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ABSTRACT

New Keynesian models of price setting under monopolistic competition involve two kinds of inefficiency: the price level is too high because firms ignore an aggregate demand externality, and when there are costs of changing prices, price stickiness may be an equilibrium response to changes in nominal money even when all agents would be better off if all adjusted prices. This paper models the consequences of allowing firms to coordinate, enforcing the coordination by punishing deviators; this is equivalent to modeling firms as an implicit cartel playing a punishment game. We show that coordination can partially or fully eliminate the first kind of inefficiency, depending on the magnitude of the punishment, but cannot always remove the second. The response of prices to a monetary shock will depend on the magnitude of the punishment, and may be asymmetric. Implications for the welfare cost of fluctuations also differ from the standard monopolistic competition case.

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1 Introduction

Can firms coordinate their prices in response to exogenous shocks?

This question is central to models with endogenously sticky nominal prices. As in Ball and Romer (1990), firms, acting as monopolistic competitors under menu costs, fail to coordinate their prices because each firm's optimal price is increasing in the aggregate price level. This coordination failure reinforces the now standard New Keynesian result first presented in Mankiw (1985) that 'small menu costs can lead to large business cycles'.

Monopolistic competitors are 'naive' price-takers who, by assumption, are incapable of internalizing an aggregate demand externality, thereby leaving the equilibrium price level too high. Alternatively, we can assume firms to be more sophisticated price-coordinators/price-makers such as a cartel and allow them to internalize at least a part of the externality. In this paper, we investigate how an implicit cartel might be able to solve the coordination problem.

Although a cartel is the most frequently cited price coordination mechanism, it is rarely perfect. Especially when a cartel is implicit, it has to enforce its coordination by inflicting punishment whenever firms try to deviate from the agreed-upon price. A cartel which has to curtail its members' incentive to cheat faces an internal coordination problem of its own. We take the Ball and Romer (1990) "yeoman farmer" model and assume that all agents collude implicitly to coordinate their own prices.

It is not our intention to generalize the assumption of an economy as a cartel. Instead, we consider this exercise to be our first step in generalizing a solution to the price coordination problem. Collusive attempts to coordinate prices are widely documented market phenomena in industrial organization. Macroeconomists, Rotemberg and Saloner (1986) in particular, have looked at the countercyclicality of the price-marginal cost markup when industries are collusive. A series of papers by Rotemberg and Woodford (1991,1992) explains the acyclicality of the real wage through a similar argument.

This paper presents an analysis of price coordination in an economy where all the firms are collusive. We show that the cartel's ability to coordinate allows them to internalize a part, if not all, of the aggregate demand externality. The stronger the cartel enforcement mechanism, (i.e. the higher the punishment), the closer the cartel equilibrium is to the social optimum. When the cartel enforcement mechanism becomes weaker (i.e. the punishment becomes small), the cartel's equilibrium price level will be closer to the monopolistically competitive price. Hence, unlike in Rotemberg and Saloner (1986) and most other cartel models, our cartel wants to *lower* prices, not raise them.

As in the Ball and Romer (1990) model, we examine the flexibility of price levels under the presence of menu costs. With a large punishment, the cartel's objective function is locally flat, and there will be a symmetric range of monetary shocks over which prices are sticky. Social welfare losses from fluctuations in aggregate demand will be small. Under low punishment, the need to maintain the cartel implies that prices are upward-flexible but downward-sticky, since for fixed prices the incentive to cheat rises with increases in nominal money. Welfare losses from economic fluctuations are correspondingly asymmetric.

The rest of the paper proceeds as follows: Section 2 gives the setup of the model, section 3 solves it and provides comparative statics and section 4 concludes.

2 Setup

We take the Ball and Romer (1990) "yeoman farmer" model and start with the aggregate demand externality problem. Assume there are N differentiated products indexed by j produced by N producer-consumers index by i, where N is large. Each consumer has utility function (i.e. firm profit function)

$$U_i = C_i - \frac{\epsilon - 1}{\gamma\epsilon} L_i^{\gamma} \tag{1}$$

where $C_i = (\sum_{j=1}^{N} C_{ij}^{\frac{\epsilon-1}{\epsilon}})^{\frac{\epsilon}{\epsilon-1}}$, and L_i is labor supply. There is increasing marginal disutility of labor, so $\gamma > 1$, and the elasticity of substitution across goods is $\epsilon > 1$. We will use utility function and profit function interchangeably. The production function is linear in labor, so that $Y_i = L_i$.

