

## Interest Rates and Monetary Policy

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### Interest Rates and Monetary Policy

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# Interest Rates and Monetary Policy

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Key words: interest rates, monetary policy, currency substitution, inflation,  
exchange rates

## Abstract

This paper conducts a thorough intertemporal analysis of nominal interest rate based monetary policy. Its main contribution is to show how such a policy can have different effects depending on the assumptions made about the saving and borrowing behaviour of firms. We consider two cases (i) consumers are savers and firms are borrowers, and (ii) both consumers and firms are borrowers (the nation as a whole is borrowing from abroad). In one case we confirm conventional wisdom, but in the other case we find there may be unexpected and surprising results. Moreover, our analysis has important implications for both inflation and nominal exchange rate targeting policies.

# 1 Introduction

The central innovation of this paper is that it conducts a thorough intertemporal analysis of the effects of using the nominal interest rate as the instrument of monetary policy. It pays careful attention to the impact of different assumptions about the saving and borrowing behaviour of consumers and firms in generating different policy effects, and the role of inflation in accounting for the divergence between the real interest rate and the real return on capital.

The debate concerning choice of monetary policy instrument can be traced right back to Poole (1970) who analysed the choice between the nominal interest rate and the nominal money stock in the presence of stochastic shocks. In the absence of risk, the choice of the nominal interest merely implies a willingness to allow the money stock to adjust endogenously to accommodate the nominal interest rate target. Sargent and Wallace (1975) then showed that, under rational expectations, nominal interest rate pegging led to an indeterminate price level. It was later shown that minor re-specifications of the model could restore price determinacy, such as specifying the aggregate demand function in terms of the real money stock, as in McCallum (1981). It is implicitly this specification that is embodied in our model, hence ensuring price determinacy. Artis and Currie (1981) then extended this conventional ISLM based analysis to explicitly consider the effects of exchange rate targeting. In the late 1980s the emphasis of research shifted to the analysis of target zones, reflecting in part the problems experienced by national monetary authorities operating under the European Exchange Rate Mechanism, and in part the development of the application of techniques of stochastic calculus. This literature used stochastic extensions of

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3 either simple monetary or Dornbusch (1976) models to focus on the analysis  
4 of regime switches and the effects of speculative attacks. A good  
5 representative collection of this literature is to be found in Krugman and  
6 Miller (1992). Mishkin (1999) and Taylor (1999) consider different monetary  
7 regimes.  
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12 Since the nominal interest rate has increasingly become the central  
13 instrument of monetary policy in recent years, it is necessary for economists  
14 once again to turn their attention to renewing the analysis of this monetary  
15 policy but under a more modern intertemporal framework. Turnovsky (1986)  
16 and Turnovsky and Grinols (1996) show how optimal monetary policy should  
17 be directed towards interest rate targeting modelling the intertemporal  
18 utility of representative agents. In their paper they show that reasonable  
19 monetary growth eliminates the need for continuous exchange rate  
20 intervention. Alexandre et al (2001), Sutherland (2000) and Svensson (1999)  
21 concentrate on inflation targeting and have similar conclusions to those of  
22 interest rate targeting. Our findings show that the determination of the  
23 exchange rate depends on the intertemporal decisions of consumers and firms  
24 under different borrowing scenarios. We analyse two cases, the first where  
25 firms are borrowers and consumers are savers, and second where both are  
26 borrowers from abroad. This change in international indebtedness brings  
27 about exchange rate movements, a central innovation of this our paper. This  
28 is the task we attempt in this paper. However, our analysis is sufficiently  
29 robust to capture the use of the nominal interest rate to target the inflation  
30 rate or the nominal exchange rate.  
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51 The paper is organised into a series of sections and subsections as detailed  
52 below. In section 2 we construct the model, focusing first on production and  
53 then on consumption. We then solve the basic model, and construct the  
54 diagram that will be used to illustrate the analysis. In section 3 we analyse  
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the effects of monetary policy in terms of interest rate changes, and the implications on inflation, first when consumers are savers and firms are borrowers, and secondly where both consumers and firms are borrowers. Conclusions are presented in section 4.

