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INFLATIONARY INERTIA IN A WAGE–PRICE SPIRAL MODEL

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This paper examines theoretical issues of inflationary inertia by use of a wage–price spiral model, in which wage and price decisions are staggered. It is shown that within such a framework inflation is inertial in the following sense: a monetary disinflation cannot immediately succeed and the rate of inflation declines gradually. It is also shown that from another aspect of inflationary inertia, which is the effect of cost shocks, inflation is less inertial even in a wage–price spiral model: a temporary cost shock has no continuing effect on the rate of inflation. Only permanent changes in costs have an inertial effect and they raise the rate of inflation in consecutive periods as well.

1. Introduction

This paper examines various aspects of inflationary inertia within the theoretical framework of a wage–price spiral. The term inflationary inertia is a generalization of the following observations, made during inflationary situations: (1) The rate of inflation is positively autocorrelated across time.[1] (2) Monetary disinflations usually take time and the decline of the rate of inflation is gradual. (3) Supply shocks seem to raise the rate of inflation not only at the time of the shock, when the price level rises, but in subsequent periods as well.[2] These observations can be considered as aspects of inflationary inertia since in all these phenomena it is the rate of inflation and not only the price level which exhibits a considerable degree of inertia.

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[1]Many empirical studies have found that the rate of inflation depends, among other variables, on former periods' rates of inflation. Such are the findings of Taylor (1979b), Sachs (1980), Gordon (1985) and many others.

[2]One example of this phenomenon has been the prolonged inflationary effect of the 1973 OPEC price shocks on western economies. Other examples have emerged during recent inflations in Israel and Latin American countries, where devaluations or massive subsidy reductions were believed to have an accelerating effect on the rate of inflation. See Liviatan and Piterman (1986) for an example.

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Inflationary inertia is a concept which is extensively used in describing inflationary situations by both economists and policymakers, though it is far from being theoretically well established. For example, in a Walrasian market clearing model with rational expectations there is no inflationary inertia, since there is no justification for the rate of inflation to be dependent on past rates of inflation. This point is forcefully stressed by Sargent (1982, 1983). A common theoretical explanation for inflationary inertia has been a combination of the 'expectations augmented Phillips Curve' and adaptive expectations, as in Sachs (1980) and Gordon (1985). This explanation is not pursued in this paper, since it is inapplicable to the issue of supply shocks. This can be seen by the fact that even if the public learns about the trend of inflation from past observations, a one-time price shock would not be taken into consideration in such a learning process.

Instead of explaining inflationary inertia by adaptive expectations, this paper adopts an alternative approach, one that seeks the explanation within the mechanism of price and wage adjustments. Thus expectations are assumed to be rational and this model departs from the standard model by abandoning the assumption of continuously clearing markets. The most appropriate framework within which inflationary inertia should be theoretically examined is therefore a model of a wage–price spiral. In such a model, wage and price adjustments are asynchronized and since wages and prices are mutually dependent, a wage–price spiral develops. This spiral creates inflationary inertia since current wage increases are followed by price rises, which in turn push wages up, causing current inflation to affect future rates of inflation. The inflationary effect of a price shock can also be analyzed within such a framework. Notice that in such a model dependence on past variables does not in any way reflect a degree of backward looking by decision makers. Both workers and firms rationally consider only the relevant present and future periods, but since wages (prices) depend on current prices (wages), which have been previously determined, the dependence on past variables is established.

In this paper inflationary inertia is examined by use of a simple wage–price spiral model, which was developed by Blanchard (1986) in order to examine price level inertia. In this model wages and prices are each set for two periods and the wage and price adjustments are staggered. This framework follows Akerlof (1969), Taylor (1979a, 1980) and Blanchard (1983), with the additional condition that wages and prices are mutually dependent. Although Blanchard's model is not a complete theory of the wage–price spiral, since the timing of wage and price decisions is assumed to be exogenous, it is nevertheless the best existing framework for an analysis of inflationary inertia due to asynchronized wage and price decisions, mutual dependence of wages and prices, forward looking decision makers and rational expectations. In contrast to Blanchard's analysis of the inertia of the price level, in this paper the model is used to analyze the inertia of the first derivative, i.e. of the rate of inflation. The model offered here differs from that of Blanchard not only in the questions it poses, but also by assuming a non-zero rate of discount. This assumption allows workers and firms to consider different discounted real wages during an inflation, since they make decisions at different points in time. This inflationary wedge plays an important role in the theory of inflation as developed in the paper.

The main conclusion of the paper is that even in the wage–price spiral model, inflation is less inertial than could be expected. It is shown that inflation reacts differently to transitory and to permanent cost shocks. While permanent changes have an inertial effect on the rate of inflation, transitory shocks have an inertial effect only on the price level, and no inertial effect at all on the rate of inflation. It is important to note that this distinction is made only between transitory and permanent shocks, and not between nominal and real shocks. Thus though a one-period subsidy reduction is a real disturbance, it has no inertial effect on the rate of inflation, while a nominal devaluation raises the rate of inflation at the time it occurs and in consecutive periods as well.

