# The Range of Equilibria, Inflation Targeting and the Non-inflationary Expansion

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**ABSTRACT**

This paper shows how using inflation targeting to set monetary policy can facilitate a non-inflationary expansion, that is a permanent increase in aggregate activity without causing an increase in the rate of inflation. This result is derived from a model with a range of equilibrium rates of unemployment. The micro-foundations of the model draw on ideas of reference dependence and loss aversion. Using an inflation target to set monetary policy is a way of influencing expected prices and thus inflation. Through this control of inflation, monetary expansion can cause a non-inflationary expansion in the level of activity without rational expectations of inflation being violated.

## 1. Introduction

This paper shows how using inflation targeting to set monetary policy can facilitate a permanent decrease in unemployment without causing an increase in the rate of inflation, that is a non-inflationary expansion or NIE. By using inflation targeting we mean making the rate of inflation the primary objective of monetary policy, with the level of activity as a secondary objective. Alternatively put, monetary policy is set to achieve the best activity result subject to satisfying the inflation target. Thus there would be a clear hierarchy in targets, with inflation first and activity second.[1] The argument of the paper is based on a macroeconomic model in which there is a range of equilibrium rates of unemployment.

Successive governors of the Reserve Bank of Australia have linked the inflation target to an NIE.[2] Bernie Fraser (1993, p.3), the Governor of the Reserve Bank of Australia when announcing the introduction of the inflation target in 1993, at a time when the rate of unemployment was very high, said that "The task now is to hold the gains on inflation while releasing the brake on activity". More recently, Ian MacFarlane (2000, p.1), the current Governor of the Reserve Bank of Australia, argued along similar lines that "the aims of a monetary policy based on inflation targeting…is to maximise the length of the economic expansion" and that expansions can only be sustained if they are accompanied by low inflation.

There is evidence that countries that use an inflation target to set monetary policy have indeed enjoyed permanent non-inflationary expansions and in this regard have fared

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[1] Governor Laurence Meyer of the US Federal Reserve Board, in describing the inflation targeting regime that he prefers, has expressed a preference for a "dual mandate" over a "hierarchical mandate". In his ideal inflation target regime, low and stable inflation is described as "essential", while for output monetary policy is recognised as able to make "some contribution", see Meyer (2001). This ranking is consistent with our definition of hierarchical. Governor Meyer's concern is that hierarchical may be interpreted as placing too low a weight on output. In the model of this paper, in which there is a range of equilibrium rates of unemployment, there is a strong case for including output in the objectives of the monetary authority, but as a secondary objective.

[2] The views and intentions of policymakers are particularly relevant for the inflation target because it was policymakers rather than academic economists who developed the concept. Debelle and Stevens (1995, p.1) have pointed out that "(I)t is striking that this trend (the increasing popularity of inflation targeting), unlike the adoption of monetary targets in the mid 1970's, has not been influenced much by academic discussion of the appropriate operational features of monetary policy...there is a relative paucity of academic literature on operating monetary policy with explicit inflation targets. Instead the discussion has been driven by central banks grappling with current problems." For example, Barro and Gordon (1993), a paper often cited to support the idea of an inflation target, does not mention the idea.

better than other countries.[3] Between 1993, the trough of the 1990's recession, and 1998, of the seven major OECD countries, the three inflation-targeting countries (UK, Canada and US) experienced large decreases in unemployment (the average decrease in unemployment for these three countries was 3.1 percentage points) and very little change in their rates of inflation.[4] In contrast, the four countries that did not target inflation (France, Germany, Japan and Italy), although experiencing about the same change in inflation, did not enjoy a decrease in unemployment. In fact for these four countries the average rate of unemployment increased by 1.3 percentage points over 1993 to 1998. The best result for unemployment of the four non-inflation targeting countries was France, which experienced no change. This was dominated by the smallest decrease in unemployment of the inflationary targeting countries; that was the US, which experienced a decrease of 2.4 percentage points.[5] As Bernanke et al (1999, p.282) concluded from reviewing cross-country evidence, "…in the inflation-targeting countries, inflation rises less than would be expected during the subsequent period of renewed output growth, a finding consistent with our evidence that inflation expectations in these countries remain relatively tame in the face of strong business-cycle upturns".[6]

The inflation target appears to have been successful in facilitating permanent falls in unemployment without inflation increasing. This paper presents a theoretical model that

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[3] The fact that inflation did not increase suggests that these expansions can be regarded as permanent.

[4] The US does not have a quantitative target for inflation, for which it is criticised in Bernanke et al (1999). However since the early 1980's the US Federal Reserve has expressed a strong preference for low and stable inflation and in that sense can be thought of as an inflation targeter, see Bernanke et al (1999, p.310).

[5] The changes in unemployment and inflation respectively for the 7 countries were; –4.2, -0.1 (UK); -2.8, -2.1 (Canada); -2.4, -1.5 (US); 0, -1.5 (France); 1.0, -2.7 (Germany); 1.6, -0.2 (Japan); and 2.0, -1.1 (Italy). For the smaller OECD countries, the impact of inflation targeting is not so great. The average reduction in unemployment for the five inflation targeters (Finland, Spain, Australia, New Zealand and Sweden) was 2.9 percentage points. The average for the eight countries without an inflation targeting policy (Ireland, Denmark, Norway, Netherlands, Portugal, Luxembourg, Belgium, Austria and Switzerland) was 1.9 percentage points. (Countries are listed in order of the size of the reduction in unemployment). The average change in the rate of inflation was the same for these two groups of countries. Another way of summarising this evidence is that of the ten countries to enjoy a reduction in unemployment greater than two percentage points, six were inflation targeters (and only 40% of the 20 countries targeted inflation). Of these ten countries, only one of the six inflation targeters compared with two of the four non-inflation targeters experienced an increase in inflation.

[6] The empirical literature suggests that adopting an inflation target has not helped reduce inflation, or, in the words of Bernanke et al (1999, p.283), "inflation targeting may not reduce the costs of the transition to low inflation". This empirical result influences the argument of this paper, see below.

explains how the inflation target facilitates an NIE. In so doing, the paper presents a theoretical case for the inflation target.

This theoretical case is based on a model with a range of equilibrium rates of unemployment. [7] In this model, when the economy is within the range, actual prices and wages are determined by expected prices and wages. The impact of demand management policy within the range of equilibria therefore depends on the manner in which expected prices and wages are formulated. There are a number of possibilities, all consistent with rational expectations of inflation. When the expected price is proportional to the money supply, monetary policy will be neutral. When the expected price exhibits a nominal rigidity, monetary policy will be expansionary. For yet a third possibility, the formulation of expected prices may be fluid. In this case the impact of monetary policy is unpredictable. With expected prices playing an important role in determining actual prices, the case for inflation targeting is that the central bank, by targeting the current rate of inflation and thus the expected rate of inflation, can control the level of expected prices. It can then expand output through expansionary monetary policy. In this way, it is possible for the economy to experience a NIE.

The theories of the range of equilibria on which this paper is based make use of prospect theory and the associated concepts of reference dependence and loss aversion. In discussing prospect theory, Myagkov and Plott (1997, p.801) conclude that "…the substance of research from psychology is that preferences are labile…because the process used by individuals to make decisions is subject to subtle framing effects". This lability of preferences implies that the formation of expected prices may be fluid in an upswing. Economic agents will have trouble forming price expectations because they have to second-guess the views of other agents.[8] In this environment, an inflation target can coordinate price expectations and thereby yield a nominal rigidity.

In earlier literature on macroeconomic models with a range of equilibria, Woglom (1982) shows that whether an expansionary monetary policy can cause a permanent

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[7] In Lye, McDonald and Sibly (2001), the range of equilibria model outperforms the natural rate model, using Australian data 1967 to 1997. According to those estimates, Australia has been within the range of equilibria since 1977.

increase in output depends on the formation of expected prices. With "classical" expectations, that is the expected price is proportional to the money supply, monetary expansion will not affect the level of output. Woglom argues that classical expectations are not plausible if the monetary authority restricts its ambitions to stabilising real output within the range of equilibria. Instead it would be ex post rational for agents to not alter their expectations of the price level. This would be true even if agents are aware that the monetary authority is acting to increase aggregate demand. Thus by eschewing a policy of excessive expansion the monetary authority is argued to coordinate agents to hold rigid expectations of inflation. On the other hand, classical expectations and thus money neutrality are more plausible if the monetary authority persistently tries to force the level of output above the maximum equilibrium level.

