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THE BACKWARD-BENDING PHILLIPS CURVE AND THE MINIMUM UNEMPLOYMENT RATE OF INFLATION: WAGE ADJUSTMENT WITH OPPORTUNISTIC FIRMS*

by
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This paper presents a theory of the backward-bending Phillips curve. There is a minimum unemployment rate of inflation which offers a policy alternative to the non-accelerating inflation rate of unemployment. Nominal wages are downwardly rigid because workers oppose cuts initiated from within the employment relation. Instead, workers may accept real wage adjustments effected by increases in the general price level, a variable outside individual firms' control. This is why inflation 'greases' labor market adjustment. However, workers resist too rapid a real wage adjustment, and too high an inflation generates wage resistance that cancels the grease effect and increases unemployment.

1 Introduction

This paper presents a theory of the backward-bending Phillips curve in which there is a minimum unemployment rate of inflation (MURI). The MURI offers an alternative to the non-accelerating inflation rate of unemployment (NAIRU) for purposes of policy formation. Nominal wages are downwardly rigid because workers oppose wage cuts initiated from within the employment relation. Instead, they may accept real wage adjustments effected by increases in the general price level, a variable outside the control of individual firms. It is for this reason that inflation 'greases' labor market adjustment. However, workers resist too rapid a real wage adjustment, so that too high an inflation cancels the grease effect and causes unemployment to increase.

2 Inflation Expectations and the Phillips Curve: Revisiting the Issue

Recently, there has been a revival of belief that the long-run Phillips curve is negatively sloped. This revival builds upon claims originally made by Tobin (1972) that inflation could grease the wheels of labor market adjustment in a multisector economy with downward nominal wage rigidity. Palley (1994,

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1997) presents a model of a multisector economy in which nominal wages display downward rigidity in sectors with unemployment. This pattern of behavior results in a negatively sloped Phillips curve in which the rate of unemployment is negatively related to the rate of inflation, and the rate of inflation in turn equals the rate of nominal demand growth minus the rate of productivity growth. Akerlof *et al*. (1996) present a similar model in which sectors are replaced by monopolistically competitive firms who set own nominal wage bargains with their workforces, and demand at these firms is sensitive to relative prices so that demand can shift amongst firms.

In all of these models the treatment of inflation expectations is critical because if inflation is fully incorporated into nominal wages and passed through into prices, nominal demand growth is fully neutralized. This raises the question of how agents respond to inflation. Viewed from this perspective, the earlier rational expectations debate can be thought of as a debate about 'how agents form' expectations of inflation, whereas the long-run Phillips curve debate is about 'how agents behave' given these expectations of inflation.[1]

In Palley (1994, 1997) the coefficient of inflation expectations is less than unity in sectors with unemployment but is unity in sectors with full employment. The argument is that workers oppose wage cuts imposed from within the employment relation as this exposes them to opportunistic exploitation by firms. Instead, workers in sectors with unemployment accept less than full compensation for inflation, thereby permitting real wage reductions without recourse to a cut imposed by firms within the employment relation.

In their earlier model Akerlof *et al*. (1996) ignored the issue of inflation expectations, but they have now (Akerlof *et al*., 2000) proposed a new model with near-rationality in price and nominal wage setting. This treatment has firms and workers ignoring inflation at low levels, and it has the interesting implication that the Phillips curve is backward-bending. The reason is that nominal demand growth is not neutralized by low inflation owing to near-rationality. However, near-rationality gives way to full rationality as inflation increases, so that nominal demand growth then gets neutralized.[2]

[1]The importance of inflation expectations was picked up long ago in the debate over the nominal wage Phillips curve and the magnitude of the coefficient of inflation expectations (Tobin, 1971). If the coefficient is less than unity, there is less than full feed-through of expectations and the long-run Phillips curve is negatively sloped; if it is unity, there is not. This earlier debate embodies questions of both (a) how agents form expectations and (b) what they do with those expectations. The issue of whether or not the coefficient is unity concerns what they do with their expectations. Unfortunately, it has often been conflated with whether agents have adaptive or rational expectations.

[2]Another argument for a backward-bending Phillips curve (Palley, 1998) is that inflation introduces both labor market "grease" and financial market "sand" effects. At low levels of inflation the grease effects dominate. At higher levels of inflation the sand effects come to dominate, and the resulting allocative distortions cause higher unemployment.

