The impact of macroeconomic policies in an oligopolistic economy with entry

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1 Introduction

The impact of macroeconomic policies on the level of economic activity is an issue that has generated considerable debate in economics. The New Classical literature which is based on the assumption that all markets clear, predicts that monetary and fiscal policies have no effect on the level of real output. In contrast, the burgeoning New Keynesian literature explores the macroeconomic consequences of price setting behaviour in product markets. These models suggest that macroeconomic policies affect the level of real economic activity either if prices are rigid, or firms have some degree of market power in product markets (see Dixon [1987], Molana and Moutos [1991], Mankiw [1988], Dixon and Rankin([992]).

However, in much of the New Keynesian literature firm behaviour is modelled as a static one-shot game. Consequently, it is assumed that an equilibrium is established either at the noncooperative Nash output level, or at some pre-specified collusive output level. By assuming that firms interact in a static one-shot game, these models have directed attention away from the consequences of group interdependence and strategic behaviour which are central features of highly concentrated industries. This paper attempts to provide an alternative model which focuses upon the macroeconomic consequences of strategic interactions in product markets.

The analysis of product markets is based on the assumption that firms in the economy interact over an indefinite period of time in an oligopoly supergame. It is well established in the supergame literature that when firms compete over an indefinite period, they have an

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incentive to implicitly collude either by restricting output levels, or raising prices (Tirole [1990] p. 245). However, such collusion gives rise to two familiar problems. First, collusive agreements inevitably create incentives for firms to defect. Second, even if such defection could be prevented, collusive profits are likely to be eroded by new entrants.

Following MacLeod *et al.* [1987] we assume that firms employ a familiar "trigger strategy" which is designed to deter both defection from the collusive agreement and entry into the industry. The trigger strategy requires that firms abide by the collusive agreement, unless either cheating is detected or a new firm enters the industry. If either defection or entry occurs, the collusive agreement is dissolved and all firms revert to the (noncooperative) Cournot-Nash output level forever. This strategy will deter defection by incumbents if the discounted future losses suffered due to retaliation exceed the immediate gains from cheating. We assume that new firms who enter the industry incur irreversible sunk entry costs. It follows, that the threat to revert to the Cournot-Nash output level will deter entry, if new firms find that at the post-entry Cournot-Nash equilibrium they are unable to earn sufficient profits to cover their fixed entry costs. Section 2 outlines the conditions under which sunk costs and the trigger strategy combine to act as a barrier to entry which allows the incumbents to collude without attracting new firms.

We incorporate this oligopoly supergame into a simple macroeconomic model. It is shown that macroeconomic policies, through their impact on interest rates, play a very different role to that in the conventional literature. This occurs because in a supergame setting the incentive to enter and defect are influenced by the interest rate. To see this, consider the problem of defection when the number of firms is fixed. Recall that if a firm cheats the collusive agreement is dissolved and all firms revert to their Nash (noncooperative) output levels. By defecting, a firm therefore forgoes the collusive profits it would have earned in future periods. It follows, that cheating will be profitable if the immediate gains from defection exceed the discounted value of foregone future collusive profits. Observe that when interest rates decline the discounted value of foregone future collusive profits rise, so that firms have less incentive to defect. Stated differently, lower interest rates raise the present value of future retaliation and this makes cheating from the collusive agreement less attractive. Since cheating is less profitable when interest rates decline, firms can lower output levels and sustain a more collusive equilibrium without prompting defection. This positive relationship between interest rates and the sustainable level of collusive output is termed the "strategic effect" of interest rates.

Since collusive output levels are influenced by interest rates, it follows that macroeconomic policies which alter the interest rate will lead to variations in output levels. For example, in Section 3 we show that if an increase in the money supply lowers interest rates, the strategic effects allow firms to sustain a more collusive equilibrium at a lower level of output. More generally, macroeconomic policies alter the level of economic activity, not only by changing aggregate demand, but by influencing the degree of competition in product markets.

Section 4 investigates the impact of monetary and fiscal policies when the number of firms is allowed to vary, so that industry structure is endogenously determined. Once more macroeconomic policies influence market structure and output levels through the interest rate. Specifically, a reduction in interest rates raises the discounted value of post-entry profits, so that new firms are attracted into the industry. It is shown that an increase in firm numbers makes collusion more difficult to sustain, so that output levels tend to rise. This is referred to as the "entry effect" of interest rates. With industry structure endogenously determined, interest rates have conflicting effects on output levels. While a reduction in interest rates make entry more profitable and raises output levels, the strategic effects allows a more collusive equilibrium to be established at lower output levels. The net effect of a change in interest rates is therefore ambiguous.

While the model outlined in this paper differs from much of the existing literature on the macroeconomic implications of imperfect competition, it is allied to the work of Rotemberg and Woodford [1992] and Damania and Madsen [1995]. Rotemberg and Woodford explore the impact of temporary changes in government spending in an oligopoly supergame with a fixed number of firms, while Damania and Madsen assess the short run effects of permanent changes in government spending and the money supply in an IS-LM model with oligopolistic firms. In contrast, this paper deals with the collusive effects of interest rate changes in both the short and long run with firm numbers endogenously determined in a general equilibrium system. Accordingly, we extend the existing literature and examine the implications of a different and hitherto unexplored mechanism in a macroeconomic context.