Bhaskar (1990) presents a model in which loss aversion by workers implies that the workers' expected aggregate wage determines their actual wage when the economy is in the range of equilibria. He makes the same point as Woglom (1982), that the neutrality of pre-announced monetary policy depends on the change it induces in the expected aggregate wage. Bhaskar uses "monetarist" for the case described as classical by Woglom and Keynesian for the rigid expectations case. Bhaskar suggests that the coordination of expectations to achieve the highest equilibrium level of output could be achieved by incomes policy, in contrast to Woglom's suggestion that rigid expectations of price can be fostered by the monetary authority eschewing excessive expansion. Bhaskar also points out that if only a small fraction of unions form expectations in a backward looking adaptive manner then the remaining rational expectations agents will also follow the adaptive approach. Thus the presence of some adaptive unions will coordinate wage expectations across the economy and implies that monetary expansion can have real effects, "in the standard Keynesian manner", Bhaskar (1990, p.64).[9]

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[8] The experimental evidence presented by Fehr and Tyran (forthcoming) shows that the second guessing of other agents can have a significant impact on expected prices.

[9] Woglom (1982) also points out that a minority of agents can dominate the determination of the expected rate of inflation.

The argument of this paper is that a policy of targeting inflation is a way monetary authorities can control expected prices if the economy is in the range of equilibria.[10] If the primary objective of monetary policy is to ensure that actual inflation is always equal to the inflation target, the inflation target will become the equilibrium for expected inflation. Having established control over inflation, increases in aggregate demand, due to aggregate demand policy or to technical progress or whatever, will reduce the rate of unemployment without increasing the rate of inflation. That is, using the terminology of Bhaskar, expected prices will behave according to the Keynesian case. As a consequence a non-inflationary expansion is possible. Thus an inflation target can facilitate the achieving of better equilibria, that is equilibria closer to the minimum equilibrium rate of unemployment. Of course, as will be seen, for this non-inflationary expansion to occur the economy has to be within the range of equilibrium levels of output. The upper boundary of the range puts a limit on the non-inflationary expansion.

The possibility shown in this paper for an inflation target to facilitate a non-inflationary expansion is a justification for adopting an inflation target to guide the setting of monetary policy. Note that this justification is different from the traditional argument used to justify an inflation target. The traditional argument is that an inflation target can reduce inflation bias through restraining the incaution of policy makers, who may otherwise attempt to push the level of activity above the natural level (that is in the language of this paper the upper boundary of the range of equilibria), see eg Fischer (1995), Haldane (1995), Leiderman and Svensson (1995) and Bernanke et al (1999). This argument is based on the time inconsistency argument of Kydland and Prescott (1977) and Barro and Gordon (1983). In the conclusion, the relation between these two arguments for an inflation target is discussed.

The paper proceeds in the following way. In section 2 the model that captures the various microeconomic foundations of the range of equilibria relevant for this paper, that is customer markets and wage bargaining, is presented. In section 3 the money market is introduced to give macro closure. Section 4 derives the range of equilibria. Section 5 shows

[10] Mishkin and Schmidt-Hebbel (2001, p.10) conclude from empirical evidence that inflation targeting "may have helped in…guiding inflation expectations".

how the impact on unemployment of monetary policy depends on the process by which the expected prices are formed. The way in which inflation targeting can facilitate an NIE is shown in Section 6. Section 7 shows that there are employment gains that the inflation target may be unable to realise. Section 8 discusses how tight money can counter increases in the rate of inflation during an NIE. Section 9 concludes the paper.

## 2. The microeconomic foundations of the range of equilibria

In this section, a model is presented that captures various mechanisms from which a range of equilibrium rates of unemployment can be derived. The mechanisms arise from buyer-seller relationships, sometimes called customer markets, in selling goods and in wage bargaining. The common feature, from which a range of equilibria follows, is the implied kinks in the firm's revenue function and the worker's utility function. These mechanisms have been developed in other papers, see below. A characteristic of these mechanisms that is crucial to the argument of this paper is that the position of the kinks in the firm's revenue function and the worker's utility function is determined by the expected price and the expected wage respectively.[11] Our model is put forward as a succinct summary of these papers and is then used to make a case for using an inflation target to guide the setting of monetary policy.

The microeconomic foundation of the model is determined by the representative firm simultaneously choosing price and bargaining over wages with its workers, who may be represented by a union. [12] The firm chooses price and, inter alia, employment to maximise profits. The outcome of worker-firm wage negotiations is determined by the standard approach in the theory of wage bargaining, cooperative game theory. Specifically, the wage bargain satisfies the asymmetric Nash bargaining solution (see Eichberger, (1993), Ch 9).

The representative firm's payoff, real profit, $\Pi$, is given by:

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[11] There are other theories of the range of equilibria, such as the downward rigid money wage theory of Akerlof, Dickens and Perry (1996) that do not have this characteristic and so would not provide a satisfactory basis for our case in this paper for an inflation target.

[12] Alternatively, the payoff captures an individual worker's interests if workers are non-unionised but have insider power as put forward by Lindbeck and Snower (1988). Insider power sets limits to the wage within which the solution to the bargaining problem will lie. Lindbeck and Snower's theory of insider power provides a source of worker bargaining power regardless of whether workers are unionised. Indeed it can be regarded as providing a reason for unions to exist.

$$\Pi = PY(P,P/P^E) / \overline{P} - VL \qquad (1)$$

where P is the firm's price, $P^E$ is the expected price $\overline{P}$ is the aggregate price level (treated as exogenous by each economic agent), L is employment, V is the real wage and $Y(P,P/P^E)$ is the demand for output. The firm has the production function:

$$Y = F(L) \qquad (2)$$

Hence, by the implicit function theorem, $L = L(P,P/P^E)$. Define $L^E = L(P^E,1)$. Profit can therefore be written as:

$$\Pi(V, L, L^E) = [R(L, L^E)/ \overline{P} ]-VL, \qquad (3)$$

where $R(L, L^E)$ is the nominal value of the firm's revenue function. Assume $R_L(=dR/dL)>0$, $R_{LL}<0$ for all $L\geq 0$ except, to capture the kink in the revenue function referred to above, $L=L^E$.

A kink in the firm's revenue function can be caused by an asymmetry between the firm's customers and its potential customers in the receipt of information about the firm's price. The importance of this asymmetry in sales response was originally put forward and analysed by Scitovsky (1952, pp.272-81). For more recent analysis and discussion see Stiglitz (1979), Okun (1981), Woglom (1983), McDonald (1987), (1995), and Sibly (2001a). The basic idea of the Scitovsky effect is this. Existing customers learn relatively quickly about changes in the firm's price; potential customers, who patronise other firms, learn relatively slowly about changes in the firm's price. This asymmetry implies an asymmetry in the response of sales to price increases compared with price decreases. Price increases will rapidly induce existing customers to purchase elsewhere causing a rapid decrease in sales; price decreases lead to only a slow increase in customers and sales as potential customers slowly become informed of the price decrease. The price around which this asymmetry is centred is the expected price, that is the price existing customers believe is offered by the competing firms, that is the firms they do not patronise. In an inflationary

situation, this price will increase according to the expected rate of inflation because customers will expect the prices at the competing firms to increase at the rate of inflation.

Another mechanism that can cause a kink in a firm's revenue function is based on combining the concepts of reference dependence and loss version. This mechanism has been put forward in Sibly (2001b), drawing on work by Kahneman, Knetsch and Thaler (1986) and Tversky and Kahneman (1991). Sibly argues that a customer has a disposition towards a firm and that this disposition will influence the size of the customer's purchases from the firm. The customer's disposition toward a firm will depend on how the firm's price compares to the customer's reference price. Furthermore, Sibly argues that the response of the customers's disposition to the firm to variations in actual price relative to the reference price will be characterised by loss aversion. In particular if the customer discovers that price is above the reference price then the customer's disposition towards the firm will be radically reduced. On the other hand a price below the reference price will increase the customer's disposition to the firm by a relatively small amount. In consequence the effect on sales of price variations around the reference price will be asymmetric, yielding a kinked revenue function similar to that in the customer market case above.

