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Adapting Prices or Quantities in the Presence of Adjustment Costs?

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Abstract

A dominant explanation of price rigidity is the so-called "menu cost model" according to which small costs of changing prices may imply that firms keep nominal prices unchanged to nominal shocks which therefore have real effects. Crucial to this explanation is the assumption that price adjustment is costly while quantity adjustment is not. This paper analyses the role of costs of adjusting both prices and quantities, and it is found that the "small cost" argument used to support menu cost models does not hold. The predictions of menu cost models only hold if price adjustment costs are larger than quantity adjustment costs. Empirical evidence clearly indicates that the costs of adjusting quantities are non-trivial. Quantity adjustment costs also open for the possibility of non-market clearing.

Keywords: Menu-costs, nominal rigidities, price adjustment and quantity adjustment.

JEL: E32.

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1 Introduction

The role taken by prices and quantities in the macroeconomic adjustment process to various types of shocks is a classical theme. The so-called "menu-cost" models have over the recent years gained momentum as an important explanation why nominal prices do not take the full adjustment burden to nominal shocks as predicted by the classical neutrality result[1]. The basic idea underlying these models is that small deviations from the optimal price have second-order consequences for profits (Akerlof and Yellen 1985 a,b). Even very small costs of changing prices will thus make it optimal to keep nominal prices unchanged to (small) changes in the state of nature. Moreover in a setting with inefficient low activity due to market power this may have first-order welfare effects.

However, the argument underlying "menu-cost" could equally be applied to quantities. Small deviations in quantities from their optimal level would only have second-order profit effects, and hence small costs of adjusting quantities may thus make it optimal for firms to keep quantities unchanged in the presence of shocks. This raises the question of how the burden of adjustment is shared between prices and quantities when account is taken of costs of adjusting both prices and quantities[2]. The assumption made in the "menu cost" literature that only price adjustment is costly naturally gives a bias towards quantities as the dominant mode of adjustment. This may be particularly problematic in the case of nominal shocks since the underlying model fulfills standard homogeneity properties implying that nominal shocks should be reflected only in prices and not in quantities in the absence of any adjustment failures.

The consideration of quantity adjustment cost is furthermore motivated by the fact that the macroeconomic literature in other contexts appeals to such costs. Recent literature on the input choices by firms stresses the costs of adjusting both labour input (see eg Hammermesh and Pfann (1996)) and capital input (see eg

[1] The first explicit analysis of price adjustment costs is found in Barro (1971), but the menu-cost literature took off with the contributions by Mankiw (1985) and Rotemberg (1982). See eg Rotemberg (1987) and Ball and Romer (1988) for introductions to the literature on menu costs.

[2] The role of quantity and price adjustment costs have been considered in partial models in Andersen (1994, 1995).

Hayashi (1982)).

By allowing for costs of adjusting both prices and quantities, we are able both to study the robustness of the "small cost" argument used to support menu-costs models, as well as develop a more general model of how prices and quantities are used in the adjustment process to shocks. We develop a dynamic macromodel to study the adjustment to unanticipated nominal shocks[3]. The main motivation for developing a general equilibrium model for this analysis is to ensure that the results do not depend on free parameters. The approach taken thus ensures that "cross equation restrictions" are satisfied. We assume firms to pre-set nominal prices and to face costs of adjusting both prices and quantities.

The paper is organized as follows. Section 2 develops a macromodel with imperfectly competitive product and labour markets. Section 3 considers the possible modes of adjustment to firms facing costs of adjusting both nominal prices and quantities. Section 4 derives the optimal mode of adjustment and provides some numerical illustrations. Section 5 offers a few concluding comments.

2 A Macromodel with Imperfectly Competitive Markets

Consider an economy with differentiated products and labour skills. Each (representative) firm produces a specific output by use of a specific labour input supplied by a (representative) household. The number of firms thus equals the number of products, the number of labour skills and the number of households. Specifically we assume a continuum of firms indexed by i $\in [0, 1]$. Firms act as monopolists in their specific product market and likewise households act as monopolists in their labour market. Labour is the only input.