## 2 The Model

In this section we construct the basic model used in our analysis, which employs a Ramsey (1928) type framework to analyse the behaviour of representative consumers and firms. Section 2.1 looks at the behaviour of firms and section 2.2 the behaviour of consumers. Section 2.3 then details the solution to the model, and finally section 2.4 constructs the diagram that is later used to illustrate the policy analysis, which takes place in section 3.

### 2.1 Production

We consider a continuum of identical monopolistically competitive firms<sup>1</sup>, each producing a single differentiated product, indexed  $i$ ,  $i \in [0,1]$ , where  $i \in [0,n]$  represents domestic production and  $i \in [n,1]$  foreign production. Each firm maximises the real profit function

$$\Pi_i = p_i(y_i)y_i - Wa_i(y_i) - Rk_i(y_i) \quad (1)$$

where<sup>2</sup>  $p_i$  is the price of good  $i$ ,  $y_i$  is the quantity produced of good  $i$ ,  $a_i$  is the total labour input for good  $i$ ,  $k_i$  is the total capital input for good  $i$ ,  $R$  is

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<sup>1</sup> In order to build a two country model we require there to be product differentiation, some varieties of which are produced domestically and some in the foreign country, hence the assumption of monopolistic competition rather than perfect competition is appropriate and standard in this type of literature, see for example Obstfeld and Rogoff (1995, 1996).

<sup>2</sup> A full symbols list is provided in Appendix A.

the real rent on capital, and  $W$  is the real wage rate. The first order conditions are

$$p_i(y_i) + p'_i(y_i)y_i = Wa'_i(y_i) + Rk'_i(y_i) \quad (2)$$

$$\tilde{p}_i = Wa_i(y_i)/y_i + Rk_i(y_i)/y_i \quad (3)$$

which are the standard conditions that marginal revenue is equal to marginal cost (equation ( 2)), and price is equal to average cost (equation ( 3))<sup>3</sup>. Rewriting equation ( 3) in terms of unit labour and capital requirements,  $a_{Hi} \equiv a_i(y_i)/y_i$  and  $a_{Ki} \equiv k_i(y_i)/y_i$  respectively yields the solution for the price<sup>4</sup> of good  $i$  as

$$\tilde{p}_i = Wa_{Hi} + Ra_{Ki} \quad (4)$$

## 2.2 Consumption

Optimal consumption is represented by the Consumption Euler Equation<sup>5</sup>

<sup>3</sup> This also implies the zero long run profit condition  $\tilde{p}_i(y_i)\tilde{y}_i - Wa_i(\tilde{y}_i) - Rk_i(\tilde{y}_i) = 0$ .

<sup>4</sup> Given the CES consumption index employed the demand function for good  $i$  of individual  $j$  can be shown to be  $A_i^j = (p_i/P)^{-\theta} A^j$ . Thus  $p_i = PA^{j^{1/\theta}} A_i^{j^{-1/\theta}}$  and hence marginal revenue is  $(\partial/\partial A_i^j)(PA^{j^{1/\theta}} A_i^{j^{(\theta-1)/\theta}}) = p_i(\theta-1)/\theta$ . Equating with marginal costs (right hand side of equation ( 2)) gives  $p_i = [Wa'_i(y_i) + Rk'_i(y_i)]\theta/(\theta-1)$  and using the definition of price in equation ( 3) yields a solution for output as  $y_i = [\{Wa_i(y_i) + Rk_i(y_i)\}/\{Wa'_i(y_i) + Rk'_i(y_i)\}][(\theta-1)/\theta]$ . This follows Helpman and Krugman (1985).