The remainder of the paper is organised as follows. Section 2 outlines the basic microeconomic structure of the model and defines certain important properties of the product market in a repeated game context. Section 3 solves for the economy wide equilibrium when the number of firms in the economy is fixed. Section 4 assesses the impact of macroeconomic policies when the number of firms in the industry is endogenously determined. Finally, Section 5 concludes the paper.

2 The Model

In this section we outline the basic structure of the model. There are assumed to be four agents in the economy: households, firms, workers and the government who interact in the goods, labour, money and bond markets. The analysis is based on simple functional forms which abstract from inessential, though not unimportant, mechanisms.

2.1 Households

All households are assumed to be identical and in each period maximise a Cobb-Douglas utility function which is defined over a homogenous consumption good, leisure, real money balances and the real value of government bonds. The household utility function is defined by[1]:

$$U_t = \alpha \log Q_t + \beta \log \frac{M_t}{P_t} + \gamma \log \frac{B_t}{P_t} + \delta \log L_t \quad , \quad \alpha + \beta + \gamma + \delta = 1 \, , \quad (1)$$

where Q_t is the consumption good consumed in period t; M_t is period t stock of nominal money balances; B_t is the period t stock of (one period) government bonds; P_t is the price level in period t and L_t is leisure consumed in period t.

Utility is maximised subject to the budget constraint:

$$Q_t = w_t(T_t - L_i) + \Pi_t - (m_t - \rho_t m_{t-1}) - \left(b_t - \rho_t(1 + R_t)b_{t-1}\right) - \tau_t \quad (2)$$

where $m_t = M_t/P_t$ is the real money supply in period t; $b_t = B_t/P_t$ is the real stock of bonds in t; $\rho_t = P_{t-1}//P_t$, R_t is the nominal rate of interest on bond holdings and $r_t \equiv \rho_t(1 + R_t - 1)$ is the corresponding real rate of interest[2]; w_t is the real wage; Π_t is distributed profits of firms in real terms; $N_t = (T_t - L_t)$ is labour supply and τ_t is a lump sum tax in real terms.

Maximisation of utility subject to the budget constraint in (2) yields the usual demand functions. Since we wish to analyse the effects of an oligopoly supergame in a manner permitting closed form solutions, we assume that these functions are stable and focus on the steady state solutions[3]. In this non-stochastic framework this implies that the time

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[1] This simple specification for utility is employed because it yields a demand function which provides an explicit closed form solution to the oligopoly supergame outlined below. More complex and realistic utility functions result in complicated demand functions which do not yield analytical solutions for the supergame.

[2] Observe that when prices are stable then $\rho_t = 1$ and $R_t = r_t$.

[3] A similar approach is adopted in Rotemberg and Woodford [1992].

subscripts on the demand functions can be ignored in the steady state solutions. In the Appendix it is demonstrated that the steady state goods, money and bonds demand and labour supply functions are given by:

$$Q = \alpha y \tag{3a}$$
$$m = \beta y/\sigma \tag{3b}$$
$$b = \gamma y/\sigma \tag{3c}$$
$$N = T(1-\delta) - \frac{\delta}{w\sigma}(\Pi - \tau) \tag{3d}$$

where $y = wT + \Pi - \tau$ and $\sigma = 1 - \beta - (1+R)\gamma$.

2.2 Government

The government purchases the consumption good at the market price paid by households. The total value of government purchases in real terms is denoted g. In addition to purchases of the consumption good, the government must pay interest on its outstanding bonds. The government funds these expenditures either by raising taxes (τ), selling bonds (B), or increasing the money supply (M). The government's budget constraint is given by[4]:

$$g_t - \tau_t = (m_t - \rho_t m_{t-1}) + \left(b_t - \rho_t(1+R_1)b_{t-1}\right). \tag{4}$$

2.3 Firms

On the production side we assume that there are several oligopolistic industries. In what follows we focus upon a representative industry which consists of identical firms in an oligopoly producing a homogenous good Q. There are two types of firms in the model: active firms and potential entrants. A firm is deemed to be active if it engages in production. Potential entrants, on the other hand, are assumed to base their entry decisions on the ex-post profits which would obtain in the post-entry equilibrium. All firms are fully informed about their rivals' demands, production levels and profits. We further assume that new firms who enter the industry incur irreversible, one-off entry costs of F, which may be interpreted as a barrier to entry. These entry costs are paid to households in the form of a lump sum transfer[5].

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[4] In the steady state this simplifies to: $g - \tau = rb$.

[5] The entry costs may be viewed as a franchise fee paid by new entrants to the owners of the franchise, who are the households in the economy.

The consumption good is produced, under constant returns to scale, using only labour as an input. The labour market is modelled as in Dixon [1987] and Molana and Moutos [1992]. Accordingly we normalise the output-labour ratio to unity. Let q_i be the output level of firm i then: $q_i = N_i$, where N_i = labour demand of firm i.

Goods demand consists of the sum of consumer demands and government purchases in equations (3a) and (4). Accordingly, the profit function of each active firm i is defined by[(6)]:

$$\Pi_i = \frac{Z}{(n-1)q_j + q_i} q_i - wq_i \quad , \quad i \neq j , \tag{5}$$

where $Z = \alpha y + g$; n is the number of active firms in the economy.

