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WAGE INDEXATION AND MACROECONOMIC FLUCTUATIONS *

by

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Abstract

The purpose of the present paper is to explore the dynamic behaviour of a simple overlapping generation model with three commodities in which, in each period, the wage rate is indexed to the price level to an extend which depends on the labour market conditions observed in the past.

I - INTRODUCTION

1. Recent theoretical developments in general equilibrium theory have incorporated the possibility of imperfectly flexible prices, the general consistency of transactions being attained through quantity rationing. The basic contributions along these lines are due to Benassy (1975), Drèze (1975) and Younès (1975).

More recent contributions by Dehez and Drèze (1984), Kurz (1982) and van der Laan (1980) have questioned both the theoretical relevance and the practical significance of demand rationing in market economies since such rationing would require a more complex coordination of economic activities and is indeed rarely observed. These authors have therefore proposed an equilibrium concept in which the rationing of supply is sufficient to achieve an equilibrium. In particular, Kurz proves the existence of an equilibrium in a framework allowing for a flexible structure of *price linkages* while Dehez and Drèze consider the more specific case of *relative price rigidities*[1].

To postulate the existence of links between prices is definitely a weaker assumption than the one of nominal price rigidity. But still the structure of price linkage is exogeneous and is therefore as vulnerable from the point of view of individual rationality. *Why do rational agents not exhaust their exchange opportunities* is the recurrent question, notably in the rational expectation-market clearing literature. But, quite apart from the fact that "auction market clearing" is more an assumption about centralization and information than about rationality, the question itself could be reversed, as suggested by Olson (1984, p.636): *Is there any agent with the incentive and ability to block mutually advantageous transactions among potential buyers and sellers and thus preventing markets from achieving a Walrasian equilibrium?*

The answer to the latter question would be positive if one allows for monopoly or monopsony power attained through collective actions —but not through individual actions because otherwise markets would clear. As suggested by Kurz (1982), price linkages could indeed arise from the fact that some groups of agents succeed in linking their incomes to those of another groups, thus reflecting stategic behaviour within the market place. More generally, it is sufficient that some group of agents have in "good times" some transient monopoly or monopsony power to obtain a structure of price linkages. This suggests that, in a dynamic and non-stationary context, the structure of price linkages will change through time in relation with the state of the economy.

2. The purpose of the present paper is precisely to investigate this aspect within a simple macroeconomic model, in the particular case where unemployment can be explained by a

too high real wage. We shall indeed assume a perfectly competitive product market, a decreasing marginal productivity of labour and a inelastic labour supply, in which case the excess supply of labour depends only on the real wage rate.[2]

On the one hand, a falling nominal wage rate may have adverse effects on the marginal efficiency of capital because it leads to a higher interest rate or simply because it prevents the interest rate to fall. In other words nominal wage flexibility may be unsuccessful in restoring full employment. This argument, raised by Keynes and substantiated by Hahn and Solow in the present volume, leads to advocate monetary expansion to cure unemployment. But then what is impossible to achieve by way of downward wage flexibility, can it be attained through inflation? It is this question which primarily motivates the present paper.

If the wage rate is fully indexed on the price level, the real wage and thus unemployment are unaffected by inflation. But indexation is hardly perfect and furthermore the extent to which indexation actually takes place is not invariant but is typically affected by the state of the labour market. Indeed, substantial amendments of indexation clauses have been recently observed in countries experiencing high rates of unemployment. On the other hand, in situations of excess demand for labour or low unemployment, the real wage is typically rising, what could be considered as a phenomenon of more-than-full indexation in a situation of continuous inflation.[3]

Accepting the fact indexation is not perfect but taking into account that its degree is not invariant through time, can inflation act as a regulatory mechanism? In the present paper we show that if does so whenever the indexation scheme is not too sensitive to labour market conditions with respect to the inflation rate. Otherwise, the economy could exhibit fluctuations which are not necessarily convergent.