In support of this theory, Sibly points out that psychological studies have found reference dependence to be a natural part of human decision making (see Tversky and Kahneman, 1991 for a discussion and theoretical approach). The literature emphasises that the manner in which a transaction is 'framed', particularly its social context, has an important influence on the determination of the reference level (see Kahneman, Knetsch and Thaler (1986) and Tversky and Kahneman (1991)). Using concepts of price, that is the comparison by customers of the actual price with a reference price, to determine their disposition to the firm follows from the fact that the price represents the 'terms of trade' in the transaction between customer and firm.

It is also reasonable to argue that the reference price will move with the general price level such that in an inflationary situation the reference price will increase with the expected rate of inflation. Kahneman, Knetsch, and Thaler (1991) note that experimental literature distinguishes two bases for the formation of reference levels: the 'status quo' and

fairness. Thus the reference price can be either the 'existing' price or the 'fair' price.[13] In either case the reference price can be argued to increase with the rate of inflation. This follows directly if the reference price represents the status quo. In the alternative case, observe that, if the reference price increases with the rate of inflation, its real price remains the same and the firm's real profit remains the same. In this respect, increasing the reference price at the inflation rate would be perceived by customers as fair. From this, the reference price increases in line with the expected rate of inflation.

The Scitovsky customer market theory and the reference dependence theory mutually reinforce each other in establishing the kink in the revenue function. The proclivity of people for the buyer-seller relationships that are central to the reference dependence theory provide a reason for repeat purchasing, that is for customers to exist. The repeat purchasing provides a scenario in which the Scitovsky effect will operate, thereby reinforcing the kink that is produced by the reference dependency theory.[14]

Formally the kink in the firm's revenue function can be described by restrictions placed on the left and right hand derivatives of the firm's revenue function at $L = L^E$. Let the left hand derivative of R(.) with respect to L at $L = L^E$ be denoted $R_L^-$ and the right hand derivative of R(.) with respect to L at $L = L^E$ be denoted $R_L^+$. The kink in the demand curve at $P = P^E$ implies $R_L^- > R_L^+$.

To incorporate into wage bargaining the experiential finding that reference dependence and loss aversion is part of human decision making, the worker's utility function is specified with a kink at the wage equal to the reference wage. Through this kink, the weight workers place on a reduction in their wage relative to their reference wage is greater than the weight they place on an increase in their wage relative to their reference wage. The implications of reference dependence and loss aversion for wage setting has been discussed

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[13] Kahneman, Knetsch, and Thaler (1986 pp. 730-1) note that people eventually 'adapt their views of fairness to the norms of actual behavior'. Thus, with time, the status quo becomes to be perceived as fair 'because it is normal, not necessarily because it is just'.

[14] Okun's description of customer markets, Okun (1981, pp.138-55) is mainly based on the Scitovsky information asymmetry. However, he also brings in fairness considerations, for example when arguing that firms are more likely to increase prices following increases in costs than following increases in demand. Kahneman, Knetsch, and Thaler (1986) use Okun's analysis of customer markets to introduce their analysis of fairness.

by Akerlof (1984), Bhaskar (1990) and McDonald and Sibly (2001). The reference wage is reasonably identified with the wage the worker expects other, similar, workers to receive, as in Bhaskar (1990). However it could also be specified as the wage expected on the basis of previous trends. It can be specified in nominal or real terms. Bhaskar (1990) assumes that the reference wage is in nominal terms. Through most of this paper we choose the real specification but in Section 6 we show how the two different specifications can yield different results in some situations. In either case the reference wage would increase with the trend growth in real wages.[15]

Formally the kink arising from loss aversion by workers in wage bargaining is described as follows. The workers utility function is $U(V, V/V^E)$ where $V^E$ is the expected real wage. It is assumed that $U_1 (=\partial U/\partial V)>0$, $U_{11}<0$, $U_2(=\partial U/\partial(V/V^E))>0$, $U_{22}<0$ for all $V\geq 0$ except $V=V^E$. At $V=V^E$ the following restrictions are placed on the left and right hand derivatives of the worker's utility function with respect to $V/V^E$. Let the left hand derivative of U(.) with respect to $V/V^E$ at $V=V^E$ be denoted $U_2^-$ and the right hand derivative of U(.) with respect to $V/V^E$ at $V=V^E$ be denoted $U_2^+$. Loss aversion by workers is captured by assuming $U_2^- > U_2^+$.

Under the asymmetric Nash Bargaining solution, agents negotiate their payoff from a fallback position. It is assumed that the firm's payoff is its profits, as given by (3). The workers' payoff is their utility as described above. The fallback position of the workers and firm is the value of utility and profits when negotiations fail. It is assumed that the firm does not operate if negotiations fail, hence fallback profit is zero. Workers' fallback utility is $U(V^D)$, where $V^D$ is the real value of the next best alternative to working at the firm. The wage bargain is therefore determined by:

$$\underset{V}{\text{Maximise}} \qquad NM = [U(V, V/V^E)-U(V^D)]^{\phi}[R(L, L^E)/\overline{P} -VL]^{(1-\phi)} \qquad (4)$$

[15] If, as is usually the case, actual bargaining sets the nominal wage then the bargain would specify the nominal wage to increase with the price level.

where $\phi$ is the relative power in bargaining of the workers ($0<\phi<1$).[16]

The presence of kinks in the revenue function and the workers utility function implies a range of equilibrium values of both the price and the bargained wage. Within these ranges the profit maximising price will be determined by the expected price and the bargained wage will be determined by the expected wage. The range within which the profit-maximising price can fall is familiar from the well-known analysis of the kinked demand curve. The kinked revenue function implies a step in the marginal revenue curve. Should marginal cost lie between these extremities then the profit maximising price is determined by the expected price. For the range of the bargained real wage, note that bargaining theory implies the bargained wage maximises the joint surplus, as in (4). The outcome determines the bargained wage as a mark-up on strike income, $V^D$.[17] Because the value of the joint surplus as a function of the wage is kinked at the expected wage, the wage mark-up falls within a range of values. Thus for a given value of $V^D$ there is a range of values of the wage consistent with maximising the joint surplus. Should the expected wage lie within this range then it will determine the bargained wage.

These results can be stated formally as follows:

Proposition 1 $P = P^E$ and $V = V^E$ if:

$$R_L^+ / \bar{P} \leq V^E \leq R_L^- / \bar{P} \qquad (5)$$

and

$$V^{MIN}(L) \leq V^E \leq V^{MAX}(L) \qquad (6)$$

where $V^{MIN}(L)$ is determined by

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[16] Note that employment does not enter the payoff to the worker after a bargaining agreement is reached. This payoff is the specification in the model of the insider-dominated union as in McDonald (1991). The idea is that the unemployed workers and those workers facing significant risk of unemployment have no influence over bargaining, because unemployed workers are not members of the union and workers at risk of unemployment are too junior to count effectively in the union's decision-making, reflecting the impact of a seniority system in layoffs. Because of this the union is not concerned about the implication of the bargained wage for employment. However re-specifying the payoff to incorporate the level of employment does not change the results.

[17] From the first order condition for (4), a given value of $V^D$ determines the bargained wage, and thus the wage mark-up as a function of $V^E$, $P^E$, the elasticity $\Psi$ and the curvature of the utility function.

$$\phi[U_1(V^{MIN},1)+(U_2^{+}(V^{MIN},1)/V^{MIN})]/[U(V^{MIN},1)-U(V^{D})]$$
$$= (1-\phi)L/[\Pi(V^{MIN}, L, L^{E})] \quad (7)$$

and $V^{MAX}(L)$ is determined by:

$$\phi[U_1(V^{MAX},1)+(U_2^{-}(V^{MAX},1)/V^{MAX})]/[U(V^{MAX},1)-U(V^{D})]$$
$$= (1-\phi)L/[\Pi(V^{MAX}, L, L^{E})] \quad (8)$$

The derivation of proposition 1 is given in the appendix. The functions $R_L^{+}$, $R_L^{-}$, $V^{MIN}(L)$ and $V^{MAX}(L)$ form the boundary of the equilibrium values of V and L.