In the current paper I argue for an alternative treatment of inflation expectations that also generates a backward-bending Phillips curve. I argue that the near-rationality approach is implausible because it implies that (i) workers ignore steady predictable low inflation and (ii) some workers ignore systematic predictable inflation even at fairly high levels. In its place, I propose an alternative account of the Phillips relation that is rooted in a theory of contested wage setting. The proposed account has two major strengths. First, workers are fully rational. Second, the treatment of inflation is consistent with an underlying general account of downward nominal wage rigidity. Nominal wages are downwardly rigid because of moral hazard associated with employers opportunistically seeking to lower wages even if business conditions do not warrant it. Because of this moral hazard, workers more readily accept downward adjustments to real wages effected from outside the employment relation by generalized price increases in the rest of the economy. This is why inflation serves to 'grease' the wheels of labor market adjustment. However, workers are unwilling to accept too rapid a real wage adjustment, so that once inflation reaches a threshold level they respond by demanding matching nominal wage increases. This response cancels out the grease effects of inflation, thereby causing the unemployment rate to increase. If the inflation resistance threshold is commonly shared by all workers, the Phillips curve exhibits a discrete break and becomes vertical at the point of backward shift. If there is a continuum across workers regarding the inflation resistance threshold point, the backward-bending Phillips curve is continuous and becomes vertical only when all workers have reached their resistance threshold.

The balance of the paper is as follows. Section 3 examines the relationship between downward nominal wage rigidity and unemployment. Section 4 reviews existing theories of the backward-bending Phillips curve. Section 5 presents the theory of nominal wage adjustment in conflictual labor markets. Section 6 presents a multisector economy in which the Phillips curve is backward-bending because workers have an inflation threshold beyond which they resist inflation-induced real wage reductions. Section 7 concludes with some policy observations.

3 Downward Nominal Wage Rigidity and Unemployment: Some Prefatory Comments

Downward nominal wage rigidity plays a critical role in the multisector theory of the Phillips curve. This raises the question as to what is the relationship between downward nominal wage rigidity and unemployment. The 'classical' approach to downward nominal wage rigidity is that it results in real wages that are too high for full employment. Behind this classical interpretation lies a concept of a negatively sloped demand for labor predicated upon a diminishing marginal product of labor. Too high a real wage means

that employers are unwilling to move down the labor demand schedule and employ more workers.

This classical construction of the link between downward nominal wage rigidity and unemployment contrasts with the Keynesian approach embedded in the current multisector model. First, in the current model every sector has a constant marginal product of labor so that there is no downward-sloping sectoral labor demand schedule. Second, sectoral real wages as measured in terms of sectoral output are fixed, and would remain fixed even if nominal wages were perfectly flexible. This is because firms are mark-up pricers, and the mark-up is constant. Thus, a fall in the nominal wage generates an equal proportionate fall in the sectoral price, leaving the sectoral real output wage unchanged. These twin features imply that the classical interpretation of the link between downward nominal wage rigidity and unemployment is not the cause of unemployment.

Instead, the cause of unemployment is that sectoral nominal demand is too low relative to sectoral nominal wages. This resonates with Keynes's discussion of the relationship between the money wage and the rate of interest:

> We can, therefore, theoretically at least, produce the same effects on the rate of interest by reducing nominal wages, whilst leaving the quantity of money unchanged, that we can produce by increasing the quantity of money whilst leaving the level of wages unchanged. (Keynes, 1936, p. 266)

In a multisector economy the problem then becomes one of how to inject nominal demand into those sectors that are short of demand. Since demand management policy works at the aggregate level, this means that policy-induced increases in aggregate nominal demand are injected into all sectors. The result is that unemployment falls in those sectors short of nominal demand relative to nominal wages, while prices rise in those sectors at full employment where nominal demand is in balance with nominal wages.

The fact that sectoral nominal demand is too low relative to nominal wages invites the response that this problem can be resolved by lowering nominal wages relative to nominal demand. However, there are two objections to this. First, as described in Section 4, it is difficult to obtain nominal wage reductions because of moral hazard afflicting the employment relation. Second, nominal wage reductions may have adverse feedbacks on the level of aggregate demand via adverse debt burden effects (Palley, 1999). This debt effect illustrates a fundamental asymmetry in the relation between nominal demand and nominal wages. Keynesian unemployment results from an imbalance between nominal demand and nominal wages, but this imbalance can only be corrected by raising nominal demand relative to nominal wages. Trying to lower nominal wages relative to nominal demand will be contested by workers, and it also generates negative feedbacks on the level of nominal demand.

