Pricing Behaviour and the Cost-Push Channel of Monetary Policy

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Abstract

This paper examines the empirical and theoretical status of the cost-push channel of monetary policy, according to which interest rates affect the costs of production and hence pricing behaviour. Particular attention is paid to modelling the cost-push channel in a manner consistent with cost-plus pricing theory, which is identified as the canonical model of pricing behaviour in heterodox economics. It is shown that different variants of cost-plus pricing behaviour give rise to qualitatively different specifications of the cost-push channel, with important consequences for macrodynamics and the conduct of monetary policy.

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1. Introduction

The "cost-push channel" of monetary policy – according to which the interest rate affects firms' costs of production and hence their pricing decisions – has, of late, received considerable attention in macroeconomics.[1] This should come as no surprise, given the contemporary predilection of central bankers to administer interest rates in the pursuit of "price stability". Hence if higher interest rates *raise* inflation via the cost-push channel, the possibility exists that tight money policies aimed at lowering inflation will be self-defeating.

A growing empirical literature identifies a positive relationship between interest rates and the rate of inflation, consistent with the cost-push channel. Much of this empirical literature derives from the mainstream New Keynesian Phillips curve, in which imperfectly competitive firms set (sticky) prices as a mark up over marginal costs, and expected future marginal costs affect price dynamics. The cost-push channel of monetary policy then arises from the impact of the interest rate on marginal costs. But discussion of a cost-push channel of monetary policy long pre-dates contemporary mainstream interest in the subject, going back to the work of Tooke (1838) and the Banking School. Moreover, there exists a long-standing interest in the cost-push channel in heterodox macroeconomics – including (but not limited to) the Sraffian and Kaleckian traditions – where the theory of endogenous money has long characterized central banks as administering interest rates, and where there has developed a corresponding concern with the macroeconomic consequences of central bank interest rate manipulations.

[1] As will become clear below, the cost-push channel of monetary policy is also variously referred to as Gibson's paradox (following Keynes, 1930), the Cavallo-Patman effect (following Taylor, 1991) and the "price puzzle" (following Eichenbaum, 1992).

The ambition of this paper is to examine existing discussion of the cost-push channel of monetary policy, and to explore different ways of modelling the cost-push channel that are consistent with the principle of cost-plus pricing by firms. We appeal to cost-plus pricing as the canonical model of pricing behaviour in heterodox economics (see, for example, Lavoie, 1992, and Lee, 1998). Ultimately, we show that variants of cost-plus pricing theory, that differ in the ways in which they describe interest rates as affecting prices, give rise to different specifications of the cost-push channel. This heterogeneity – which is largely absent from the mainstream literature – suggests that the cost-push channel may be richer and more complicated than it appears in mainstream macroeconomics, a finding that has important implications for both macrodynamic analysis and the conduct of monetary policy.

The remainder of the paper is organized as follows. In section 2, we briefly review the history of the cost-push channel in macroeconomic analysis, and its current empirical standing. Section 3 focuses on modelling the cost-push channel in the context of cost-plus pricing behaviour on the part of firms. Finally, section 4 offers some conclusions.

2. A Brief History of the Cost Push Channel in Macroeconomics

Since the turn of the millennium, a growing empirical literature has drawn increasing attention to the cost-push channel of monetary policy. In an early investigation based on two and three-digit industry data for the US (and on the assumption of markup pricing), Seelig (1974) claimed that the impact of interest rate changes on prices was fairly negligible during the 1950s and 19960s. However, using US data for 1960—96, Barth and Ramey (2001) show that prices and real activity are significantly affected by changes in the cost of working capital. Given that higher nominal interest rates directly raise firms' costs of working capital, the inflation response to an interest rate shock is mitigated (and the output response amplified) by the cost-channel of monetary transmission. Ultimately, Barth and Ramey (2001) conclude that the supply-side, cost-channel effect on inflation dominates the standard demand-side effect, using both industry level and aggregate data for the United States. More recent work by Christiano, Eichenbaum and Evans (2005) reaches the same conclusion using aggregate data – although a sub-sample investigation conducted by Hanson (2004), using US data for the 1959-1998 period, suggests that evidence of a price puzzle is associated primarily with the 1959-1979 sample period.

Elsewhere Dedola and Lippi (2005), using disaggregated industry data from five industrialized countries, provide evidence of the importance of working capital for the transmission of interest rate shocks in France, Germany, Italy, and the UK. Their results show that sectoral output responses to monetary policy shocks are systematically related to industrial characteristics such as output durability, financing requirements, borrowing capacity and firm size. Similarly, Peersman and Smets (2005) estimate the effects of monetary policy on 11 industries in seven Euro area countries, finding considerable cross-industry heterogeneity in interest policy sensitivity that is statistically related to differences in output durability, financial structure and firm size. In both of these studies, temporary increases in the price level in response to unanticipated rises in nominal interest rates are found.

Gaiotti and Secchi (2006), meanwhile, employ a panel covering some 2,000 Italian manufacturing firms, with 14 years of data on individual prices and individual interest rates paid on several types of debt. They test for the existence of a monetary policy transmission channel operating through the effect of interest expenses on the marginal cost of production. The authors find robust evidence for the presence of this channel, and for it being proportional to the amount of working capital held by each firm.

Chowdhury, Hoffmann and Schabert (2006), using G7 data for the 1980-1997 period, find that changes in short-run nominal interest rates significantly affect short-run inflation rates in Canada, France, Italy, the UK and the US – i.e., throughout the G-7, with the exception of Germany and Japan. In the same vein, Ravenna and Walsh (2006), using data for the US for the 1960-2001 period, estimate a new Phillips curve which explicitly incorporates a cost channel of monetary policy. They find a large elasticity of inflation with respect to the nominal interest rate.

However, results obtained by Rabanal (2007), using a likelihood-based estimated structural model for the US for 1959-2004, support the view that inflation and interest rates move in *opposite* directions after a monetary policy shock. This contradicts the view that the supply-side, cost-push channel effect of monetary policy dominates the more traditional demand-side effect. Indeed, estimates of the model's parameters assuming that only a fraction of firms need to borrow money to pay their wage bill point to a low elasticity of inflation with respect to changes in the nominal interest rate, with a posterior mean of just 0.15. Hence the posterior probability of observing an increase in inflation following a tightening of monetary policy is zero. Even when the model is estimated assuming that *all* firms borrow to pay their wage bill, no positive response of inflation to a monetary policy contraction is observed.