Given this, and assuming a cash-in-advance requirement, one can easily show that the demand for each good is:

$$Y_i = \frac{M}{P}\left(\frac{P_i}{P}\right)^{-\epsilon} \tag{2}$$

We may then rewrite each consumer's utility as a function of the price of his or her good, the money stock and the aggregate price level as:

$$U_i = \frac{M}{P}\left(\frac{P_i}{P}\right)^{1-\epsilon} - \frac{\epsilon-1}{\gamma\epsilon}\left(\frac{M}{P}\right)^{\gamma}\left(\frac{P_i}{P}\right)^{-\gamma\epsilon}. \qquad (3)$$

As in Ball and Romer, one can derive that the symmetric monopolistic competition solution is to have $P_i = P = M$, which yields individual utility of $\frac{\epsilon(\gamma-1)-1}{\gamma\epsilon}$. The utility maximizing (henceforth 'socially optimal') choice of P is to set $P = (\frac{\epsilon-1}{\epsilon})^{\frac{1}{\gamma-1}}M$. This is lower than the price level arising from the monopolistically competitive solution because of the presence of an aggregate demand externality; individual firms ignore the effect of their pricing decisions on the price level. Were individuals able to coordinate, they would choose the utility maximizing price level. One can easily show that at $P_i = P = M$, $\frac{\partial U_i}{\partial P} < 0$ and $\frac{\partial U_i}{\partial P_i \partial P} > 0$. This combination of negative spillovers with strategic complementarity implies, from the results of Cooper and John (1988) that there is coordination failure; firms would all prefer to lower their prices, but no individual firm has an incentive to do so.

In the presence of a cost of changing prices (menu cost) z, for a sufficiently small change in nominal money M, individual producer-consumers will not be willing to change their prices, since the gain in utility from doing so is second order (since $\frac{\partial U_i}{\partial P_i} = 0$) and thus less than even a small menu cost. There is again coordination failure, for exactly the same reasons as given above in the flexible price case; all firms would be better off if they all changed prices, but no individual firm has an incentive to do so. Below, we show that the first type of coordination failure is partially resolved by allowing for implicit collusion with punishment.

3 Collusive Pricing

3.1 Flexible Price Case

Now suppose the N firms implicitly collude. It is not our purpose to generalize the entire economy as a cartel. We are simply taking the coordination problem more seriously and using collusion as our first step. Moreover, this cartel colludes to lower prices, contrary to our general expectation that a cartel raises prices. This is a consequence of the aggregate demand externality which produces the coordination failure, and is standard in imperfectly competitive macroeconomic models of price adjustment.

The cartel chooses a collusive price P_c to maximize joint profits, subject to a 'non-cheating' constraint: if a firm deviates from the collusive price, the cartel inflicts punishment K on all of its members. The cartel's coordination is enforced through this threat of punishment. Thus, the collusive price, which will be a function of the money stock M, solves the following problem:

$$P_c(M) = arg\max_{P} N\left(\left(\frac{M}{P}\right) - \frac{\epsilon - 1}{\gamma\epsilon}\left(\frac{M}{P}\right)^{\gamma}\right) \tag{4}$$

$$s.t. \Delta U_i(P_c(M), M) \leq K \tag{5}$$

where K can be thought as the future lost profit when firms engage in the worst feasible price war. Since our model is static, we will take the amount K to be exogenous[1].

$\Delta U_i(P_c(M), M)$ is the maximum gain that a firm can obtain from cheating when everyone else is charging the agreed price $P_c(M)$ and the level of the money stock is M.

To calculate $\Delta U_i(P_c(M), M)$, first note that given any price P, one can derive an individual firm's optimal choice of $\frac{P_i}{P}$, from maximizing (3), as:

$$\frac{P_i}{P} = \left(\frac{M}{P}\right)^{\frac{\gamma-1}{\epsilon(\gamma-1)+1}} \tag{6}$$

Hence

$$\Delta U_i(P_c(M), M) = \frac{\epsilon(\gamma-1)+1}{\gamma\epsilon}\left(\frac{M}{P_c}\right)^{\frac{\gamma}{\epsilon(\gamma-1)+1}} - \frac{M}{P_c} + \frac{\epsilon - 1}{\gamma\epsilon}\left(\frac{M}{P_c}\right)^{\gamma} \tag{7}$$

We consider the case in which this non-cheating constraint is binding (small K) and another case in which this constraint is not binding (large K).