From the first-order conditions we obtain the following best response function for firm i under Cournot conjectures:

$$R_i(q_i) = \sqrt{\frac{Z(n-1)q_j}{w}} - (n-1)q_j . \tag{6a}$$

Since all firms are symmetric, solving yields the noncooperative Cournot-Nash equilibrium output (q_i^N) and profits (Π_i^N) for each firm i:

$$\left.\begin{aligned} q_i^N &= \frac{Z(N-1)}{n^2 w} \\ \Pi_i^N &= \frac{Z}{n^2} . \end{aligned}\right\} \tag{6b}$$

It is assumed that the active firms in the industry interact repeatedly for an indefinite period of time. It is well established that under these circumstances firms have an incentive to collude by restricting output levels (Tirole [1990]). However, collusion gives rise to two familiar problems. Firstly, collusive agreements invariably create incentives for firms to defect. Secondly, even if such defection could be prevented, there still remains the possibility that collusive profits may be eroded by new entrants. It follows that collusion can be sustained only if firms employ a strategy which prevents further entry into the industry and deters cheating by the incumbents.

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(6) We implicitly assume that firms ignore the impact of their profits on household incomes. Similarly, households ignore the impact of their optimising decisions on firms' distributed profits This is an approach which has been widely employed in models of imperfect competition and serves to ensure that firms maximise their profits treating demand as exogenous, while households maximise utility treating income as exogenous (see Hart [1982] and Bonanno [1990]).

Following MacLeod *et al.* [1987] we assume that firms employ a simple trigger strategy which is designed to deter entry into the industry and defection from the collusive agreement. Specifically, we assume that each firm produces at the agreed collusive output level unless either cheating is detected or there is new entry beyond a certain level to be specified below. If either cheating or entry occurs the collusive agreement is immediately dissolved and all firms revert to Cournot-Nash output levels forever. It has been shown by MacLeod *et al.* [1987] that this strategy defines a subgame perfect equilibrium with credible threats which deter both entry and defection(7).

In order to define the equilibrium collusive output level we must first describe the manner in which the number of active firms in the industry is determined. Consider first the entry decision of new firms. New entrants are assumed to incur fixed one-off entry costs of F. Hence, in the absence of collusion, entry will occur until the following condition is satisfied:

$$\frac{\Pi_i^N}{r} = F \tag{7}$$

where r is the uniform interest rate.

The left hand side of equation (7) describes the net present value of a new entrant's profits in the Cournot-Nash equilibrium, while the right hand side defines the irreversible fixed entry costs incurred by the entrant. When (7) is satisfied the discounted profits from entry are sufficient to cover the fixed entry costs.

Let $\underline{n}$ denote the number of firms which solves (7). Suppose that the initial number of firms in the industry is: $n < \underline{n}$. It is clear, that even in the absence of collusion it would be impossible for the incumbents to deter entry into the industry. This is because new firms earn sufficient profits to cover their fixed costs. It follows that entry will occur until $n = \underline{n}$. Suppose instead that there are $n \geqslant \underline{n}$ firms in the industry, who collude and earn profits in excess of the Cournot-Nash level. Assume that the firms employ the trigger strategy and threaten to revert to the Cournot-Nash equilibrium if a new firm enters. This threat will now successfully deter new entry into the industry. This follows from the fact that when the existing firms move to the Cournot-Nash equilibrium, the new entrant also maximises profits by producing at the Cournot-Nash output level. However, from equation (7) it can be seen that when the

(7) In addition, the strategy ensures that the defector or new entrant is forced to produce at the Cournot-Nash equilibrium once the punishment is delivered. This follows from the property of a Nash equilibrium. Specifically, when all other firms revert to Cournot-Nash output levels, then it is optimal for a particular firm to also produce at its Cournot-Nash output level.

number of firms in the industry exceeds $\underline{n}$, new entrants do not earn sufficient profits in the post-entry equilibrium to cover their fixed costs. It follows that if potential entrants are rational and base their decisions upon post- entry profits, they will have no incentive to enter the industry. Thus, the threat to revert to the Nash equilibrium can be used to credibly deter entry when the number of firms in the industry exceeds $\underline{n}$. In what follows, we assume that equation (7) determines the initial number of firms in the industry, which is given by $\underline{n}$.

Having determined the number of active firms we now turn to the problem of defining the collusive output level. Firms interact for an indefinite period and therefore implicitly collude by restricting output levels. This, however, gives rise to the usual problem that the individual firm has an incentive to defect from the collusive agreement when all its rivals are producing at the collusive output level. More specifically, let q_i^c denote the collusive output level of some firm i and Π_i^c the corresponding level of collusive profits. Substituting into the best-response function in equation (6a), we find that when all other $(n-1)$ firms produce at the collusive output level q^c, then firm j maximises profits by defecting and producing at output level q^c with corresponding defection profits of Π_j^d:

$$\left.\begin{aligned} q_j^d &= \sqrt{\frac{Z(n-1)q^c}{w}} - (n-1)q^c \\ \Pi_j^d &= \left\{\frac{Z}{(n-1)q^c + q_j^d} - w\right\} q_j^d . \end{aligned}\right\} \tag{8}$$

Observe that in equation (8) we have $d\Pi^d/dq^c < 0$. Thus, defection profits can be lowered by raising collusive output levels.