## 3. The money market and the price level.

It is assumed that in the economy there are n identical producers. Therefore the wage determined by the individual bargain described above is the economy wide wage. Assuming to simplify notation and without loss of generality that n=1, the aggregate level of output, Y, is given by equation (2). The demand for money is equal to the volume of nominal transactions per period. This is given by $PY/\upsilon$, where $\upsilon$ is the exogenously fixed velocity of money and, because there is one firm we can, when moving to the macro level, identify the firm's price P with the aggregate price level $\overline{P}$. Equilibrium is given when demand for money equals its supply, i.e.

$$PY = M\upsilon \quad (9)$$

## 4. The diamond of equilibria

The range of equilibrium values of the marginal revenue product of labour and the range of equilibrium values of the real wage imply a range of equilibrium levels of employment. This range is illustrated in Figure 1. For ease of analysis $V^{MIN}(L)$ and $V^{MAX}(L)$ are depicted in Figure 1 as independent of L, although this need not be the case. Two curves of the real value of the marginal revenue product of labour are shown, $R_L^{+}/P$ and

$R_L^-/P$. $R_L^+/P$ is the real value of marginal revenue when the firm is on the verge of cutting output price and $R_L^-/P$ is the real value of marginal revenue when the firm is on the verge of increasing output price. The above analysis implies that any $R_L/P$ between $R_L^+/P$ and $R_L^-/P$ is consistent with equilibrium. Loss aversion in wage bargaining implies that any wage in the range $\{V^{MIN}, V^{MAX}\}$ can be an equilibrium. The two horizontal lines at $V^{MIN}$ and $V^{MAX}$ are the extremum of the wage setting curves and so labelled $V^{MIN}(L)$ and $V^{MAX}(L)$. Thus any outcome in the diamond described by $\{V^{MIN}, V^{MAX}, R_L^+/P, R_L^-/P\}$ can be an equilibrium. We call this the diamond of equilibria.

The model of wage bargaining can also be represented in money wage/employment space, as in Figure 2. This representation will be useful below in considering the NIE. In Figure 2, assuming $P=P_1$, the money value of $V^{MAX}$, $P_1V^{MAX}$, is shown at the level equal to the value at the bottom of the step in the firm's marginal revenue product of labour curve, $R_L^{MAX}$ at $L=L^{MIN}$. Assuming that the implied profit-maximising price, $P_1$, is equal to $P^E$, $L^{MIN}$ as drawn in Figure 2 is a macro-equilibrium, i.e. in equilibrium the price people expect is equal to the actual price. It is also, given the values of $P^E$ and $V^{MAX}$, the lowest equilibrium level of employment. To see this, consider, holding $P^E$ constant, a lower level of demand for the firm's product. The ARPL curve and $R_L$ curve would lie to the left of $ARPL^{MAX}$ and $R_L^{MAX}$. Because of diminishing returns to labour, the kink in the ARPL curve will lie above the kink in $ARPL^{MAX}$ and the bottom of the step in the $R_L$ curve will lie above the bottom of the step in $R_L^{MAX}$. In consequence, the profit maximising price will be less than $P_1$ and so this level of demand combined with $P^E=P_1$ is not an equilibrium. But there are higher levels of demand than $ARPL^{MAX}$ that, along with $V=V^{MAX}$ and $P^E=P_1$, will be consistent with a profit maximising price of $P_1$. A higher level of demand can place ARPL and $R_L$ to the right of $ARPL^{MAX}$ and $R_L^{MAX}$ such that $P_1V^{MAX}$ is within the step of $R_L^{MAX}$ and so the profit maximising price will remain $P_1$. A similar argument establishes that, with a wage of $V^{MIN}$ and $P^E=P_1$, the highest level of demand consistent with equilibrium is given by $ARPL^{MAX}$.

## 5. How the real impact of monetary expansion depends on the response of expected wage and price levels

While the range of equilibrium rates of unemployment presents in principle the possibility that money is non-neutral, that is not guaranteed. It is shown in this section that whether expansionary monetary policy can move the economy within the range from one equilibrium to another with a lower rate of unemployment depends on the reaction of expected prices and wages to monetary policy. Our discussion draws on Woglom (1982) and Bhaskar (1990). Because the behaviour of the model depends on whether the economy is on the eastern facet of the diamond of equilibria, as shown in Figure 1, we focus in this section on the case where the equilibrium wage outcome is to the west of the eastern facet. We consider the eastern facet in a later section of the paper.

Money is neutral if the reference wage is specified in real terms, (eg. the reference wage may be the real wage in the previous period) and changes in the expected price, $P^E$, are proportional to the changes in the money supply. In this case P is proportional to the money supply and so by (2) and (9) output and employment are fixed.

However, if the reference wage is specified in real terms and changes in the expected price are not proportional to M, then monetary policy is not neutral. Suppose $P^E$ is fixed in nominal terms. Then (2) and (9) implies employment and output increase as the money supply increases. In terms of Figure 1, the economy moves horizontally to the right. Intuitively, an increase in the money supply reduces the price/marginal cost margin, shifting the curve of the real value of the marginal revenue product of labour, $R_L/P$ (not shown in Figure 1 but lying somewhere between $R_L^+/P$ and $R_L^-/P$) upwards, thus leading, at a given real wage, to an expansion of

employment and output.[18] This is an NIE.

It is useful to consider the NIE in money wage-employment space, as shown in Figure 3. Initially the money supply places the ARPL and $R_L$ at $ARPL_1$ and $R_{L,1}$. The wage-employment outcome is at $\{P_1V_1, L_1\}$. The increase in the money supply shifts the ARPL and $R_L$ to the right to $ARPL_2$ and $R_{L,2}$. Because $P_1V_1$ is within the step of $R_{L,2}$ the firm will expand L to $L_2$ without changing price or wage. The economy has enjoyed an NIE.

If instead, the increase in the money supply triggered an increase in $P^E$, as in the classical case, then ARPL and $R_L$ would be shifted upwards. In consequence the profit maximising price would increase. This would reduce or even nullify any increase in real aggregate demand and thus any increase in output.

The above two plausible examples of expected price formation shows the model embodies both classical behaviour (if $P^E$ is proportional to M) and Keynesian behaviour (if $P^E$ is fixed in nominal terms). An intermediate case is where expectations are "fluid". In this case, because of the framing effects suggested by prospect theory, it is hard for people to predict how other people will adjust their expectation of inflation in the event of a monetary expansion. People may decide to take a chance that wages and prices will increase, fearful of falling behind the living standards of others, and so push for increases in their wages and prices. Or people may fear the consequences of setting their wages and prices ahead of others, thereby losing transactions, and so not increase wages and prices.

We now consider how an inflation target can influence the behaviour of expected prices and thereby the effect of changes in the money supply.

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[18] Note that the increase in employment discussed here occurs without a reduction in the real wage. Even although returns to labour diminish, the contraction of the price/marginal cost markup due to the customer market assumption, allows the real wage to be unchanged. This property of the model, that there can be little or no cyclical variation in real wages is consistent with observed pattern of employment and wages over the business cycle (see Abrahams and Haltiwanger (1995)). It will be seen below that this property does not hold on the eastern facet.

## 6. Inflation targeting and expected wage and price levels

From the above section it is clear that the impact of monetary policy depends critically on the way in which the expected price and expected wage are determined. If they are proportional to the money supply then monetary policy is neutral. If they are rigid then monetary policy can create an NIE. If they are "fluid" then monetary policy has unpredictable effects.

By announcing an inflation target, the central bank may establish an equilibrium in which expected prices are rigid with respect to changes in the money supply.[19] If such an equilibrium could be established in this way then that would be a strong case for an inflation target. The mechanism to do this would be for the central bank to set the first priority of monetary policy to maintain inflation at its target level. If people then expect that prices will rise according to the inflation target they will set their expected prices accordingly. Then prices will indeed rise according to the inflation target. Thus the expectation of people about the rate of inflation will turn out to be correct, or, in Woglom's language, ex post rational.

