Asymmetric Adjustment in Menu Cost Duopoly*

Per Svejstrup Hansen, Hans Peter Møllgaard, Per Baltzer Overgaard,

and Jan Rose Sørensen

Department of Economics, University of Aarhus

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Abstract

Contrary to existing menu cost models we assume oligopolistic interaction. Symmetric duopoly may lead to asymmetric adjustment even when menu costs are negligible: In some equilibria only one firm adjusts to negative shocks, while both firms adjust to positive shocks.

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* Correspondence: Per B. Overgaard, Department of Economics, University of Aarhus, Universitetsparken 350, DK-8000 Aarhus C. Phone: +45-89421605. Fax: +45-86136334. e-mail: povergaard@eco.aau.dk

1. Introduction

It is well known that the presence of menu costs may cause price rigidities in models based on monopoly or monopolistic competition, see e.g. Mankiw (1985) and Ball and Romer (1991). Strategic interaction has, on the other hand, been strangely absent from menu cost models. This is surprising since oligopoly may explain both downward price rigidity and behavioural asymmetries across symmetric firms. The latter phenomenon is not found in monopoly models (by default) or in models based on monopolistic competition (by assumption). We demonstrate in a duopoly setting that even when menu costs are negligible (or absent), some equilibria have only one of the firms adjusting its price to a shock thus creating price level inertia. Equilibria where only one firm adjusts its price arise when demand is hit by a (small) *negative* shock, whereas both firms adjust when the shock is *positive*. Hence, we find a new micro foundation for prices being more rigid downwards than upwards to supplement the results based on dynamic explanations in inflationary economies, see e.g. Kuran (1983), Tsiddon (1991), and Ball and Mankiw (1994).

2. The Model

We set up a model of a symmetric differentiated duopoly. Demand functions may be derived from a continuum of identical consumers with quasi-linear utility functions to yield

$$q_i = a - bp_i + cp_j, \qquad i, j = 1, 2, \quad i \neq j, \qquad \mid c \mid \leq b \tag{2.1}$$

where q_i is the quantity demanded of good i, and p_i is its price. a and b are positive parameters and c is positive if the goods are substitutes and negative if they are complements. Marginal costs are constant and normalized at zero. We assume that the two markets initially are in Bertrand equilibrium. The resulting prices and quantities are:

$$(p_i, q_i) = \left(\frac{a}{2b - c}, \frac{ab}{2b - c} \right), \qquad i = 1, 2. \tag{2.2}$$

Now assume – as is common to menu cost models, see e.g. Mankiw (1985), Blanchard and Kiyotaki (1987) or Andersen (1995) – that a completely unanticipated shock alters a by an amount Δa. Once the change has occurred it becomes public information and is fully known. Firms now have to decide whether to adjust prices (action A) or not (D). If they do, they incur a menu cost of size $z \geq 0$; if not, they are stuck with the old value in (2.2). Once the decision is taken, it is irreversible.

The adjustment decisions may be taken either simultaneously or sequentially according to some predetermined order. Consider the simultaneous decision first. There may be four outcomes of the decision game corresponding to the situation in which both firms do not adjust, (D, D), one firm adjusts while the other does not, (A, D) or (D, A), and both firms adjust, (A, A). The outcome of the decision game becomes common knowledge, and firms who have paid the menu costs (so, have decided to adjust) subsequently set their price optimally given the decision of the rival. If the decision outcome was (A, A), a new Bertrand equilibrium will thus obtain, while if the outcome was (A, D), then firm 1 optimizes given the known price of firm 2. The resulting change in optimal profits will be:

$$\Delta\Pi^i(A, A) = \frac{b}{(2b-c)^2}(2a + \Delta a)\Delta a - z \tag{2.3}$$

$$\Delta\Pi^i(D, D) = \frac{a\Delta a}{2b-c} \tag{2.4}$$

$$\Delta\Pi^1(A, D) = \Delta\Pi^2(D, A) = \frac{\Delta a^2}{4b} + \frac{a\Delta a}{2b-c} - z \tag{2.5}$$

$$\Delta\Pi^1(D, A) = \Delta\Pi^2(A, D) = \frac{2b+c}{2b(2b-c)}a\Delta a \tag{2.6}$$

and the simultaneous decision game may be represented by the following simple matrix game:

Firm 2 / Firm 1	D	A
D	$\Delta\Pi^2(D,D)$ $\Delta\Pi^1(D,D)$	$\Delta\Pi^2(D,A)$ $\Delta\Pi^1(D,A)$
A	$\Delta\Pi^2(A,D)$ $\Delta\Pi^1(A,D)$	$\Delta\Pi^2(A,A)$ $\Delta\Pi^1(A,A)$

3. Equilibria of the simultaneous move game

One may now test when e.g. (A, D) will be a Nash equilibrium of the decision game by requiring the simultaneous fulfillment of $\Delta\Pi^1(A, D) \geq \Delta\Pi^1(D, D)$ and $\Delta\Pi^2(A, D) \geq \Delta\Pi^2(A, A)$. It may be shown that; on the assumption that $z = 0$; 1) (D, D) is never a Nash equilibrium; 2) (A, A) is the only Nash equilibrium if Δa is positive; 3) (A, D) and (D, A) are both Nash equilibria if the shock is relatively small and negative; and (A, A) is the only Nash equilibrium if the shock is relatively large and negative.[1] By a relatively small and negative shock is meant