As noted earlier, firms deter defection from the collusive agreement by threatening to revert to the Cournot-Nash equilibrium forever if any firm deviates. This strategy will prevent defection if the following "incentive compatibility" constraint is satisfied:

$$\Pi_i^d - \Pi_i^c \leqslant \frac{1}{r}\left(\Pi_i^c - \Pi_i^N\right) . \tag{9}$$

The left hand side of equation (9) describes the one period gain from cheating, while the right hand side represents the net present value of collusive profits foregone when the punishment is delivered and all firms revert to the Cournot-Nash output level. When this weak inequality holds, firms have no incentive to defect from the collusive agreement, since the losses from the punishment exceed the gains from defection.

It is assumed that the cartel chooses an output level which is consistent with the absence of defection. Thus, given firm numbers (n)

and the discount rate (r) the industry's maximisation problem reduces to one of choosing the minimum feasible output level which satisfies the constraint in equation (9) with equality[(8)]. More formally the problem may be expressed as:

$$\max_{Q^c} \Pi^c \tag{10}$$

subject to:

$$\Pi_i^d - \Pi_i^c = \frac{1}{r}\left(\Pi_i^c - \Pi_i^N\right).$$

Substituting for Π^d and Π^N and solving yields industry collusive output level (denoted Q^c)[(9)]:

$$Q^c = \alpha Z S \tag{11}$$

where

$$S = \frac{(n-1)\left(2n^2r^2 - \sqrt{3n^4r^4 + 4n^2r^2 - 1}\right)}{nw\,(nr+1)^2}.$$

Let $q^c = Q^c/n$ be the output level of a firm in the symmetric collusive equilibrium defined by equation (11). Then q^c must satisfy the constraint in equation (10) which may be expressed as:

$$\begin{aligned} G(q^c) &= \Pi_i^d(q^c) - \Pi_i^c(q^c)\left(1 + \frac{1}{r}\right) + \frac{\Pi_i^N}{r} \\ &= 0. \end{aligned}$$

The following property of the collusive equilibrium is proved in the Appendix.

Lemma 1

$$\frac{\partial G(q^c)}{\partial q^c} < 0.$$

Lemma 1 informs us that as collusive output levels are increased, the incentive to defect from the collusive output level declines[(10)]. Lemma 1 plays a critical role in what follows.

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(8) Friedman [1989] terms this a "balanced temptation equilibrium" since it defines the highest interest rate which is consistent with a given level of collusive output. With Cobb Douglas utility functions and demand as defined in (3a) the constraint in (10) always binds since the joint profit maximising solution occurs at an infinitesimal output level.

(9) The solution yields a quadratic, the smallest positive root of which provides the relevant solution.

(10) Intuitively, when collusive output levels rise, defection profits decline more rapidly than do collusive profits. Hence, the incentive to defect diminishes as collusive output levels are increased.

Of further significance in equation (11) is the role that the interest rate plays in determining market structure and industry output levels. To see this, consider first the impact of an increase in interest rates (r) on collusive output levels, holding n constant. It is shown in the Appendix that in equation (11): $\partial Q^c/\partial r > 0$. Thus, output levels increase in response to a rise in interest rates. This occurs because higher interest rates lower the discounted value of future punishments. Specifically, increases in the interest rate lower the right hand side of (9) (*i.e.* $(\Pi^C - \Pi^N)/r$), so that the net present value of the punishment declines and defection becomes more attractive. However, from Lemma 1 we know that this greater incentive to cheat can be negated by raising collusive output levels. Accordingly, equation (11) reveals that when interest rates rise collusion can only be sustained by increasing output levels. In what follows this (positive) relationship between interest rates and the sustainable level of collusive output is termed the "strategic effect" of interest rates.

Changes in the interest rate also influence the entry condition in equation (7). Specifically, lower interest rates raise the discounted value of post-entry Nash profits and lead to an industry with more firms. Equation (11) reveals that an increase in firm numbers makes collusion more difficult to sustain (*i.e.* $\partial Q^c/\partial n > 0$). This occurs because output is now divided among a larger number of firms, so that collusive profits decline more rapidly than do defection profits. Thus, the incentive to cheat increases, and by Lemma 1 output levels must be increased to sustain collusion. In what follows we term this the "entry effect" of interest rates. In the remaining sections we explore the conflicting influences of the strategic and entry effects in a macroeconomic context.

3 The impact of macroeconomic policies with fixed firm numbers

We begin by examining the effect of various macroeconomic policies when the number of firms in the industry is fixed. We incorporate the model of oligopoly into the general equilibrium system outlined in Section 2. The economy contains four markets: goods, money, labour and bonds. By Walras' law we exclude the bond market and solve for equilibrium in the remaining markets. Thus money market equilibrium is described by:

$$\frac{M}{P} = \frac{\beta y}{\sigma}. \tag{12a}$$

Aggregate goods demand is given by the sum of household and government demand for the consumption good (denoted Q^d). Collusive output (Q^c) is determined by the maximisation problem described in equation

(10). Goods market equilibrium is defined by the usual condition:

$$Q^d = Q^c . \tag{12b}$$

Finally, using equation (3d) labour market equilibrium is given by[11]:

$$N^d = T(1-\delta) - \frac{\delta}{w\sigma}(\Pi - \tau) . \tag{12c}$$

The system can be solved in the usual manner to determine the equilibrium level of output (employment) and the various policy multipliers. The solution is presented in the Appendix. We also show that the system is stable whenever the strategic effect of interest rates on output is stronger than the income effect.