1

4 The Microeconomics of Nominal Wage Setting

At a theoretical level, Akerlof *et al.*'s (2000) theory of near-rationality in nominal wage setting can be framed as an extension of earlier neo-Keynesian beliefs about the importance of money illusion in explaining downward nominal wage rigidity (Blinder, 2000). In effect, near-rationality in nominal wage setting can be thought of as expanding Keynesian money illusion so that it extends to inflation. Thus, not only are nominal wages downwardly rigid because workers mistake nominal wage reductions as real wage reductions, but nominal wages are also upwardly rigid because workers fail to take account of the real wage effects of low inflation.

Though capable of generating a backward-bending Phillips curve, a nominal wage near-rationality argument has significant microeconomic and empirical problems. First, it is unclear why workers cognitive faculties are such that they systematically underestimate low inflation, yet suddenly get inflation right when it reaches a threshold level. Second, the empirical estimates of the backward-bending Phillips curve provided by Akerlof *et al.* (2000) show that the Phillips curve only becomes vertical when consumer price index inflation is over 7%. If near-rationality in nominal wage setting is operative, it implies that some workers are being fooled at 7% inflation. When the PCE deflator is used as the measure of inflation, the Phillips curve becomes vertical at about 5% inflation, so that near-rationality persists through to 5% inflation.

Given these twin problems, the current paper suggests an alternative theory of nominal wage setting that also explains both downward nominal wage rigidity and incomplete adjustment in the presence of low inflation. Accounting for downward nominal wage rigidity requires explaining (1) why workers are concerned with enforcing downward rigidity and (2) how workers manage to deter firms from cutting nominal wages. Palley (1990) presents a theory of downward wage rigidity in which workers resist nominal wage cuts imposed by firms because of a fundamental moral hazard in the employment relation. This moral hazard stems from the fact that firms may try to cut wages and raise profits even when product market conditions do not warrant it. Workers cannot trust wage cuts sponsored from within the employment relation because it is intrinsically antagonistic. This generates an asymmetry in the pattern of nominal wage adjustment whereby workers willingly accept firm-sponsored nominal wage increases but resist firm-sponsored cuts. Instead, they prefer that downward real wage adjustments be effected from outside the employment relation by increases in the general price level, thereby avoiding the opportunistic exploitation problem.

Two other reasons for downward nominal wage rigidity are relative wage and nominal debt concerns. Keynes (1936) emphasized relative wage concerns:

> any individual or group of individuals who consent to a reduction of money wages relatively to others will suffer a relative reduction in real wages, which is sufficient justification for them to resist it. On the other hand it would be impractical to resist every reduction of real wages due to changes in the purchasing power of money, which affects all workers alike. (1936, p. 14)

This reasoning has also been emphasized by Summers (1988). When nominal wage reductions are imposed in a decentralized uncoordinated manner, workers have an incentive to resist as this stands to lower their relative wage. A second reason why workers oppose nominal wage cuts is that they are frequently large nominal debtors. Nominal wage reductions therefore increase the burden of their debts as measured by their debt-to-income ratio.

Workers are able to prevent firms from cutting wages, despite the presence of unemployed replacement workers who are willing to work for less, because of the structure of employment. Firms are deterred from unilaterally cutting wages because workers respond by reducing their effort provision.[3] At the same time, firms are deterred from hiring replacement workers because it is costly to find and train these workers. As a result, individual workers are able to enforce wage rigidity as long as the gap between the current wage and the replacement wage is not too large. The maximum size of this gap depends on the costs of finding and training replacement workers, and the value of output lost during the replacement period. Bewley (2000) reports empirical evidence that strongly supports this picture of labor markets. Nominal wages are downwardly rigid in recessions, and an important reason cited by firms is the fear that a unilaterally imposed nominal wage cut will induce a withdrawal of effort by workers.

5 Implications for Disequilibrium Wage Adjustment

The key feature of the above account of labor markets is that workers oppose nominal wage cuts because they are instituted from within the employment relation. However, they can accept real wage cuts implemented from outside the employment relation through increases in the general price level. This is because the general price level is beyond the control of individual firms, so that firms cannot opportunistically exploit workers via this channel.

In such a world, the pattern of disequilibrium wage adjustment is significantly different from the standard nominal wage Phillips curve. The standard Phillips curve embodies a dichotomy whereby nominal wage adjustment is divided into independent parts consisting of a real and an inflation component. This standard approach is given by

[3]Though not formally organized, workers engage in "tacit coordination". They are all opposed to wage cuts sponsored from within the employment relation, and such cuts become the trigger that generates a common formally uncoordinated withdrawal of effort.