The economy has two assets, money and a bond. Money is needed for transactions purposes and thus provides a liquidity service. We follow the suggestion made by Feenstra (1986) that there is an equivalence between having liquidity costs in the budget constraint and having real balances included in the (semi-indirect) utility function.

[3] The structure of the model builds on Bénassy (1995).

2.1 Firms

Technology

The representative firm i uses a specific labour input N_t^i to produce Y_t^i subject to a constant returns to scale technology ($Y_t^i = N_t^i$). Hence, its real profits are given as

$$\left(\frac{P_t^i}{P_t} - \frac{W_t^i}{P_t}\right) Y_t^i, \tag{1}$$

where P_t^i is the price of commodity i at time t, P_t is the general price level at time t and W_t^i is the wage paid by firm i to its worker.

Demand

There is a continuum of differentiated commodities distributed on [0,1]. The consumption bundle of household j is defined over the differentiated commodities as

$$C_t^j = \left(\int_0^1 \left(C_t^{ji}\right)^{\frac{\eta-1}{\eta}} di\right)^{\frac{\eta}{\eta-1}}$$

where C_t^j is the consumption bundle of household j at time t, C_t^{ji} is the consumption of commodity i by household j at time t and η is the elasticity of substitution between any two goods ($\eta > 1$).

The demand for commodity i by household j in period t is therefore

$$C_t^{ji} = \left(\frac{P_t^i}{P_t}\right)^{-\eta} C_t^j$$

where

$$P_t \equiv \left(\int_0^1 \left(P_t^i\right)^{1-\eta} di\right)^{\frac{1}{1-\eta}}.$$

Hence, the total demand for commodity i in period t is

$$C_t^i = \int_0^1 C_t^{ji} dj = \left(\frac{P_t^i}{P_t}\right)^{-\eta} C_t \tag{2}$$

where

$$C_t = \int_0^1 C_t^j dj.$$

Optimal price

In equilibrium firm i produces what is demanded: $Y_t^i = C_t^i$. Hence, using (1) and (2), real profits are given as

$$\left(\frac{P_t^i}{P_t} - \frac{W_t^i}{P_t}\right)\left(\frac{P_t^i}{P_t}\right)^{-\eta} C_t,$$

implying that the optimal price is given as

$$\frac{P_t^i}{P_t} = \frac{W_t^i}{P_t}\left(\frac{\eta}{\eta - 1}\right). \tag{3}$$

Therefore, using (2), output Y_t^i, labour demand N_t^i and consumption C_t^i are

$$Y_t^i = N_t^i = C_t^i = \left[\frac{W_t^i}{P_t}\left(\frac{\eta}{\eta - 1}\right)\right]^{-\eta} C_t. \tag{4}$$

2.2 Households

The representative household of type j has a utility function given by

$$\sum_{t=0}^{\infty} \beta^t \left[\ln C_t^j + \theta \ln \frac{M_t^j}{P_t} - \frac{1}{\gamma}\left(N_t^j\right)^{\gamma}\right] \tag{5}$$

where M_t^j denotes money holdings, N_t^j the working time and γ measures the extent of increasing marginal disutility of labour. The temporary budget constraint reads

$$C_t^j + \frac{M_t^j}{P_t} + B_t^j = \frac{W_t^j}{P_t} N_t^j + \frac{\Pi_t^j}{P_t} + R_t B_{t-1}^j + \frac{M_{t-1}^j}{P_t} + \frac{T_t^j}{P_t}.$$

The right-hand-side gives the available resources in period t as the sum of labour income $\left(N_t^j W_t^j / P_t\right)$, profit income $\left(\Pi_t^j / P_t\right)$, gross return on bond holdings $\left(R_t B_{t-1}^j\right)$, initial money holdings $\left(M_{t-1}^j / P_t\right)$ and transfers from the government $\left(T_t^j / P_t\right)$. Transfers depend on initial money holdings such that

$$M_t^j \equiv M_{t-1}^j + T_t^j = \left(1 + \delta_t\right) M_{t-1}^j.$$

Each household acts as a monopolist in the labour market, determining the wage W_t^j that maximises its utility (5) subject to the labour demand (4) (see