If the punishment K is zero, the only sustainable collusive price will be the one for which the incentive to cheat is also zero, the monopolistically competitive solution.

If the punishment is large, larger than the gain from cheating ($K > \Delta U_i(P_c(M), M)$), the cartel will attain the socially optimal price. Without

[1] In a dynamic model of oligopoly, it is possible to endogenize the size of the punishment as in Green and Porter (1984). The optimal equilibrium path is enforced by the threat the worst feasible punishment (Abreu et. al., 1986). Rotemberg and Saloner (1986) and Rotemberg and Woodford (1991,1992) use this feature to obtain a countercyclical markup of price over marginal cost.

the cheating constraint binding, firms are able to jointly internalize the aggregate demand externality. This is why they collude to *lower* the price, rather than colluding to *raise* the price, as in traditional collusive models.

For small values of K, the non-cheating constraint is binding, so collusive prices will be between the socially optimal price and the monopolistically competitive price. Hence, depending on K, for a given M the aggregate price level will lie in the interval $\left[\left(\frac{\epsilon-1}{\epsilon}\right)^{\frac{1}{\gamma-1}} M, M\right]$.

The slope of the individual profit function with respect to its own price is positive at the collusive price P_c. Thus, individual firms have incentive to *raise* their prices above the collusive level unless the incentive is constrained by the punishment.

The incentive to cheat $\Delta U_i(P_c(M), M)$ is largest when the cartel is at the socially optimal price, and reaches a local minimum of zero at the monopolistically competitive price level.

In the absence of costs of changing prices, changes in nominal money will only affect the price level, and not affect the real quantity sold. This is because the collusive pricing problem is homogenous of degree zero in M and P. One could rewrite the problem by defining $\psi = \frac{M}{P}$, and solving for the optimal level of ψ. Although multiple solutions in ψ cannot be ruled out, in all such instances $P \propto M$.

3.2 Collusion with Menu Costs

Now suppose there is a cost of changing prices, z, for each firm.[2] Money stock increases and decrease yield asymmetric results depending on the magnitude of the punishment. Thus we will consider each case separately.

When a cartel wants to move its price, but an individual firm does not conform, it is considered as a deviation and calls for punishment.

For the original money stock M_0, the price is at the collusive level defined by the solution to (4) and (5). When the money stock changes from M_0 to M', the following conditions become important determinants of the cartel's price response.

(1) The Non-Cheating Constraint

$$\Delta U_i(P_c, M') \leq K + z \tag{8}$$

[2]This is assumed to be small, although Levy et. al. (1997) have recently found evidence to the contrary.

This is the constraint with the highest priority. At any point in time, with any level of the money stock, the above non-cheating constraint has to be satisfied.

Note that $\frac{\partial \Delta U_i}{\partial M} > 0$ and $\frac{\partial \Delta U_i}{\partial P_C} < 0$, so that the incentive to cheat is increasing in the level of the money stock when the price is kept constant, but is decreasing in the cartel price P_c while the money stock is kept constant.

(2) Optimal Move Condition

When the non-cheating constraint is not binding, the next criterion for the price move is that the cartel's gain from the move, denoted by ΔG, has to be larger than the total menu costs; we call this the "optimal move condition."

$$\Delta G(M_0, M') = U_c(P_c(M'), M') - U_c(P_c(M_0), M') \geq Nz \tag{9}$$

The cartel's gain from moving is always positive for all $M' \neq M_0$ and is increasing in $\mid M_0 - M' \mid$. Let δ be such that $\Delta G(M_0, M_0 + \delta) = Nz$. There will be two solutions to this equation, δ^+ and δ^-. For a small change in the money stock, $M' \in [M_0 - \delta^-, M_0 + \delta^+]$, the cartel's gain from the price move is smaller than the total menu costs. The width of this hysteresis band, $\mid \delta^+ - \delta^- \mid$, depends on the slope of the cartel profit function at the original cartel price.

(3) Individual Rationality Constraint

Once the cartel decides to move, we have to check that it is indeed rational for the individual firm to follow the cartel's decision and to move its price from $P_c(M_0)$ to $P_c(M')$ by paying the menu costs. If a cartel member does not conform, the cartel may choose to inflict the punishment K. The individual incentive not to follow the cartel's suit, ΔR, has to be smaller than the punishment.