The persuasiveness of the idea that an inflation target can determine the actual rate of inflation is increased by the fact that, as pointed out by both Woglom and Bhaskar, in the range of equilibria model, a minority of economic agents can dominate the expectation process. Translating their arguments to the operation of inflation targeting, even if only a minority of agents believe that inflation will be in accord with the central bank's target, then for the remaining agents the rational expectation will be to follow the beliefs of the inflation-target believers. The argument is as follows. Imagine that, to decide on an expected rate of inflation, any agent with rational expectations considers each possible inflation rate for the future. Among all possible rates, the rate chosen by the inflation-target believers has some attraction to those with rational expectations. It has some support and, provided that there is no other rate of inflation with similar or greater support, is a rational expectations choice. The inflation-target believers will, adapting Bhaskar's words, remove a degree of freedom in expectation formation. Thus the rational expectation for inflation will be

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[19] It should be clear that the equilibrium in the model is consistent with any positive rate of inflation, by assuming that the reference price is increasing at an equal expected rate of inflation. The money supply would also have to be increasing to maintain the real level of aggregate demand.

determined by the inflation target.

For the adaptive expectations sub-group to dominate the expected rate of inflation, their belief must be well defined and well known. Thus a period of volatility of inflation would reduce their influence and thereby generate fluidity in expectations. However, an inflation target that backs up the view of an adaptive sub-group will increase the stability of inflation expectations in the face of volatility in the actual rate of inflation.

In addition to the rational expectations argument, it is also the case that customers and workers may see the inflation target as a fairness benchmark, thereby adding to the force of the central bank's announcement. If their transaction partner sets a price or wage that appears to violate the inflation target then that action would be thought unfair. Along the lines of the psychological arguments cited above, such violations would provoke a sharp reaction. The threat of this response would reduce the likelihood of such violations. This would add to the influence of the inflation target on the expected rate of inflation.

It seems unlikely that announcing an inflation target can change people's expectation of the future rate of inflation. Central banks do not have that degree of influence over people's beliefs. The empirical evidence "suggests that the adoption of inflation targeting does not establish immediate credibility for monetary policy" Bernanke et al (1999, pp. 274). Thus an inflation target is more likely to be successful if it is consistent with recent inflation experience. As pointed out above, within the range of equilibria even if a small number of people form expectations of inflation adaptively they can, if all other agents are guided by rational expectations, dominate everybody's inflation expectation. By announcing an inflation target different from the existing rate of inflation, the central bank will not be able to change the expectations of the adaptive agents, who, by looking backward, will take no notice of the central bank. For those agents with rational expectations, the central bank's announcement may introduce some confusion. If they collectively ignore the central bank's announcement of an inflation target and stick with the expectation of the adaptive sub group that would be a rational expectation.

To foster an NIE the central bank should announce an inflation target policy consistent with existing expectations of inflation. This, by coordinating the expectations of agents on a credible focus, will focus expectations of inflation on a particular target rate or

target range and reinforce the expectation that that rate of inflation will continue. Thus the rate of inflation will be stabilised.

The inflation target therefore is a mechanism by which the central bank can determine expected prices. Agents are induced to follow the central bank's announcement because, one, adopting the central bank's target is a rational expectation, two, the target is seen as a fairness benchmark and, three, they are not asked to adopt an expectation inconsistent with recent experience. Thus, the central bank can use the inflation target to set an expected price that is fixed in nominal terms. Expansionary monetary policy can then increase output and employment as described in the previous section.

## 7. How far can the non-inflationary expansion go on the eastern facet?

Now consider the case where the economy is on the eastern facet of the diamond of equilibria. In contrast to movements within the diamond, on the eastern facet, for a monetary expansion to increase employment, the real wage has to fall. If $V^E$ is fixed in real terms then money is neutral. No further NIE is possible once the eastern facet is reached. But if monetary expansion can reduce $V^E$ then monetary policy can expand employment. One such possibility is analysed in McDonald and Sibly (2001). In that case $V^E$ is determined by the lagged real wage and there is a temporary nominal wage rigidity. The latter is due to money wages being determined before the money supply is announced. With these assumptions a monetary expansion will lower the real wage and, because this feeds through to next period's reference real wage, the lower real wage will be permanent. Workers will have suffered an unanticipated reduction in their real wage. But because their reference real wage adjusts to this, in the long run the wage bargain validates the lower real wage and so monetary policy is not neutral.

For this expansion to have occurred, the actions of the monetary authority have caused workers to lower their reference real wage. It could be said that the monetary authority has fooled the workers. However, in contrast to fooling in natural rate models, this is not a fatal flaw. Note that the tricking in this range of equilibria model is temporary. By contrast, in natural rate models, to increase permanently employment above the equilibrium level requires permanent fooling of workers. The dictum of Abraham Lincoln, that "You cannot fool all the people all the time" is a reasonable presumption and renders the

possibility of a permanent increase in employment in natural rate models implausible. But it is not impossible to fool all the people some of the time. Furthermore the utility value of the fooling is small. There would be a small cut in real wages that would soon be offset by productivity growth. And the temporary nature of the fooling makes it less discernable if there is noise in the system. Because of these points, the fooling required in the loss aversion model is qualitatively different.

In the mechanism just described the monetary expansion increases employment by reducing the real value of the reference wage. But this reduction has been facilitated by increasing the price level relative to the pre-set money wage. Given that the money wage was set with the target rate of inflation in mind, to achieve a particular real wage, the inflation target would have been violated.

By how much the inflation target is violated depends on the speed with which the economy slides down the marginal product of labour curve. Through this consideration, the emphasis central bankers and other policy makers place on speed limits comes into focus.[20]

It should also be realised that even although the inflation target is violated, the violation is only temporary. Once a lower point on the eastern facet is established then there will be no further upward movement in prices and so no further violations of the inflation target. Thus in this case on the eastern facet only temporary violations of the inflation target are required to increase employment. In keeping with the discussion above about the temporary fooling of workers, the effect on the credibility of the inflation target of temporary violations is different from the effect of permanent violations.

Alternatively, monetary expansion can expand employment when the economy is on the eastern facet if the reference wage is specified in nominal terms, rather than real terms. The nominal specification is used by Bhaskar (1990). In that case, a monetary expansion raises the price level but does not change the bargained nominal

[20]Tax cuts could be used to assist this process. (This has been called tax bribery by Faxen (1982)). Tax cuts can lower pre tax real wages without reducing living standards. In the loss aversion framework if the reference wage is the post tax real wage then tax cuts can be effective. However, if the reference wage is the pre-tax real wage then tax cuts will be less helpful.

wage, provided the economy is within the range of equilibria. So the workers, being concerned about their nominal wage relative to their reference (nominal) wage accept the reduction in the real wage. The economy can slide down the eastern facet and enjoy an increased equilibrium level of unemployment. However, as for the case above where the reference wage is equal to last period's real wage, the inflation target would be violated.[21]

Rigidly following the inflation target carries the risk that the gains to employment from moving down the eastern facet will not be realised. On the other hand, setting policy to attempt to realise those gains will deliberately cause the inflation target to be violated and thereby reduce the credibility of the inflation target and thus its influence on the expected rate of inflation.

## 8. Enforcement

We have argued that by simply announcing an inflation target at the appropriate rate, the central bank can set the expected rate of inflation of economic agents such that it can produce by expansionary monetary policy an NIE. We have also argued that the eastern facet is an upper limit to such an NIE. In this section we consider how monetary contraction can enforce an inflation target.

Consider the possibility that during an NIE the expected rate of inflation changes and exceeds the inflation target. We have seen that if the economy hits the eastern facet then further monetary expansion will violate the inflation target. At that point further expansion will threaten the central bank's credibility and may cause the expected rate of inflation to increase above the target. In addition within the range other factors, outside the model of this paper, can occur. Supply shocks may increase inflation. Also a very rapid expansion and the existence of bottlenecks in supply may push up inflation. There is plenty of evidence, as shown by estimates of the speed limit effect, that expansions increase the rate of inflation. While it appears to be the case that inflation targeting reduces the size of the speed limit effect, i.e. increases the speed limit, it would be unwise to conclude that the inflation target abolishes in all

[21] Bhaskar's model has a competitive product market and thus the real marginal revenue product of labour curve was fixed. In terms of Figure 1, the range of equilibria in Bhaskar's model is captured by the eastern facet.

circumstances the speed limit effect. Any increases in the actual rate of inflation may feed through to the expected rate of inflation. What then is the power of monetary policy in preventing or reversing deviations of expected inflation above the inflation target?

