# DISCUSSION PAPER SERIES

No. 3612


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*INTERNATIONAL MACROECONOMICS and LABOUR ECONOMICS*


Centre for Economic Policy Research

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Available online at: www.cepr.org/pubs/dps/DP3612.asp

*ISSN 0265-8003*

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Discussion Paper No. 3612
October 2002

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CEPR Discussion Paper No. 3612

October 2002

# ABSTRACT

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Nominal price and wage rigidity renders monetary policy effective over output. However, this effectiveness extends, under widely used overlapping-wage and Calvo-contract Phillips Curves, to planned monetary policy ('exploitability') and not merely to policy surprises. We argue that within both frameworks, when agents write optimal nominal contracts, they will not be exploitable by planned monetary policy. We therefore suggest non-exploitability as a specification test for Phillips Curves.

JEL Classification: E24, E32 and J41
Keywords: Calvo contract, overlapping wages and Phillips Curve

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Submitted 18 September 2002

# Exploitability as a specification test of the Phillips Curve

Patrick Minford and David Peel (Cardiff University)

**Abstract**

*Nominal price and wage rigidity renders monetary policy effective over output. However, this effectiveness extends, under widely used overlapping-wage and Calvo-contract Phillips Curves, to planned monetary policy ('exploitability') and not merely to policy surprises. We argue that within both frameworks, when agents write optimal nominal contracts, they will not be exploitable by planned monetary policy. We therefore suggest non-exploitability as a specification test for Phillips Curves.*

The major transmission channel for monetary policy to output is nominal rigidity, and the usual ways in which this is modelled are overlapping wage/price contracts (following Phelps and Taylor, 1977; Fischer, 1977; and Taylor, 1979) and Calvo's (1983) suggested model of stochastic wage/price setting: these give rise to Phillips Curves. In this paper we suggest as a specification test that the resulting Phillips Curve should not be 'exploitable' (or equivalently 'should have the natural rate property') by which we mean that the monetary authorities should not be able to influence output in a period ahead after which all nominal contracts will have been renegotiated. For example, take the following simple one-period 'surprise' Phillips Curve often used to analyse optimal monetary policy:

$$y_t = y_t^* + \alpha(\pi_t - E_{t-1}\pi_t) + u_t \tag{1}$$

This can be interpreted conveniently as embodying a 'period' (e.g. a year) long enough to cover the length of wage/price contracts, in which all contracts are signed for next period just before the end of the previous period. Plainly this is not exploitable at $t-1$ since

$$E_{t-1}y_t = y_t^* \tag{2}$$

Thus $E_{t-1}\pi_t$ has no effect on output.

Compare with this the standard Calvo model

$$\pi_t = \alpha E_t \pi_{t+1} + \gamma(y_t - y_t^*) + u_t \tag{3}$$

where $0 \prec \alpha$ (not otherwise restricted, greater or less than unity). This is exploitable since

$$E_{t-1}y_t = E_{t-1}y_t^* + \frac{1}{\gamma}(E_{t-1}\pi_t - \alpha E_{t-1}\pi_{t+1}) \tag{4}$$

Or take a Taylor Phillips Curve:

$$\pi_t = \alpha E_t \pi_{t+1} + \beta \pi_{t-1} + \gamma(y_t - y_t^*) + u_t \tag{5}$$

Again this is exploitable since

$$E_{t-1} y_t = E_{t-1} y_t^* + \frac{1}{\gamma}(E_{t-1}\pi_t - \alpha E_{t-1}\pi_{t+1} - \beta \pi_{t-1}) \tag{6}$$

Exploitability clearly creates opportunities for monetary policy that would normally not be considered desirable to utilise. If we assumed that the monetary authorities could not control inflation to an exact path, then it would open wage/price contractors to expected movements in inflation also emerging from events outside the authorities' control. However our argument is that rational optimisers would not allow these opportunities to exist. We begin by considering this point in the simplest set-up: where agents sign a one-period contract of the sort assumed in equation (1). The optimal contract would take the form:

$$W_t = E_{t-1} w_t^* + E_{t-1} p_t \tag{7}$$

where $w_t^*$ is the real wage equilibrium conditional on the $t-1$ state. Combining this with the production function and the marginal productivity condition yields (1). Thus any $t-1$ planned movement in price is impounded into the wage contract: a rational contract impounds this nominal information in order that the real wage objective is not expected to be frustrated. (By hypothesis $E_{t-1} w_t^*$ is the optimised real wage as seen from $t-1$; thus if a contractor expected it to be frustrated by movements in prices, he would alter the nominal wage contract to ensure that it was not.)