3. We shall consider a three commodity macroeconomic model extending over an infinite number of discrete periods with a simple overlapping generation structure. In each period the price level is determined competitively so that the consumption good market always clears. In turn the price level determines the wage rate through a linkage function established at the beginning of the period. Thus, in the short-run, the economy can be either in situation of unemployment or in situation of excess demand for labour (excess capacity). Because an interest rate is paid on money holdings, the stock of money keeps expanding from one period to the next, generating a continuous inflation. In this way, we can say that the wage rate is "indexed" on the price level.

Underlying the linkage or indexation function, there is a bargaining process whose aim is to fix the indexation formula to be applied during the period. And the bargaining power of the trade unions which represent the workers and are involved in the negociations is affected by the conditions observed on the labour market in the preceeding period: The larger the unemployment, the lower is their bargaining power and there is a critical rate of unemployment above which less-than-full indexation occurs, i.e. inflation induces a fall in the real wage; and below which more-than-full indexation occurs, i.e. inflation induces a rise in the wage[4]. This can be explained in particular by the fact that the relative strength of a union critically depends on the proportion of its members which are unemployed. Furthermore, if there are several trade unions involved, it is even more likely that the indexation scheme will be affected by the conditions prevailing on the labour market[5].

In this framework, the long run equilibrium or stationary state is not necessarily characterized by full employment. Instead, it is defined by the level of unemployment at which indexation is perfect i.e. by the critical unemployment rate just defined. Hence, to say that inflation is stabilizing means that the process of indexation is such that inflation will drive the economy (not necessarily in a monotonic way) towards the long run equilibrium through the process of weakening or strengthening the bargaining position of the unions.

4. The rest of the paper is organized as follows. The formal model is introduced and the short run equilibrium is defined in Section II. The dynamics of the economy is then analyzed in Section III and concluding remarks are offered in the last Section. Finally an Appendix gathers the more technical aspects of the model and also contains an illustration.

II - THE MODEL

1. We use the overlapping generation model in its simplest form.[6] The population and its characteristics are assumed to be invariant through time, there is no bequest and the agents live only two periods. For further simplicity we assume that there are only two agents living in every period, one "young" and one "old". This is equivalent to assume that all agents are identical. There is one *perishable* consumption good. It is produced out of the labour which is supplied *inelastically* by the young agent only. A further commodity, "money", is used as a medium of exchange and reserve of value. We denote by p and w the price level and the wage rate which are both expressed in terms of money.

The production sector is simply described by a production function, $y = f(\ell)$, and there is no production lag. It is assumed to satisfy the following properties:

(a.1) f is continuously differentiable, increasing and *strictly* concave;

(a.2) $f(0) = 0$ and $f'(0) = +\infty$.

The maximization of profit, $pf(\ell) - w\ell$, at given price and wage determines the demand for labour. It then only depends on the real wage rate, $q = w/q$, and is simply given by $\ell = f'^{-1}(q)$.

The assumption (a.1) and (a.2) ensure that the demand for labour is well defined and positive for all $q > 0$.

We denote by ℓ^*, $\ell^* > 0$, the quantity of labour which is (inelastically) supplied by the agent when young. The agent has intertemporal preferences over present consumption, c_1, and future consumption, c_2, which are represented by the separable utility function:

$$u(c_1,c_2) = u_1(c_1) + u_2(c_2).$$

It is assumed to satisfy the following properties:

(b.1) u_1 and u_2 are continuously diffentiable, increasing and strictly concave;

(b.2) $u_1'(0) = +\infty$.

The last assumption is introduced to ensure that the agent is always willing to consume when young.

The profit realized within one period is distributed entirely to the young agent *at the end of the period*. Hence, labour income is the unique source of income for the young agent and the profit is transfered to the next period with the saving, if any.

We shall consider the possibility of interest payments on nominal money balances held by the old agent. If r denotes the interest rate, $r \geq 0$, and M_0 is the quantity of money transfered from the preceeding period, $(1+r)M_0$ is then the quantity of money which will be spent by the old agent in the current period. In the sequel we shall use the notation $\lambda = 1+r$ with $\lambda \geqslant 1$.

