse it, they are dismissed and replaced by previously unemployed people. Conversely in the case of a labor shortage ($U < 0$), the relative wage of each firm increases to attract workers from other companies or inactive people. As in the other neoclassical models, there is no unemployment in the long term. The hypotheses that labor supply and the labor demand are respectively increasing and decreasing with the real wage guaranties that the real wage clears the labor market. If the labor supply is sticky and independent of the real wage ($\psi = 0$ in Equation (19)), this model may generate a permanent labor shortage (Figure I) with a permanently positive growth rate of wages (Phelps 1968).

Neoclassical models' conclusions rely on the questionable assumption that workers are perfectly substitutable. In reality, unemployed and incumbent workers are rarely considered as equivalent by employers. Unemployed people are generally less attractive because of the uncertainty around their skills and because each job requires a minimum of training. This

argument is largely developed by some efficiency wage models (Section A.2) to explain why companies generally prefer not to hire unemployed people willing to accept a lower wage than their current employees. Wage bargaining models highlight the role of trade unions that may defend primarily current workers at the expense of the unemployed people (Section A.3).

A.2. Efficiency wage models

Unlike neoclassical models, *efficiency wage models* describe a wage setting mechanism where wages do not clear the market. The long run steady state is characterized by permanent involuntary unemployment. Following the seminal work of Leibenstein (1957), labor productivity is endogenous to the wage level. To justify this relationship, several models highlight the important role played by the wage level on the workers' motivation. On the one hand, high wages encourage workers to provide more effort. On the other hand, they are a means to attract and keep the most productive elements[11].

In *shirking models* of Calvo and Wellisz (1978, 1979) or Shapiro and Stiglitz (1984), the company cannot perfectly control the effort of its employees, but it may reduce the risk that an employee shirks by offering generous wages. Indeed, making the situation of a worker better off than an unemployed person increases the cost to workers of a possible dismissal and therefore encourages more effort.

According to *gift exchange models* of Akerlof (1982, 1984), Akerlof and Yellen (1987, 1988, 1990) (see also Solow 1979, 1980, 1990, Collard and de la Croix 2000), the motivation of workers depends on social norms, in particular on the wage level considered as fair. This hypothesis is supported by empirical studies on employees' behavior conducted by psychologists, sociologists and anthropologists. They suggest that the higher the gap between the actual and the reference wage, the higher the effort of the worker. In exchange for

remuneration higher that the standard wage, the "gift" of an employee to the employer is to exceed the standard work effort.

In *labor turnover models*, firms propose a wage higher than the one for which unemployed people are willing to work in order to reduce the labor turnover and its induced losses in productivity (Stiglitz 1974, 1985; Calvo 1979; Salop 1979). When turnover is high, labor is generally less productive for several reasons. The newly hired workers are not yet fully trained. The senior workers who are usually the most productive may be demotivated because they anticipate their imminent departure. Finally, labor is less efficient because the best elements are likely to be the first to find better paid job.

According to *adverse selection models* (or *screening models*) proposed by Greenwald (1979, 1986), Weiss (1980) and Malcomson (1981), high wages increase productivity because they help to select the most efficient workers. These models assume that the skills of the candidates for jobs are unobservable but increases with the workers' wage aspirations. By offering high salaries, the company increases the quality of its potential labor supply and thus increases its chances of hiring a competent worker.

In all these models, the unemployment rate is expected to positively influence the productivity because the labor market tightness also has an impact on the motivation of workers. When unemployment is high, it takes longer to find a job and the turnover is thus reduced. In shirking models, the worker's welfare increases relatively to an unemployed person. In gift exchange models, workers are more aware of how lucky they are to have a job when the situation on the labor market is unfavorable. Finally, in adverse selection models, the number of candidates increases with the number of unemployed people.