In the range of equilibria model, the central bank can reduce inflation by a monetary tightening that increases unemployment above the maximum equilibrium rate. At such high rates of unemployment, disequilibrium forces will exert downward pressure on wages and prices. Through such a contraction the central bank can enforce an inflation target. Furthermore, the credible threat of such a contraction is sufficient to keep inflationary expectations in check.

If the size of the range of equilibria is large, then having to rely on pushing unemployment to rates greater than the maximum equilibrium rate imposes a large cost on the economy.[22] The dismal prospect is raised that the economy has to be pushed to a high rate of unemployment and then, after inflation has receded, begin an NIE all over again. The costs of this prospect may call into question the credibility of the inflation target.[23] However, by extending the range model a less dismal prospect can be developed. A contraction in economic activity may cause agents to cut their reference prices and wages even without the economy being forced out of the range of equilibria. This does not violate the range of equilibria theory. The crucial requirement in the model of this paper for a range of equilibria to exist is that, at a lower level of activity, the reference wages and prices can settle at levels which are consistent with equilibrium as given by proposition 1.

If the rate of inflation increases above the target rate, a tightening of monetary policy with the clear announcement that the reason is because inflation exceeds the target seems likely to push agents to set their reference wages and prices in line with the inflation target. Note that a contraction of sales usually causes a contraction in profits, for several reasons. The increase in interest rates caused by tighter money will directly reduce profits for those firms who have debt. In addition, if firms have fixed costs, or purchase inputs at fixed or sticky prices or are pushed below the minimum

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[22] For this reason, Woglom (1983, p. 104) has argued that in the range of equilibria model monetary policy "is less powerful in fighting inflation".

[23] Leading perhaps to inflation bias.

efficient scale of output, i.e. pushed into a region of increasing returns to labour, then the profit contraction will be more severe. Reduced profits that threaten the financial viability of a firm are likely to cause a downward revision of reference wages. As Kahneman, Knetsch and Thaler (1986, p. 739) conclude, "The survey findings suggest that nominal wage cuts by a firm that is losing money or threatened with bankruptcy do not violate community standards of fairness". In the popular language the pattern is described as credit squeeze leading to profit squeeze leading to wage concessions.

It may be that eventually firms will enjoy some restoration in their profits as the wage and price cuts from the aggregate contraction pass through the economy into the input prices paid by the firm[24]. The temporary nature of the decrease in profits raises the question why can't the firm ride out a temporary loss of profits even with no cuts in wages? One possible reason is that the losses incurred before the price of inputs adjusts may be sufficient to make the firm unprofitable. These losses may never be recouped even after the price of fixed inputs has adjusted. Furthermore, there is reason to doubt that the firm could survive the period of losses. Even if the firm is solvent, the contraction may make it illiquid. The firm's financial backers face the problem of distinguishing the temporary effects from the permanent effects. They will be concerned about how long the negative profits will last. How long will they have to wait for the suppliers to cut prices? Some prices may be locked in long term contracts. Will other lenders to the firm bail out before the firm emerges from the period of negative profits, as would be suggested by the considerations raised in the Diamond and Dybvig (1983) model? Thus it appears that even if the period of negative profits with unchanged wages is temporary, there is still good reason to expect wage cuts.

[24] According to the process of gradual price adjustment, see Gordon (1981). Firms buy goods and services from other firms at pre-set prices. As Gordon described it, the decrease in demand of a monetary contraction will work through the economy as a ripple, hitting firms as it passes through the input-output chain. Prices adjust gradually. During the ripple profits will suffer.

This section has explored two mechanisms through which in the range of equilibria model, the monetary authority can enforce the inflation target by monetary contraction.[25] The first mechanism is the disequilibrium forces that operate when unemployment exceeds the maximum equilibrium rate. The second mechanism is the forces that reduce reference price and wage levels when the economy is within the range of equilibria. The latter mechanism enhances the credibility of the monetary authority's inflation target. Unemployment does not have to be increased above the maximum equilibrium rate for downward pressure to be exerted on the rate of inflation. This power increases the influence of the inflation target on people's expectations of inflation and thereby strengthens the possibility of a non-inflationary expansion.

## 9. Conclusion

This paper argues that using an inflation target to set monetary policy can facilitate a non-inflationary expansion, that is a permanent increase in aggregate activity, without causing an increase in the rate of inflation. This result is derived from a model with a range of equilibria based on reference dependence and loss aversion, in which, because of buyer-seller relationships, sometimes called customer markets, in selling goods and in wage bargaining, expected prices and wages determine actual prices and wages when the economy is within the range. Using an inflation target to set monetary policy is a way of influencing expected prices and thus inflation. This influence arises because the inflation target establishes a particular equilibrium level of expected prices and wages. The argument of this paper extends earlier arguments of Woglom (1982) and Bhaskar (1990) who showed, in models with a range of equilibria, the importance for successful expansionary

[25] The other possibility is that the rate of inflation is below the target rate. The announcement of an inflation target greater than an established rate of inflation would appear to lack credibility for the same reason argued above in the opposite case. Of course, if aggregate demand can be increased but inflation stays low, then eventually the economy would hit the eastern facet and the rate of inflation would then be subject to upward pressure. But, as argued by Krugman (1998) for Japan, a liquidity trap situation may make it impossible for fiscal or monetary policy to increase aggregate demand. In this case the central bank cannot cause reference wages and prices to be revised up, either within the range as a result of activity expansion, or at the eastern facet, which could not be reached. Krugman argues that the best solution to Japan's problem is for the Bank of Japan to adopt an inflation target of three to four percent. He acknowledges that this may not be enough.

aggregate demand policy of coordinating expected prices. We argue that a policy of the central bank to target inflation is another way to coordinate expected prices if the economy is in the range of equilibria.[26] We also argue that the reference dependence/loss aversion theory, which contributes to our models of price and wage rigidities, suggests that the inflation target can provide a fairness benchmark. This adds to its ability to influence the actual rate of inflation. The empirical evidence on inflation targeting supports our argument.

While an inflation target can facilitate a non-inflationary expansion, we show that there are employment gains that the inflation target may be unable to realise. In our range of equilibria model there is a region, we call the eastern facet, along which employment can only be increased if real wages are reduced. But to do this by monetary expansion would violate the inflation target, albeit only temporarily. It may be that even temporary violations of the inflation target will impair the credibility of the target. If so there is a case not to force such violations. Instead monetary policy should focus on increasing employment until the economy hits the eastern facet and then to move to a more neutral setting.[27]

The possibility shown in this paper for an inflation target to facilitate a non-inflationary expansion is a justification for adopting an inflation target to guide the setting of monetary policy. This justification is different from the traditional argument used to justify an inflation target. The traditional argument is based on curbing the inflation bias of policymakers. Whilst for both arguments the inflation target locks in the expected rate of inflation, for the traditional argument the case for an inflation target is that it would prevent the policymaker from attempting to set the rate of unemployment below the natural rate. In the range model in this paper the traditional argument would also be relevant because an inflation bias can arise if the policy maker attempts to maintain a rate of unemployment below the minimum equilibrium rate, or is simply thought to do so by the public.[28] But the

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[26] A prices and incomes policy is similar to an inflation targeting policy in that it may also create an equilibrium for prices and wages, as pointed out by Bhaskar (1990). If such an equilibrium is credible then incomes policy can facilitate a non-inflationary expansion.

[27] It may be that incomes policies can help to realise the employment gains from moving down the eastern facet.

[28] The traditional argument may also be relevant in cautioning policy makers not to use monetary policy to achieve the employment gains from forcing the economy down the eastern facet.

range model adds an extra plank to the case for the inflation target.[29] It shows that, through the control exerted over inflation by the target whilst the economy is within the range, that is west of the eastern facet, the inflation target can facilitate a permanent reduction to a lower equilibrium rate of unemployment.

The argument in favour of the inflation target put forward in this paper has implications for the definition of the inflation target. The underlying principle is that the inflation target should influence the expectation of inflation held by economic agents. To achieve this, the target should have a small range, in order to encourage a focus that is influential in price and wage setting. Emphasis on a central point would strengthen this focus. The target should also be achievable, to avoid allegations, such as media comment, that the target has failed when the "failure" is apparent rather than real. Such allegations would reduce the credibility of the target and thus the influence over expectations. Given the limited control of central banks over inflation, achievability is, as the inflation target literature recognises, a crucial issue. Excluding volatile items, such as house prices, from the targeted index reduces the probability of apparent failure. Furthermore a target horizon of reasonable length will reduce the risk of charges of failure. Setting an electric fence, such that inflation in any quarter should never be outside specified limits, is to court charges of failure and thus is a bad idea.