Let us consider a given period of time. If p^e and λ^e denote the price level and the interest factor which are expected to prevail at the next period, then $\theta-1$, with $\theta = \lambda^e p/p^e$, defines the *expected real interest rate*. As shown in Appendix (A.1), conditionally to a given employment level ℓ, $0 \leqslant \ell \leqslant \ell^*$, the young agent's current and planned demand for consumption good can be written as functions of the real interest rate and real wage rate, i.e.

$$c_1 = c_1(\theta, q, \ell),$$

$$c_2 = c_2(\theta, q, \ell).$$

The assumptions (b.1) and (b.2) ensure that these functions are well defined and continuous. Moreover, c_1 and c_2 are positive whenever $q\ell > 0$ and c_2 is an increasing function of θ. An example is given in Appendix (A.3).

2. As to the formation of expectations, we assume that $\lambda^e = \lambda$. This is consistent with the fact that we shall restrict ourselves to a *constant interest rate policy*. On the other hand the young agent's price expectation is given by some function ψ,

$$p^e = \psi(p, \lambda),$$

in which the past history of the economy is implicitely incorporated. It is assumed to satisfy the following properties:

(c.1) ψ is continuous and increasing in p and λ;

(c.2) $\psi(p,\lambda)/p$ is non-increasing in p for all $p > 0$ and $\lambda \geqslant 1$.

Hence, the elasticity (if well defined) of the future price with respect to the current one is positive but does not exceed one[7].

3. It remains to specify how the price level and wage rate are determined in each period. As explained in the Introduction, the price level is determined *competitively* on the consumption good market and, in turn, the price level determines the wage rate. More precisely, the wage rate is *linked to* the price level through some functional relation φ,

$$w = \varphi(p),$$

which incorporates implicitely the past history of the economy. It is assumed to satisfy the following properties:

(d.1) φ is continuous and has positive values for all $p \geqslant 0$;

(d.2) there exists $b > 0$ such that $\frac{\varphi(p)}{p} \leqslant b$ for all $p \geqslant 0$.

This last assumption simply requires that the real wage rate remains *bounded*.

At this stage it is not necessary to specify further the linkage function φ. This will be done after having defined the concept of short run equilibrium and before proceeding to the dynamic analysis.

4. Let us consider a given period of time. The data consist of the expectation function ψ, the linkage function φ and the past history of the economy which includes the stock of money in the preceeding period, $M_0 > 0$, and the interest factor $\lambda \geqslant 1$.

A *short-run equilibrium* is defined by a price level $p > 0$, a wage rate $w > 0$ and an employment level $\ell > 0$ satisfying the following conditions:

(i) $w = \varphi(p)$;

(ii) $\ell = \mathrm{Min}(\ell^*, f'^{-1}(\frac{w}{p}))$

(iii) $c_1(\frac{\lambda}{\psi(p,\lambda)}, \frac{w}{p}, \ell) + \frac{\lambda M_0}{p} = f(\ell)$.

The last condition simply says that (effective) demand and supply coïncide on the consumption good market. By the *Walras Identity* it is equivalent to the following condition:

(iv) $\frac{\varphi(p,\lambda)}{\lambda} c_2(\frac{\lambda p}{\psi(p,\lambda)}, \frac{w}{p}, \ell) = \lambda M_0$

which says that the demand for and the supply of money are equal.[8]

Let us define $q^* = f'(\ell^*)$, the *Walrasian* real wage rate at which the labour market clears. There are two types of *non-Walrasian equilibria* depending on the actual value of the real wage rate. If at the equilibrium the real wage rate exceeds q^*, there is *excess supply of labour*, i.e.

$$\ell = f'^{-1}(q) < \ell^*.$$

This corresponds to the boundary between "Keynesian" and "classical" unemployment in the terminology used by Malinvaud (1977). On the other hand, if $q < q^*$, there is *excess demand for labour*, i.e.

$$\ell = \ell^* < f'^{-1}(q).$$

This corresponds to the boundary between "repressed inflation" and Keynesian unemployment in the same terminology.

The existence of an equilibrium is proved in Appendix (A.2) where it is shown that an equilibrium is defined by a pair (p,q) satisfying

$$p = \mu(q,M)$$

$$q = \frac{\varphi(p)}{p}$$

where $M = \lambda M_0$ and μ is a continuous function, non-decreasing in q and increasing in M. An example is given in Appendix (A.3).