**The Taylor overlapping wage contract**

Now consider a simple Taylor 2-period overlapping wage contract. Suppose there are two equal-sized groups, signing in alternate periods and constrained to have a constant wage throughout the contract period. Then:

$$W_t = 0.5(\widetilde{W}_{t-1} + \widetilde{W}_{t-2}) \tag{8}$$

$$\widetilde{W}_{t-1} = 0.5 E_{t-1}(w_t^* + w_{t+1}^*) + 0.5 E_{t-1}(p_t + p_{t+1}) \tag{9}$$

$$\widetilde{W}_{t-2} = 0.5 E_{t-2}(w_t^* + w_{t-1}^*) + 0.5 E_{t-2}(p_t + p_{t-1}) \tag{10}$$

so that:

$$W_t = 0.25[(E_{t-1} + E_{t-2}) w_t^* + E_{t-2} w_{t-1}^* + E_{t-1} w_{t+1}^*] + 0.25[(E_{t-1} + E_{t-2}) p_t + E_{t-2} p_{t-1} + E_{t-1} p_{t+1}] \tag{11}$$

Embedding this into the production function and the marginal productivity of labour condition yields the following Phillips Curve:

$$y_t = y_t^* + \alpha\{w_t^* - 0.25[(E_{t-1} + E_{t-2}) w_t^* + E_{t-2} w_{t-1}^* + E_{t-1} w_{t+1}^*]\} + \alpha\{p_t - 0.25[(E_{t-1} + E_{t-2}) p_t + E_{t-2} p_{t-1} + E_{t-1} p_{t+1}]\} + u_t \tag{12}$$

(With suitable manipulation this can be turned into a Taylor equation similar to (5); a variety of such forms can be found in e.g. Coenen and Wieland, 2000) Here we note that derived in this way there is exploitability at $t-2$ because though the wage bargainers at $t-2$ impound into the contract all state $t-2$ information (as do, a fortiori, bargainers at $t-1$), their real wage can be altered from its optimal planned value by the expected pattern of real and nominal variables (including planned monetary policy). Thus:

$$E_{t-2}y_t = E_{t-2}y_t^* + \alpha\{0.5E_{t-2}w_t^* - 0.25E_{t-2}w_{t-1}^* - 0.25E_{t-2}w_{t+1}^*\} + \alpha\{0.5E_{t-2}p_t - 0.25E_{t-2}p_{t-1} - 0.25E_{t-2}p_{t+1}\} \quad (13)$$

What we notice is that the exploitability arises from the assumed constraint that the wage contracted must be constant throughout the contract period. If the wage bargainers are permitted to contract for a time-varying wage we have:

$$\widetilde{W}_{t-1} = E_{t-1}w_t^* + E_{t-1}p_t \quad (14)$$

$$\widetilde{W}_{t-2} = E_{t-2}w_t^* + E_{t-2}p_t \quad (15)$$

so that the Phillips Curve to emerge is:

$$y_t = y_t^* + \alpha\{w_t^* - 0.5(E_{t-1} + E_{t-2})w_t^*\} + \alpha\{p_t - 0.5(E_{t-1} + E_{t-2})p_t\} + u_t \quad (16)$$

which is non-exploitable, since

$$E_{t-2}y_t = E_{t-2}y_t^* \quad (17)$$

What we notice is that wage bargainers will incorporate the available information efficiently into their nominal contract provided they are able to make it time-varying; this property appears to be costless (the stroke of a pen defining a different number for different periods of the contract). If this is not implemented, they become vulnerable to disequilibrium produced by the expected exogenous processes.

**The Calvo contract**

We turn next to the Calvo contract. We can first derive the standard equation based on participants' assumption that the general price level is not changing. Price-setters (or wage-setters, analysed analogously) operate under imperfect competition where if prices were flexible they would be continuously set as a mark-up on marginal cost. They are assumed to face a menu cost of changing their price: this takes the form of a lump sum cost which acts as a threshold. If some unexpected shock to costs exceeds this threshold, they will change their price and set it to the newly expected marginal cost. It is assumed that there is a constant probability, $1-\xi$, of such a shock for each (identical) price-setter. The expected losses at $t=0$ of the $h$th price-setter can be written:

$$\sum_{t=0}^{\infty} E_0\beta^t[p_t^h - (1+m)c_t^h]^2 \quad (18)$$

where $m$ is the mark-up and $c$ is the marginal cost.

The first order condition with respect to the decision to set his price at $\widetilde{p}_0^h$ then implies:

$$\widetilde{p}_0^h = (1+m)(1-\beta\xi)\sum_{t=0}^{\infty}(\beta\xi)^t E_0 c_t^h \tag{19}$$

In other words the reset price is equal to a weighted average of all future expected marginal costs plus the mark-up for states of the world where the 0-period price remains unchanged. In general at time $t$ the $h$th's agent's decision is therefore:

$$\widetilde{p}_t^h = (1+m)(1-\beta\xi)\sum_{i=0}^{\infty}(\beta\xi)^i E_t c_{t+i}^h \tag{20}$$