Meanwhile, Castelnuovo and Surico (2006) re-examine the empirical evidence on the price puzzle and propose a new theoretical interpretation. In their view, the positive response of prices to a monetary policy shock is historically limited to subsamples associated with a *weak* central bank response to inflation (and thus inflation expectations that were not well anchored). These are the years prior to the appointment of Paul Volcker as Fed Chairman in August 1979 for the US, and the period prior to the introduction of the inflation-targeting framework in October 1992 for the UK. Using a micro-founded New Keynesian monetary policy model for the US economy, they show that their structural VARs are capable of reproducing the price puzzle from artificial data *only* when monetary policy is *passive* and hence multiple equilibria arise. In contrast, their model never generates a positive inflation response to a policy shock, even when the nominal interest rate responds less than fully to inflation. They claim that the omission from VARs of a variable capturing the high persistence of *expected inflation* under indeterminacy accounts for the price puzzle observed in actual data.[2] Clearly, then, not all empirical studies point unambiguously to the existence of a cost-push channel of monetary policy – or at least to the *dominance* by this channel of the traditional (inverse) demand-side relationship between interest rates and inflation.

[2] As they explain: "The presence of a price puzzle is important because it casts serious doubts on the possibility of correctly identifying a monetary policy shock. If the central bank monitors and responds to a larger information set than that of the econometrician, what may be referred to as a policy shock by the latter is actually a combination of a genuine policy shock and some endogenous policy reactions. The result of this omission is that a policy tightening in anticipation of future inflation could be wrongly interpreted by the econometrician as a policy shock, delivering spurious correlation between a tightening of policy and a rise in inflation: the price puzzle"(p. 4). In fact, this is essentially Sims' (1992) argument. Sims was the first to draw attention to the anomaly labelled "the price puzzle". He also claimed that the inclusion of a commodity price index in a VAR seems to capture enough additional information about future inflation as to possibly solve this puzzle.

As noted in the introduction, much of the empirical literature surveyed above derives impetus from the notion of a New Keynesian Phillips curve, in which interest rates affect current and expected future marginal costs and hence inflation.[3] In Chowdhury, Hoffmann and Schabert (2006), for example, firms are assumed to face a liquidity constraint in factor markets by virtue of the fact that they need to pay for inputs before the goods market opens. Firms therefore borrow to raise working capital to buy inputs, as a result of which the interest rate on borrowed funds affects the marginal cost of production.[4] Current and expected future marginal costs, in turn, affect pricing decisions and hence the rate of inflation. While this approach focuses on the costs of external funds, the logic of interest rate effects on firms' costs also applies when firms are primarily financed by internal funds, as stressed by Barth and Ramey (2001). Thus, direct cost effects of interest rates are not particular to economies with a high ratio of external to internal funds, as the opportunity costs of working capital increase with the interest rate regardless of whether funds are internally or externally generated. The upshot of all this,

[3] The cost-push channel of monetary policy also serves as the main building block in limited participation models of money (e.g. Christiano, Eichenbaum and Evans, 1997), which are the most prominent mainstream alternatives to sticky price, rational expectations versions of the IS-LM model, and in the literature on agency cost effects in monetary transmission (e.g. Cooley & Nam, 1998). In the canonical limited participation model, the friction which generates monetary non-neutrality is not stickiness in price setting, but a credit market friction implying that firms need to borrow cash in advance from financial intermediaries to finance the wage bill.

[4] Linnemann (2005) offers a different explanation for the supply-side effect of monetary policy. Under a balanced government budget, a higher nominal interest rate leading to a higher real interest rate commands a higher tax rate since it implies higher interest payments on the existing stock of debt and because reduced demand diminishes the tax base. Thus, by discouraging current labor supply for intertemporal substitution reasons, there is an upward pressure on wages and hence prices. Note that a heterodox variant of this mechanism could be derived by combining Linnemann's (2005) balanced budget assumptions with Mott and Slattery's (1994) discussion of tax shifting. In this case, monetary-policy-induced tax increases would directly impact prices via firms price setting behaviour.

then, is that the short-run nominal interest rate is hypothesized to have a positive effect on the rate of inflation in the New Keynesian Phillips curve.[5]

But discussion of the cost-push channel of monetary policy long pre-dates the development of the new Keynesian Phillips curve. The earliest advocate of a long-run causal relationship running from the interest rate to the price level was Thomas Tooke (1838), a founding member of the Banking School.[6] Marx mentions in passing that fluctuations in the interest rate enter into the determination of cost-prices (1967, p. 551), while Keynes (1930) labeled the positive correlation between the interest rate and the price level the "Gibson paradox", after the work of A. H. Gibson in the early 1920's. Gibson showed that a positive correlation existed between interest rates and prices in the UK over a period of two hundred years (see, for example, Gibson, 1923).[7] According to Keynes, Gibson's paradox is "one of the most completely established empirical facts within the whole field of quantitative economics, though theoretical economists have mostly ignored it" (1930, p. 178). Keynes believed that that correlation could not be attributed either to the tendency of prices and interest rates to rise (fall) together on the

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[5] It should be noted that the presence of the cost-push channel of monetary transmission in New Keynesian models of optimal monetary policy has serious implications for equilibrium determinacy, uniqueness and stability. For instance, Brückner and Schabert (2003) introduce working capital into an otherwise conventional New Keynesian model and show that active interest rate policy remains necessary but should be moderate to ensure real determinacy. The nominal interest rate enters the aggregate supply curve as it raises the marginal costs of firms, implying that the reactiveness of the interest rate rule now has both a lower bound (the Taylor principle, which requires that the nominal interest rate is raised by more than one for one in response to changes in the inflation rate, so as to avoid self-fulfilling inflation expectations) and an upper bound (which varies negatively with the elasticity of labor supply) to ensure equilibrium uniqueness.