We begin by exploring the impact of a reduction in the money supply accompanied by a corresponding change in the supply of bonds. In the Appendix we show that the impact on the level of employment of a change in the stock of money is given by:

$$\frac{dN}{dM} = \frac{\Psi}{\Delta}\left[\frac{\Omega_2}{\eta\sigma^2}\left(\alpha + \frac{\delta}{w}\right) - \frac{\alpha\Omega_1}{\sigma^2}\right] < 0 . \tag{13a}$$

In the Appendix it is demonstrated that (13a) is negative when the strategic effect of interest rates outweighs the income effect of a change in interest rates (*i.e.*, in a stable system). This is because households can only be induced to hold less money by raising the demand for bonds and lowering their price, so that interest rates rise. However, higher interest rates lower the present value of future punishments and provide firms with a greater incentive to cheat. From Lemma 1 it follows that the gains from defection can be negated by raising collusive output levels. Hence, when the money supply contracts and interest rates rise, then collusion can only be sustained by raising output levels. Thus, the strategic effects of a monetary contraction induce an increase in output levels. However, higher output levels (*i.e.* lower levels of collusion) result in lower distributed profits and a decline in household incomes and demands for the consumption good. When the system is stable the strategic effects of interest rates outweigh these income effects, so that output expands in response to a contraction in the money supply.

This result contradicts the conventional wisdom in macroeconomics, which holds that monetary expansions (contractions) tend to raise (lower) aggregate demand and output levels only if prices are rigid in

[11] Since we have assumed that the output-labour ratio is normalised to unity, it follows that $N^d = Q^c$.

some markets (see Sargent [1979]). The results presented here suggest that in a dynamic repeated game context the interest rate plays a critical role in determining the degree of competition. When interest rates rise, future punishments are discounted more heavily so that firms have a greater incentive to cheat and the market is therefore more competitive. In contrast, much of the standard macroeconomic literature assumes that firms interact in a static environment so that interest rates have no impact on the degree of competition and hence output levels. In addition, the direction of the effects of monetary policy is reversed in the present model: a rise in interest rates increases output.

Consider next the consequences of an unanticipated bond financed increase in government spending. In the Appendix we demonstrate that when the number of firms is fixed the impact is summarised by:

$$\frac{dN}{dg} = \frac{1}{\Delta}\left[(\beta\Pi_r - \sigma_r)\left(\frac{\Omega_2}{\eta} - \frac{\Omega_1}{\xi}\right) + \frac{\Psi\beta\delta\Pi_w}{w\xi\eta}\right] > 0. \tag{13b}$$

Thus, bond financed increases in government spending are unambiguously stimulatory. This result reflects the fact that a bond financed increase in government spending raises goods demand and interest rates, both of which tend to raise output levels. Once again this result contrasts with the standard macroeconomic literature, where bond financed increases in government spending tend to crowd-out the stimulatory impact of government expenditure. In the present model, the strategic effects of higher interest rates raise output levels[12].

4 The impact of macroeconomic policies with variable firm numbers

In this section we examine the consequences of allowing the number of firms in the industry to vary. We explore two main issues: First, we investigate the manner in which sunk costs influence the entry of new firms and the exit decision of incumbents. Second, we examine the impact of changes in the money supply and government spending on output levels when the number of firms is endogenously determined.

Consider first the entry decision of firms. Assume that the economy is initially in an equilibrium with $\underline{n}$ firms who successfully deter entry

[12] Observe that these results rely on the assumption that macroeconomic policy variations are unanticipated. If firms are able to predict policy changes, then these policies will ex-ante be incorporated into the profit maximising problem which determines collusive output levels. However, this appears to be an extreme assumption. In practice, it would appear that at least some components of policy changes are likely to be unanticipated.

by threatening to revert to the Cournot-Nash equilibrium. Suppose that there is a reduction in interest rates. This raises the discounted value of post-entry profits earned in the Cournot-Nash equilibrium. It follows, that new firms will enter the industry until the zero profit entry condition (equation (7)) is satisfied. Let $n' > \underline{n}$ denote the resulting number of firms in the industry.

Suppose that interest rates subsequently return back to their previous levels. This will lead to a decline in the discounted value of future profits. However, there may be no exit from the industry even if the net present value of profits earned at the Cournot-Nash equilibrium are negative. This is because the n' firms have already paid their sunk costs. Moreover, in equilibrium these firms collude and earn profits in excess of the Cournot-Nash level. Hence, even though firms may be making losses at the Cournot-Nash equilibrium, at the collusive equilibrium profits may be sufficient to cover the sunk costs. Accordingly, an incumbent will leave the industry only if collusive profits are negative. From this it follows that the zero profit entry condition in equation (7) only defines the minimum number of firms in the industry. In this Section it is suggested that this distinction between the incentive to enter and exit may result in an asymmetry in the response of firms to policy changes.

We now turn to the problem of determining the impact of macroeconomic policies on output levels. Equilibrium is defined by the goods, bond and money market clearing conditions, together with the entry condition (in equation (7)) which determines the minimum number of firms in the economy. As noted in Section 2 it is assumed that new entrants pay a lump sum entry cost of F which accrues to households[13]. Using Walras' law we eliminate the bond market and solve for equilibrium in the remaining sectors of the economy. The long run equilibrium relations are therefore given by the entry condition in (7); money market equilibrium in (12a); goods market equilibrium in (12b) and labour market equilibrium in (12c).