Across the population $1-\xi$ will on average reset their prices in exactly the same way, and $\xi$ will retain last period's price, hence $\widetilde{p}_t^h = \widetilde{p}_t$, $E_t c_{t+i}^h = E_t c_{t+i}$ and

$$p_t - p_{t-1} = (1-\xi)(\widetilde{p}_t - p_{t-1}) \tag{21}$$

Now let $(1-m)E_t c_{t+i} = \delta E_t(y_{t+i} - y_{t+i}^*)$, that is marginal costs are a rising function of output (and approximately linear in the region of $y^*$, the natural rate of output). Then we can rewrite (20) as:

$$\pi_t = p_t - p_{t-1} = \frac{(1-\xi)(1-\beta\xi)\delta(y_t - y_t^*)}{1-\beta\xi B^{-1}} - (1-\xi)p_{t-1} \tag{22}$$

where $B^{-1}$ is the forward operator, leading the variable but not the date of expectation. Hence, multiplying through by the expression in the forward operator and collecting terms, we obtain

$$\pi_t = \frac{\beta\xi}{1-\beta\xi(1-\beta\xi)}E_t\pi_{t+1} + \frac{\delta(1-\xi)(1-\beta\xi)}{1-\beta\xi(1-\beta\xi)}(y_t - y_t^*) - \frac{(1-\beta\xi)(1-\xi)}{1-\beta\xi(1-\beta\xi)}p_{t-1} \tag{23}$$

This is the Calvo forward-looking Phillips Curve in which effectively the whole path of future output (marginal costs) affects current price rises. For small $\xi$ we can neglect the term in $p_{t-1}$ and the term in $\pi_{t+1}$ will be less than one (e.g. for $\xi = 0.25$ they are respectively 0.08 and 0.93). What this implies is that prices are rising because some (relative) prices are rising — which given that there is no general expected inflation implies that they also rise by this much in nominal terms —and the other prices are held fixed in nominal terms (because the menu cost is greater than the cost of them staying out of equilibrium). Thus the basic Calvo equation is conditioned on the assumption that the expected general inflation rate is zero. To extend the Calvo model it is assumed (e.g. Henderson et al, 2000; Gali and Monacelli, 2002; Christiano et al, 2002) that it is costless for all agents to uprate prices or wages by the generally expected (or 'core') rate of inflation — this being like a 'relabelling' or 'indexing' of all prices on the 'menu'. Call this core rate of inflation $\widetilde{\pi}_t$. Then the equation should be rewritten:

$$\pi_t - \widetilde{\pi}_t = \mu(E_t\pi_{t+1} - E_t\widetilde{\pi}_{t+1}) + \lambda(y_t - y_t^*) + u_t \tag{24}$$

Following different practices of different authors, we could emerge with three forms of Phillips Curve:

(a) $\widetilde{\pi}_t = \overline{\pi}_t$, core inflation:

$$\pi_t = \mu E_t \pi_{t+1} + (1-\mu)\overline{\pi}_t + \lambda(y_t - y_t^*) + u_t \tag{25}$$

(b) $\widetilde{\pi}_t = \pi_{t-1}$, lagged inflation:

$$\pi_t = \frac{\mu}{1+\mu} E_t \pi_{t+1} + \frac{1}{1+\mu}\pi_{t-1} + \frac{\lambda}{1+\mu}(y_t - y_t^*) + \frac{1}{1+\mu} u_t \tag{26}$$

(c) $\widetilde{\pi}_t = E_{t-1}\pi_t$, rational expectations using available (lagged) information:

$$\pi_t = E_{t-1}\pi_t + \lambda(y_t - y_t^*) + u_t \tag{27}$$

Of these both (a) and (b) are exploitable; in effect the updating rule makes agents vulnerable to expected nominal processes. Thus under (a)

$$E_{t-1}y_t = E_{t-1}y_t^* + \frac{1}{\lambda}E_{t-1}\pi_t - \frac{\mu}{\lambda}E_{t-1}\pi_{t+1} - \frac{1-\mu}{\lambda}\overline{\pi}_t \tag{28}$$

while under (b)

$$E_{t-1}y_t = E_{t-1}y_t^* + \frac{1+\mu}{\lambda}E_{t-1}\pi_t - \frac{\mu}{\lambda}E_{t-1}\pi_{t+1} - \frac{1}{\lambda}\overline{\pi}_{t-1} \tag{29}$$

However, it is clear that, if necessarily there is a lag in the 'indexation' process, the rational index formula is the expectational one under (c), since this implies that all agents will optimise their expected relative price response with respect to micro shocks. Of course (c) returns us to the surprise supply curve of (1). It would seem that once rational indexing is allowed for the Calvo contract implies only one-period rigidity, i.e. the length of time it takes for information to be incorporated in the index. This is analogous to the information lag in the 'New Classical' Phillips Curve of Lucas and Rapping (1979), Sargent and Wallace (1985).

**Conclusions**

What we have found is, rather similarly to the arguments of Phelps (1970) and Friedman (1968) when they 'augmented' the Phillips Curve, that if we allow rational agents to set contracts to optimise their welfare, this then causes the Phillips Curve to be non-exploitable, in the sense that expected exogenous processes including monetary policy cannot cause the expected real wage to diverge from the planned optimal or equilibrium real wage. This applies whether one uses the overlapping-contracts approach initiated by Taylor and Fischer or that initiated by Calvo. In both cases contracting agents should optimally allow for the time-pattern of the exogenous processes they face. Phillips Curves that have assumed otherwise have implicitly placed arbitrary constraints on agents' contracting; yet there seems to be no micro-basis for imposing constraints on agents that prevent them from using the available information efficiently, so that their plans are invulnerable to known movements in the relevant exogenous variables.

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