The paper is organized as follows. Section 2 presents the wage–price spiral model. The dynamics of inflation and disinflation are analyzed in section 3 and the long-run equilibrium is discussed in section 4. Section 5 examines the inertial effect of cost shocks and section 6 extends the analysis to the open economy and studies the effect of exchange rate devaluations. Section 7 summarizes the paper.

2. The model

Consider a closed economy with one physical good, which is produced by labor and capital and is used for consumption and investment. It is a monetary economy with a government which finances its deficits by printing money. Labor and goods markets do not continuously clear in this economy and it is assumed that prices and wages are adjusted only once in two periods. It is further assumed that wage and price changes are staggered: wages are set in even periods and prices in odd periods. This somewhat mechanical framework is a simplified representation of a very basic characteristic of inflationary processes, namely that prices change in discrete jumps and that these changes are not fully synchronized. In our model the frequency of these adjustments is fixed and exogenously determined. While such an assumption should not be used in analysis of accelerating hyperinflations, where wages and prices are adjusted more and more frequently, we believe that this framework is suitable for the analysis of inertia in moderate chronic inflations.[3]

The physical good is produced by use of labor and capital (tools) in a fixed proportion and with constant returns to scale. Thus one unit of labor with K units of capital produces A_t units of the good. Total production of the good is described by

$$Y_t = A_t \cdot L_t. \tag{1}$$

where Y_t is output and L_t is labor input. This can also be described by the following equation, using lowercase letters for logarithms:

$$y_t = a_t + l_t. \tag{2}$$

At each odd period t firms adjust the price P_t for periods t and $t+1$. Due to competition between firms, the price is determined at a level that sets the expected discounted profit per unit over the two periods at zero. The discount rate, $0<\rho<1$, is assumed to be constant.[4] Thus the price P_t satisfies

$$\left[(1-T_t)A_t - \frac{W_t}{P_t} - \rho K\right] + \frac{1}{1+\rho} E_t\left[(1-T_{t+1})A_{t+1} - \frac{W_{t+1}}{P_t} - \rho K\right] = 0, \tag{3}$$

where W_t is the wage rate in period t, T_t is the rate of excise tax on the physical good, and E_t are expectations based on information in period t. By use of an appropriate unit scale the real wage can be normalized to be in the neighborhood of unity, therefore allowing the following approximation:

$$\frac{W_t}{P_t} = w_t - p_t + 1,$$

where again lowercase letters denote logarithms. By use of this approximation we derive from eq. (3) the following pricing rule:

$$(p_t - w_t) + \frac{1}{1+\rho}(p_t - w_{t+1}^t) = c_t + \frac{1}{1+\rho} c_{t+1}^t, \tag{4}$$

[3]For the distinction between hyperinflations and moderate chronic inflations see Kiguel and Liviatan (1988).

[4]This can be justified in a model of a representative risk-neutral agent with a rate of discount ρ: $U = \sum_{t=0}^{\infty} (1/(1+\rho)^t)[C_t + \log LE_t]$, where C_t is consumption and LE_t is leisure.

where the time superscript denotes the time of expectations and where c_t is a cost variable defined by

$$c_t = 1 + \rho K - (1 - T_t) A_t. \tag{5}$$

Notice that the cost variable c_t reflects production costs through A_t, financial costs through ρK, and consumer costs through the excise tax or subsidy on the good. From eq. (3) we see that if ρK is high enough, operating profits are positive in next period $t+1$, even when wages are expected to rise. Hence we can assume that the full amount of the good demanded both in period t and in period $t+1$ would be produced by the firms.

We now turn to describe labor market equilibrium and wage determination in an even period t. A wage contract, whether explicit or implicit, specifies both a nominal wage rate W_t for periods t and $t+1$ and the terms of hiring. In period t each worker supplies an amount of labor he/she chooses and agrees to supply the same amount in period $t+1$. It is also understood that firms can change their future labor input, and that workers must supply the labor to meet this demand. For the sake of simplicity we assume that each worker will supply in period $t+1$ a proportionate amount of labor to that supplied in period t. Within such a framework the supply of labor in period t, L_t^s, depends on two variables: the expected discounted real wage for these periods described by

$$(w_t - p_t + 1) + \frac{1}{1+\rho}(w_t - p_{t+1}^t + 1),$$

and the expected change in total labor input, L_{t+1}/L_t. Under standard assumptions the effect of the real wage on the labor supply is positive. The effect of L_{t+1}/L_t is ambiguous, since there is a positive income effect due to higher expected wage income, as well as a negative substitution effect. Due to this ambiguity and to the relatively small changes in employment from period to period, which cause L_{t+1}/L_t to be near unity, we can assume that the effect of this variable on labor supply is null. Hence labor supply, L_t^s, depends on the expected discounted two periods real wage only. We can therefore write the equilibrium condition in the labor market in an even period t in the following way:

$$L_t = L_t^s\left[(w_t - p_t + 1) + \frac{1}{1+\rho}(w_t - p_{t+1}^t + 1)\right], \tag{6}$$

or in a log-linearized version

$$w_t - p_t + \frac{1}{1+\rho}(w_t - p^t_{t+1}) = \alpha l_t, \tag{7}$$

where α is a positive coefficient.[5] Eq. (7) therefore describes wage determination in even periods in the economy.

In order to conclude the model we describe the demand side of the goods market and we assume that output, Y_t, is demand determined and is equal to real balances

$$Y_t = \frac{M_t}{P_t}, \tag{8}$$

where M_t is the nominal amount of money. This assumption can be justified in several ways, either by use of a simple IS–LM model with a vertical LM curve or by using a cash-in-advance representative model. Eq. (8) can be rewritten as

$$y_t = m_t - p_t. \tag{9}$$

Finally, we assume that expectations of both workers and firms are formed rationally, based on their knowledge of the model and on their expected future monetary policy. Hence in order to derive a full dynamic solution to the model, represented by eqs. (2), (4), (5), (7) and (9), it is necessary to specify both the cost variable and the monetary policy rule. But before turning to various solutions of the model, the price and wage adjustment equations [eqs. (4) and (7)] need to be arranged in the following dynamic price equation:

$$\begin{aligned}(1+\beta+\beta^2)p_t = {} & p_{t-2} + \beta p^{t-1}_t + \beta^2 p^t_{t+2} + \alpha l_{t-1} + \alpha\beta l^t_{t+1} \\ & + (1+\beta)(c_t + \beta c^t_{t+1}),\end{aligned} \tag{10}$$

where β denotes the rate of time preference: $\beta = 1/1+\rho$. Eq. (10) plays an important role in the following sections.

3. Inflationary dynamics and inflationary inertia

We begin our analysis of inflationary inertia in the wage–price spiral model by examining the basic dynamics of inflation in this model. This is done by determining whether inflation is positively time autocorrelated in the

[5]The constant in eq. (7) is equal to zero due to unit choice.

wage–price spiral model and whether the effect of a monetary disinflation in this model is gradual. In order to simplify the analysis let us assume that the cost variable is fixed: $c_t = c$ for all t, with productivity being fixed as well. This assumption is later dropped in section 5 when dealing with the effect of cost changes on inflation.

We consider here two types of monetary policies: the accommodative policy and the strict monetary rule. The accommodative monetary policy is taken by the government when it wishes to stabilize employment at some target level l. The amount of money is therefore adjusted in every period t in order to have

$$l_t = l \quad \text{for all} \quad t. \tag{11}$$

The strict monetary rule is defined to be a policy which keeps the rate of monetary expansion fixed. The government increases the amount of money in a fixed proportion, μ, in every odd period t

$$m_t = m_{t-2} + \mu. \tag{12}$$

The specific method of money injection, through transfer payments or through direct purchases of goods is not relevant in this model, due to the vertical LM curve, as implied by eq. (9).

In order to describe inflationary dynamics under an accommodating monetary policy, let us return to eq. (10), which under this policy and with fixed costs becomes

$$(1+\beta^2)p_t = p_{t-2} + \beta^2 p_{t+2} + \alpha(1+\beta)l + (1+\beta)^2 c. \tag{13}$$

We apply the method of undetermined coefficients in order to solve (13). It is clear from (13) that the solution has the following functional form:

$$p_t = x_0 + z_0 p_{t-2}. \tag{14}$$

Substituting (14) in (13), and solving for the coefficients we get two possible solutions: $z_0 = 1$ and $z_0 = 1/\beta^2$. Only the first solution is used, since it guarantees stability of the process of expectations formulation, according to a criterion suggested by Evans (1986).[6] Thus we get

[6]Let expectations be: $p_{t+2} = x_s + z_s p_t$, where x_s and z_s are arbitrary. Apply these expectations to (13) and get: $p_t = x_{s+1} + z_{s+1} p_{t-2}$, where $z_{s+1} = (1+\beta^2 - \beta z_s)^{-1}$ and x_{s+1} is similarly computed. Now the public can update their expectations, apply them to $t+2$, and do it again and again. The difference equation $z_{s+1} = (1+\beta^2 - \beta z_s)^{-1}$ has two long-run values, 1 and $1/\beta^2$, but only the first is stable. Hence at z_0 expectations are stable.

$$p_t = p_{t-2} + \frac{\alpha l + (1+\beta)c}{1-\beta}, \tag{15}$$

and hence the rate of inflation Π is fixed under such an accommodative policy

$$\Pi_t = p_t - p_{t-2} = \frac{\alpha l + (1+\beta)c}{1-\beta}. \tag{16}$$

Notice that the rate of inflation is positively related to the level of employment both in the short and in the long run. This wage–price spiral model therefore gives rise to a long-run Philips Curve relationship, which is discussed in section 4.