$$w = f(u) + p \qquad f_u < 0 \tag{1}$$

where w is nominal wage inflation, u is unemployment and p is price inflation. The real adjustment component, $f(u)$, reflects the pressure on nominal wages of labor market fundamentals (as measured by excess supply or demand). The inflation component p reflects pure nominal considerations relating to inflation. Theories of downward 'real' wage rigidity block off the downward influence of labor market fundamentals (excess supplies), but fully incorporate the inflation component. Theories of downward 'nominal' wage rigidity block off the downward influences of labor market fundamentals, but they are incoherent about the inflation component.[4]

In the 'standard' model both the labor market disequilibrium component and the inflation component operate smoothly, independent of whether there is excess demand or supply. Contrastingly, in the suggested 'opportunistic exploitation' model, nominal wage adjustment exhibits significant asymmetries and there are three regimes. (i) When there is excess labor demand, the fundamentals and inflation components operate as standard theory predicts. (ii) When there is moderate unemployment, both components are blocked off and nominal wages are constant. This means that instead of serving to raise nominal wages, inflation serves to lower real wages (i.e. inflation takes on a quasi-fundamentals adjustment role). (iii) Lastly, when there is high unemployment, firms can credibly turn to a replacement strategy and the fundamentals component to wage adjustment again kicks in to lower nominal wages.

This asymmetric pattern of wage adjustment can be summarized as follows. In labor markets with excess demands, real and nominal wages adjust as follows:

$$w = f(u) + p \tag{2a}$$

$$w = w - p = f(u) + p - p = f(u) \tag{2b}$$

where w is the rate of real wage change. In markets with moderate unemployment the pattern is

$$w = 0 \tag{2c}$$

$$w = w - p = -p \tag{2d}$$

Lastly, in markets with high unemployment, the nominal wage discreetly falls to the market clearing level, and is then governed by (2a) and (2b).

According to the above, inflation lowers real wages in markets with

[4]One way of thinking about the near-rationality approach advocated by Akerlof *et al*. (2000) is that it aims to block off the inflation component, at least for low levels of inflation. However, this blocking off applies independently of the state of labor market fundamentals (whether or not there is excess supply or demand).

moderate unemployment. However, though workers may be willing to accept some reduction in real wages, they may resist excessively rapid real wage reductions. Thus, there may exist an inflation threshold beyond which workers react protectively to maintain their real wage. Such a threshold concept has been suggested by Rowthorn (1977). In this event, there is a further wage adjustment regime for regions of moderate unemployment but higher inflation, given by

$$w = p \qquad p \geq p^{\wedge} \tag{2e}$$

$$w = w - p = p - p = 0 \qquad p \geq p^{\wedge} \tag{2f}$$

where $p^{\wedge}$ is the inflation threshold. As with near-rationality, the inflation threshold argument also results in full feed-through of inflation into nominal wage setting. However, the economic logic is profoundly different. In the former, workers suddenly become aware of inflation when it reaches a threshold. In the latter, workers are always aware of inflation, but they only resist when inflation threatens too rapid a reduction in real wages.

6 Macroeconomics: a Multisector Model of the Backward-bending Phillips Curve

The above theory of nominal wage adjustment can be placed in a multisector model so as to generate a backward-bending Phillips curve. The relevance of a multisector approach for understanding inflation and unemployment is suggested by consideration of the geographical distribution of unemployment rates in the USA in December 2001. Out of the 50 states plus the District of Columbia, two had unemployment rates exceeding 7%, seven had rates between 6 and 7%, 17 had unemployment rates between 5 and 6%, 16 had rates between 4 and 5% and nine had rates below 9%. The national average unemployment rate was 5.8%.

By and large downward nominal wage reductions have been rare in the USA since the Second World War, and the multisector model of the backward-bending Phillips curve is therefore constructed under the assumption of complete downward nominal wage rigidity. This simplifies the presentation without changing the substance of the results.[5] The static logic of the model is illustrated in Fig. 1. There are N sectors, each of which has a reverse L-shaped supply curve which becomes vertical when sectoral full employment is reached. Nominal wages are downwardly rigid in sectors with unemployment; they are upwardly flexible in sectors with full employment and adjust to their market clearing level. Each sector is subject to random nominal

[5]Allowing for gradual downward nominal wage adjustment just shifts the negatively sloped portion of the Phillips curve down so that unemployment is lower for any given inflation rate. Other than that, it has no effect on the rest of the argument.