[1] Proof is available from the authors upon request.

that

$$0 \geq \frac{\Delta a}{a} \geq -\frac{1}{2}\left(\frac{c}{b}\right)^2. \tag{3.1}$$

FIGURE 1: ASYMMETRIC ADJUSTMENT

The intuition behind this result may be found by studying figure 1. A negative shock will shift the reaction functions R_i left $(i = 1)$ and down $(i = 2)$ by the same amount. Reaction functions thus move from R_i to $R_i^{'}$. The initial equilibrium is point (D, D) and if both firms decide not to adjust, these are also the prices that obtain after the shock. However, (D, D) could never be a post shock equilibrium in the absence of menu costs, since at least one firm has an incentive to jump to its reaction function. Let that one firm be firm 2. Now we have to check whether it is also optimal for firm 1 to adjust. Firm 1 will have to compare profits in point (D, A) with profits in point (A, A). In the figure the shock is such that the iso-profit curve that goes through (A, A) also goes through (D, A) corresponding to a shock of relative size $\frac{\Delta a}{a} = -\frac{1}{2}\left(\frac{c}{b}\right)^2$. In this case, firm 1 is indifferent between adjusting and not adjusting. If, however, the shock were smaller (numerically speaking), $R_i^{'}$ would be closer to R_i, and the iso-profit locus through (A, A) would be below (D, A). Vice versa if the shock was negative and larger.

Following a relatively small negative shock, prices will be higher and quantities correspondingly smaller than if full adjustment is carried out. The decision not to adjust serves as a vehicle for the firms to move in the direction of the new collusive equilibrium, but (D, D) can not be an equilibrium in the absence of menu costs because it violates incentive compatibility.

If the demand shock were positive, we could imagine the initial equilibrium to correspond to the intersection of the R_i' curves, and the new full adjustment equilibrium would correspond to the intersection of the R_i curves. The new collusive outcome would be further toward north-east implying that both firms would always have an incentive to adjust to the new equilibrium if menu costs are zero.

If menu costs are positive, the equilibria change in obvious ways. In particular, (D, D) will become an equilibrium if the shock is not big enough to merit adjustment. Furthermore, there may be sizes of the shock for which (A, A) and (D, D) are both equilibria: One firm will adjust only if the other firm adjusts as well.

In sum, even if menu costs are negligible – in fact: absent – firms' reactions to a demand shock will differ depending on the size and the sign of the shock: Adjustment will be partial (i.e. only one firm moves) if the shock is small and negative, while it will be full if the shock is positive or relatively large and negative. This means that strategic interaction may in and of itself create rigidity in the aggregate price level: Prices are (partly) rigid downward and (fully) flexible upward even with $z = 0$!

4. Equilibrium of the sequential move game

Assume that for some reason firm 1 has to decide whether or not to adjust before firm 2, and that firm 2 knows this decision before making its own decision. Furthermore, assume that adjustment costs are zero.

If firm 1 decides not to adjust it knows that firm 2 will adjust since $\Delta\Pi^2(D, D) < \Delta\Pi^2(D, A)$ for all values of the parameters given that $z = 0$. If firm 1 decides to adjust it knows that firm 2 will choose not to adjust iff inequality (2.7) holds, i.e. iff the shock is relatively small and negative. In choosing whether to adjust or not, firm 1 thus compares $\Delta\Pi^1(D, A)$ with $\Delta\Pi^1(A, D)$ if the inequality holds, and $\Delta\Pi^1(D, A)$ with $\Delta\Pi^1(A, A)$ if it does not hold.

The equilibrium will be unique and asymmetric if the inequality holds and firm 1 will then choose to adjust if goods are substitutes ($c > 0$) leaving it to firm 2 not to adjust, while it will decide not to adjust if goods are complements. If (2.7) does not hold, both firms will adjust as in the simultaneous move game.[2]

[2] Proof is available from the authors upon request.

The reason why firm 1 chooses not to adjust if goods are complements is that it prefers that firm 2 sets a low price in order to get a high demand for both goods while at the same time it keeps its own price high.

In sum, compared to the simultaneous move adjustment decision game the sequential game ensures uniqueness of asymmetric equilibrium.

5. Conclusion

This paper has aimed at introducing strategic interaction between firms in menu cost models – a phenomenon that has been strangely absent from these models. We have shown that in a simple, differentiated Bertrand model adjustment asymmetries arise because of the commitment effect lain down in the irreversible decision on whether to adjust or not. This strategic effect persists even as menu costs disappear.

We have identified three types of adjustment asymmetries: The first is that firms react differently to positive and to negative shocks. The second is that, if the shock is relatively small and negative, only one firm adjusts. The third phenomenon is that whether a first mover will decide to adjust or not will depend on whether goods are substitutes or complements.

This summary strongly suggests that models incorporating true strategic interaction can explain a richer class of phenomena than existing models. The model presented may be seen as a special case of a more general model of adjustment asymmetries in oligopoly; see Hansen, Møllgaard, Overgaard and Sørensen (1996), where we consider both price and quantity competition and set out the details of the analysis.

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