III - DYNAMIC ANALYSIS

1. We shall first specify the indexation scheme in a dynamic context where *deflation does not occur*.

Let us consider the economy at some period t. Following the description made in Introduction, the indexation scheme is fixed at the beginning of the period through some bargaining process in which the relative bargaining power of the workers depends on the excess supply of labour which was observed in period t-1. To capture this idea, we assume that the current real wage rate q depends on the current price level according to the following indexation formula:

$$q = F(q_{t-1}, \frac{p}{p_{t-1}})$$

which defines indirectly the linkage function φ by $\varphi(p) = pF(q_{t-1}, p/p_{t-1})$. The dependence of q on q_{t-1} is twofold. On the one hand q_{t-1} is the *initial* (or reference) real wage rate, i.e. $F(q_{t-1}, 1) = q_{t-1}$: in absence of inflation, the real wage rate does not change. On the other hand the excess supply of labour in period t-1 is given by $\ell^* - f'^{-1}(q_{t-1})$. It depends only on q_{t-1} and therefore it is q_{t-1} which affects the extend of current indexation.

The function F is assumed to be continuously differentiable and to satisfy the following properties:

(e.1) there exists $\bar{q} > 0$ such that, for all $x > 1$, $F(q,x) < q$ if $q > \bar{q}$ and $F(q,x) > q$ if $q < \bar{q}$;

(e.2) for all $x > 1$, $F'_x(q,x) \leqslant 0$ if $q > \bar{q}$ and $F'_x(q,x) \geqslant 0$ if $q < \bar{q}$.

Here F'_x denote the partial derivative of F with respect to x. In the same way, F'_q will denote the partial derivative of F with respect to q. Continuity of F and F'_x implies that $F(\bar{q},x) = \bar{q}$ and $F'_x(\bar{q},x) = 0$ for all $x \geqslant 1$.

Hence, inflation induces a decrease in the real wage rate if $q_{t-1} > \bar{q}$ and the larger the inflation, the lower will be the current real wage rate. And vice-versa if $q_{t-1} < \bar{q}$. The level $\bar{q}$ defines the critical level of excess supply of labour above which less-than-full indexation takes place and below which more-than-full indexation takes place. Typically $\bar{q} > q^*$ in which case inflation induces an increase in the real wage rate if there was an excess demand for labour or if unemployment was not "too large"; and it induces a decrease in the real wage rate if unemployment was "large". Nevertheless, $\bar{q}$ will not be assumed to take any specific value with respect to the Walrasian real wage rate q^*.

2. We fix from now on the interest rate at some positive value, i.e. $\lambda_t = \lambda$ and $\lambda^e_{t+1} = \lambda$ for all t, with $\lambda > 1$. As to

price expectations, we simply assume that $p^e_{t+1} = \lambda p_t$, i.e.

$$\varphi(p,\lambda) = \lambda p$$

As we shall see, this corresponds to a self-fulfilling expectation along a sequence of short-run equilibria characterized by a constant real wage rate, i.e. a sequence of equilibria along which $q_t = \bar{q}$ for all t. Given that we shall restrict our attention mainly on the dynamics in a neighbourhood of $\bar{q}$, this assumption is hardly restrictive. Hence $\theta_t = 1$ for all t and the equilibrium function μ can be written as $\mu(q,M) = M/h(q)$ where $h(q) = c_2(1,q,\ell(q))$. This is a direct consequence of the equilibrium condition (iv) or, equivalently, of equation (2) in the Appendix (A.2). Therefore, along an equilibrium sequence $\{M_t, p_t, q_t\}$ we have for all t

$$p_t = \frac{M_t}{h(q_t)} \qquad (\alpha)$$

Let us now assume that in period t-1 the economy was in some equilibrium position defined by $(M_{t-1}, p_{t-1}, q_{t-1})$, i.e. $p_{t-1} = M_{t-1}/h(q_{t-1})$. The initial stock of money in period t is then given by

$$M_t = \lambda M_{t-1} \qquad (\beta)$$

and the new equilibrium position is determined through a tatonnement process starting from (p_{t-1}, q_{t-1}) along which the price level keeps rising until an equilibrium is reached at some $p_t > p_{t-1}$. Hence, p_t is the *smallest* price level in the set

$$\{ p \geqslant p_{t-1} \mid p = \frac{M_t}{h(q)} , q = F(q_{t-1} , \frac{p}{p_{t-1}}) \} \qquad (\gamma)$$

In this sense, the short-run equilibrium is *uniquely determined*: we ignore possible equilibria characterized by a price level larger than p_t. Along the tatonnement process, the real wage rate is rising or declining, depending whether $q_{t-1} < \bar{q}$ or $q_{t-1} > \bar{q}$.