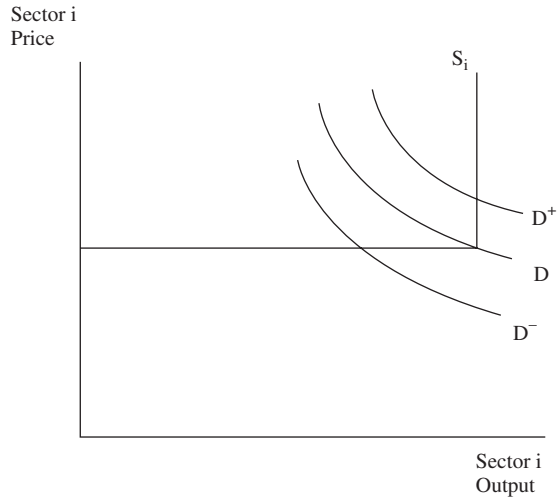

FIG. 1 Static Effect of Sectoral Nominal Demand Shocks in an Economy with Downward Nominal Wage Rigidity

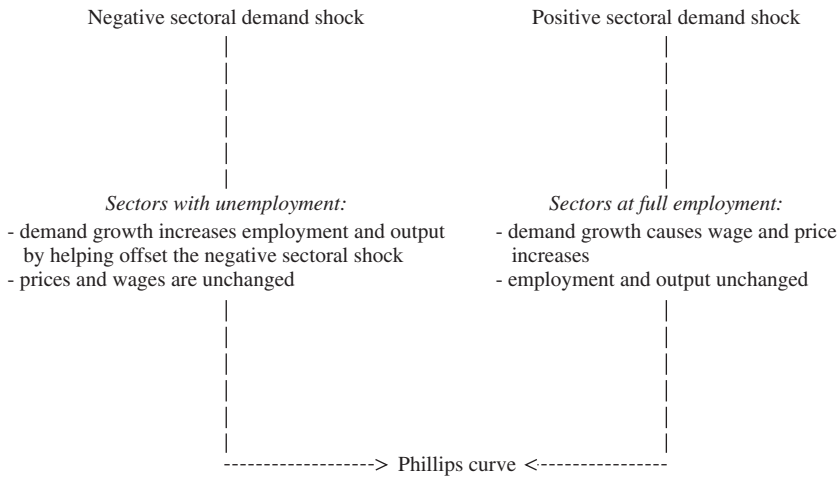

FIG. 2 Dualistic Sectoral Adjustment Process that Generates the Aggregate Phillips Relation

demand shocks and the average aggregate shock is zero. Sectors receiving negative shocks experience unemployment, while those receiving positive shocks experience full employment with rising prices and nominal wages.

The economic process that gives rise to the Phillips curve is illustrated in Fig. 2. At any moment, the economy is subject to two distinct adjustment

processes—one for sectors with unemployment, and one for sectors at full employment. In sectors with unemployment, nominal demand growth translates into increased employment and output, while prices and nominal wages are unchanged. In sectors at full employment, nominal demand growth translates into increased prices and nominal wages, while employment and output remain fixed. The aggregation of these two adjustment process then produces a Phillips curve.

6.1 The Backward-bending Phillips Curve with a Discrete Break

The formal model is as follows. Within each period, labor is immobile across sectors. But at the end of each period unemployed workers move between sectors so as to equalize beginning of period unemployment rates across sectors.[6] In product markets prices are a mark-up over average costs which are determined by nominal wages.[7]

The rate of aggregate nominal demand growth in each sector is given by

$$gd_{i,t} = gd + ed_{i,t} \qquad i = 1, \ldots, n \tag{3}$$

where $gd_{i,t}$ is the rate of nominal demand growth in sector i in period t, gd is the exogenous trend rate of aggregate nominal demand growth that is controlled by the monetary authority, and $ed_{i,t}$ is the sector-specific shock. Sectoral nominal demand growth shocks are drawn from a two-point zero-mean uniform distribution given by ed^+ and ed^-. Thus, 50% of sectors receive positive shocks of ed^+, while 50% receive negative shocks of ed^-. Trend aggregate nominal demand growth, gd, is non-stochastic. Lastly, the absolute value of sectoral demand growth shocks is greater than the trend rate ($|ed| > gd$) so that some sectors experience unemployment.

Nominal wage adjustment in each sector is governed by

$$gw_{i,t} = \begin{cases} 0 & ed_{i,t} < 0 \text{ and } p_t < p^{\wedge} \\ p_t & ed_{i,t} < 0 \text{ and } p_t > p^{\wedge} \\ gd + ed^+ - (1 - n_{t-1})/n_{t-1} & ed_{i,t} > 0 \end{cases} \tag{4}$$

where $gw_{i,t}$ is the sectoral nominal wage inflation and n_{t-1} is last period's aggregate employment rate. By (4), nominal wage adjustment is asymmetric. In sectors with unemployment (i.e. those receiving negative demand

[6]This represents a "quantity" based allocation principle which implies that sectoral labor supplies are independent of sectoral relative wages. This is a simplifying assumption, but there is also some economic justification if workers get such disutility from unemployment that they seek to maximize the likelihood of being employed.