<sup>5</sup> We assume that the government runs a balanced budget. Since the government deficit is always zero it therefore does not need to appear in the national income identity. The Ricardian Equivalence Proposition, which holds in this model, implies that we do not need to analyse issues surrounding the effects of tax versus bond finance, as in Obstfeld and Rogoff (1995, 1996).



$$\frac{U_A^d(A^d, M^d, L^d)}{U_M^d(A^d, M^d, L^d)} = (1 + R^d) \quad (5)$$

This states that the marginal rate of substitution of consumption to money holdings (i.e. future consumption) is equal to the intertemporal price<sup>6</sup>. Another way of stating this is the more familiar condition that the marginal rate of intertemporal substitution (MRIS) is equal to the real interest rate. Graphically this yields the tangency condition between the budget line (BCI) and the community indifference curve at point **A0** on Figure 1. This may be rewritten as

$$U_M^d(A^d, M^d, L^d) = \frac{U_A^d(A^d, M^d, L^d)}{(1 + R^d)} = U_A^d(A^d, M^d, L^d) \frac{(1 + \pi^d)}{(1 + I^d)} \quad (6)$$

using the definition of the real interest rate  $(1 + R^d) = (1 + I^d)/(1 + \pi^d)$ , where  $I^d$  is the domestic nominal interest rate and  $\pi^d$  the domestic inflation rate<sup>7</sup>,

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<sup>6</sup> Note that usually the marginal rate of intertemporal substitution refers to the substitution between goods over time, whereas here it is between goods consumed today and money held today (that is saving today held as money balance for future consumption).

<sup>7</sup> Domestic inflation is defined as  $\pi^d \equiv \dot{P}^d / P^d$  where  $P^d$  is the price index<sup>7</sup>

$$P^d = \left[ \int_0^n p^d(i)^{1-\theta} di + \int_n^1 (E/C) p^f(i)^{1-\theta} di \right]^{\frac{1}{1-\theta}}$$

where  $E$  is the domestic nominal exchange rate (domestic price of foreign currency). Since we have assumed that the domestic country is large, this implies  $n$  is closer to one than zero. Similarly, foreign inflation is defined as  $\pi^f \equiv \dot{P}^f / P^f$  where  $P^f$  is the price index

from which we can obtain, given  $U_A > 0$ ,  $U_M > 0$ , that  $M_A > 0$  (money demand varies positively with domestic *consumption*<sup>8</sup>),  $M_I < 0$  (money demand varies inversely with the nominal interest rate)<sup>9</sup> and  $M_\pi > 0$  (money *demand* varies positively with inflation)<sup>10</sup>. Note that changes in the nominal interest rate, which is the policy variable in this model, induces endogenous changes in the money supply. In other words, a change in the nominal interest rate affects the money supply directly, and affects the inflation rate through changes in the transaction demand for money. Inflation therefore is not entirely a monetary phenomenon.

#### 2.2.4.2 Production Euler Equation

Assuming a standard<sup>11</sup> production function for the representative monopolistically competitive firm of the form  $Y = Zq(K, H)$  we obtain

$$P^f = \left[ \int_0^n (C/E) p^d(i)^{1-\theta} di + \int_n^1 p^f(i)^{1-\theta} di \right]^{\frac{1}{1-\theta}}$$

Notice that this implies that  $\dot{P} = \dot{P} \left( \dot{p}^d, \dot{p}^f \right)$  and since  $p^d = p^d(W^d, R^d)$ ,  $p^f = p^f(W^f, R^f)$  (prices equal to marginal products) from equation (4), noting that  $\dot{W}^d = \dot{M}^d$ ,  $\dot{W}^f = \dot{M}^f$  (growth of real wages must equal the growth of real money), hence  $\dot{p}^d = \dot{p}^d \left( \dot{M}^+ \right)$  and  $\dot{p}^f = \dot{p}^f \left( \dot{L}^+ \right)$  *a la* Quantity Theory, but not in one for one proportion.