Consequently, the efficiency wage theory suggests that the labor productivity (P_j^{rod}) in firm $j = [1; J]$ is higher the higher the unemployment rate and the higher the wage relatively to the reservation wage (which represents the potential revenue outside the company)[12]:

$$P_j^{rod} = \left[e^{\delta(\tilde{w}_j - \tilde{w}^r)} - (1-\delta) e^{\delta(m^w - \beta U)} \right] (1+\gamma)^t \qquad (23)$$

Where γ is the trend of technical progress. The hypothesis that $\delta \in]0;1[$ implies that the marginal productivity is strictly decreasing ($p_j^{rod''}(\tilde{w}_j) < 0$).

The firm chooses the wage level that maximizes its profit, that is the wage that minimizes the efficient labor cost: $c_j = \tilde{w}_j - p_j^{rod}$. The first-order condition ($c_j'(\tilde{w}_j) = 0$), sometimes known as the Solow (1979)'condition[13], states that at the optimum, the elasticity of substitution of productivity with respect to wages is equal to one: $p_j^{rod'}(\tilde{w}_j) = 1$ [14]. This implies the following optimal real wage:

$$\tilde{w}_j = \tilde{w}^r + m^w - \beta U \qquad (24)$$

The calculation of the average real wage, $\tilde{w} = \frac{1}{J} \sum_{j=1}^{J} \tilde{w}_j$, gives the aggregated wage Equation (1).

A.3. Wage bargaining models

Wage bargaining models also propose a theory in which the wage is set above the full employment wage level. Compared to the wage efficiency model, the firm does not determine the wage alone, but the latter is negotiated with the trade unions[15]. The negotiation between workers and firms is formulated as a bargaining problem between two agents in order to use resolution techniques borrowed from game theory.

The *right-to-manage model* proposed by Nickell and Andrews (1983) is one of the most popular models. During the negotiation process, trade unions present in firm *j* are assumed to maximize a utility function on (V_j^s) which depends positively on the difference between the worker's utility within the company (V_j) and the alternative utility (V_j^a) that she could get

outside the company (wage paid by other companies, unemployment benefit, domestic production, etc.):

$$V_j^s = (V_j - V_j^a)(L_j)^{\psi} \qquad \text{with } \psi \geq 0,\ V_j'(\tilde{W}_j) > 0 \text{ and } L_j'(\tilde{W}_j) < 0 \qquad (25)$$

The trade union may also take into account the firm's labor demand (L_j) if the level of employment inside the firm is part of its concerns. However, the level of employment is not negotiated as it is the case in the *efficient contract model* of McDonald and Solow (1981). The firm has the "right-to-manage", that is to choose the level of employment after a wage agreement with trade unions has been signed.

The employer is assumed to maximize her relative profit ($\tilde{\Pi}_j$), that is the difference between the profit in case of a successful negotiation (Π_j) and the alternative profit (Π_j^a) in case that the negotiation fails:

$$\tilde{\Pi}_j = \Pi_j - \Pi_j^a \qquad \text{with } \Pi_j'(\tilde{W}_j) < 0 \qquad (26)$$

Under the assumptions of rationality and perfect information, the negotiation never fails, provided that the relative profit and the utility function are positive. The outcome is a Nash equilibrium (1950, 1953) where the negotiated wage maximizes the so called "generalized Nash criterion" which is the geometric mean of the net gains of each agent weighted by their respective bargaining power (for a demonstration see, *e.g.* Rubinstein, 1982; Binmore *et al.*, 1986; Sutton, 1986, Osborne and Rubinstein, 1990 and Layard *et al.*, 1991, Chap. 2):

$$\tilde{W}_j = \arg\max \left[e^{\Omega} = (V_j^s)^{\chi} (\tilde{\Gamma}_j)^{1-\chi} \right] \qquad (27)$$

Where $\chi \in]0,1]$ is the relative bargaining power of workers.