According to eq. (16), the rate of inflation is constant through time: $\Pi_t = \Pi_{t-1}$, which could be interpreted as inertia, i.e. positive autocorrelation. But eq. (16) also implies that this interpretation is not necessarily true, since the rate of inflation, even under accommodative policy, is not historically determined but rather depends on real variables in the economy, i.e. α, β, l and c.

In order to examine the effect of a monetary disinflation we have to first analyze inflationary dynamics under a fixed monetary rule. If the rate of monetary expansion is μ, as in (12), and costs are fixed, eq. (10) becomes

$$\begin{aligned}(1+\beta^2+\alpha\beta)(p_t - m_t) &= (1-\alpha)(p_{t-2} - m_{t-2}) + \beta^2(p_{t+2} - m_{t+2}) \\ &\quad + (1+\beta)[(1+\beta)c - (1-\beta)\mu - \alpha a].\end{aligned} \tag{17}$$

In a similar manner we apply the method of undetermined coefficients to (17) and get the following rational expectations solution:

$$p_t - m_t = x_1 + z_1(p_{t-2} - m_{t-2}), \tag{18}$$

where z_1 is the lower solution to

$$\beta^2 z_1^2 - (1+\beta^2+\alpha\beta)z_1 + 1 - \alpha = 0. \tag{19}$$

It is easy to verify that $z_1 < 1$, and if we assume that $2\beta^2 + 2 + \alpha\beta - \alpha$ is positive, then $-1 < z_1 < 1$ and the dynamic equation (18) is stable. From eq. (18) we get, by subtracting period $t-2$ from period t

$$\Pi_t = z_1 \Pi_{t-2} + (1-z_1)\mu. \tag{20}$$

A few conclusions can be derived from eq. (20). First, it is clear that Π_t

converges to μ and hence the long-run rate of inflation under a strict monetary policy is equal to the rate of money expansion. It also follows from (20) that inflation exhibits some degree of persistence (inertia) if z_1 is positive. This persistence can be demonstrated by use of a simple example of a monetary disinflation. Imagine an economy in a steady state with a fixed high rate of inflation Π. The government intends to reduce the rate of inflation to zero and thus it adopts a strict policy rule of no monetary expansion. This policy is formulated and announced in an even period, T, so that from period T on, we have $m_t = m_{T-1}$, for all $t \geqq T$. The rational expectations equilibrium, which prevails from $t = T+1$ on, is given by eq. (18), where $x_1 = (1-z_1)[(1+\beta)c/\alpha - a]$. Since $p_{T-1} - m_{T-1} = [(1+\beta)c - (1-\beta)\Pi - \alpha a]/\alpha$, it can be shown that

$$\Pi_{T+1} = p_{T+1} - p_{T-1} = (1-z_1)\frac{(1-\beta)\Pi}{\alpha}. \tag{21}$$

Hence the rate of inflation after the beginning of the monetary disinflation program remains positive.[7] According to eq. (20) the rate of inflation falls gradually from this level from period $t = T+3$ on, according to

$$\Pi_t = z_1 \Pi_{t-2}.$$

Thus if z_1 is positive, the rate of inflation declines only gradually after the government implements a monetary disinflation program. This inflationary persistence is positively correlated with the size of the coefficient z_1. Notice that z_1 is positive if and only if $\alpha < 1$, namely if the wage elasticity of labor is greater than unity. Furthermore, z_1 converges to 1 as α approaches 0, therefore illustrating that greater elasticity of the labor supply causes the rate of inflation to exhibit a greater degree of persistence. Since an elastic labor supply can be interpreted as real wage rigidity, this constitutes a positive relationship between real wage rigidity and inflationary inertia.

As mentioned above, inflationary inertia resulting from a wage–price spiral is weakened in hyperinflations, where wage and price adjustments become more frequent. This can be demonstrated by use of eq. (21). The shorter the time period between adjustments, the closer β is to unity. Hence in a hyperinflation with $1-\beta$ very small, Π_{T+1} is low, and a monetary disinflation reduces the rate of inflation much more rapidly than in a moderate inflation.

[7]A similar and even stronger result holds if disinflation starts in an odd period. Inflation then is higher since wages rise by more.