Let $U_i(P, M)$ be the individual firm's profit when it charges the price P while all other firms charge $P_c(M)$. Then, it is rational for an individual firm to follow the cartel price if:

$$\Delta R(M_0, M') = U_i(P_c(M_0), M') - U_i(P_c(M'), M') < K - z. \tag{10}$$

We assume that the punishment is larger than the menu costs ($K > z$), so the right-hand side of the inequality is positive. When the money stock increases ($M' > M_0$), $\Delta R(M_0, M') < 0$, so this constraint does not bind and it is fully rational for the individual firm to conform the cartel's price hike. When the money stock decreases ($M' < M_0$), on the other hand,

$\Delta R(M_0, M')$ is positive and may become a binding constraint. We consider the consequences of the binding individual rationality constraint in footnotes 3, 4, and 5.

3.2.1 Large Punishment

If the punishment is large, the non-cheating constraint does not bind. So, the cartel is already at the social optimum.

When the money stock moves (in either positive or negative directions), prices move only when the optimal move condition (9) is satisfied. Prices will be locally sticky in both directions. The hysteresis band will be $[M_0 - \delta^-, M_0 + \delta^+]$. [3]

3.2.2 Small Punishment

For a small K, the non-cheating constraint binds at the original level of the money stock, and the price level is away from the social optimum. Because the slope of the utility function is negative at this price level, the price movement will be asymmetric between the money stock increase and decrease.

When the money stock increases, from M_0 to M_1, the non-cheating constraint will be violated if the cartel maintains the original price $P_c(M_0)$. Thus, the cartel will move immediately to $P_c(M_1)$ to maintain the non-cheating constraint. The cartel price adjustment is smooth, but not necessarily optimal as it may violate the optimal move condition.

When the money stock decreases, from M_0 to M_2, the non-cheating constraint will be relaxed if the cartel maintains the original price $P_c(M_0)$. The cartel will move its price only when the optimal move condition is satisfied.

The cartel is already at a very steep portion of its profit curve, so the cartel's incentive to shift the price, $\Delta G(M_0, M_2)$, is very large even for a small decline in the money stock. Thus, the price will be locally sticky downward if $M_2 \in [M_0 - \delta^-, M_0]$, but this asymmetric hysteresis band becomes narrower as the punishment becomes smaller, although it never goes to zero. [4]

[3] When the money stock decreases, the individual rationality constraint may bind, although since $|\Delta U_i| > \Delta R|$, this is unlikely if the non-cheating constraint is not binding. If the individual rationality constraint does bind, the size of the downward hysteresis band will increase.

[4] In the limiting case where $K \approx 0$, prices are at the monopolistically competitive level. The individual rationality constraint never binds, and the optimal move condition alone determines the width of the hysteresis band.

3.2.3 Width of the Hysteresis Bands

An implication of the Ball and Romer model (1990) is that small menu costs can generate a wide hysteresis band for prices. To see if an implicit cartel may generate a similar result, we compare the widths of the hysteresis bands to that under the monopolistic competition.

The hysteresis bands in our model are derived from the optimal move condition in (9). Given the original price level M_0, we look for the levels of the money stock M' for which the optimal move condition holds with an equality. [5]

$$\Delta G(M_0, M') = U_c(P_C(M'), M') - U_c(P_C(M_0), M') = Nz \tag{11}$$

Then, $\delta = M' - M_0$ will be the one-sided width of the hysteresis band.

We have two types of hysteresis bands. First, for the large-punishment hysteresis, we evaluate U_c in equation (11) where $P_C(M')$ and $P_C(M_0)$ are socially optimal prices for M' and M_0 respectively. Since $\Delta G(M_0, M')$ is highly nonlinear in M', we take a second-order Taylor expansion around M_0 and derive the following expression for δ^{largeK}.

$$\delta^{largeK} = \left(\left(\frac{\epsilon}{\epsilon - 1} \right)^{\frac{1}{\gamma-1}} \frac{2}{\gamma - 1} M_0^{\gamma} z \right)^{\frac{1}{2}} \tag{12}$$