<sup>8</sup> This is similar to the Keynesian transactions demand for money.

<sup>9</sup> Due to an intertemporal effect, rather than a Keynesian speculative effect.

<sup>10</sup> A rise in inflation causes agents to substitute present consumption in place of future consumption, increasing the real demand for money (life-cycle theory of consumption).

<sup>11</sup> That is, the production function has the normal properties (importantly, diminishing marginal productivity).

$$\frac{\partial \mathcal{L}}{\partial K^d} = \beta\lambda - \dot{\lambda} \rightarrow \lambda Zq_K = \beta\lambda - \dot{\lambda} \rightarrow Zq_K = \beta - \dot{\lambda}/\lambda = 1 + R^d \quad (7)$$

$$\frac{\partial \mathcal{L}}{\partial H^d} = \beta\lambda - \dot{\lambda} \rightarrow \lambda Zq_H = \beta\lambda - \dot{\lambda} \rightarrow Zq_H = \beta - \dot{\lambda}/\lambda = 1 + W^d \quad (8)$$

Equation (7) states that the marginal rate of intertemporal transformation (MRIT) is equal to the real return on capital. Graphically this yields the tangency condition between the budget line (BC) and the intertemporal production possibility frontier (IPPF) at point **P0** on Figure 1. As the real interest rate declines, given the property of diminishing marginal productivity, the marginal product should decline. This encourages and investment and increases capital. Similarly, equation (8) states the usual condition that the marginal product of labour is equal to the real wage rate.

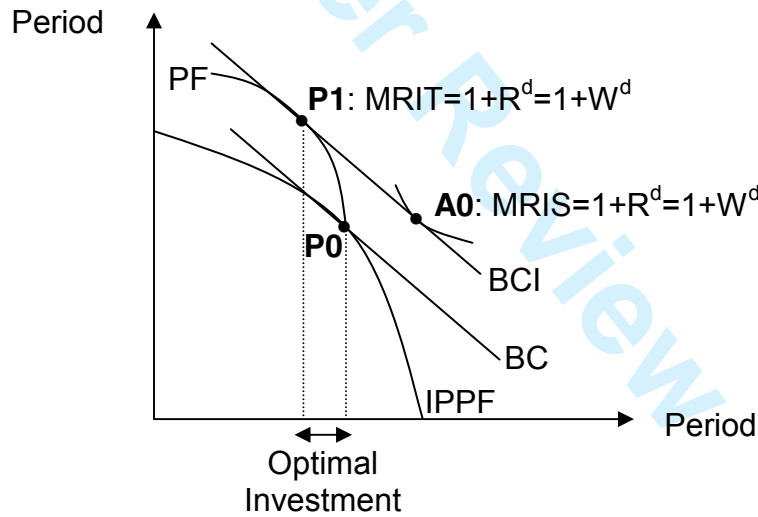


Figure 1

Optimal investment takes place where the cost of investment, given by the marginal product of capital,  $Zq_K$  in equation (7), is equal to the return on investment, given by the real return on capital  $(1 + R^d)$  in equation (7).

Graphically, this is represented by the tangency between the production function (PF) and the budget line (BCI) at point **P1** in Figure 1. Thus **P0** gives us the production point with no investment and **P1** gives us the production point with optimal investment.

### 2.3.2.3. General equilibrium condition

The model is closed by equating ( 5) with ( 7), which yields the general equilibrium condition that the marginal rates of intertemporal transformation and substitution are equal

$$(U_A/U_M) = Zq'(K^d) = (1 + R^d) \quad (9)$$

## 3 Monetary Policy

Our analysis is subdivided into two sections. The first details the case where firms are borrowers and consumers are savers. The second details the case where both firms and consumers are borrowers.

### 3.1 Case I (Firms are borrowers, consumers are savers)

In this section we consider the effect of a nominal interest rate cut by the domestic government under the assumption that firms are borrowers and consumers are savers. The cut in the nominal rate of interest affects both the domestic inflation rate and the real interest rate.