4. Inflation, employment and the inflationary wedge

As shown above in section 3, under a fixed monetary rule the rate of inflation converges to μ, the rate of monetary expansion. It can also be shown, by use of eq. (17), that the level of employment converges to a long-run level l:

$$l=\frac{(1-\beta)\mu-(1+\beta)c}{\alpha}, \tag{22}$$

which is positively related to the rate of inflation, $\Pi=\mu$. Notice that this long-run relationship is the same under the accommodative policy, and that eq. (22) is equivalent to eq. (16). The trade-off between inflation and unemployment is therefore independent of the policy regime, and is in fact a result of the wage–price spiral. The only difference between policies is the choice of the target variable: an accommodating government stabilizes l and Π is endogenously determined, while a strict monetary policy determines the rate of inflation and employment is endogenously determined.

The long-run relationship between employment and inflation, which can also be directly derived from eq. (10), is therefore inherent to the wage–price spiral model. It can best be understood by reference to the concept of an 'inflationary wedge'. During an inflationary period the real wage repeatedly fluctuates, being high in even periods when nominal wages are adjusted, and low in odd periods when prices are adjusted. But in this economy price setters and wage setters act in different periods of time – odd and even periods respectively. Therefore the two-period discounted sum of real wages, which is relevant for each sector, is different: wage setters consider periods $t-1$ and t, while price setters consider periods t and $t+1$. Since there is a positive discount rate and $\beta<1$, these two discounted sums are not equal and there is an inflationary wedge of size $(1-\beta)\Pi$ between the two. In Blanchard (1986), where the rate of time preference equals unity, such a wedge is possible only during short-run fluctuations of the real wage, disappearing in the long run. But if on the contrary the rate of time preference β is less than one, then the inflationary wedge exists in a steady state as well. The wedge is relevant because firms and workers make decisions at different points in time. Firms decide on both their price and, more importantly, whether to enter the market in odd periods.[8] Workers decide whether to sign a wage contract in even periods. Thus the discounted sum of real wages for workers, which affects the labor supply [eq. (7)], is higher than the discounted sum viewed by firms, which affects the product supply [eq. (4)]. This inflationary wedge therefore leads to the long-run positive relationship between inflation and employment in eqs. (16) and (22).

[8]Firms do not invest and enter in even periods when the wage rate is higher.

The concept of an inflationary wedge can also shed some light on the social aspects of the inflationary process. Inflation can be viewed as a situation in which labor and firms cannot reach an agreement on the level of real wages, resulting in each side trying to change the level of real wages whenever possible. Firms raise prices in odd periods and workers raise wages in even periods. And though on average each side does not enlarge its share, the respective shares are temporarily increased during the period of decision making, due to the positive discount rate.

Furthermore, the inflationary wedge is also important for an intuitive understanding of inertia in the inflationary process. Inflation is positively related to the wedge between price and wage setters, and thus the rate of inflation is affected by the levels of real wages that workers and firms are trying to set. Hence permanent changes in these levels tend to have a stronger effect on the rate of inflation than temporary changes, as is shown below.

5. The inflationary effect of cost changes

We now turn to examine another aspect of inflationary inertia in the wage–price spiral model, namely the reaction of inflation to changes in costs. Many economists claim that cost shocks tend to raise not only the price level but the rate of inflation as well. The argument is as follows: higher costs raise the price level, this raises wages in the next period, with a following higher level of prices. These dynamics raise the rate of inflation to a higher level. This scenario is mostly applicable to an economy under an accommodating monetary policy, where the amount of money is adjusted to any price level. In this section we examine the validity of this argument.

The following analysis distinguishes between two types of cost shocks: transitory and permanent. It is shown that these have different effects on the rate of inflation: while transitory shocks are not at all inertial, permanent shocks do have an inertial effect. These results hold under both the accommodative monetary policy and under the strict monetary rule.

Consider first the case of the accommodating monetary policy where the government stabilizes employment at a fixed level, l. Let transitory shocks to costs be modelled as follows: c_t is a random variable, which becomes known only at t, but not before. All c_t have a known identical distribution and they are independent random variables. Let c denote the time invariant expectation of c_t. With such transitory shocks and under the accommodating policy, eq. (10) becomes

$$(1+\beta+\beta^2)p_t = p_{t-2} + \beta p_t^{t-1} + \beta^2 p_{t+2}^t + \alpha(1+\beta)l + (1+\beta)c_t + \beta(1+\beta)c. \tag{23}$$

The rational expectations solution to (23) is derived by the method of undetermined coefficients as described in section 3, and the stable solution is

$$p_t = \frac{2\beta c + \alpha l}{1-\beta} + p_{t-2} + c_t. \tag{24}$$

Hence the rate of inflation under an accommodating monetary policy when cost shocks are transitory is

$$\Pi_t = p_t - p_{t-2} = \frac{(1+\beta)c + \alpha l}{1-\beta} + (c_t - c). \tag{25}$$