Second, we consider the downward hysteresis band for the small-punishment case. More specifically, we consider the limit case where K is infinitesimally small and the price will be identical to the monopolistically competitive level. We evaluate equation (11) by replacing $P_C(M')$ and $P_C(M_0)$ with the monopolistically competitive price level for M' and M_0 respectively. A second order Taylor expansion yields the following expression for the hysteresis width.

$$\delta^{smallK} = \frac{M_0}{(\epsilon - 1)(\gamma - 1)} \left(1 - \sqrt{1 + 2z\epsilon(\epsilon - 1)(\gamma - 1)} \right) \tag{13}$$

Finally, for the hysteresis band width under monopolistically competition, the gain from individual price movement should be at least as big as the menu cost. So, we evaluate the gain from cheating in equation (7) at $P_c = M_0$ and

[5] As noted above, when the money stock decreases, the individual rationality constraint may bind for some parameter values. But this simply makes the downward hysteresis band wider.

$M = M'$ and equate it with the menu costs to derive the condition for the optimal move.

$$\Delta U_i(M_0, M') = z \tag{14}$$

A second-order Taylor expansion around M_0 will yield

$$\delta^{MC} = \frac{M_0}{(\gamma - 1)} \sqrt{2z \frac{(\epsilon(\gamma - 1) + 1)}{\epsilon - 1}} \tag{15}$$

It is not possible to analytically rank these conditions. Numerical simulation shows that $\delta^{MC} > \delta^{smallK}$. That is, the hysteresis band under an implicit cartel with infinitesimally small menu cost will be narrower than the hysteresis band under monopolistic competition. Although they are at exactly the same price equilibrium, the different equilibrating forces generate different width of the hysteresis bands.

The comparison of δ^{largeK} and δ^{smallK} did not yield a definite result in numerical simulations. Although we expect the cartel profit function to be relatively flat at the socially optimal level under large K, the width of the hysteresis band also depends on the second derivative of the profit function as well.

3.3 Implications for Aggregate Supply and Welfare

As the previous subsections indicated, there are two possible kinds of responses of prices and output to changes in the money stock in the presence of menu costs. They are illustrated in the two aggregate supply curves in Figure 1.

If the punishment is large, so that coordination is easy, prices are sticky for small increases and decreases in the money stock, but are flexible for larger increases. The range of inaction is symmetric because the social gain from changing price is zero to first order. The price level is at the social-welfare-maximizing point.

If the punishment is small, prices increase in response to a positive money shock, but are locally sticky in response to a negative money shock. Hence the implied aggregate supply curve is kinked at the current price. The price level is higher than the price level under high punishment because firms fail to fully internalize the aggregate demand externality.

The model has different predictions for the welfare costs of economic fluctuations than the standard monopolistic competition model for both cases. This is because the criterion for changing prices now depends in part on evaluating the effects on social welfare. In the standard monopolistic competition model, social welfare rises if prices are sticky in response to a positive monetary shock, but falls in response to a negative monetary shock. In this model, in the large-punishment case, since firms are near the social optimum the social welfare loss from being away from the optimum is zero to first order; hence the welfare cost of fluctuations is small, although quantity fluctuations may still be large. In the small-punishment case, since prices are flexible for positive monetary shocks, there is no change in social welfare. Welfare declines by first-order amounts for negative monetary shocks, as in the monopolistic-competition model. Prices are downwardly rigid both in actuality and in welfare terms in the sense of Mankiw (1985). Monetary policy follows the "pushing on a string" analogy.[6]

Both results violate the spirit of the original menu-cost papers, which were in part designed to show that small menu costs could lead to business cycles with large welfare losses. Ball and Romer (1990) argue that large real rigidities are needed to boost the welfare cost of fluctuations to significant levels. This result relied on the fact that monopolistic competition implied a difference between private and social optima. Here, the two may coincide.[7] This means that it may not be possible to make the welfare cost of business cycles large, even in the presence of significant real rigidities.

3.4 Price Dynamics and Future Research

The welfare implications that we drew in the previous sections, of course, are based on our static analysis. We recognize that the welfare implications of a dynamic model can be quite different. Caplin and Spulber (1987) and Caplin and Leahy (1991) have shown that the neutrality of money can depend on assumptions about the money supply process and idiosyncratic shocks. Caplin and Leahy (1997) present a dynamic model of coordination failure

[6]See Brunner and Meltzer (1968) for a discussion of this idea in its original formulation as a liquidity trap story.