This can be illustrated in the (p,q) plane as in figure 1 where it has been assumed that $q_{t-1} > \bar{q}$.

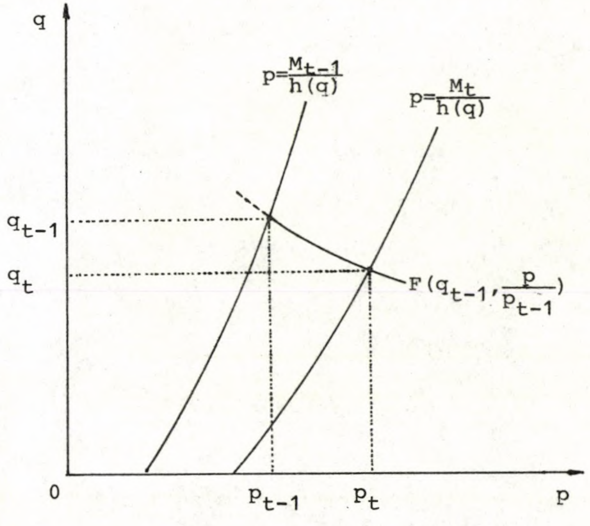

Figure 1

3. Combining (α), (β) and (γ), and using the fact that h is a non-increasing function of q, one verifies that the sequence of equilibrium real wage rates satisfies the following equations

$$q_t = \text{Min}\,\{\, q \,|\, h(q) \leq \lambda h(q_{t-1}),\ q = F(q_{t-1}, \frac{\lambda h(q_{t-1})}{h(q)}\,\} \qquad (\delta)$$

which implicitely defines the dynamics of the real wage rate and therefore of employment.

Clearly, the sequence of equilibria along which the real wage rate is constant and equal to $\bar{q}$ is a *stationary state* in real terms along which the inflation rate is constant and equal to $\lambda-1$, and price expectations are self-fulfilling[9]. Indeed, if $q_{t-1} = \bar{q}$, then $q_t = q_{t-1} = \bar{q}$ and $p_t = \lambda p_{t-1}$. Furthermore, by definition of F, if $q_{t-1} < \bar{q}$, then $q_t > q_{t-1}$ while if $q_{t-1} > \bar{q}$, then $q_t < q_{t-1}$. Hence, if $q = 0$ is a stationary state, it is necessarily unstable. On the other hand, there are *at most two* stationary states. Indeed, again by definition of F, $q_t = q_{t-1} \neq 0$ implies $q_t = q_{t-1} = \bar{q}$.

4. The evolution of the economy in terms of the real wage rate, and therefore in terms of employment and imbalance on the labour market, needs not be monotonic. Indeed, if q_{t-1} happens to be above $\bar{q}$, it may be that q_t finds itself below $\bar{q}$, and vice versa. The possibility of

such fluctuations are illustrated in figure 2 where we have successively $q_{t-1} > \bar{q}$, $q_t < \bar{q}$ and $q_{t+1} > \bar{q}$.

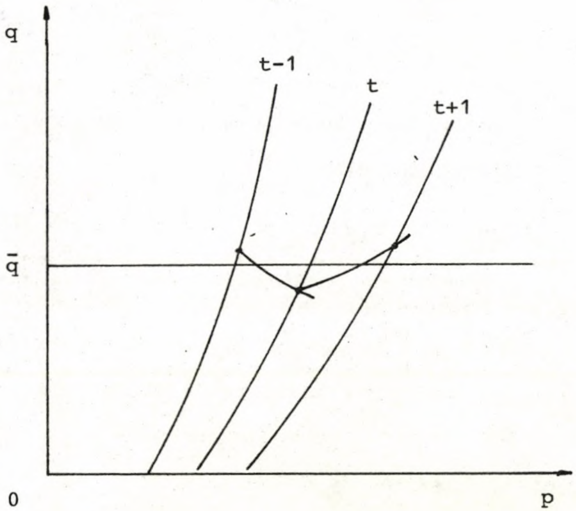

Figure 2

This does not necessarily correspond to a proprer *regime switching*, from unemployment to excess demand for labour or vice versa, except in the particular case where $\bar{q} = q^*$.