Firstly the interest rate cut reduces consumers' income from savings and hence depresses domestic consumption. The real money supply adjusts

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3 endogenously, reducing the domestic rate of inflation (there is demand  
4 deficient deflation).  
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9 Secondly, using the definition of the real interest rate  $(1 + R^d)$   
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$$(1 + R^d) \equiv \frac{(1 + I^d)}{(1 + \pi^d)} \quad (10)$$

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18 we can see clearly that the combination of the fall in the nominal interest  
19 rate  $(1 + I^d)$  and fall in the domestic inflation rate  $(1 + \pi^d)$  will generate a fall  
20 in the real interest rate assuming that the fall in the inflation rate is less  
21 than the fall in the interest rate, a plausible assumption due to consumption  
22 smoothing behaviour.  
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30 Graphically, the fall in the real interest rate is represented by an  
31 anticlockwise rotation of the budget line to the position BCG shown on Figure  
32 2. The aim of the government's reduction in nominal interest rates is to  
33 reduce the costs of firms' borrowing and hence stimulate investment and  
34 production. In terms of this model, firms are borrowing by bringing forward  
35 production (extracting capital resources from the future to use for today's  
36 production). Thus the production function (PF) drawn in Figure 2 faces in the  
37 opposite direction from that drawn earlier in Figure 1. The fall in the real  
38 interest rate established above, from equations ( 7) and ( 8), however, means  
39 that firms bring forward *less* production (comparing pre policy point **P1** with  
40 post policy point **P2**). That is, current production falls and the real return on  
41 capital is reduced (the slope of BCG is less than the slope of BCI).  
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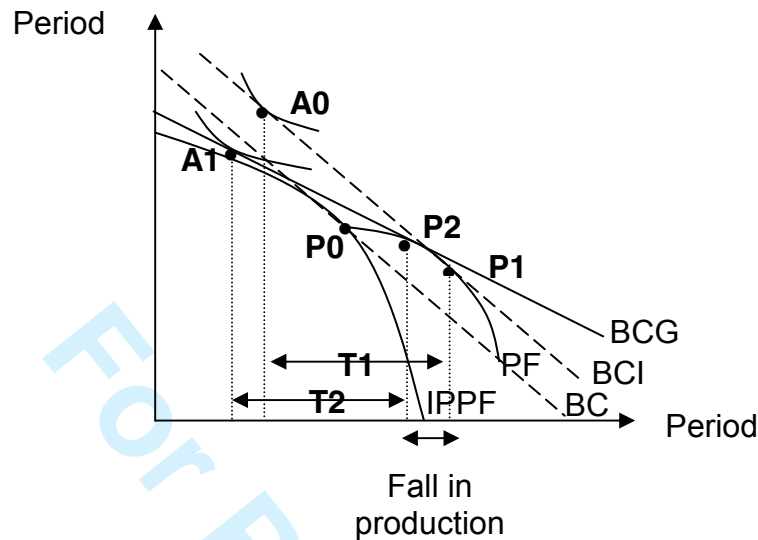


Figure 2

Interest rate cut when firms are borrowers and consumers are savers

From equations ( 9) and ( 10) we can see that there is clearly a fall in consumption in *both* periods by comparing pre-policy point **A0** with post-policy point **A1**. Consumers have decreased future consumption in order to partially offset the fall in present consumption that arises from the fall in their income from savings (consumption has been brought forward in response to the lower real interest rate). In other words, consumption smoothing behaviour is taking place.