[7]If we replace the assumption that agents are producer-consumers with the assumption that they are just producers, we still obtain the result that internalization of the aggregate demand externality implies the socially optimal price is at the competitive level, yielding the same results.

with idiosyncratic shocks; they show that there is only one equilbrium, in which some firms adjust even though they know no other firm will do so.

We may be able to introduce dynamics into our model allowing idiosyncratic shocks to individual producers. However, the current cartel pricing scheme cannot take account of such idiosyncratic price shocks and will simply impose the same pricing rules. Such a dynamic model will be a degenerate case of the current statis model.

In order to accomodate idiosyncratic shocks to individual pricing decisions, we have to incorporate the Green and Porter (1984) setup.[8] In Green and Porter (1984), the cartel can observe only the industry price aggregate, and thus cannot distinguish between exogenous demand shocks and individual cheating. To be consistent with our model, we expect the individual firms to raise the price above the cartel optimum price. Thus we expect individual prices to cluster above the cartel price in response to idiosyncratic shocks. Hence the invariant distribution of prices assumed in Caplin and Spulber (1987) and Caplin and Leahy (1991, 1997) is unlikely to hold. The aggregate welfare implications of this extension are therefore unclear, and we leave it for future research.

4 Conclusion

Coordination failure results in New Keynesian pricing models often rest on the assumption of monopolistically competitive firms that fail to internalize an aggregate demand externality. Acting on their own, these firms generates an equilibrium price that is too high. Under menu costs, they generate price rigidity by failing to coordinate their price responses to a nominal shock. In this paper, we replace this monopolistic competition assumption with an implicit cartel as in Rotemberg and Saloner (1986) in order to explore a possible solution to the above coordination problem. In particular, we analyze how well an implicit cartel can internalize the aggregate demand externality. By doing so, it lowers prices, rather than raising prices as cartels usually do.

[8]The recent paper by Athey et. al. (1998) has drawn a rich set of a dynamic model implications into static cartel models. It shows that the degree of patience influences the price rigidity. An impatient cartel will move prices in order to attenuate the incentive to cheat as in Rotemberg and Saloner (1986) while a patient cartel will follow a rigid-pricing scheme.

We show that if the punishment is small, so that firms, while able to coordinate, are not able to heavily deter cheating, the price will not be much different from the monopolistically competitive price. If the punishment is large, the price will be at the social optimum, and if the punishment is intermediate, the price will be in between the two. The resulting aggregate supply curve implies either downward price rigidity or full flexibility of prices in response to nominal shocks. Thus the way in which coordination is enforced has important macroeconomic consequences.

The coordination failure problem is unlikely to be solved by fiat, but rather by developing mechanisms or institutions designed to address it. In this paper, we take such a coordination mechanism seriously and explore its macroeconomic consequences. We find that an implicit cartel is an imperfect coordination mechanism, although its equilibrium is closer to the social optimum than the monopolistically competitive one. In addition an implicit cartel generate prices responses to nominal shocks that are empirically distinguishable from the those of monopolistic competitors.

5 References

Abreu, Dilip, David Pearce and Ennio Stacchetti. "Optimal Cartel Equilibria with Imperfect Monitoring." *Journal of Economic Theory* 39(1), 1986.

Athey, Susan, Kyle Bagwell and Chris Sachirico. "Collusion and Price Rigidity." MIT Working Paper 98-23

Ball, Laurence and David Romer. "Real Rigidities and the Nonneutrality of Money." *Review of Economic Studies*, 57(1), 1990.

————. "Sticky Prices as Coordination Failure." *American Economic Review*, 81(3), 1991.

Brunner, Karl and Allan Meltzer. "Liquidity Traps for Money, Bank Credit and Interest Rates." *Journal of Political Economy*, 76(1), 1968.

Caplin, Andrew and John Leahy. "State-Dependent Pricing and the Dynamics of Money and Output." *Quarterly Journal of Economics* 103(3), 1991.

————. "Aggregation and Optimization with State-Dependent Pricing." *Econometrica* 65(30), 1997.

Caplin, Andrew and Daniel Spulber. "Menu Costs and the Neutrality of Money." *Quarterly Journal of Economics* 102(4), 1987.

Cooper, Russell and Andrew John. "Coordinating Coordination Failures in Keynesian Models." *Quarterly Journal of Economics*, 103(3), 1988.

Green, Edward and Robert Porter "Noncooperative Collusion under Imperfect Price Information." *Econometrica*,52(1), January 1984.