By locking in inflationary expectations, the model suggests that inflation targeting may reduce fluctuations in the rate of inflation and thus have a self-fulfilling property. There is evidence that inflation targets have reduced fluctuations in inflation. Mishkin and Schmidt-Hebbel (2001, pp. 9-10) note that inflation targeting appears to have guided inflation expectations and furthermore has been tested favourably by adverse shocks, such as the adverse exchange rate and terms of trade shocks suffered by Australia. The range of equilibria model of this paper in which, within the range of equilibria, the wage mark-up and the retial price-marginal cost mark-up are variable is a theoretical basis for the proposition that, to a certain extent, cost and demand shocks are absorbed by endogenous variation in

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[29] The analysis of this paper also adds an extra plank to the inflation bias case for an inflation target. In as far as controlling inflation excesses requires a contraction in activity large enough to push the rate of unemployment above the maximum equilibrium rate, policy makers may be reluctant to do so. An

these mark-ups. Through this absorption, the

inflation target may stiffen their resolve by providing a justification for contraction acceptable to the public. Thus inflation bias would be reduced.

lockin-in effect of the inflation target is strengthened.

Governor Meyer (2001) has recommended that the US Federal Reserve add an inflation target specified in a similar way to that of Australia. That target, that inflation average between 2 and 3 percent over the medium term, is consistent with the discussion above on the appropriate specification of the inflation target suggested by the range of equilibria model of this paper. Thus this paper gives some theoretical support for Governor Meyer's recommendation.[30]

[30] Meyer (2001) does not describe the adoption of an explicit target as a break with existing US monetary policy but instead as ensuring that monetary policy "remains well focused and disciplined as the leadership of the Fed changes". Bernanke et al (1999, p.310-12) put forward a similar argument.

## Appendix

### Derivation of Proposition 1

Proposition 1 is that there are a range of values of $P^E$ and $V^E$ consistent with equilibrium. Note that setting L implies setting P because, as pointed out in the text, $L^E = L(P^E,1)$, that is there is a single-valued relation between $L^E$ and $P^E$. To derive proposition 1, we view the price and wage setting process as a two-decision process.

Decision 1. Employment is chosen to maximise profits given the real wage,( i.e. given decision 2).

For $L^E$ to be the level of employment that maximises profit as given by equation (3), assuming the real wage is equal to $V^E$, the following conditions hold:

$$\left(\frac{d\Pi}{dL}\right)^{-}\Bigg|_{L=L^E} = \frac{R_L^-}{\bar{P}} - V^E \geq 0 \quad \text{and} \quad \left(\frac{d\Pi}{dL}\right)^{+}\Bigg|_{L=L^E} = \frac{R_L^+}{\bar{P}} - V^E \leq 0 \qquad \text{(A1)}$$

Decision 2. The real wage is chosen to maximise the Nash maximand given the level of employment, (i.e. given decision 1).

For $V^E$ to be the real wage that maximises the Nash maximand as given by equation (4), assuming the level of employment is equal to $L^E$, the following conditions hold:

$$\left(\frac{dNM}{dV}\right)^{-}\Bigg|_{V=V^E} = \frac{\phi\left(U_1(V^E,1) + U_2^-(V^E,1)/V^E\right)}{U(V^E,1) - U(V^D)} - \frac{(1-\phi)L}{\left(R(L^E)/\bar{P}\right) - V^E L^E} \geq 0 \qquad \text{(A2)}$$

and

$$\left(\frac{dNM}{dV}\right)^{+}\Bigg|_{V=V^E} = \frac{\phi\left(U_1(V^E,1) + U_2^+(V^E,1)/V^E\right)}{U(V^E,1) - U(V^D)} - \frac{(1-\phi)L}{\left(R(L^E)/\bar{P}\right) - V^E L^E} \leq 0 \qquad \text{(A3)}$$

From these results proposition 1 holds.

### Specific functional forms

By assuming specific functional forms for the utility function and the revenue function, closed form equations for the limits on the range of values of $P^E$ and $V^E$ can be derived. For the revenue function, noting that revenue=PY, define

$Y=AL^{\alpha}$, $P= C Y^{\chi^-}$ for $Y \leq Y^E$ , $P= C Y^{\chi^+}$ for $Y \geq Y^E$ , with $-1 < \chi^- < \chi^+ < 0$.

For the utility function, define $U(V, V/V^E)$ as

$U(V, V/V^E) = BV^{\beta_1}(V/V^E)^{\beta_2^-}$ for $V \leq V^E$

$U(V, V/V^E) = BV^{\beta_1}(V/V^E)^{\beta_2^+}$ for $V \leq V^E$

and

$U(V^D) = BV^{D\beta_1}$,

with $0<\beta_1, \beta_2<1$ and $0<\beta_2^+<\beta_2^-<1$.

From these specific forms (A1) implies that the limits on $P^E$ are given by

$$\left(\frac{V^E\overline{P}}{\alpha A\left(L^E\right)^{\alpha-1}}\right)\frac{1}{1+\chi^-} \le P^E \le \left(\frac{V^E\overline{P}}{\alpha A\left(L^E\right)^{\alpha-1}}\right)\frac{1}{1+\chi^+} \qquad \text{(A1')}$$

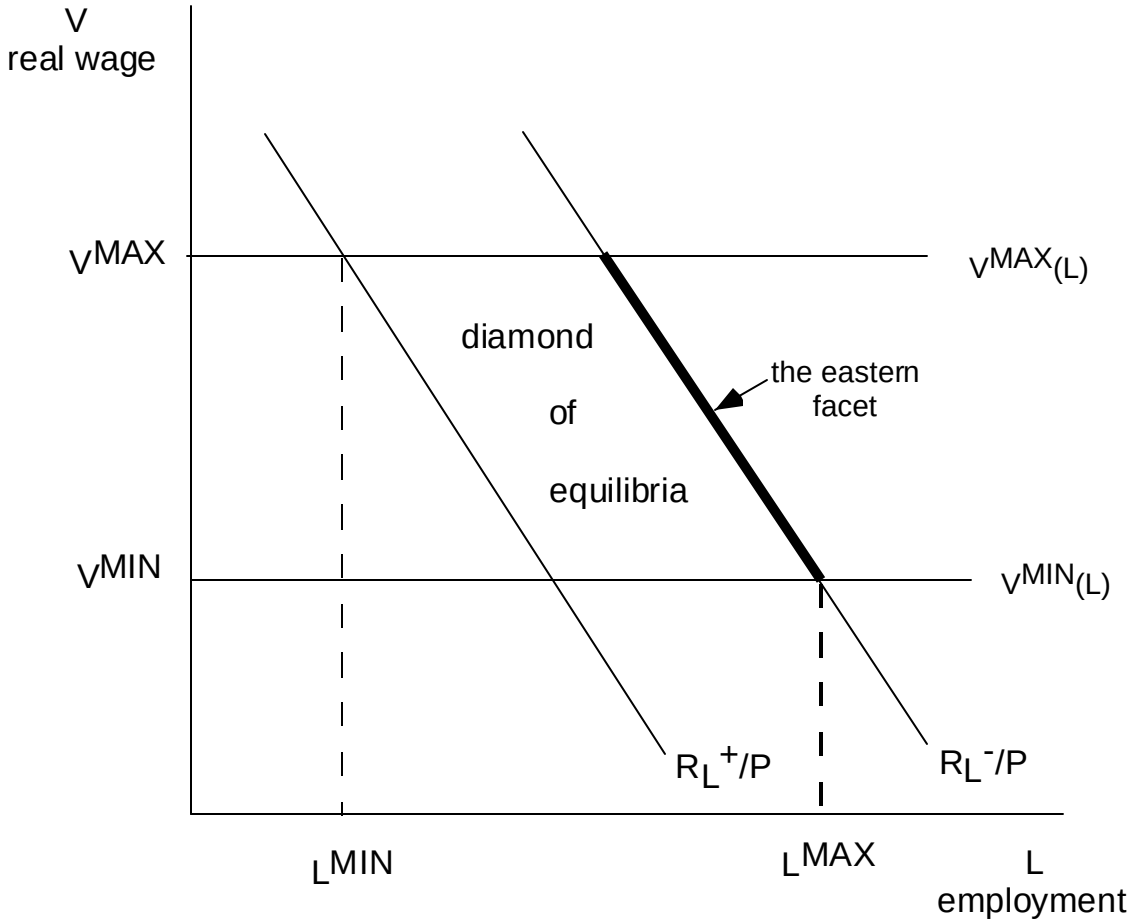
and (A2) and (A3) imply that the limits on $V^E$ are given by

$$\left[1-\frac{\phi(\beta_1+\beta_2^+)(1-\alpha(1+\chi^-)}{(1-\phi)\alpha(1+\chi^-)}\right]^{\frac{-1}{\beta_1}} V^D \le V^E \le \left[1-\frac{\phi(\beta_1+\beta_2^-)(1-\alpha(1+\chi^+)}{(1-\phi)\alpha(1+\chi^+)}\right]^{\frac{-1}{\beta_1}} V^D. \text{(A2)}$$

Note that in (A1') the terms in brackets are marginal cost and the ratios are the markups of price over marginal cost.