[6] As summarized by Smith (2001, p. 47): "In conjunction, Tooke's Banking School theory proposed that in the long run causality ran from the rate of interest to the price level, and then to the quantity of money in circulation, given the technique of production, level of aggregate output and institutional setting of the financial system (i.e., normal income-velocity). In the short run, Tooke proposed that causality ran from fluctuations in nominal income – according to changes in market prices and economic activity – to the quantity of money in circulation associated with variations in the velocity of circulation of banknotes and coin".

[7] Kitchin (1923) and Peake (1928) also report evidence of a positive correlation between short-term interest rates and prices, though only the latter is mentioned by Keynes.

upward (downward) phase of the credit cycle (since Gibson's correlation is not a strictly short-period phenomenon), or to Irving Fisher's theorem as to the relation between the rate of interest and the appreciation (or depreciation) in the value of money. Instead, Keynes put forward a tentative explanation based on the stickiness of the market rate of interest with respect to the natural rate which is in the spirit of his *Treatise on Money*.[8]

More recently, the cost-push channel of monetary policy has been referred to as the "Wright Patman effect", after US Congressman Wright Patman's oft-quoted remark regarding "the senselessness of trying to fight inflation by raising interest rates, ... throwing gasoline on a fire to put out the flames would be as logical" (U.S. Congress, 1970, p. 55-56). As recalled by Taylor (2004, p. 90), the current Latin American label for the cost-push channel is the "Cavallo effect", named after the Argentine minister of the economy during the 1990s who found empirical support for the phenomenon in his Harvard Ph.D. thesis (Cavallo, 1977). The existence of a positive correlation between increases in the short-term interest rate and the price level has also been labeled the "price puzzle" by Eichenbaum (1992), in his comments on the paper by Sims (1992) – mentioned in footnote 2 above – in which this correlation is identified.

The notion of a cost-push channel of monetary policy also has an established history in heterodox macroeconomics. For example, discussion of the relationship between the interest rate, costs of production and prices can be found in the neo-

[8] "That is to say, when the natural rate of interest is falling (or rising), the banking world does not quickly detect this or respond to it, so that there is a tendency for the market rate to lag behind and to fall (or rise) less than it should if it is to maintain contact with the natural rate. In other words, when savings are abundant or deficient in relation to the demand for them for investment at the pre-existing level of interest, the rate does not adjust itself to the new situation quick enough to maintain equilibrium between savings and investment" (1930, p. 182). As it goes well beyond the scope of this paper to discuss either Keynes' or Fisher's explanations of the Gibson paradox, we would redirect the reader to, for instance, Shiller and Siegel (1977), where the whole controversy surrounding Gibson's work (including Wicksell's and other later contributions to the debate) is empirically evaluated.

Ricardian tradition following Sraffa (1960). While the classical economists and Marx considered the real wage as an independent variable and the rate of profit a residual determined on the basis of the dominant techniques, Sraffa suggested that the rate of profit is susceptible to being determined outside the system of production, in particular by the level of the money rate of interest.

Both Panico's (1988) and Pivetti's (1990, 1991) writings on money and distribution fall within the Sraffian recovery of the classical surplus approach to distribution. Following Sraffa, Panico puts forward a monetary theory of the rate of profits intended to describe how monetary factors and policies are likely to affect inflationary processes and the distribution of income amongst bankers, industrial capitalists and workers. Panico's model features a Sraffian price system explicitly containing a credit sector, and with the own rates of money interest on financial and real assets being equalized in a manner similar to that described by Keynes in Chapter 17 of the *General Theory* (1936). As it turns out, changes in the rate of interest on loans can affect distribution and prices in two ways. First, interest payments on short-term loans to firms are directly introduced into the cost of production of commodities. Hence a rise in the interest rate, by increasing the cost of production, leads to an immediate transfer of profits from industrialists to bankers. Industrial producers may then try (if circumstances allow) to pass their higher costs on in the form of higher prices. In this case, workers will then suffer a loss in their purchasing power. In the presence of real wage resistance, however, this may generate a demand for higher money wages and a subsequent wage-price inflation process (p. 98). Second, if a rise in the rate of interest on loans is considered permanent, an increase both in the price level and the general rate of profits can come about, as the illiquidity discounts on financial assets and hence the whole structure of interest rates are increased. As a consequence, workers will again suffer a loss in their purchasing power, unless they are able to resist it by demanding higher money wages. Once again, an inflationary process may set in.

Pivetti's work is also intended to take steps in the direction suggested by Sraffa for explaining income distribution in terms of monetary factors. Basically, Pivetti's argument is that the rate of interest is a monetary phenomenon which regulates normal distribution by regulating the ratio of prices to money wages.[9] The argument runs as follows. The rate of interest can be considered the regulator of the ratio of prices to money wages when it is recognized that the rate of interest is an autonomous determinant of normal production cost. The normal rate of profit in each particular sphere of production is arrived at by a process of adding up two autonomous components: the long-term interest rate and the normal profit of the enterprise. Competition is seen as the mechanism through which prices tend to be equated with normal costs. Hence, lasting changes in normal costs will result in corresponding changes in the price level. Finally, by virtue of competition, a lasting change in interest rates causes a change in the same direction in the level of prices in relation to the level of money wages, thereby generating changes in income distribution (1991, p. 22). That is to say, a prolonged fall (rise) in interest rates causes a fall (rise) in prices relative to the wage level, and thereby brings about a lower (higher) rate of profit and a higher (lower) real wage. Hence, the effects of

[9] Pivetti's notion of normal distribution does not refer to actual or effective profits, but to normal profits: "The latter, reckoned gross of interest, correspond to the rate of return on capital which would be obtained by firms using dominant or generally accessible techniques, and producing output at levels regarded as normal at the time the capacity was installed" (p. 20). As for the money rate of interest, Pivetti means the average rate, the mean of the loan and deposit interest rates prevailing within a given economy (1991, p. 21).

the wage bargain on distribution depend on its influence on monetary policy. Once the normal profit of the enterprise is regarded as independent of the behaviour of any other component of total unit cost, then wage bargaining, in order to have any persistent effect on income distribution, must ultimately exert some influence on the rate of interest. For Pivetti, there are no direct effects of wage bargaining on normal distribution, but only possible indirect effects through monetary policy (1991, p. 33).[10]

Another discussion of the relationship between the interest rate, costs of production and prices along Sraffian lines is found in Podkaminer (1998). While acknowledging that in some formulations (for example, Taylor, 1983; 1992) a rising interest rate may push up the price level, for Podkaminer, a sufficiently high but otherwise *constant* nominal interest rate is capable of generating steady inflation. In order to show this, he examines a dynamic process of cost-price adjustments when all working capital is financed by credit, in a model akin to the standard multi-good Sraffian framework. It is then shown that, even if nominal wages and markups are constant, any positive nominal interest rate has an inflationary effect. Depending on the characteristics of the input-output matrix, any positive nominal interest rate will make for an inflationary process, that either decays (if the nominal interest rate is low enough) or produces steady inflation (if the nominal interest is sufficiently high).