Levy, Daniel, Mark Bergen, Shantanu Dutta and Robert Venable. "The Magnitude of Menu Costs: Direct Evidence from Large U.S. Supermarket Chains." *Quarterly Journal of Economics*, 113(3), 1997.

Mankiw, N. Gregory. "Small Menu Costs and Large Business Cycles: A Macroeconomic Model of Monopoly." *Quarterly Journal of Economics*, 100(2), 1985.

Rotemberg, Julio J. and Garth Saloner. "A Supergame-Theoretic Model of Price Wars during Booms." *American Economic Review*, 76(2), 1986.

Rotemberg, Julio J. and Michael Woodford. "Markups and the Business Cycle." *NBER Macroeconomics Annual*, 1991.

————. "Oligopolistic Pricing and the Effects of Aggregate Demand on Economic Activity." *Journal of Political Economy*, 100(4), 1992.

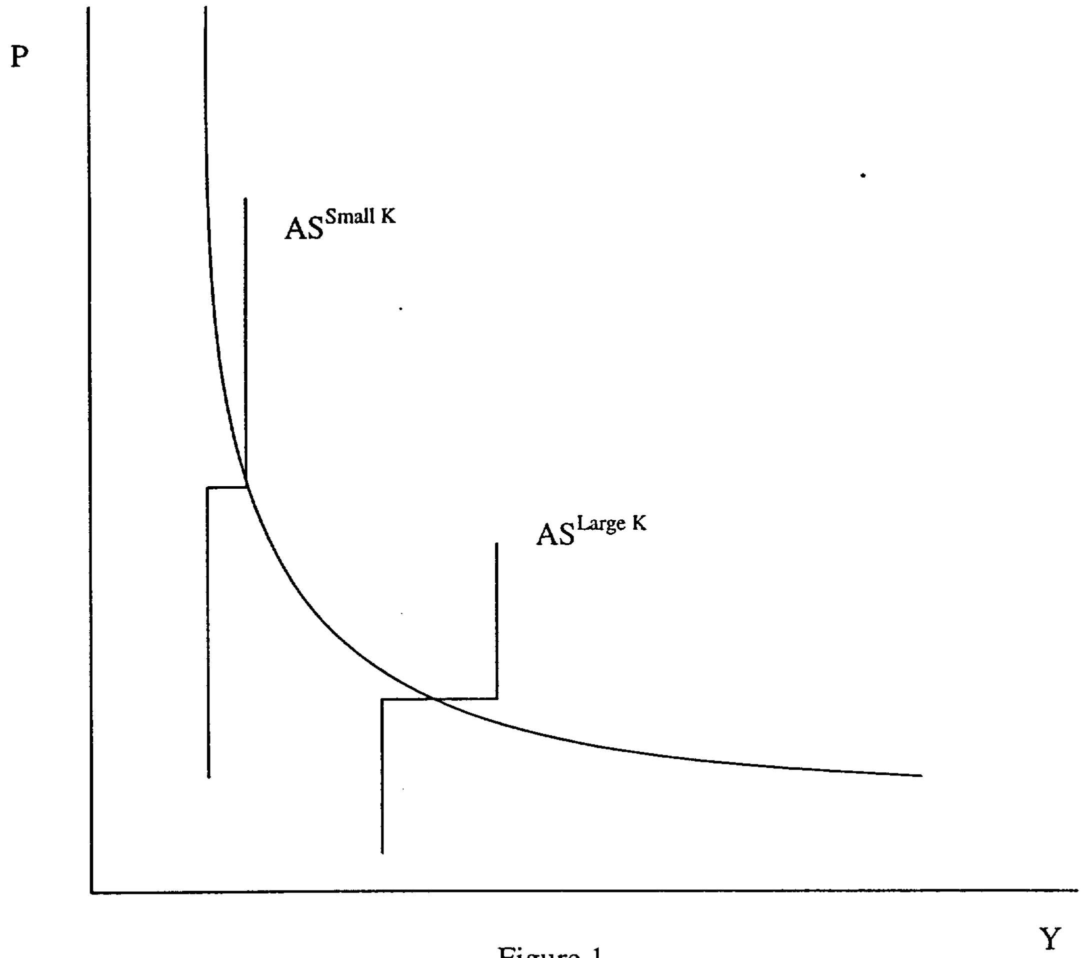

Figure 1