The fact that consumers are savers (and hence the fall in the nominal interest rate has led to a fall in the real interest rate due to the effect of the fall in inflation that results from the fall in consumption) has thwarted the

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3 government's attempt to stimulate the real economy through the production  
4 side (by attempting to induce firms to increase today's production).  
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9 Note that redistribution has occurred from consumers to producers.  
10 Consumer welfare has fallen, but producers' stocks of capital have been less  
11 depleted (there remain higher stocks of future capital). Thus, the effect of the  
12 government's cut in the nominal interest rate has led to a fall in current  
13 production, reduced consumption and welfare, fall in real wages and  
14 deflation.  
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21 The effect on the trade balance is ambiguous (we do not know whether **T2** is  
22 greater or less than **T1**) since it is impossible to say whether the fall in  
23 production is greater or less than the fall in consumption. Consumers are  
24 consuming less in the current period and domestic producers are also  
25 producing less.  
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33 If consumption is cut less than production, the trade balance worsens (since  
34 imports must rise to fill the gap between domestic production and domestic  
35 consumption). The real exchange rate will consequently rise (there will be a  
36 real depreciation). It is impossible to say whether the nominal exchange rate  
37 will appreciate or depreciate since, from equation ( 10), the inflation rate has  
38 also fallen<sup>12</sup>. Thus if policy makers are using the nominal interest rate as an  
39 instrument to achieve a nominal exchange rate target, their target may not  
40 be realised.  
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54 <sup>12</sup> From the definition of the real exchange rate,  $1 + (\dot{C}/C) = [1 + (\dot{E}/E)]/[1 + \pi]$ , then  
55  $1 + (\dot{E}/E) = [1 + (\dot{C}/C)][1 + \pi]$ . Since  $1 + (\dot{C}/C)$  and  $[1 + \pi]$  are moving in opposite  
56 directions, the effect on  $1 + (\dot{E}/E)$  is ambiguous.  
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4 If consumption is cut more than production, the trade balance improves  
5 (since fewer imports are needed to meet the shortfall of domestic production  
6 in meeting domestic consumption). The real exchange rate will consequently  
7 fall (there will be a real appreciation. A real appreciation combined with a  
8 fall in inflation implies a nominal appreciation. In this case, if policy makers  
9 had an exchange rate target, there is here the opportunity to meet it. Of  
10 course, in practice, policy makers do not necessarily have all the information  
11 at hand ex ante to know which of these cases prevails. Here, a cut in the  
12 nominal interest rate has led to a fall in inflation and possibly a nominal  
13 appreciation (a strengthening of the domestic currency). This is somewhat at  
14 variance with conventional wisdom (Bank of England Monetary Policy  
15 Committee, 1999) that a fall in the nominal interest rate leads to a rise in the  
16 nominal exchange rate (a nominal depreciation). This may explain why  
17 Pound Sterling remained strong in the UK despite the successive 25 basis  
18 points nominal interest rate cuts from 1998:Q4 through 1999:Q1 (essentially  
19 as consumers postponed their consumption).  
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### 35 *3.2 Case II (Both firms and consumers are borrowers)*

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38 It is not hard to replicate this analysis for other plausible scenarios<sup>13</sup>. For  
39 example, suppose that firms are again borrowers, but this time consumers  
40 are borrowers, too. The fall in the nominal interest rate will reduce consumer'  
41 cost of borrowing, stimulating consumption in both periods (again due to  
42 consumption smoothing behaviour). This leads to demand push inflation.  
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51 <sup>13</sup> To avoid undue repetition of analysis, we don't consider the case where both  
52 consumers and firms are savers (in this scenario, there is a similar ambiguity  
53 concerning the effects on the trade balance and hence the exchange rate that  
54 are detailed above in Case I). Likewise we don't repeat the standard textbook  
55 (Obstfeld and Rogoff, 1996) case where firms are savers and consumers are  
56 borrowers (here the trade balance unambiguously improves, and hence is  
57 identically opposite to the analysis provided in Case II below).  
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From equation ( 10) we can see that the real interest rate again falls, but this time by a higher magnitude, since now the fall in the nominal interest rate and rise in inflation are working in the same direction to reduce the real interest rate. The analysis conducted above for producers carries through to this case, too. That is production falls. The corresponding diagrammatic representation is shown in Figure 3 below.