[7]Real own product wages in each sector are fixed and determined exclusively by the mark-up, and sectoral employment depends only on sectoral demand. In this sense, there is no standard labor demand curve whereby real wages determine employment.

shocks), nominal wages are fixed as long as $p < p^{\wedge}$. If $p > p^{\wedge}$, they increase at the rate of inflation. In sectors at full employment (i.e. those receiving positive demand shocks), nominal wages are bid up to market clearing levels. The increase is equal to the growth of nominal demand minus the growth of real output resulting from employing the existing sectoral pool of unemployed.

The change in the sectoral rate of unemployment is

$$dU_{i,t-1} = \begin{cases} (ed^{-} - gd)n_{t-1} & ed_{i,t} = ed^{-} \text{ and } p_t < p^{\wedge} \\ (ed^{-} + p - gd)n_{t-1} & ed_{i,t} = ed^{-} \text{ and } p_t \geq p^{\wedge} \\ (1 - n_{t-1}) & ed_{i,t} = ed^{+} \end{cases} \quad (5)$$

The unemployment rate increases in sectors receiving negative shocks. Trend nominal demand growth (gd) reduces unemployment, but this effect is overwhelmed by the negative demand growth shock (ed^{-}). If $p > p^{\wedge}$, then wages and prices increase in sectors with unemployment and this further diminishes the impact of nominal demand growth and further adds to unemployment. Lastly, unemployment is eliminated in sectors receiving positive nominal demand shocks, with the decrease equaling the beginning of period sectoral unemployment rate of $1 - n_{t-1}$.

The economy is in macroeconomic equilibrium when the aggregate unemployment rate is constant. There are also two regimes corresponding to a high ($p_t \geq p^{\wedge}$) and low ($p_t < p^{\wedge}$) inflation regime. This implies the following equilibrium conditions:

$$dU_t = \begin{cases} -0.5(1 - n_{t-1}) + 0.5(ed - gd)n_{t-1} = 0 & p_t < p^{\wedge} \\ -0.5(1 - n_{t-1}) + 0.5(ed + p_t - gd)n_{t-1} = 0 & p_t \geq p^{\wedge} \end{cases} \quad (6)$$

where ed is the absolute value of the demand growth shock.

Product prices are a fixed mark-up over average costs, so that aggregate equilibrium inflation is[8]

$$p_t = \begin{cases} 0.5[gd + ed - (1 - n^*)/n^* - gs] - 0.5gs & p_t < p^{\wedge} \\ 0.5[gd + ed - (1 - n^*)/n^* - gs] + 0.5(p_t - gs) & p_t \geq p^{\wedge} \end{cases} \quad (7)$$

where gs is the non-stochastic trend rate of productivity growth and n^* is the equilibrium employment rate. The logic of (6) is that 50 per cent of sectors are at full employment and prices in these sectors rise at the rate of nominal wage inflation less any labor productivity growth. The other 50 per cent of sectors have unemployment. If inflation is below the inflation threshold, prices in these sectors fall by the rate of labor productivity growth. If inflation is above the threshold, prices rise by the aggregate rate of inflation

[8]The sectoral price level is given by $P_{i,t} = (1 + m)w_{i,t}/a$ where m is the mark-up and a is labor productivity. The parameters m and a are assumed to be the same across sectors.

(which determines the rise in nominal wages) less the rate of productivity growth.

Solving (6) and (7) yields

$$n^* = \begin{cases} 1/(1+ed-gd) & p_t < p^\wedge \\ 1/(1+ed-gs) & p_t \geq p^\wedge \end{cases} \tag{8}$$

$$U^* = \begin{cases} (ed-gd)/(1+ed-gd) & p_t < p^\wedge \\ (ed-gs)/(1+ed-gs) & p_t \geq p^\wedge \end{cases} \tag{9}$$

$$p^* = \begin{cases} gd-gs & p_t < p^\wedge \\ gd-gs & p_t \geq p^\wedge \end{cases} \tag{10}$$

Lastly, substituting (9) into (10) and rearranging yields the Phillips equation, which is given by

$$p^* = \begin{cases} 1+ed-gs-1/(1-U^*) & p_t < p^\wedge \\ gd-gs & p_t \geq p^\wedge \end{cases} \tag{11}$$