The first-order condition ($\Omega'(\tilde{W}_j) = 0$) states that the wage is set so that the utility of an employee in the company exceeds the alternative utility [16]:

$$V_j = \upsilon . V_j^a \qquad \text{with } \upsilon = \left[1 - \eta_{V/\tilde{W}} \left[\eta_{L/\tilde{W}} . \psi\chi + \eta_{\Pi/\tilde{W}} (\chi^{-1} - 1) \Pi_j (\Pi_j - \Pi_j^a)^{-1} \right]^{-1} \right]^{-1} \qquad (28)$$

Where $\eta_{V/\tilde{W}} = V_j'(\tilde{W}_j)\tilde{W}_j / V_j$, $\eta_{L/\tilde{W}} = \left|L_j'(\tilde{W}_j)\right|\tilde{W}_j / L_j$ et $\eta_{\Pi/\tilde{W}} = \left|\Pi_j'(\tilde{W}_j)\right|\tilde{W}_j / \Pi_j$.

The term υ is the "mark-up" obtained by trade unions over the alternative income an employee could get outside the firm. It decreases with the wage-elasticity of labor demand ($\eta_{L/\tilde{W}}$) and of profit ($\eta_{\Pi/\tilde{W}}$) and increases with the wage-elasticity of the workers' utility ($\eta_{V/\tilde{W}}$) and with their bargaining power (χ) if unions are not concerned with the employment level ($\psi = 0$). Otherwise ($\psi > 0$), the impact of bargaining power (χ) is ambiguous since an increase in union power can lower the wage if the wage-elasticity of labor demand is relatively large compared to the wage-elasticity of profit ($\eta_{L/\tilde{W}} / \eta_{\Pi/\tilde{W}}$).

One common way to obtain the wage equation from relation (28) is to express the workers' utility functions in terms of intertemporal expected gains that reflect the transition probabilities between employment and unemployment (see *e.g.* Manning, 1993; Cahuc and Zylberberg, 1996, Chap. 8). For the sake of brevity, we skip this algebraic complication since the same result can be obtained using a more intuitive and straightforward approach. At first approximation, the worker's utility corresponds to her wage: $v_j = \tilde{w}_j$ and the worker's alternative utility corresponds to the revenue she may obtain outside the firm: $v_j^a = \tilde{w}^r$. The worker's "mark-up" may be negatively related to the level of unemployment since union's bargaining power is expected to decrease when unemployment increases: $\ln(\upsilon) = m^w - \beta U$. The effect of the unemployment rate may transit through the worker's alternative utility because of the link between unemployment and the transition probabilities between employment and unemployment (Manning, 1993; Cahuc and Zylberberg, 1996, Chap. 8): $v_j^a = \tilde{w}^r - \beta U$. In both cases, Equation (28) written as an average collapses into the aggregate wage Equation (1).

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Notes

[1] "Despite the prominence given to the Phillips Curve in macroeconomics textbooks, the traditional autoregression of wage levels that has been found in many decades of empirical studies may be due to the omission of variables and aggregation error […] This raises the possibility that the Phillips Curve is an error of interpretation that would not have arisen if previous researchers had been able to use micro data" (Blanchflower and Oswald 1995, p. 1035).

[2] In this paper, the theoretical discussions focus on the wage equation. As a consequence, the term of *Phillips curve* refers to a structural wage equation that is to a negative relationship between the growth rate of wages and the unemployment rate as in Phillips (1958). Specifications relating inflation directly to the unemployment rate are described as *reduced Phillips curve*. Contrary to the structural wage Phillips curve, the reduced Phillips curve is considered as a standard model in the literature in particular because of the influential works related to the Time-Varying NAIRU (Gordon 1997) and the neo-Keynesian Phillips curve (Gali and Gertler 1999; Mankiw and Reis 2002) (see the survey of Karanassou *et al.*, 2010).

[3] The lower-case variables are in logarithm. Variables in first difference and in growth rate are respectively referred to as $\Delta X_t = X_t - X_{t-1}$ and $\dot{X}_t = X_t / X_{t-1} - 1 \approx \Delta x_t$. The time operator t as an index will be omitted. All coefficients are positive and long-run, ignoring adjustment lags for algebraic simplicity.

[4] In Layard et al. (1991), the reservation wage is in fact the capital to labor ratio. It is interpreted as an indicator of the labor productivity since it follows the labor productivity (at least) in the long run.