[10] Another implication of this view is that changes in interest rates will tend to be related to changes in aggregate demand, but through a very different route from that traditionally emphasized. For instance, demand for capital goods will *not* be directly affected by changes in the interest rate. Since normal returns are not independent of the interest rate, but rather tend to move parallel with it, a lasting reduction (increase) in the long-term rate will not raise (lower) the demand price of a capital good relative to its supply price. Hence no increase in investment can be expected as a result of a lasting reduction in interest rates (1991, p. 44-5). The propensities to consume and to invest are important determinants of output, but their influence on the latter in response to changes in the interest rate operates through changes in the normal distribution of income between profits and wages (1991, p. 45).

Discussion of the cost-push channel of monetary policy also has an identifiable lineage in Kaleckian macroeconomics. In the Kaleckian tradition, the seeds of the cost-push channel can be traced to Kalecki's (1971) claim that the degree of monopoly is likely to increase whenever overhead costs (which can be thought of as including the interest costs associated with debt servicing) rise. Alternatively, if firms borrow primarily working capital to finance the wage bill, the interest rate can be thought of as influencing the direct or prime costs of production to which the mark up is applied.[11] These insights have been incorporated into macroeconomic models by Taylor (1983, 2004) and Dutt (1990—91). The cost-push effect of interest rate changes is also mentioned by Galbraith (1957, pp. 130-132) in an early attempt at introducing considerations of market structure – differing degrees of competition among industries – into the analysis of how monetary and fiscal stabilization policies impact business firms. Indeed, Galbraith (1958) claims that oligopolistic firms are likely to be able to pass higher interest charges along to consumers, the argument being that if they can pass along wage increases, they can obviously do the same with interest costs (p. 177). Likewise, Kaldor (1982, p. 63) alludes to the cost- and price-reducing effect of a reduction in interest rates, on the basis that interest costs will be passed on in the form of higher prices in much the same way as

[11] There is an obvious parallel between this discussion of the impact of interest rates on firms' pricing procedures and Mott and Slattery's (1994) Kaleckian analysis of "tax shifting" (the process by which firms pass on taxes to consumers in the form of higher prices). Indeed, while the main motivation for this paper is the recent increase in interest in the cost-push channel of monetary policy, it can also be thought of as a counterpart to Mott and Slattery's work, in which the impact of monetary (rather than fiscal) policy on pricing procedures (and ultimately macroeconomic outcomes) is the focus of attention. There is also a parallel between the analysis of the cost-push channel of monetary policy pursued in this paper and Arestis and Milberg's (1994) analysis of exchange rate pass-through in a Kaleckian framework, where changes in the nominal exchange rate lead to changes in either unit prime costs or markups. In an open economy with capital mobility and flexible exchange rates, therefore, a rise in the domestic interest rate, by causing an appreciation in the nominal exchange rate, would have an indirect cost-reducing effect on domestic inflation, alongside the cost-push effect examined in this paper. The reason is that such an exchange rate appreciation would reduce unit prime costs associated with imported inputs (including any external borrowing) and/or markups.

wage costs. Recently, these views have been reiterated by Wray (2007). In his critique of the notion that raising interest rates will retard growth an hence inflation, Wray (2007, p.17) notes that "interest is also a cost, most importantly, an addition to working capital expenses. Much as rising energy costs are passed along in higher prices, interest costs are incorporated in sales prices. While higher costs and prices might negatively affect economic growth, no one has proposed policy to push up the price of oil – or other production costs, such as wages – as an inflation-fighting tactic".

3. Modelling the Cost-Push Channel of Monetary Policy

Having established the pedigree of the cost-push channel in contemporary empirical studies, the history of thought and both mainstream and heterodox macroeconomics, we now explore different substantive models of the cost-push channel that are consistent with the canonical model of pricing behaviour in heterodox economics. Hence throughout this section, we assume that firms set prices as:

$$P = kWa \qquad [1]$$

where P is the price level, k is the gross mark up (one plus the percentage margin for gross profits), W is the nominal wage and a is the labour:output ratio (which is assumed fixed). Our purpose is to then consider how debt-servicing costs (and hence the rate of interest) affect the pricing decision and ultimately aggregate price dynamics (as summarized by the short-run Phillips curve, or SRPC).[12]

[12] Admittedly, the rate of interest could affect the pricing decision through its effects on labour productivity ($1/a$), if technological innovation depends on external financing. Moreover, high debt-servicing costs are

i) Debt servicing as an overhead cost

The first approach to modelling the cost-push channel of monetary policy that we consider begins by postulating that:

$$k = \delta \iota D \qquad [2]$$

where δ is a constant coefficient, D is firms' outstanding stock of debt and ι denotes the nominal rate of interest.[13] In other words, the gross mark-up varies with firms' debt-servicing costs. The idea here is that – per Kalecki (1971) – the mark-up is sensitive to overhead costs, and debt-servicing can be construed as an overhead. This is essentially the approach taken by Dutt (1990—91), who assumes that a higher nominal interest rate will induce firms to raise the mark up because firms must meet their debt-servicing obligations out of the income (in excess of the wage bill) that is generated by the mark up.[14]

The implications for price dynamics can be seen by first substituting [2] into [1] to yield:

$$P = \delta \iota D W a$$

from which it follows that:

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likely to impart negatively on firms' ability to finance technological innovation from retained net profits. We abstract from these possibilities in this paper.

[13] Note that equation [2] focuses on the effects of the interest rate on firms' financial liabilities and hence the pricing decision. If firms retain profits, however, then they will accumulate financial *assets* which will also be affected by changes in the interest rate. We abstract from this fact both here and in what follows. See, however, the discussion of changes in the leverage ratio in section 3(iii) below, which is informed by the notion that firms that accumulate retained earnings may be induced to substitute internal for external financing in the event of an increase in the interest rate.