The conditions under which such fluctuations may occur can be studied by considering the real wage dynamics around the stationary state $\bar{q}$. From (δ), the sequence $\{q_t\}$ of equilibrium real wage rates satisfies the equation

$$q_t = F(q_{t-1}, \frac{\lambda h(q_{t-1})}{h(q_t)}) .$$

Differentiating it and using the fact that $F'_x(\bar{q},x) = 0$ for all $x \geqslant 1$, a consequence of assumption (e.2), we obtain

$$\left.\frac{dq_t}{dq_{t-1}}\right|_{q_{t-1}=\bar{q}} = F'_q(\bar{q},\lambda)$$

In other words, the real wage dynamics *in a neighbourhood of* $\bar{q}$ is essentially described by the indexation formula, i.e.

$$q_t = F(q_{t-1},\lambda).$$

On the one hand, by assumption (e.1), we have $F'_q(\bar{q},\lambda) \leqslant 1$. It remains therefore three possible cases, namely:

(a) $\quad 0 \leqslant F'_q(\bar{q},\lambda) \leqslant 1;$

(b) $\quad -1 < F'_q(\bar{q},\lambda) < 0;$

(c) $\quad F'_q(\bar{q},\lambda) \leqslant -1.$

In cases (a) and (b), the stationary state is *locally stable*: starting from any q_0 "near" $\bar{q}$, the sequence of real wage rates converges to $\bar{q}$. In case (a), the convergence is *monotonic* while in case (b) there are *fluctuations* around $\bar{q}$. In the last case, the stationary state is *unstable* and there are *diverging fluctuations*.

Given λ, the difference $1 - F'_q(\bar{q},\lambda)$ measures the sensitivity of indexation with respect to small changes in the real wage rate away from the "long run" or stationary equilibrium level $\bar{q}$. Hence, instability results from a too high sensitivity of the indexation scheme with respect to the inflation rate $\lambda-1$. It is to be noticed that $F'_q(\bar{q},1) = 1$ and therefore , if λ close to one, $1 - F'_q(\bar{q},\lambda)$ will be close to zero. In other words, under a reasonnable exogenous inflation, the long run equilibrium defined by $\bar{q}$ is likely to be stable, at least locally. Otherwise, if inflation is large and/or if the indexation scheme is very sensitive to labour market conditions, large fluctuations are likely to be observed.

5. We conclude this section by remarking that out of the stationary state, the real wage rate never falls below the one which would result if indexation had been based on expected inflation. Indeed, when $q_{t-1} < \bar{q}$ inflation is accelerated i.e. $p_t/p_{t-1} \geqslant \lambda$ and therefore, by assumption (d.2), $q_t = F(q_{t-1},p_t/p_{t-1}) \geqslant F(q_t,\lambda)$. Similarly, when $q_{t-1} > \bar{q}$ inflation is slowed down and $q_t \geqslant F(q_t,\lambda)$. From the preceeding discussion , we have seen that the two indexation schemes coincide in a neighbourhood of $\bar{q}$.

IV - CONCLUSIONS

While giving interesting insights into the role of indexation in the employment dynamics of an economy, the model remains rudimentary and ought to be extended in several directions.

On the labour demand side, it would be interesting to consider an imperfectly competitive model, a case in which the labour demand is not any more a function of the real wage rate. Also, this would allow to consider the possibility of non-decreasing returns to scale.[10]

On the other hand, it would be interesting to make explicit the underlying bargaining between unions and firms through some game theoretic approach so that the indexation scheme and the resulting fluctuations become endogeneous.