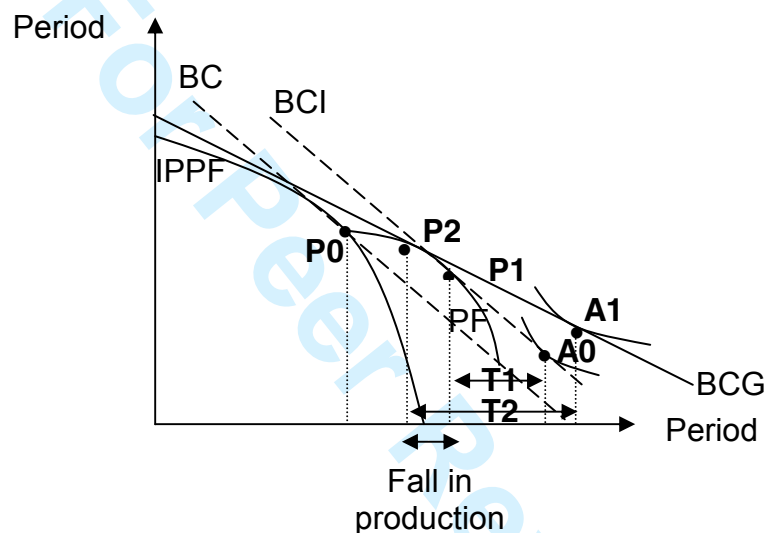


Figure 3

Interest rate cut when both firms and consumers are borrowers

Thus in this case, we have the same redistribution from consumers to firms, reduced production (and, from equation ( 8), reduced real wages), but this time the added ogre of increased inflation. It is also clear that the trade deficit has increased, from **T1** to **T2**, and hence net international debt will have risen. Balance of payments adjustment will, of course, mean that there will follow a real depreciation (weakening) of domestic currency. Since there has been a real depreciation and a rise in inflation, this implies by definition that there will be a nominal depreciation.

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5 If policy makers increase the nominal interest rate, they will succeed in  
6 cutting inflation, but at the cost of a nominal appreciation (strengthening of  
7 the domestic currency). This is precisely what happened in the UK during the  
8 nominal interest rate rises leading up to 1998.  
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14 In summary, a cut in the nominal interest rate when both firms and  
15 consumers are borrowers leads to a fall in real wages, a fall in the real return  
16 on capital, a rise in net international debt, a weakening of the domestic  
17 currency and a rise in domestic inflation. However, despite these, the welfare  
18 of the consumer and the benefits to firms have improved. Essentially, the  
19 firms and consumers are borrowing from themselves in the future through  
20 the mechanism of increasing international indebtedness today (borrowing  
21 from the rest of the world). This is to be contrasted with the first case where  
22 the welfare effects are ambiguous. In that case it is not known whether  
23 benefits to firms outweigh the loss of welfare to consumers. Production falls  
24 but consumption falls too. So the effect on the trade balance cannot be  
25 determined. Hence the effect on the exchange rate is also ambiguous.  
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## 4 Conclusions

Since control of the money supply has proved to be an elusive target, governments have increasingly switched to using the nominal interest rate as their instrument of monetary policy. Policy makers have, however, been surprised by results that seem to be at variance with the effects suggested by orthodox economic theory. This paper makes a significant contribution to the policy making debate by explicitly considering the effects of different assumptions about consumers' and producers' saving and borrowing behaviour on the policy outcomes.