[14] Equation [2] can also capture Minsky's (1975) theory of counter-cyclical markups, in which a fall in sales during a downturn forces firms to raise markups to meet outstanding financial obligations. This would be captured by an increase in the parameter δ in equation [2]. See also Chevalier & Scharfstein (1996) for a mainstream counterpart to Minsky's theory, in which the counter-cyclical behavior of mark ups is justified by the claim that, since capital-market imperfections constrain the ability of firms to raise external financing, liquidity-constrained firms will increase (lower) markups during recessions (booms).

$$p = \hat{\imath} + w \quad [3]$$

where p and w denote the rates of price and wage inflation, respectively. Now assume that w is sensitive to inflation expectations and the level of output, so that:[15]

$$w = \beta p^e + \gamma y \quad [4]$$

Substituting [4] into [3] gives us a short-run Phillips curve (SRPC) of the form:

$$p = \hat{\imath} + \beta p^e + \gamma y \quad [5]$$

As is clear by inspection of [5], in this formulation the *rate of growth* of the interest rate is a determinant of inflation in the SRPC.

ii) Debt servicing and the target rate of return

A second approach to modelling the cost-push channel is based on a special case of mark-up pricing – namely, target return pricing – in conjunction with insights from the conflicting claims theory of inflation.[16] We begin by hypothesizing that:

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[15] There are, of course, many ways of describing the determinants of wage inflation, and we make no claim that equation [4] is definitive. It is employed here (and in what follows) as a simple first approximation that, in each case, allows us to write an equation for the rate of inflation in which inflation is sensitive to (*inter alia)* the level of real activity – i.e., an equation that takes the recognizable form of a SRPC. The precise functional form of [4] has no bearing on the relationship between price inflation and the interest rate in which we are interested, except in so far as it assumes that interest rates have no direct effect on wage formation (only an indirect effect operating through actual and hence expected price inflation). This is tantamount to assuming that only firms carry debt. In a world in which households also carry debt, the interest rate may influence workers' target real wage in which case it may have a secondary effect on price inflation via the rate of wage inflation. Even if workers do not carry debt, the possibility remains (following Pivetti 1991) that since the normal profit of the enterprise does not depend on the behaviour of any component of total unit cost other than interest expenses, wage bargaining – in order to have any permanent effect on income distribution – will seek to influence the interest rate. The models of the Phillips curve set out in this paper can be thought of as abstracting from these possibilities. We would therefore identify the relationship between the interest rate, wage formation and hence prices and price inflation as an important topic for further research into the precise workings of the cost-push channel of monetary policy.

[16] Rowthorn (1977) develops an early model of conflict inflation, while Lavoie (1992, chpt. 7) and Burdekin and Burkett (1996) provide surveys of the conflicting claims approach to inflation.

See Lee (1998) and Lavoie (1992, pp.129—33) for discussion of target return pricing procedures, and Lee (1998, p.206) for evidence of the use of target return pricing by firms. Note that target return pricing can be related to the cost plus pricing models of Wood (1975), Harcourt and Kenyon (1976) and Eichner (1987) that emphasize the influence of investment and growth on the size of the mark up. See, for example, Lavoie (1992, p.133).

$$\hat{k} = \varphi(\omega - \omega_F) \qquad [6]$$

where ω and ω_F are the wage share and firms' target wage share, respectively. The idea here is that the mark-up grows in response to any disparity between the actual wage share and firms' target wage share, an idea that is well established in the conflicting-claims literature. Since it follows from [1] that:

$$p = \hat{k} + w \qquad [7]$$

(recalling that *a* is a constant), substituting [6] into [7] we get:

$$p = \varphi(\omega - \omega_F) + w \qquad [8]$$

as our initial description of the rate of inflation.

Appealing once again to conflicting-claims theory, we now write:

$$w = \mu(\omega_W - \omega) + \beta p^e$$

and:

$$\mu = \eta y$$

where ω_W is the target wage share of workers. Together, these expressions imply that:

$$w = \eta y(\omega_W - \omega) + \beta p^e \qquad [4a]$$

Equation [4a] is immediately recognizable as a special case of equation [4], in which $\gamma = \eta(\omega_W - \omega)$. The idea here is that the growth of nominal wages now depends on inflation expectations, the gap between workers' target wage share and the actual wage share, and the state of the real economy (which influences workers' bargaining power and hence the size of μ).[17]

[17] The parameter β will also likely vary with *y*, but this is overlooked for the sake of simplicity.

An important feature of conflicting claims models of inflation is that their equilibrium solutions describe *both* the rate of inflation *and* the value of the wage share. In order to derive an expression for the SRPC that is consistent with the equilibrium conditions of the conflicting claims process, we therefore need to consider the situation where the wage share is constant (at its equilibrium value) in order to further our analysis. From the definition of the wage share, a constant wage share implies that $p = w$ (recalling once again that a is constant). Substituting this condition into [8], we get:

$$\omega = \omega_F \qquad [9]$$

In other words, the actual (equilibrium) wage share – and hence, by definition, the actual (equilibrium) size of $k = P/Wa = 1/\omega$ – is consistent with firms' target wage share. If we now substitute [9] into [4a] and again use the condition $p = w$, we arrive at a SRPC of the form:

$$p = \eta y(\omega_W - \omega_F) + \beta p^e \qquad [10]$$

So far, however, our model makes no connection between interest rates, prices and inflation. This problem is solved by appeal to the theory of target return pricing. Suppose, then, that what is really driving the equilibrium value of k established by firms is a target rate of return on their capital, r^T. By definition:

$$r = \frac{(1-\omega)u}{v}$$

where r is the rate of profit, u is the rate of capacity utilization, and v is the capital: output ratio (assumed fixed). It therefore follows that:

$$r^T = \frac{(1-\omega_F)u_n}{v}$$

or:

$$\omega_F = 1 - \frac{r^T v}{u_n} \qquad [11]$$

where u_n denotes the normal rate of capacity utilization at which the target rate of return, r^T, is calculated. In other words, firms' target wage share (the inverse of the equilibrium mark up) is ultimately explained by a target rate of return (given the values of v and u_n).