Andersen and Toulemonde (1999) or Gali (1995) for further discussion). The maximisation of (5) with respect to C_t^j, M_t^j, B_t^j and W_t^j yields

$$\frac{1}{C_t^j} = \lambda_t^j \tag{6}$$

$$\lambda_t^j = \beta \lambda_{t+1}^j R_{t+1} \tag{7}$$

$$\lambda_t^j = \frac{\theta P_t}{M_t^j} + \beta \lambda_{t+1}^j \frac{(1+\delta_{t+1}) P_t}{P_{t+1}} \tag{8}$$

$$\frac{\lambda_t^j W_t^j}{P_t} = \frac{-\eta}{1-\eta} \left(N_t^j\right)^{\gamma-1}. \tag{9}$$

Using (6) and (9) yields the optimal wage

$$\frac{W_t^j}{P_t} = \frac{-\eta}{1-\eta} \left(N_t^j\right)^{\gamma-1} C_t^j. \tag{10}$$

2.3 Equilibrium

Exploiting the symmetry of the model we know that $W_t^j = W_t \; \forall j$ and $C_t^i = C_t = Y_t \; \forall i$. Hence, the wage formula (10) can be written

$$\frac{W_t}{P_t} = \frac{\eta}{\eta - 1} Y_t^{\gamma} \tag{11}$$

and the optimal price (3) becomes

$$\frac{P_t^i}{P_t} = \frac{W_t}{P_t} \left(\frac{\eta}{\eta - 1}\right). \tag{12}$$

Using (4) and (12) we have

$$Y_t^i = Y \left(\frac{P_t^i}{P_t}\right)^{-\eta}. \tag{13}$$

We can also find the equilibrium output by using (11), (12) and $P_t^i = P_t$:

$$Y_t = \left(\frac{\eta}{\eta - 1}\right)^{\frac{-2}{\gamma}}. \tag{14}$$

Furthermore, using (6) and (8) we have (see appendix)

$$\frac{M_t}{P_t} = \frac{\theta}{1-\beta} Y_t. \tag{15}$$

Crucial to the following analysis is the wage equation (11) relating real wages positively to activity (employment), the mark-up pricing rule (12) and the aggregate demand relation (15). While the preceding analysis shows that these have support in a fully specified dynamic macromodel, it is equally clear that they can be arrived at through different routes[4]. The structure of the semi-reduced form of the model is thus equivalent to for instance those derived in static models with either imperfectly competitive markets (see eg Blanchard and Kiyotaki (1985)) or efficiency wage effects (see eg Ball and Romer (1990)).

3 The modes of adjustment

Assume that the economy up to and including period t-1 has been in a stationary equilibrium. In period t there is an unanticipated but temporary shock ($\delta_t \gtreqless 0$) to the money supply, ie from M_{t-1} to $(1+\delta_t)M_{t-1}$, where $(1+\delta_t)(1+\delta_{t+1}) = 1$ since the shock is temporary. Consequently, the economy is back to the stationary equilibrium from period t+1 onwards[5]. It is accordingly appropriate to compare period t profits under the various adjustment modes available to firms[6].

The firm has four modes of adapting to the change in money: adapting price and quantity (mode I), adapting price only (mode II), adapting quantity only (mode III), or not adjusting at all (mode IV). To determine which strategy is optimal, we compare the firm's profit in each case, given that each agent believes that the other agents do not adjust (Nash-assumption)[7]. In general the firm's

[4]The fact that the model does not include real capital allows a considerable simplification.

[5]It is assumed that it is always optimal for firms to redress their decision if they have made an adjustment to adjust to a temporary shock. This assumption holds if the rate of interest is not too large. Notice that this assumption biases the results towards adjusting to temporary shocks.

[6]In the case of permanent shocks, it is easy to use the same expressions to compare the different regime, but the costs will be correspondingly smaller. Accordingly, the mode of adjusting both price and quantity is more likely in this case. See Hansen (1996) for a two-period analysis.