[5] Moreover, this similarity between the WS and PS curves raises an econometric issue of identification which was abundantly treated in the literature devoted to WS/PS models (e.g. Layard *et al.* 1991, p. 405; Manning 1993; Bean 1994).

[6] Using Bean's (1989) metaphor, many authors consider the wage and price setting processes as akin to a "battle of mark-ups" in which the unemployment rate would be the "referee".

[7] Phelps uses the term of ERU even though the definition he proposes will become known as NAIRU: "The quantity u* measures the 'equilibrium' unemployment ratio, for it is the unemployment rate at which the actual

rate of inflation equals the expected rate of inflation so that the expected inflation remains unchanged. [...] The rate of inflation will continue to increase as long as the unemployment ratio is smaller than u* [...]" (Phelps, 1967, p. 255).

[8] This property explains the use of the term of hysteresis when (in addition to the level of unemployment rate) the variation of unemployment rate affects wages. But several authors find this use abusive (*e.g.* Cross 1995). Originally invented by mathematicians, the term of hysteresis refers, strictly speaking, to the property of a certain type of input - output system for which a transitory variation of the input generates a permanent variation of the output. In our case, we qualified this property as full hysteresis which is generally the definition adopted by labor macroeconomics.

[9] In fact, according to microeconomic theory, the effect of an increase in the real wage on the labor supply and demand is ambiguous. The substitution effect between labor and leisure increases the labor supply whereas the (endowment) income effect decreases the labor supply (see Varian 1992, Chap. 9). Symmetrically, the substitution effect between production factors decreases the labor demand whereas an income effect increases the demand for goods (since consumers are richer) and thus increases the demand for labor. The traditional representation of the equilibrium of the labor market implicitly assumes that substitution effects outweigh the income effects.

[10] Here the concept of unemployment is more general than its usual definition since it may be negative in case of labor force shortage.

[11] For a review of literature on efficiency wage models see Yellen (1984), Akerlof and Yellen (1986), Blanchard and Fischer (1989, chap. 9), Layard *et al.* (1991, Chap. 3) or Cahuc and Zylberberg (1996, Chap. 3).

[12] This formulation is used for analytical convenience since it avoids the use of a linear approximation. It leads to the same specification of the wage equation derived by the wage efficiency model proposed by Akerlof *et al.* (2000) who assume that $P_j^{rod} = \lambda_2(\tilde{W}_j / \tilde{W}^r)^{\delta} + \lambda_1 U - \lambda_0$.

[13] In fact, this condition was previously found by Leibenstein (1957) or Stiglitz (1976).

[14] The second-order condition, $c_j''(\tilde{w}_j) = -p_j^{rod\prime\prime}(\tilde{w}_j) = (1-\delta) > 0$, is satisfied since by hypothesis $\delta \in]0;1[$.

[15] For a review of literature see *e.g.* Cahuc and Zylberberg (1996, Chap. 5, 2004, Chap. 7) and Layard *et al.* (1991, Chap. 2).

[16] The second-order condition ($\Omega''(\tilde{W}_j) < 0$) is satisfied as long as $V_j''(\tilde{W}_j) \leq 0$, $L_j''(\tilde{W}_j) \leq 0$, $\Pi_j''(\tilde{W}_j) \leq 0$, $V_j > V_j^a$ and $\Pi_j > \Pi_j^a$, which we shall assume. Relation (28) is often written as: $\tilde{W}_j = \upsilon_2(V_j - V_j^a)$

with $\upsilon_2 = (1-\upsilon^{-1})^{-1}\tilde{W}_j V_j^{-1} = \left[V_j'(\tilde{W}_j)\right]^{-1}\left[\eta_{L/\tilde{W}}\cdot\psi\chi + \eta_{\Pi/\tilde{W}}(\chi^{-1}-1)\Pi_j(\Pi_j - \Pi_j^a)^{-1}\right]$ (see *e.g.* Layard *et al*. 1991, p.102; Manning 1993; Cahuc and Zylberberg 1996, chap. 8, 2004, p. 395).