Now suppose further that firms carry debt on which they must pay interest, so that:

$$\Pi_E = \Pi - \iota D$$

where Π_E denotes enterprise profits and Π denotes gross profits (with ιD being rental income that is earned by creditors).[18] We can therefore write:

$$\frac{\Pi_E}{PK} = \frac{\Pi}{PK} - \frac{\iota D}{PK}$$

where K is the stock of capital, or:

$$r_E = r - \iota\lambda$$

where $\lambda = D/PK$ is the ratio of corporate debt to the stock of capital, which (following Lavoie, 1995) we assume to be constant in the short run. It therefore follows that:

$$r = r_E + \iota\lambda$$

so that we can write:

$$r^T = r_E^T + \iota\lambda \qquad [12]$$

[18] Note that enterprise profit as defined here is based on firms' cash flow, so that the rate of enterprise profits derived above is, in fact, the real cash flow rate (see Setterfield, 2006 for further discussion). It is appropriate for firms to target the cash flow rate if cash flows constrain investment spending (as suggested by, for example, Fazzari and Mott, 1986-7, Fazzari et al, 1988, and Ndikumana, 1999) and the purpose of the mark up is to raise funds to finance investment.

In other words, the target rate of return which determines firms' target wage share depends, *inter alia*, on the nominal interest rate. Substituting [12] into [11], we get:[19]

$$\omega_F = 1 - \frac{(r_E^T + \iota\lambda)v}{u_n} \qquad [13]$$

Finally, substituting [13] into [10] yields:

$$p = \eta y\left[\omega_W - \left(1 - \frac{[r_E^T + \iota\lambda]v}{u_n}\right)\right] + \beta p^e \qquad [14]$$

This is essentially a conventional SRPC, in which p is increasing in p^e, y (given the conventional assumption that $\omega_W > \omega_F$) *and* the nominal interest rate, ι. Linearizing [14] for the sake of simplicity, we can now write (as an approximation of the inflation process):

$$p = \theta_1 \iota + \theta_2 p^e + \theta_3 y \qquad [15]$$

In this formulation of the SRPC, then, it is the level of the interest rate that is a determinant of inflation.

iii) Debt servicing, the target rate of return, and the "normal" rate of interest

A third approach to modelling the cost-push channel stems from a refinement of the previous approach, and in particular equation [12]. Note that according to [12], the target rate of return and hence the equilibrium mark up will vary every time the interest rate changes. But mark ups are conventionally regarded as fixed for discrete intervals of time. In light of this observation, it might be more accurate to describe firm behaviour as:

[19] Note that not all variants of target return pricing admit a role for the interest rate in the determination of the mark up in this fashion. See, for example, Lavoie (1992, pp.360—1; 1995) on the pricing theory of Eichner (1987).

$$r^T = r_E^T + \imath_n \lambda \qquad [12a]$$

where $\imath_n$ is the (given) normal rate of interest that firms build into their pricing decisions.[20] Now, it seems reasonable to think that what firms regard as a "normal" rate of interest will change over time in response to their experience of prevailing actual rates of interest. Strictly speaking, this variation is likely discrete (corresponding to the periodic revisions of an otherwise fixed mark up). But suppose we represent this process of discrete change with a continuous approximation of the form:

$$\dot{\imath}_n = \rho(\imath - \imath_n) \qquad [16]$$

If we now substitute [12a] into [11] and the result into [10], we get an SRPC of the form:

$$p = \eta y \left[\omega_W - \left(1 - \frac{[r_E^T + \imath_n \lambda]v}{u_n} \right) \right] + \beta p^e \qquad [14a]$$

Linearizing this SRPC now yields:

$$p = \psi_1 \imath_n + \psi_2 p^e + \psi_3 y \qquad [15a]$$

from which it follows that:

$$\dot{p} = \psi_1 \dot{\imath}_n + \psi_2 \dot{p}^e + \psi_3 \dot{y}$$

Finally, substituting [16] into this expression, we arrive at:

$$\dot{p} = \psi_1 \rho(\imath - \imath_n) + \psi_2 \dot{p}^e + \psi_3 \dot{y} \qquad [17]$$

The substance of these results is that the rate of inflation now depends on the normal rate of interest (equation [15a]), whereas the actual rate of interest affects the *rate of change* of inflation (equation [17]).

[20] This recalls the emphasis on permanent or lasting changes in the interest rate in the work of Panico (1988) and Pivetti (1991) discussed earlier. Hence consistent with equation [12a], short-run variations in the interest rate that leave the normal rate of interest, $\imath_n$, unchanged will leave the equilibrium mark up and hence prices unchanged, *ceteris paribus*.

Recall, however, that the leverage ratio, λ, was treated as given in the derivation of the SRPC in [15a]. But it is reasonable to conjecture that, corresponding to a given normal rate of interest, there may be a normal leverage ratio that firms build into their pricing decisions. In this case, [12a] would be given by:

$$r^T = r_E^T + \iota_n \lambda_n \qquad [12b]$$

with $\lambda_n = \chi(\iota_n), \quad \chi' < 0$ capturing the idea that firms will seek to reduce their dependence on external financing when the normal rate of interest increases. In this case, what firms regard as normal values for both the interest rate and the leverage ratio will change over time in response to prevailing actual rates of interest. If we now substitute [12b] into [11] and the result into [10], we get an SRPC of the form:

$$p = \eta y \left[\omega_W - \left(1 - \frac{[r_E^T + \iota_n \chi(\iota_n)]v}{u_n} \right) \right] + \beta p^e \qquad [14a]$$

Linearizing this SRPC now yields:

$$p = (\psi_1 - \psi_2)\iota_n + \psi_3 p^e + \psi_4 y \qquad [15b]$$

from which (given [16]) it follows that:

$$\dot{p} = \rho(\psi_1 - \psi_2)(\iota - \iota_n) + \psi_3 \dot{p}^e + \psi_4 \dot{y} \qquad [17a]$$