Equation (11) show the Phillips curve to have a discrete break when $p_t \geq p^\wedge$. For inflation rates greater than $p^\wedge$, it is vertical. For inflation rates less than $p^\wedge$, the slope is negative and given by

$$\frac{dp^*}{dU^*} = \frac{-1}{(1-U^*)^2}$$

Moreover, it is convex to the origin. Such a Phillips curve is shown in Fig. 3. Finally, differentiating (9) with respect to ed yields

$$\frac{dU^*}{ded} = \frac{1}{(1+ed-gd)^2} > 0$$

Increases in the variance of demand shocks, measured by ed, raise the equilibrium unemployment rate. This is consistent with the empirical findings of Lillien (1982) who reports that the unemployment rate is very sensitive to increases in the variance of sectoral employment growth rates. Lastly, inspection of (11) shows that the long-run equilibrium rate of inflation is unaffected by the variance of sectoral demand shocks, a finding that contradicts claims made by early neo-Keynesian Phillips curve theorists (Archibald, 1969; Tobin, 1972; Brechling, 1973).

6.2 A Continuous Backward-bending Phillips Curve

The above Phillips curve shows a discrete break when inflation hits the real wage adjustment resistance threshold of $p^\wedge$. This is because all sectors share this threshold. However, the backward-bending Phillips curve will be con-

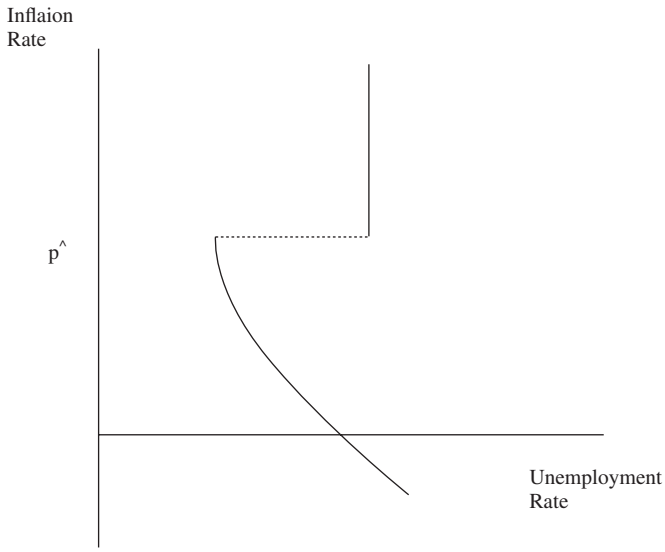

FIG. 3 The Backward-bending Phillips Curve with a Discrete Break owing to a Commonly Shared Inflation Resistance Threshold

tinuous if this resistance threshold differs continuously across sectors. Suppose $p^{\wedge}$ is the inflation rate at which real wage resistance first occurs in some sectors, and $p^{\wedge\wedge}$ is the inflation rate at which it appears in all sectors ($p^{\wedge\wedge} > p^{\wedge}$).

Moreover, suppose the distribution of resistance is spread uniformly across sectors. In this case, when $p_t \leq p^{\wedge}$ no sectors show resistance to real wage adjustment via inflation. When $p_t \geq p^{\wedge\wedge}$ all sectors show resistance to real wage adjustment via inflation. Finally, when $p^{\wedge} \leq p_t < p^{\wedge\wedge}$ a fraction $z = (p_t - p^{\wedge})/(p^{\wedge\wedge} - p^{\wedge})$ show resistance, and fraction $1 - z$ show no resistance.

There are now three regimes of wage adjustment: one in which all sectors with unemployment ignore inflation, a second where some sectors with unemployment ignore inflation, and a third where all sectors with unemployment fully incorporate inflation. Given this, the equilibrium conditions defining points on the long-run Phillips curve are given by

$$p_t = \begin{cases} 0.5[gd + ed - (1-n^*)/n^* - gs] - 0.5gs & p_t < p^{\wedge} \\ 0.5[gd + ed - (1-n^*)/n^* - gs] + 0.5[z(p_t - gs) - (1-z)gs] & p^{\wedge} \leq p_t < p^{\wedge\wedge} \\ 0.5[gd + ed - (1-n^*)/n^* - gs] + 0.5(p_t - gs) & p_t \geq p^{\wedge} \end{cases} \quad (6a)$$

$$dU_t = \begin{cases} -0.5(1-n_{t-1}) + 0.5(ed-gd)n_{t-1} = 0 & p_t < p^{\wedge} \\ -0.5(1-n_{t-1}) + 0.5[z(ed+p_t-gd)n_{t-1} & \\ \quad + (1-z)(ed-gd)n_{t-1}] = 0 & p^{\wedge} \le p_t < p^{\wedge\wedge} \\ -0.5(1-n_{t-1}) + 0.5(ed+p_t-gd)n_{t-1} = 0 & p_t \ge p^{\wedge} \end{cases} \tag{7a}$$