We begin by assuming that in the initial collusive equilibrium, the entry condition in equation (7) holds as an equality, so that there are $\underline{n}$ firms in the economy. In the Appendix we solve the system which is stable when the determinant (denoted D) is positive.

Consider an unanticipated increase in the money supply accompanied by a corresponding change in the supply of bonds. In the Appendix

[13] Accordingly household income is now defined by $y + Fn^e$, where $n^e = (n' - n)$ is the number of new firms in the industry.

it is shown that:

$$\frac{dN}{dM} = -\frac{S}{D}\left\{ K_2\left(\Omega_1\Phi_2 - \Omega_2\Phi_1\right) + \Psi\left[\left(\alpha + \frac{\delta}{w}\right)\left(K_3\left(\frac{\Phi_2}{\eta} + \frac{\Phi_1}{\xi}\right) - K_4\Omega_2\right) + \alpha\frac{\Omega_1}{\xi}\right]\right\}. \tag{14a}$$

The sign of dN/dM is indeterminate because of the conflicting influences of the strategic and entry effects of interest rates. As in section 3, the increase in the money supply is accompanied by a reduction in interest rates. With a given number of firms the strategic effects induce a decline in output levels. However, lower interest rates also raise the discounted value of post-entry profits, and this prompts new firms to enter the industry. An increase in firm numbers makes defection more attractive. From Lemma 1 we know that collusion can only be restored by raising output levels. The net effect of an increase in the money supply is therefore ambiguous and depends on the conflicting strategic and entry effects. If the strategic effects dominate then output levels will contract and vice-versa.

Consider next a reduction in the money supply. Ceteris paribus, interest rates rise so that the strategic effects induce an increase in output levels. However, higher interest rates also lower the discounted value of post-entry profits earned in the Cournot-Nash equilibrium and this renders entry into the industry unprofitable. As noted earlier, existing firms will not exit since they collude and earn profits in excess of the Cournot-Nash level. For firms to exit from the industry, collusive profits must be negative. For marginal changes in the money supply, it will always be more profitable for these firms to remain in the industry. More formally, this implies that $dn = 0$. It follows that there are no entry effects and hence the strategic effects will lead to an increase in output levels in response to a contraction in the money supply.

This asymmetric response to changes in the money supply has interesting policy implications. It suggests that the economy may exhibit hysteresis in the sense that the level of output in period t depends on the previous path of the economy. To see this assume that there are $\underline{n}$ firms in the economy so that the zero profit entry condition is just satisfied. Suppose there is an increase in the money supply. If the entry effects dominate, then there will be an expansion in output levels. In contrast, suppose that the number of active firms exceeds $\underline{n}$, then an expansion in the money supply may not induce new entry and the strategic effects would dominate leading to a decline in output levels. This example illustrates that past levels of entry play a crucial role in determining current responses to policy changes, since increases in output induced by monetary expansions (due to entry of new firms) may not be reversed by monetary contractions.

Consider next an unanticipated bond financed increase in government spending. The impact on output levels is summarised by:

$$\frac{dN}{dg} = \frac{\Omega_2}{D}(K_2\Phi_1 - (\beta\Pi_r - \sigma_r)K_4) > 0. \qquad (14b)$$

A bond financed increase in government spending leads to increases in both aggregate demand and interest rates. The increase in interest rates lowers the discounted value of future punishments which makes defection more attractive. To restore collusion firms must therefore raise output levels. The impact of government spending on firm numbers is somewhat more complicated. While higher levels of government spending raise aggregate demand and post-entry profits, higher interest rates lower the discounted value of post-entry profits and make entry less attractive. The impact on firm numbers is therefore indeterminate and depends critically on whether the demand effects outweigh the interest rate effects. If there is entry, then equation (14b) summarises the impact of higher government spending. In contrast, if there is no new entry, then $dn = 0$ and the impact is given by equation (13b). Similarly, when government spending declines, the fall in interest rates and demand lead to a decline in output levels. However, the impact on firm numbers is once again indeterminate.

5 Conclusions

In this paper we have analysed the impact of various macroeconomic policies in a model where the product market is modelled in terms of a repeated supergame with entry. Following MacLeod *et al.* [1987] it was assumed that the collusive equilibrium was sustained by threats of future retaliation against entrants and defectors. The degree of collusion and entry were both shown to depend on the interest rate. Thus, macroeconomic policies which altered interest rates influenced the sustainable production plan of the industry.

The paper also demonstrated the possibility of obtaining some counter intuitive policy implications. For instance, it was shown that variations in the money supply may have real and somewhat "perverse" effects in a collusive equilibrium. The real impact of monetary policy was shown to derive from the influence of interest rates on the degree of competition, as output levels vary in order to maintain collusion. These effects are "perverse" from the standpoint of standard macro theory, in that a rise in interest rates is accompanied by an increase in output and lower industry profits. There is at least some anecdotal evidence in support of this result. In the Australian economy over the period September, 1983 to March, 1995, the interest rate on 90-day bank bills was negatively correlated with company profits before taxes[14]. Similarly in the UK over the period January, 1989 to March, 1993, the Treasury bill rate was negatively correlated with retail margins[15].

The analysis further revealed that with firm numbers endogenously determined sunk costs may lead to an asymmetric response to monetary policy variations. Moreover, it was suggested that the economy might exhibit hysteresis in the long run since increases in output brought about through lower interest rates (as new firms enter the industry) may not be offset by decreases in output as interest rates rise.