**Figures**

Figure 1



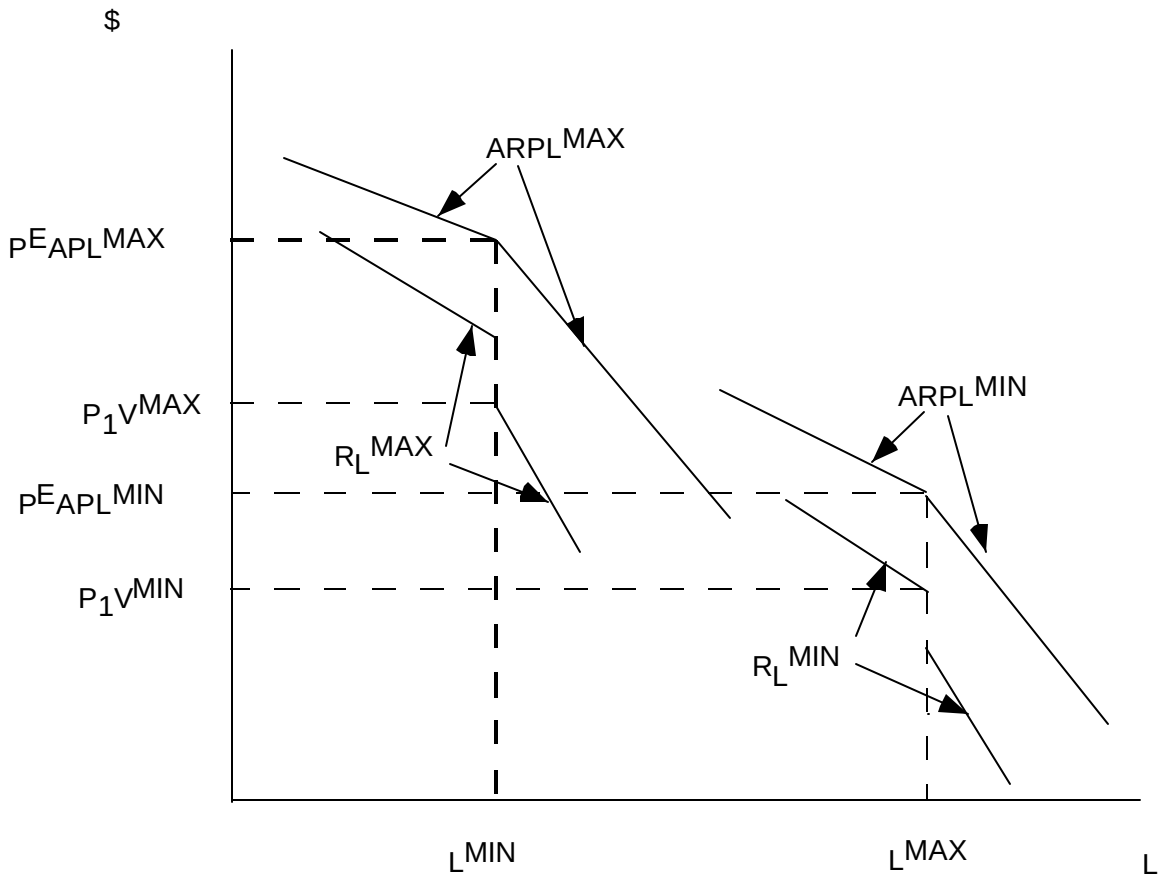

$
ARPL^MAX
P^E_APL^MAX
P_1V^MAX
R_L^MAX
P^E_APL^MIN
P_1V^MIN
ARPL^MIN
R_L^MIN
L^MIN
L^MAX
L

Figure 2

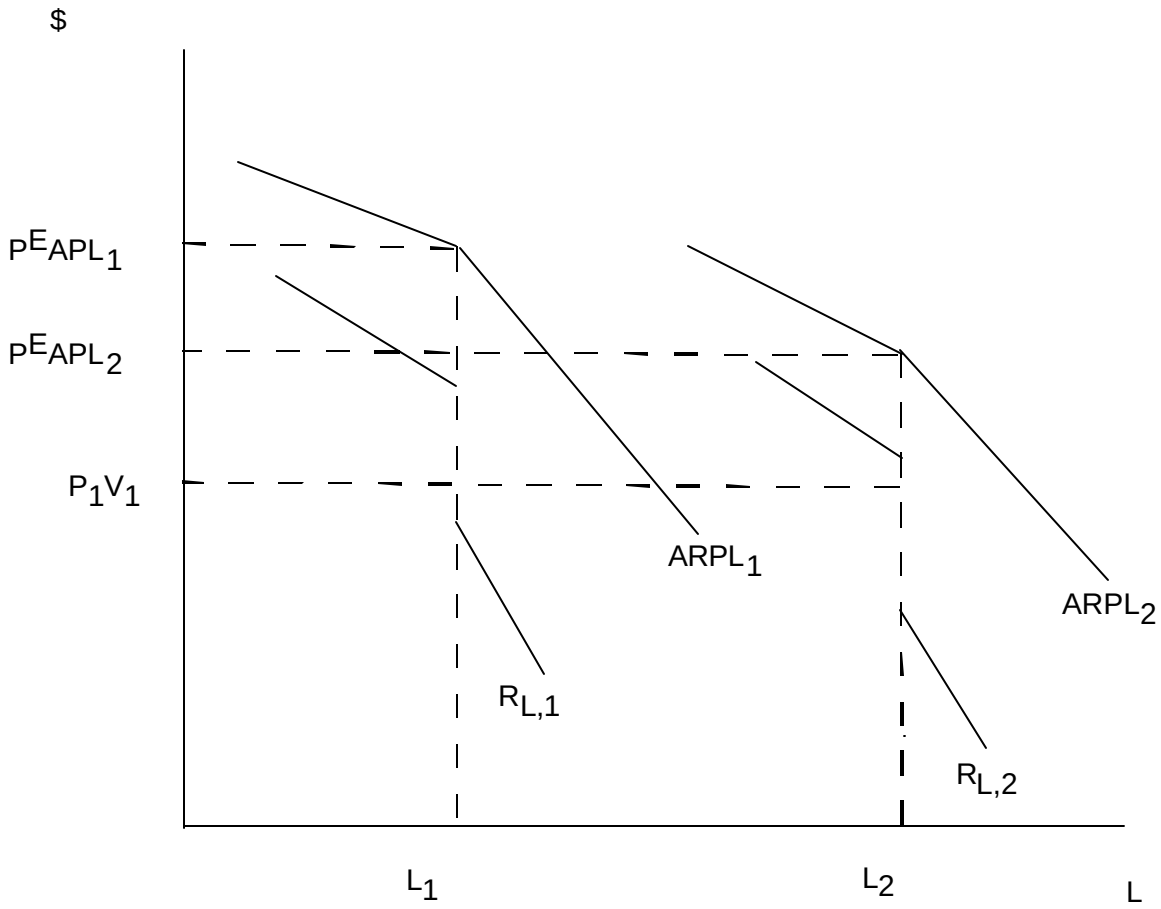


Figure 3

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