Solving (6a) and (7a) for the region where $p^{\wedge} \le p_t < p^{\wedge\wedge}$ yields

$$n^* = 1/[1+ed-(1-z)gd-zgs] \tag{8a}$$

$$U^* = \frac{ed-(1-z)gd-zgs}{1+ed-(1-z)gd-zgs} \tag{9a}$$

$$p^* = gd - gs \tag{10a}$$

The economy-wide Phillips curve now consists of three segments. For rates of inflation $p_t < p^{\wedge}$ it is negatively sloped. For rates of inflation $p_t \ge p^{\wedge\wedge}$ it is vertical. For the region where rates of inflation are $p^{\wedge} \le p_t < p^{\wedge\wedge}$ it is bow shaped. It can be shown by differentiating (8a) with respect to gd that the minimum attainable rate of unemployment corresponds to a rate of inflation given by $p = p^{\wedge\wedge}/2$. The associated rate of nominal demand growth is $gd = p^{\wedge\wedge}/2 - gs$. Such a Phillips curve is shown in Fig. 4.

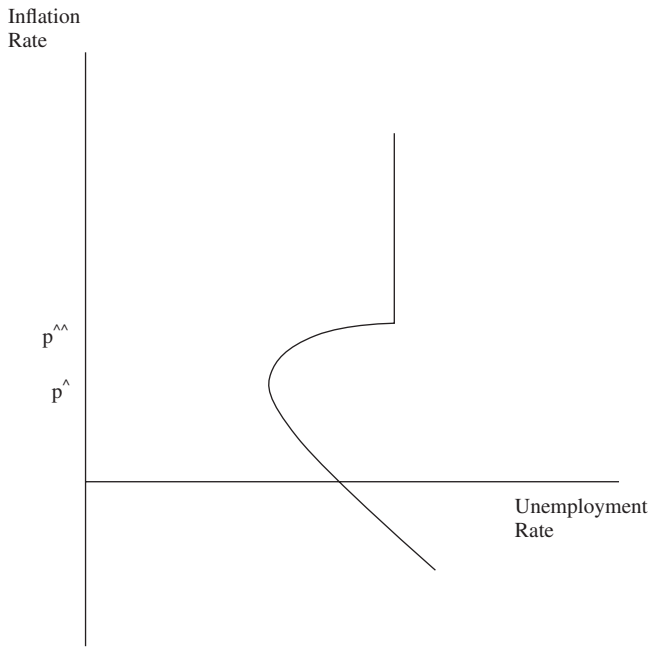

FIG. 4 The Continuous Backward-bending Phillips Curve in which the Inflation Resistance Threshold Varies Across Sectors

Even as the inflation rate rises above $p^{\wedge}$ the Phillips curve will remain negatively sloped, but it will steepen rapidly. In some sectors real wage resistance kicks in, causing unemployment in those sectors to jump as nominal wage and price increases now fully cancel out the effect of sectoral nominal demand growth. In these sectors the grease effect of inflation is forfeited. However, in other sectors marginally higher inflation results in a marginally larger grease effect. As inflation further increases, more and more sectors hit the resistance threshold, causing unemployment in those sectors to jump. Eventually, the cumulative jump in unemployment in sectors hitting the resistance threshold outweighs the marginal employment grease effect of faster nominal demand growth in those sectors not yet displaying real wage resistance. At this point the Phillips curve bends backwards, and further increases in the inflation rate add to unemployment because the resistance effect now dominates the marginal grease effect.

Finally, the exact turning point in the Phillips curve depends on the resistance threshold $p^{\wedge\wedge}$. This threshold may be influenced by social factors. For instance greater wage militancy in society would shift it down, in which case the minimum attainable unemployment rate would increase, and the Phillips curve would become vertical at a lower rate of inflation.

7 Policy Implications

The above model has important policy implications. The theory of the backward-bending Phillips curve implies that there is a MURI corresponding to that unemployment rate at which the Phillip curve bends backwards. The MURI offers an alternative policy framework to the NAIRU. It also offers a clear rationale for low inflation targeting which has become a popular recommended monetary policy strategy in recent years. Policymakers interested in minimizing the unemployment rate should target the MURI. This contrasts with NAIRU models which offer little theoretical support for low inflation targeting. In these models, if there are no costs to adjusting inflation, all inflation rates are equally optimal; if there are costs to lowering the inflation rate, then the current inflation rate is optimal. If there are shoe leather costs to inflation, then zero inflation is optimal.

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