These results highlight the potentially important role which strategic factors may play in an economy with high levels of concentration and suggest the need for further research which draws upon recent developments in industrial economics.

APPENDIX

Derivation of Equations (3a) - (3d)

Maximisation of (1) subject to (2) yields the following demand functions:

$$q_t = \alpha v_t \tag{A1}$$

$$m_t = \beta v_t \tag{A2}$$

$$b_t = \gamma v_t \tag{A3}$$

$$n_t = T(1-\delta) - \frac{\delta}{w_t}\left(\Pi_t - \tau_t + \rho_t\left(m_{t-1} + (1+R)b_{t-1}\right)\right) \tag{A4}$$

where

$$v_t = w_t + \Pi_t - \tau_t + \rho_t\left(m_{t-1} + (1+R)b_{t-1}\right)$$

Observe that equations (A2) and (A3) imply the following VAR:

$$\begin{bmatrix} m_t \\ b_t \end{bmatrix} = \begin{bmatrix} \beta \\ \gamma \end{bmatrix} \begin{bmatrix} w_t & \Pi_t \end{bmatrix} + \rho_t \begin{bmatrix} \beta \\ \gamma \end{bmatrix} \begin{bmatrix} 1 & (1+R_t) \end{bmatrix} \begin{bmatrix} m_{t-1} \\ b_{t-1} \end{bmatrix}.$$

[14] This data was obtained from the Australian Bureau of Statistics.

[15] This data was obtained from *Economic Trends*, 1995.

Stationarity of this system requires that $|h| > 1$, where:

$$h = \frac{\beta + \gamma(1+R_t)}{2\gamma\beta(1+R_t)\rho_t} \pm \frac{\sqrt{[\beta - \gamma(1+R_t)]^2 - 4\gamma^2\beta^2\rho_t^2(1+R_t)^2}}{2\gamma\beta(1+R_t)\rho_t}.$$

It can be verified that the stability condition is satisfied if $\beta < 1/\rho_t$, $\forall t$. This clearly holds for all $P_t \geqslant P_{t-1}$. Thus so long as either prices are stable or there is no deflation the processes are stationary.

In the text we focus on the steady state with $\rho = 1$, $m_t = m_{t-1} = m$ and $b_t = b_{t-1} = b$. Substituting in (A1)-(A4) and solving yields equations (3a)-(3d) in the text.

Proof of Lemma 1

Let q^c denote the output level of a firm in the solution to the maximising problem in equation (10) when the constraint binds. Thus, q^c satisfies:

$$G(q^c) = \Pi_i^d(q^c) - \left(1 + \frac{1}{r}\right)\Pi_i^c(q^c) + \frac{1}{r}\Pi_i^N = 0.$$

If Lemma 1 is true then an increase in q^c lowers the gains from defection, thus: $\partial G(q^c)/\partial q^c < 0$.

Suppose that Lemma 1 is not true, then a reduction in collusive output levels induces no defection, so that: $\partial G(q^c)/\partial q^c \geqslant 0$. However, from equation (5) we know that $\partial \Pi^c/\partial q^c < 0$. That is, a reduction in collusive output levels raises collusive profits. It follows that if Lemma 1 is not true then collusive profits can be increased by lowering output levels, without prompting defection. This, however, contradicts the hypothesis that q^c solves the maximisation problem in (10) when the constraint binds[16]. It follows that if q^c is a solution to (10) then $\partial G(q^c)/\partial q^c < 0$. □

Proof of Sign of dQ^c/dr

In the text it was stated that $dQ^c/dr > 0$. This result may be established directly by differentiating equation (10). However, in what follows we provide a more general proof of this result.

Suppose this assertion is not true. Then $dQ^c/dr \leqslant 0$. This then implies that higher interest rates lower sustainable collusive output levels. From the profit function in equation (5) we know that $d\Pi^c/dQ^c < 0$. Thus lower collusive output levels raise profits. If these higher profits are to be sustainable then either the gains from defection must be lower and/or the discounted value of future punishments must rise. This in turn requires that $d\Pi^d/dQ^c > 0$. However, we know that $d\Pi^d/dQ^c < 0$ and that higher interest rates lower the discounted value of future punishments. These two factors therefore combine to imply that a fall in Q^c is not sustainable when r rises. Thus $dQ^c/dr > 0$. □

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(16) Alternatively, this result can be established more tediously by substituting q^c into $G(q^c)$ and differentiating.

Short run multipliers with firm numbers fixed

Solving the system defined by equations (12a), (12b), (12c) and totally differentiating yields

$$\begin{bmatrix} -1+\frac{\Pi_N}{\eta}\left(\alpha+\frac{\delta}{w}\right) & \left(\alpha+\frac{\delta}{w}\right)\frac{1}{\eta\sigma^2}\Psi & \Omega_1 \\ -1+\frac{\alpha\Pi_N}{\sigma} & \frac{\alpha\Psi}{\sigma^2} & \Omega_2 \\ \beta(w+\Pi_N) & \beta\Pi_r-\sigma_r & \beta(T+\Pi_w) \end{bmatrix}\begin{bmatrix} dN \\ dr \\ dw \end{bmatrix}=\begin{bmatrix} -\frac{1}{\eta}dg \\ -\frac{1}{\xi}dg \\ SdM \end{bmatrix}$$