Although these expressions are qualitatively similar to [15a] and [17], in that the normal rate of interest affects the rate of inflation while the actual rate of interest affects the rate of change of inflation, the corresponding relationships between p and ι_n, and $\dot{p}$ and ι, will now be negative in the event that $\psi_1 < \psi_2$. Hence, for example, a large enough fall in the normal leverage ratio brought about by a rise in the rate of interest will cause the rate of inflation (rate of change of inflation) to vary *negatively* with the normal (actual) rate of interest.[21]

iv) Debt servicing and the "normal" rate of interest: an alternative approach

In the previous sub-section, the mark up, k, adjusts in response to the disequilibrium conditions $\omega \neq \omega_F$, as described in equation [6]. But consider continuous maintenance of the equilibrium condition $\omega = \omega_F$, such that $k = Wa / P = 1/\omega_F$.[22] It follows that:

$$\hat{k} = -\hat{\omega}_F$$

Now note that, by combining [1] and [12a], we get:

[21] A nonlinearity would emerge in the event that the SRPC given by [14a] were not linearized in the normal rate of interest, as in [15b]. Suppose, then, that the leverage ratio is given by $\lambda_n = \psi_0 - \psi_1 \iota_n$, so that the $\iota_n \lambda_n$ term in [14a] becomes an inverted-U function of the normal rate of interest, with roots given by $r_1 = 0$ and $r_2 = \psi_0 / \psi_1$. As a result, an increase in the normal rate of interest would lead to a rise (fall) in the *level* of inflation if the normal rate of interest were lower (higher) than $\iota_n^* = \psi_0 / 2\psi_1$. Meanwhile, the *change* in inflation would vary positively (negatively) with the actual rate of interest if the normal rate of interest were lower (higher) than ι_n^*. Indeed, the *level* of inflation would be nonlinear in the actual interest rate in the approach taken in section 3(ii) if the actual leverage ratio is given by $\lambda = \psi_0 - \psi_1 \iota$. In this case, both the *level* and the *rate of change* of inflation will vary positively (negatively) with the nominal rate of interest if the latter is lower (higher) than $\iota^* = \psi_0 / 2\psi_1$. Given the sometimes ambiguous – or even contradictory – results found in the burgeoning empirical literature on the cost-push channel of monetary policy reviewed in the previous section, we would suggest that these nonlinear specifications are worthy of further (particularly empirical) investigation.

[22] In other words, having determined the size of $k = 1/\omega_F$, firms immediately set prices consistent with this value of k, rather than undertaking the process of gradual adjustment described in [6]. Note that the model of pricing and price dynamics developed by Hannsgen (2006) to accommodate the cost-push channel of monetary policy considers only a gradual adjustment process akin to [6]. Another problematic feature of Hannsgen's model is the assumption that firms start with no money, having to borrow the full amount of the wage bill. Nonetheless, firms are assumed to pay back their loans and retain profit at the end of each period. It is therefore unclear why firms must borrow the full amount of the wage bill at the start of the period if there may exist retained profits from preceding periods. Fortunately, the interesting macroeconomic results of the Hannsgen model are not compromised by the fact that not all of its microeconomic assumptions are spelled out.

$$\omega_F = 1 - \frac{(r_E^T + \iota_n \lambda)v}{u_n}$$

from which it follows that:

$$\dot{\omega}_F = -\frac{\lambda v}{u_n \omega_F} \dot{\iota}_n$$

Combining the results derived above yields:

$$\hat{k} = \frac{\lambda v}{u_n \omega_F} \dot{\iota}_n$$

or:

$$\dot{k} = k\tau \dot{\iota}_n \qquad [18]$$

where $\tau = \lambda v / u_n \omega_F$. Again, it seems reasonable to believe that what firms regard as a "normal" rate of interest will change over time according to their experience of prevailing actual rates of interest, as represented by the continuous approximation in [16]. Substituting the latter into [18], and the resulting expression together with [4] into equation [7], we now obtain a SRPC of the form:

$$p = \tau\rho(\iota - \iota_n) + \beta p^e + \gamma y \qquad [19]$$

from which, using [16] again, it follows that:

$$\dot{p} = \tau\rho[\dot{\iota} - \rho(\iota - \iota_n)] + \beta \dot{p}^e + \gamma \dot{y} \qquad [20]$$

Since the rate of inflation now depends on the levels of both the actual and the normal rates of interest, the *rate of change* of inflation depends on the *rate of change* of the actual rate of interest *and* on the levels of both the actual and the normal rates of interest. However, the level (rate of change) of inflation varies positively (negatively) with the actual rate of interest and negatively (positively) with the normal rate of interest.

v) Debt servicing as a component of prime costs

The approaches to modelling the cost-push channel that we have discussed so far have one important thing in common: they all regard the interest rate as impacting prices (and ultimately price dynamics) via the value of the mark up. However, an altogether different approach is found in Taylor (1983, pp.88—89) and Atesoglu and Smithin (2006, pp.5—6), where firms are assumed to borrow working capital to finance the wage bill. In this approach, the interest charged on debt contributes to the prime or direct costs (which are now given by the size of the wage bill after interest charges have been applied) to which firms apply their mark-ups in order to determine prices. For both Taylor (1983) and Atesoglu and Smithin (2006), the price level can therefore be described as:

$$P = k(1+\imath)Wa \qquad [21]$$

from which it follows that:

$$\ln P = \ln k + \ln(1+\imath) + \ln W + \ln a$$

If we appeal to the approximation $\ln(1 + \imath) = \imath$ for small values of $\imath$ and differentiate this last expression with respect to time, bearing in mind that both k and a are now being treated as constant, we arrive at:

$$p = i + w \qquad [22]$$

Finally, substituting [4] into [22] gives us a SRPC of the form:

$$p = i + \beta p^e + \gamma y \qquad [23]$$

In this approach to modelling the cost-push channel, then, we arrive at a formulation of the SRPC in which the *rate of change* of the nominal interest rate affects the rate of inflation.