It is clear from eq. (25) that transitory shocks, like temporary changes in taxes (subsidies) or in productivity, affect the rate of inflation only at the time they occur and have no effect in later periods. Notice that a transitory shock does have a permanent effect on the price level, as can be seen from eq. (24), but no inertia at all on the rate of inflation. The rate of inflation under accommodating monetary policy is therefore a constant rate with an additional white noise and no serial correlation. This result contradicts the common belief that all price shocks are inertial under accommodating monetary policy, and hence that the rate of inflation follows a random walk.[9] Interestingly, a thorough look at empirical investigations of recent inflations reveals that the result obtained here is indeed in accordance with the facts. In a recent study of various inflations, Helpman and Leiderman (1987) have found that if inflation is detrended the degree of serial correlation significantly declines. In an interesting work, Sussman (1987) examines the Israeli inflation, which went through three phases, each with a higher but relatively stable rate of inflation. Sussman finds that during each phase there is almost no serial correlation and the rate of inflation during these phases indeed behaves like a constant plus white noise.

It can therefore be stated that transitory shocks to costs have no inertial effect on the rate of inflation. Nevertheless, a permanent change does have an inertial effect, as can be seen by considering the following example: let costs be fixed at c_0 until time T, when they unexpectedly rise to c_1, and remain so from that period on. Let T be an odd period.

According to eq. (16) in section 3 the rate of inflation before the shock is

$$\frac{\alpha l + (1+\beta)c_0}{1-\beta},$$

[9]See Liviatan and Piterman (1986) and Bruno and Fischer (1986).

while after the shock it reaches a higher long-run rate of inflation in period $T+2$

$$\frac{\alpha l+(1+\beta)c_1}{1-\beta}.$$

By use of eq. (10) we can easily calculate the rate of inflation at T, the period of the shock

$$p_T-p_{T-2}=\frac{\alpha l+(1+\beta)c_0}{1-\beta}+\frac{c_1-c_0}{1-\beta}=\frac{\alpha l+(1+\beta)c_1}{1-\beta}-\beta\frac{c_1-c_0}{1-\beta}.$$

Hence the rate of inflation at T is higher than before the shock, but still lower than the new long-run rate, which prevails from $T+2$ on. Thus a permanent rise in costs raises the rate of inflation not only at the period of the shock, but in all consecutive periods as well, and it is therefore inertial.

What is the intuitive explanation for the drastically different inertia of transitory and permanent cost shocks? It seems that the answer lies in the inflationary wedge. A continuing change in the rate of inflation occurs only when one side, whether firms or labor, consistently tries to change the real wage it faces, by persistently raising prices above wages or vice versa. This occurs when the change in costs is permanent, but not when it is temporary.

Let us now turn to the other policy we wish to examine, a fixed rate of monetary expansion μ, as described by eq. (12). It is clear that under a more stringent monetary rule inflation should be even less inertial than under an accommodating policy, and that is indeed the case. Let us first view the case of transitory cost shocks, where $\{c_t\}$ is an i.i.d. series of random variables. In order to simplify the analysis under this policy we assume that productivity is fixed: $a_t=a$, and all changes are in taxes or subsidies. This assumption only simplifies the dynamic calculations and has no substantive effect on the results. The rational expectations solution can be derived in a similar way to that in section 3, resulting in a dynamic equation which is similar to (20) with the additional effect of the shocks

$$\Pi_t=z_1\Pi_{t-2}+(1-z_1)\mu+u_1(c_t-c_{t-2}), \tag{26}$$

where z_1 is defined by eq. (19) and u_1 is described by

$$u_1=\frac{1+\beta}{1+\beta+\alpha\beta+\beta^2-\beta^2 z_1}<1. \tag{27}$$

From eq. (26) it is clear that the rate of inflation converges on the average to

μ, which is the rate of monetary expansion. As for short-run dynamics, we can see that (26) implies that although inflation exhibits positive serial correlation, transitory cost shocks have no inertial effect. Let us consider the following example: assume that in period $t-2$ the rate of inflation is at the long-run level, $\Pi_{t-2}=\mu$, and that the cost variable is at the average level, $c_{t-2}=c$. In period t costs temporarily rise by $\varepsilon>0$ to $c_t=c+\varepsilon$, and then fall back in period $t+1$ to c. The rate of inflation rises in period t as a result of the shock

$$\Pi_t=\mu+u_1\varepsilon,$$

but in period $t+2$ the rate of inflation falls to

$$\Pi_{t+2}=\mu+u_1\varepsilon(z_1-1)<\mu,$$

since $z_1<1$. Thus not only do temporary cost shocks have no inertial effect, as in the case of an accommodative policy, but there is even an opposite effect under a strict monetary rule. The explanation is quite simple: the shock raises the price level and thus reduces real balances, output and employment. This exerts a downward pressure on wages, which consequently reduces the rate of inflation.