where subscripts are used to denote partial derivatives, and

$$\begin{aligned}
\Omega_1 &= \frac{-\delta y}{\eta\sigma w^2}+\frac{\alpha\left(\frac{\alpha+\delta}{w}\left(-\frac{y}{\sigma}-g\right)\right)}{\eta}+\frac{\frac{\alpha+\delta}{w}\Pi_w}{\eta}<0\,, \\
\Omega_2 &= \frac{\left(\alpha\sigma\left(L-\Pi_w\right)+\alpha\left(\alpha\left(\Pi+wL\right)+g\sigma\right)\right)}{\sigma^2}>0\,. \\
\Psi &= \left(\sigma\Pi_r-\sigma_r y\right), \\
\sigma &= 1-\beta-\gamma(1+r), \\
\eta &= 1-\delta-\alpha w\,, \\
\xi &= 1-\alpha w \\
&= \eta-\delta\,.
\end{aligned}$$

We assume that the system is stable so that the determinant, denoted Δ, is assumed to be negative. Using the fact that the output-labour ratio is normalised to unity we obtain the following solutions: The impact of a change in the money supply on employment (output) is given by:

$$\frac{dN}{dM}=\frac{\Psi}{\Delta}\left[\frac{\Omega_2}{\eta\sigma^2}\left(\alpha+\frac{\delta}{w}\right)-\frac{\alpha\Omega_1}{\sigma^2}\right]>0\,.$$

It can be verified that $\Pi_r<0$, $\Pi_w<0$, $\Omega_1<0$, $\Omega_2>0$, $\sigma-r<0$ and by assumption $\Delta<0$. It follows that $dN/dM<0$ iff $\Psi>0$. Observe that a sufficient condition for $\Psi>0$ is that: $|\Pi_r|<|\sigma_r|$ which implies that the strategic effects (σ_r) outweigh the income effects (Π_r). When this condition is satisfied the determinant of the system Δ is negative. Upon substitution and rearrangement, the impact of government spending on N is given by:

$$\frac{dN}{dg}=\frac{1}{\Delta}\left(\left(\beta\Pi_r-\sigma_r\right)\left(\frac{\Omega_2}{\eta}-\frac{\Omega_1}{\xi}\right)+\frac{\Psi\delta\beta\Pi_w}{w\xi\eta}\right),$$

which is positive when $\Delta<0$.

Multipliers with variable firm numbers

Solving and totally differentiating we obtain the following matrix of coefficients:

$$\begin{bmatrix} -1+\left(\alpha+\frac{\delta}{w}\right)\frac{\Pi_n}{\eta} & \left(\alpha+\frac{\delta}{w}\right)\frac{\Psi}{\eta\sigma^2} & \Omega_1 & \frac{\alpha\Pi_n + XS_n\left(\alpha+\frac{\delta}{w}\right)+\alpha F}{\eta} \\ -1+\frac{\alpha\Pi_N}{\sigma} & \frac{\alpha\Psi}{\sigma^2} & \Omega_2 & \frac{\alpha}{\xi}\left(\Pi_n + XS_n + F\right) \\ \beta\left(w+\Pi_n\right) & \beta\Pi_r - \sigma_r & \beta\left(T+\Pi_w\right) & \beta\left(\Pi_n + XS_N\right) \\ \sqrt{\frac{\alpha\left(w+\Pi_n\right)}{rF}} & \sqrt{\frac{\alpha\Pi_r}{rF}} - K & \sqrt{\frac{\alpha\left(\Pi_w+n\right)}{rF}} & \sqrt{\alpha\left(\Pi_n+\frac{1}{F}\right)} \end{bmatrix}$$

Let D denote the determinant. Stability considerations require that D must be positive. In what follows, we assume that the system is stable. The impact of changing the money supply is:

$$\begin{aligned} \frac{dN}{dM} &= -\frac{S}{D}\left\{K_2\left(\Omega_1\Phi_2 - \Omega_2\Phi_1\right) + \Psi\left[K_3\left(\left(\alpha+\frac{\delta}{w}\right)\frac{\Phi_2}{\eta} + \frac{\Phi_1}{\xi}\right)\right.\right. \\ &\qquad \left.\left. -K_4\left(\left(\alpha+\frac{\delta}{w}\right) + \frac{\alpha\Omega_1}{\xi}\right)\right]\right\} \end{aligned}$$

where:

$$\begin{aligned} \Phi_1 &= \frac{1}{\eta}\left(\alpha\Pi_n + XS_n\left(\alpha+\frac{\delta}{w}\right)+\alpha F\right) ; \\ \Phi_2 &= \frac{\alpha}{\xi}\left(\Pi_n + XS_n + F\right) , \\ K_2 &= \left(\frac{\alpha\Pi_r}{rF}\right)^{1/2} , \\ K_3 &= -\left(\frac{\alpha\Pi_w + n}{rF}\right)^{1/2} , \\ K_4 &= -\left(\alpha\Pi_n - \frac{1}{F}\right)^{1/2} . \end{aligned}$$

The impact of a bond financed increase in government spending is positive since differentiation of Π and S with respect to n reveals that $|\Pi_n| < |S_n|$. Thus

$$\frac{dN}{dg} = \frac{\Omega_2}{D}\left(K_2\Phi_1 - \left(\beta\Pi_r - \sigma_r\right)K_4\right) > 0 .$$

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