vi) Inventory accumulation, debt and the pricing decision

A final model of the cost-push channel arises from the work of Taylor (2004, pp.88—90). In Taylor's model, firms borrow specifically to finance the accumulation of inventories. In order to derive the implications of this behaviour for pricing and price dynamics, we begin with the expression:

$$WaX + \pi PX + \iota D = P(C + I + G) + P\dot{Z} + \dot{P}Z \qquad [24]$$

where X denotes real output, π is the profit share of income, $D = PZ$ is the debt undertaken by firms to finance inventories (Z), C, I, and G denote (respectively) aggregate consumption, investment and public expenditures (all in real terms), and all other variables are as previously defined. The terms $P\dot{Z}$ and $\dot{P}Z$ denote additions to inventories and capital gains on existing inventories, respectively. Real output is given by:

$$X = C + I + G + \dot{Z} \qquad [25]$$

and it is assumed that:

$$Z = \xi X \qquad [26]$$

where the ratio of inventories to total output, ξ, is fixed. Substituting [25] and [26] into [24], recalling that $D = PZ$, and solving for P, we arrive at an expression identical to equation [1] with:

$$k = \frac{1}{1 - \pi - (\iota - p)\xi} \qquad [27]$$

Intuitively, firms adjust the mark up in response to the negative impact of the nominal interest rate on profits (which arises from the effect of the nominal interest rate on the costs of servicing the debt that finances inventory accumulation), and the positive impact of inflation on profits (which arises from the realization of capital gains on inventories). Of course, this amounts to the claim that the mark up is sensitive to the *real* rate of interest – as in equation [27].

What does this pricing behaviour imply for price dynamics? Defining $\iota_R = (\iota - p)$ as the real rate of interest, note that it follows from [27] that:

$$\dot{k} = \frac{\xi \dot{\iota}_R}{(1-\pi-\iota_R\xi)^2} = k^2 \xi \dot{\iota}_R$$

which implies that:

$$\hat{k} = k\xi \dot{\iota}_R$$

Substituting this last expression together with equation [4] into equation [7] now gives us a SRPC of the form:

$$p = k\xi \dot{\iota}_R + \beta p^e + \gamma y \qquad [28]$$

In other words, price dynamics now operate in such a way that it is the rate of change of the *real* interest rate that affects the rate of inflation.[23]

[23] In the model developed by Godley (1999), the mark up also depends on the nominal interest rate because of debt-financed inventory accumulation. Capital gains on existing inventories are not considered, but the ratio of inventories to total output, ξ, is made to vary negatively with the nominal interest rate. Under these alternative assumptions, we would again arrive at an expression identical to [1], with the mark up now given by $k = 1/[1-\pi-\iota\xi(\iota)]$, with $\xi'(\iota) < 0$. A rise in the nominal interest rate would now exert both an upward pressure (due to the rise in the cost of servicing debt-financed inventory accumulation) and a downward pressure (due to the fall in the ratio of inventories to total output, ξ) on the mark up. A rise in the nominal interest rate could lower the rate of inflation if it induces a sufficiently large fall in the ratio of inventories to output.

Alternatively, suppose that ξ varies negatively with the normal rate of interest, and that ι_n again varies in response to firms' experience of prevailing actual rates of interest, as represented by [16]. In this case, the rate of change of the inventories to output ratio would depend on the level of the nominal interest rate, and not on its rate of change, though a rise in the nominal interest rate could still end up lowering the rate of inflation. Therefore, a ratio of inventories to total output that varies negatively with the nominal rate of interest is another mechanism through which the cost-push channel of monetary policy may operate in a nonlinear manner, as described on footnote 21.

4. Conclusion

In this paper, we have provided an overview of both the theoretical standing and contemporary empirical status of the cost-push channel of monetary policy. In addition, we have explored several possibilities for modelling the cost-push channel in the context of cost-plus pricing behaviour – the canonical model of pricing in heterodox economics. Based on the findings of this exercise, we can identify six plausible models of the cost-push channel of monetary policy, rooted in standard and recognizable principles of cost-plus pricing theory. These models result in six plausible specifications of the SRPC, each of which provides a particular account of price dynamics based on a specific relationship between the interest rate and the rate of inflation. The SRPCs in question are:

a) Equation [5] (inflation varies with the *rate of growth* of the nominal interest rate)

b) Equation [15] (inflation varies with the *level* of the nominal interest rate)

c) Equation [15a] (inflation varies with the normal rate of interest, so that *changes* in inflation vary with the *level* of the nominal rate of interest)

d) Equation [19] (inflation varies with the *levels* of both the actual and the normal rates of interest, so that the *rate of change* of inflation varies with the *level* and the *rate of change* of the nominal interest rate)

e) Equation [23] (inflation varies with *changes* in the nominal rate of interest)

f) Equation [28] (inflation varies with changes in the *real* rate of interest)

We make no claim that the various models of the cost-push channel discussed in this paper are exhaustive. On the contrary, it is clearly evident from the discussion in section

3 that they are *not*. For example, as noted in section 3, our models capture only the *direct* effect of interest rates on prices, abstracting from *indirect* effects that may arise from the impact of interest rates on wage bargaining when households carry debt.[24] But this lack of completeness does not prevent us from arriving at a critically important conclusion: even on the basis of the models that *are* discussed in section 3, it is apparent that different plausible cost-plus pricing procedures can give rise to qualitatively different characterizations of the cost-push channel of monetary policy. The obvious contrast here is with mainstream theory, which admits much less heterogeneity in the discussion of the cost-push channel. Instead, the overwhelming emphasis in mainstream theory is on a positive relationship between the level of the interest rate and the rate of inflation, consistent with the strictures of the New Keynesian Phillips curve.

Having thus identified the multiplicity of plausible SRPCs grounded in cost-plus pricing theory that embody some variant or other of the cost-push channel, the key question becomes: how do the price dynamics described by these SRPCs affect macroeconomic outcomes and the stability of macroeconomic equilibrium?[25] As intimated earlier, this question becomes pressing in an environment where the central bank deliberately manipulates the interest rate in the pursuit of a macroeconomic goal such as low inflation. In our opinion, it is the single most important question that further heterodox research into the macroeconomics of the cost-push channel of monetary policy should seek to address.

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[24] Moreover, as also mentioned earlier, interest rates may affect pricing: (a) if fiscal-monetary interaction cause interest rates to affect tax rates, and if firms practice what Mott and Slattery (1994) describe as "tax shifting" in their pricing behaviour; (b) via the exchange rate (and hence the cost of imported inputs into the production process); and (c) if technological change – and hence labour productivity – is sensitive to the costs of external financing.

[25] See Hannsgen (2006) for a recent attempt to consider the implications for macroeconomic stability of one particular variant of the cost-push channel.

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