Finally, the way in which inflation is generated is of course ad hoc. An alternative way which we have actually explored is to generate inflation through deficit spending. It turns out that this does not affect the basic results. It would have therefore complicated unnecessarily the model. On the other hand, inflation has been postulated to activate the process of indexation and enable us to answer the question which was raised in the introduction.

FOOTNOTES

1. For applications of this concept within a macroeconomic framework, see Dehez and Fitoussi (1985).

2. When positive, it measures unemployment; when negative, it measures the excess demand for labour.

3. The relevance of over-full-indexation was suggested to us by Arrow in a comment on our earlier paper.

4. Here, a change within a given period in some variable involves a comparison between the current value of this variable and its value at the end of the preceeding period.

5. All this is very much in the spirit of Hicks (1974, third chapter). See also Tobin (1980, p.38).

6. The overlapping generation modelling is convenient and indeed popular. See for example Hahn and Solow in the present volume or Grandmont (1983,1985).

7. Hence we allow for unit elastic price expectations. This does not prevent the existence of a short-run equilibrium because the young agent is "forced" to save the profit. See Grandmont (1983) for existence conditions outside such an assumption.

8. Benassy (1985) considers a similar definition but with *downward price rigidity*.

9. Actually indexation induces a kind of Phillips curve. Indeed it is possible to construct the locus of short-run equilibrium points in the (q,x) plane as a falling curve passing through the point $(\bar{q},\lambda)$.

10. See for example the paper of Weitzman in the present volume. An other example is the paper of Dehez (1985).

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APPENDIX

A.1 Determination of the short-run demand functions

Given some ℓ, $0 \leqslant \ell \leqslant \ell^*$, the optimization problem of the young agent can be written as

$$\text{Max } u(c_1, c_2)$$

subject to $c_1, c_2 \geqslant 0$, $m \geqslant 0$,

$$pc_1 + m = w\ell,$$

$$pc_1 + p^e c_2 = \lambda^e (m + pf(\ell) - w\ell).$$

It can equivalently be written as

$$\text{Max } u(c_1, c_2)$$

subject to $c_1, c_2 \geqslant 0$,

$$c_1 \leqslant q\ell,$$

$$c_1 + \frac{1}{\theta} c_2 = f(\ell),$$

where $q = w/p$ and $\theta = \lambda^e p/p^e$.

A.2 Existence of a short-run equilibrium

Let $\ell(q) = \text{Min}(\ell^*, f'^{-1}(q))$, the actual employment level as a function of the real wage rate. We first fix the real wage rate at some value $q > 0$. Then condition (iii) defines the corresponding equilibrium price level as a solution of the following equation

$$c_1(\theta(p), q, \ell(q)) + \frac{M}{p} = f(\ell(q)) \qquad (1)$$

where $\theta(p) = \lambda p/\psi(p,\lambda)$ and $M = \lambda M_0$. The existence of a positive solution is immediate and does not require particular assumptions on ψ except continuity. Indeed, when p goes to zero, the aggregate demand goes to infinity. On the other hand, the profit is positive, i.e. $q\ell(q) < f(\ell(q))$, and $c_1 \leqslant q\ell(q)$. Hence, for p large enough, aggregate demand falls below $f(\ell(q))$. By continuity there exists at least one solution to equation (1) and all solutions are positive.

From condition (iv), we know that equation (1) is equivalent to the following equation:

$$\psi(p,\lambda)c_2(\theta(p),q,\ell(q)) = \lambda M. \qquad (2)$$

Unicity of a solution to equation (1) then follows from the fact that the left-hand-side of equation (2) is increasing in p. This is a consequence of assumption (c.2) and of the fact that c_2 is increasing in θ.

Equation (1) then defines a continuous function $p = \mu(q,M)$ which satisfies $\mu(q,M) > 0$ for all $q \geqslant 0$ and $M > 0$, and $\mu(0,M) = M/f(\ell^*)$. Furthermore, μ is a non-decreasing function of q and an increasing function of M. This follows in particular from the fact that real profit, $f(\ell(q)) - q\ell(q)$, and the production level, $f(\ell(q))$, are both non-increasing in q implying that $c_2(\theta,q,\ell(q))$ is itself non-increasing in q.