Unlike transitory changes, permanent cost shocks have an inertial effect on the rate of inflation even under a strict monetary rule. This is surprising since in the long-run such shocks do not change the rate of inflation. But a permanent cost change raises the rate of inflation for a long period. Consider the simple case where costs are fixed at a level c_0, until in period T costs unexpectedly rise to a higher level, c_1, and remain so ever after. Let us assume for simplicity that the economy is in a steady state before T, with a rate of inflation μ, and that T is an even period.[10]

A solution of the rational expectations equilibrium path after the change yields that at time $T+1$ the rate of inflation is

$$\Pi_{T+1}=p_{T+1}-p_{T-1}=\mu+\frac{(1-z_1)(1+\beta)(c_1-c_0)}{\alpha}>\mu, \tag{28}$$

and in the following periods the rate of inflation converges back to μ:

$$\Pi_t=z_1\Pi_{t-2}+(1-z_1)\mu \quad \text{for} \quad t\geqq T+3. \tag{29}$$

Thus the permanent change in costs raises the rate of inflation not only in the first period after the shock, but for a long period after with Π returning

[10]These results hold if T is an odd period too.

gradually to μ. Therefore permanent shocks have an inertial effect on the rate of inflation even if monetary policy is rather strict.

6. Devaluations and inflationary inertia

In this section we extend the analysis of inflationary inertia to the open economy. We concentrate here only on one of the issues which arise in such a context, the inertial effect of exchange rate changes. Many economists and policymakers claim that devaluations tend to raise the rate of inflation, not only at the time of the devaluation, but for a much longer period and possibly even permanently. This prediction is explained by the effects of the exchange rate on costs, which have an inertial effect through the wage–price spiral. This section theoretically examines this claim.

Consider a small open economy which produces one good, called the home good, and consumes two goods, the home good and an imported good.[11] Production of the home good is the same as in the closed economy described in section 2 by eqs. (1) and (2). The foreign currency price of the imported good is 1 and hence its home price is the exchange rate E_t, or e_t in logarithms. We assume that preferences between the home and the imported goods are Cobb–Douglas, and thus they are consumed in constant shares, θ and $1-\theta$ respectively where $0<\theta<1$. We further assume that the wage and price adjustment are staggered in the same way as in the closed economy described in section 2. It is also assumed that there is full capital mobility and that the world rate of interest is ρ, which is equal to the home rate of discount. Under these assumptions price adjustment in odd periods is given by eqs. (4) and (5), as in the closed economy. The supply of labor is assumed to be the same as in section 2, except that the cost of living now includes both the home good price and the exchange rate and is equal in logarithms to: $\theta p_t+(1-\theta)e_t$. Wage adjustment in even periods is therefore described by

$$w_t-\theta p_t-(1-\theta)e_t+\beta[w_t-\theta p^e_{t+1}-(1-\theta)e^e_{t+1}]=\alpha l_t. \tag{30}$$

Finally we retain the closed economy assumption that LM is vertical and that the demand for home production is determined by the real balances, as in eq. (9).

Let us first examine the dynamic price equation, which is found by arranging the price and wage eqs. (4) and (30), and where we assume for simplicity that the cost variable, c_t, is fixed

[11] Investment is assumed to be of the home good only.

$$(1+2\beta+\beta^2-\beta\theta)p_t=\theta p_{t-2}+\beta\theta p_t^{t-1}+\beta^2\theta p_{t+2}^t+(1-\theta)e_{t-1}$$
$$+\beta(1-\theta)e_t^{t-1}+\beta(1-\theta)e_{t+1}^t+\beta^2(1-\theta)e_{t+2}^t+\alpha l_t$$
$$+\alpha\beta l_{t+1}^t+(1+\beta)^2c. \tag{31}$$

Let us now consider the policy of a managed exchange rate at a constant rate of depreciation δ. In every odd period t the exchange rate rises according to

$$e_t=e_{t-2}+\delta. \tag{32}$$

We first consider the long-run implications of such a policy. In the long-run employment l is fixed, as is the rate of inflation. Thus (31) implies that in the long-run the rate of inflation must be equal to the rate of devaluation δ, and that the following relationship holds:

$$l=\frac{(1-\beta)\delta-(1+\beta)c-(1+\beta)(1-\theta)(e-p)}{\alpha}. \tag{33}$$

Notice that eq. (33) is similar to eq. (22) (in the case of a closed economy), except for the adverse effect of the real exchange rate, $e-p$. Since a higher real exchange rate raises cost of living and lowers real wage, it reduces labor supply. According to eq. (33), the government has two degrees of freedom in its choice of long-run targets among the rate of inflation δ, the real exchange rate $e-p$ and employment l. This is somewhat misleading, since there is only one unique long-run real exchange rate which equilibrates long-run balance of payments and prevents a 'run' on foreign reserves. This leaves the government with only one degree of freedom, to choose between l and δ. Therefore, for the rest of the section let us assume that the government keeps a constant rate of devaluation δ, and also conducts an accommodating monetary policy which is aimed at stabilizing employment at l. The choice of l and δ is such that the long-run real exchange rate equilibrates the balance of payments.