A cut in the nominal interest rate is normally expected to increase investment and consumption expenditure and hence output. However, we show in this paper that in some circumstances neither of these may happen and hence the results of the policy are very different from those which the policy makers expected. When firms are borrowers and consumers are savers, a cut in the nominal interest rate reduces current production and current consumption. The fall in the nominal interest rate reduces consumers' income from savings, forcing them to decrease their consumption, not only in the current period, but also in the future period due to consumption smoothing behaviour. The fall in current consumption leads to an endogenous fall in the money stock and hence demand deficient deflation. Since consumption smoothing implies that the fall in the inflation rate is less than the fall in the nominal interest rate, there will be a fall in the real interest rate. The fall in the real interest rate means that firms will bring forward less production from the future (that is, deplete the future capital stock less). Thus, both current consumption and production have fallen, giving an ambiguous effect on the trade balance. The fall in the real interest rate implies in the long run a fall in the real wage (there is long run factor price equalisation). Overall,

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3 consumer welfare has fallen and there has been a redistribution from  
4 consumers to producers.  
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9 The ambiguous effect on the trade balance implies an ambiguous effect on the  
10 real exchange rate. In one case the cut in the inflation rate and decrease in  
11 the real exchange rate work in the same direction to cause a nominal  
12 exchange rate fall (nominal appreciation). In the other case, the fall in  
13 inflation and rise in the real exchange rate generate an ambiguous effect on  
14 the nominal exchange rate. The conclusion in this respect therefore is that if  
15 policy makers explicitly or implicitly target the nominal exchange rate they  
16 may get unexpected results.  
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25 When both consumers and producers are borrowers, a fall in the nominal  
26 interest rate stimulates consumption in the current period (due to the lower  
27 cost of borrowing) and in the future period (due to consumption smoothing  
28 behaviour). The increase in current consumption causes an endogenous rise  
29 in the money stock and hence demand push inflation. The combination of the  
30 fall in the nominal interest rate and the rise in the inflation rate work in the  
31 same direction to reduce the real interest rate. Thus production again falls.  
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40 Since current consumption has risen and production has fallen, the trade  
41 deficit widens, implying that the domestic country becomes more indebted to  
42 the rest of the world. One could therefore reinterpret the rise in inflation as  
43 imported inflation – the terms of trade have worsened. There has not only  
44 been a redistribution from consumers to firms, but also from the domestic  
45 country as a whole to the foreign country (even though domestic consumer  
46 welfare improves).  
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55 Thus, the saving and borrowing behaviour of firms and consumers matters  
56 crucially when determining the likely effects of nominal interest rate policy.  
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## Appendix

A	consumption index
$C$	domestic real exchange rate (domestic price of foreign currency)
$E$	domestic nominal exchange rate (domestic price of foreign currency)
$H$	domestic human capital stock
$I$	nominal interest rate
$J$	domestic physical capital investment expenditure
$K$	domestic physical capital stock
$L$	foreign real money supply
$M$	domestic real money supply
$P$	domestic price index
$R$	consumption based real interest rate
$T$	real domestic trade balance
U	domestic utility
$W$	real wage rate
$Y$	aggregate real income
$Z$	exogenous technology parameter
$a$	total labour input
$a_H$	unit labour input
$a_K$	unit capital input
$d$	superscript denoting domestic
$f$	superscript denoting foreign
$i$	continuum of differentiated products
$j$	index of consumers
$k$	total capital input
$n$	interval of $i$
$p$	national price level
$q$	production function
$t$	nominal domestic trade balance
$y$	real output
$\mathcal{H}$	current value Hamiltonian
$\beta$	beta discount rate
$\gamma$	gamma domestic net international credit
$\lambda$	lambda multiplier associated with current value Hamiltonian $\mathcal{H}$
$\pi$	pi inflation (in terms of an index, defined in )
$\Pi$	pi (u/c) total profit
$\vartheta$	theta 1 stable eigen vector
$\theta$	theta 2 CES coefficient (price elasticity of demand faced by each firm)
$\phi$	phi domestic share of gains from holding domestic money
$\partial$	delta 2 partial differential operator

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3 ~ equilibrium (used above a symbol)  
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6 Throughout the text, subscripts denote partial derivatives. A dot over a  
7 variable indicates a time derivative.  
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