A short-run equilibrium is then defined by a price level $p > 0$ such that

$$p = \mu(\frac{\varphi(p)}{p}, M)$$

i.e. it is the intersection in the (p,q) plane between the curves defined respectively by $p = \mu(q,M)$ and $q = \varphi(p)/p$. Clearly, the properties of μ and the assumptions (d.1) and (d.2) ensure the existence of at least one intersection.

A.3 An illustration

Let us consider the following specification:

$$f(\ell) = 2\sqrt{\ell}$$
$$u(c_1, c_2) = \sqrt{c}_1 + \sqrt{c}_2$$
$$\psi(p,\lambda) = \lambda p$$
$$\ell^* = 1.$$

Then $q^* = 1$, $\theta(p) = 1$ for all p and

$$c_1(1,q,\ell) = \mathrm{Min}(q\ell, F(\ell)/2),$$
$$\ell(q) = \mathrm{Min}(1, 1/q^2),$$

The function μ is then given by:

$$\mu(q,M) = \begin{cases} \frac{M}{2-q} & \text{if } q \leqslant 1, \\ Mq & \text{if } q \geqslant 1. \end{cases}$$

Let us now assume that the linkage function φ is given by

$$w = [1+\alpha_t(\frac{p}{p_{t-1}} - 1)]\, w_{t-1}$$

where $\alpha_t = g(q_{t-1})$ is the *indexation coefficient*. The corresponding indexation formula F is then given by

$$F(q,x) = [g(q) + (1-g(q))\frac{1}{x}]\ q.$$

The simplest dynamics is provided by the case where $qg(q)$, the slope of φ with respect to the current price level is *constant*. Then $g(q) = \bar{q}/q$ and, starting from any $q_0 \neq \bar{q}$, the sequence of real wage rates *converges monotically* to $\bar{q}$. Indeed, we have the following equation

$$q_t = \bar{q} + (q_{t-1}-\bar{q})\frac{h(q_t)}{\lambda h(q_{t-1})}$$

which, when applied recursively, reduces to

$$\frac{q_t-\bar{q}}{h(q_t)} = \frac{q_0-\bar{q}}{h(q_0)}\frac{1}{\lambda^t}.$$

An other example is provided by the case where the indexation coefficient depends *linearly* on the real wage rate, i.e.

$$g(q) = \mathrm{Max}(0,\beta(\bar{q}-q))$$

where $\beta > 0$. Then $F'_q(\bar{q},\lambda) = 1 - \beta\bar{q}(1-1/\lambda)$ and (δ) defines implicitely a difference equation in q_t whose possible shapes are given in the figures (3.a) and (3.b), assuming $\bar{q} = q^*$.

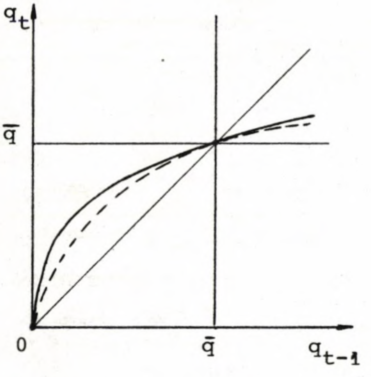

Figure 3.a

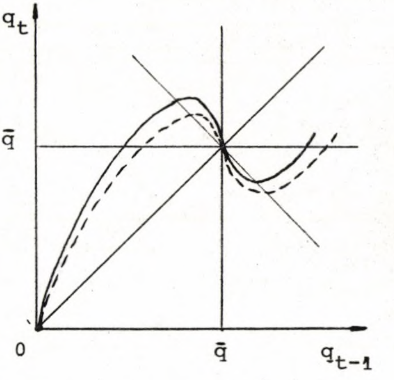

Figure 3.b

Figure (3.a) corresponds to case (a) where $\beta \leq \lambda/(\lambda-1)$ and the stationary state $\bar{q}$ is stable. On the other hand, case (c) where $\beta > 2\lambda/(\lambda-1)$ is illustrated in figure (3.b). The dotted curves correspond to the graph of the function $q_t = F(q_{t-1},\lambda)$.

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