Under such a policy rule we can show that the rational expectations solution to (31) is given by

$$p_t-e_t=x_2+z_2(p_{t-2}-e_{t-2}), \tag{34}$$

where z_2 is the lower solution to

$$\beta^2\theta z_2^2-(1+2\beta+\beta^2-2\beta\theta)z_2+\theta=0, \tag{35}$$

and where $x_2=(1-z_2)[\alpha l+(1+\beta)c-(1-\beta)\delta](1+\beta)^{-1}(1-\theta)^{-1}$. It can be shown that $0<z_2<1$. From eq. (34) we get

$$\Pi_t=z_2\cdot\Pi_{t-2}+(1-z_2)\delta. \tag{36}$$

Hence the rate of inflation converges monotonically to the long-run rate of devaluation, δ. Notice that z_2 depends positively on θ and hence the more open the economy, the lower both θ and inflationary inertia are under a managed exchange rate.

Consider now the case of a one-time devaluation, where the exchange rate is devalued by more than the constant rate δ. The exchange rate rises at T, an odd period, to: $e_T=e_{T-2}+\delta+\varepsilon$, where $\varepsilon>0$. The public knows that in later periods the rate of devaluation is back to δ. Assume that before the devaluation the economy is in a steady state and the rate of inflation is δ. From the rational expectations solution to (31) we get

$$p_T-e_T=p_{T-2}-e_{T-2}-\frac{1+\beta}{1+2\beta+\beta^2-\beta\theta-\beta^2\theta z_2}\varepsilon, \tag{37}$$

and from period $T+2$ on p_t-e_t gradually returns to its former level, according to (34). From (37) we get

$$\Pi_T=p_T-p_{T-2}=\delta+\frac{\beta(1-\theta)+\beta^2(1-\theta z_2)}{1+2\beta+\beta^2-\beta\theta-\beta^2\theta z_2}\varepsilon>\delta, \tag{38}$$

namely that inflation rises in period T. But the rate of inflation is higher in period $T+1$ too

$$\Pi_{T+1}=\delta+\frac{(1-z_2)(1+\beta)}{1+2\beta+\beta^2-\beta\theta+\beta^2\theta z_2}\varepsilon, \tag{39}$$

and hence in later periods as well, according to (36). Thus a one-time devaluation has an inertial effect on the rate of inflation. Even if it does not change the long-run rate of inflation, it raises inflation for more than one period. This result is of course similar to what is shown in section 5. A devaluation is a permanent change in costs and therefore has an inertial effect on inflation. Indeed, this permanent change is nominal and not real, and thus it does not affect the long-run rate of inflation, though it is inertial nonetheless.

Notice that a one-time devaluation raises the real exchange rate at T and in later periods, as is shown by eq. (37), though not in the long run. If the government wishes to raise $e-p$ in the long run as well, it would have to keep a higher rate of devaluation. Consequently only a policy that aims at permanently raising the real exchange rate would push inflation to a higher long-run rate.

Finally, notice that the wage–price spiral model in the open economy can shed some light on the issue of 'Southern-Cone Disinflation'.[12] If the government disinflates by reducing the rate of currency depreciation, the real exchange rate falls both in the long and in the short run. This creates a worsening of the current account deficit. Furthermore, the rate of inflation does not immediately adjust to the new lower rate of depreciation, but remains higher for a while. Hence disinflation is gradual and for a time prices rise by more than the exchange rate.

7. Summary and conclusions

In this paper a wage–price spiral model, where price and wage adjustments are asynchronized, is used to examine inertia in an inflationary process. In the analysis conducted in the paper two main criteria are applied: the speed of adjustment of inflation to demand changes, and the sensitivity of the rate of inflation to cost shocks.

It is shown that in the wage–price spiral model a demand reduction lowers the rate of inflation gradually. This is the case whether the government disinflates by fixing the amount of money or by fixing the exchange rate.

The conclusion is less clear for the inertial effect of cost changes. Transitory shocks have no inertial effect on the rate of inflation even if monetary policy is fully accommodative. Permanent cost changes, on the contrary, have a strong inertial effect on the rate of inflation even if the long-run rate does not change under a strict monetary rule.

This paper touches on only some aspects of inflationary inertia in a wage–price spiral model. There are many more issues which can be discussed within this framework. I will mention just one. It would be interesting to examine the degree of inertia in an open economy under managed exchange rates versus floating rates. This issue could also be empirically examined and it certainly has important policy implications.

[12]See discussion by van Wijnbergen (1986), who cites other works.

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