[7]It is well-known that strategic complementarity can create multiple equilibria, ie the incentive to adjust depends on whether the competing firms adjust, see Ball and Romer (1991). We disregard this possiblity and restrict attention to Nash-equilibria having the past as their focal point (Cooper (1994)).

profit gross of adjustment costs is given by

$$\pi^i = \left(\frac{P^i - W}{P} \right) Y^i. \qquad (16)$$

To economise on notation the time subscript is dropped.

Mode I: Full Adjustment

In this mode, the firm sets its price according to equation (12). We substitute the resulting price and the wage (11) in (16). We replace Y^i by its value in (13), Y by its old value in (14) times $(1+\delta)$ to find

$$\pi_I = \left(\frac{\eta}{\eta - 1} \right)^{\frac{-2}{\gamma}} \frac{(1+\delta)^{1+\gamma-\gamma\eta}}{\eta} - Cp - Cq, \qquad (17)$$

where Cp and Cq are the (fixed) costs of adjusting price and quantity, respectively.

Mode II: Adapting price only

In this mode, Y^i is unchanged at its previous value, that is, equal to $(\eta/(\eta - 1))^{-2/\gamma}$. The firm sets the highest price compatible with the sale of Y^i according to equation (13). We substitute the resulting price and the wage (11) in the profit function, and we replace Y by its old value in (14) times $(1+\delta)$ to find

$$\pi_{II} = \left(\frac{\eta}{\eta - 1} \right)^{\frac{-2}{\gamma}} \left[(1+\delta)^{1/\eta} - \frac{\eta - 1}{\eta} (1+\delta)^{\gamma} \right] - Cp. \qquad (18)$$

Mode III: Adapting quantity only

In this mode, P^i is unchanged and equal to the general price level: $P^i = P$. We substitute this and the wage (11) in (16). We replace Y^i by its value in (13), Y by its old value in (14) times $(1+\delta)$ to find

$$\pi_{III} = \left(\frac{\eta}{\eta - 1} \right)^{\frac{-2}{\gamma}} (1+\delta) \left[1 - \frac{\eta - 1}{\eta} (1+\delta)^{\gamma} \right] - Cq. \qquad (19)$$

Mode IV: No adjustment

In this mode, either the firms or the consumers are rationed. If demand increases ($\delta > 0$), consumers are rationed: the firm produces less than what is demanded and the price does not adjust. On the contrary, if demand decreases ($\delta < 0$) firms are rationed: they produce more than what is demanded and the price does not adjust. We analyze these subcases in turn.

Subcase 1 Demand increases

P^i is unchanged, it is equal to the general price level: $P^i = P$. Y^i is also unchanged and equal to $(\eta/(\eta-1))^{-2/\gamma}$ (the old value of Y). We substitute these two results and the wage (11) in (16), and we replace Y by its old value in (14) times $(1+\delta)$ to find

$$\pi_{IV+} = \left(\frac{\eta}{\eta-1}\right)^{\frac{-2}{\gamma}} \left[1 - \frac{\eta-1}{\eta}(1+\delta)^{\gamma}\right]. \tag{20}$$

Subcase 2 Demand decreases

P^i is unchanged, it is equal to the general price level: $P^i = P$. Y^i is also unchanged and equal to $(\eta/(\eta-1))^{-2/\gamma}$ (the old value of Y) but the firm can only sell a quantity $Y < Y^i$. Therefore, profit is equal to $Y - (W/P)Y^i$. We substitute the wage (11) in the profit expression and replace Y by its old value in (14) times $(1+\delta)$, Y^i by the old value of Y to find

$$\pi_{IV-} = \left(\frac{\eta}{\eta-1}\right)^{\frac{-2}{\gamma}} (1+\delta) \left[1 - \frac{\eta-1}{\eta}(1+\delta)^{\gamma-1}\right]. \tag{21}$$

4 Optimal adjustment

We are now able to determine the optimal mode of behavior. At the beginning of the period, firms have fully adjusted prices and quantities to the state of the market. Consider the case of an unanticipated and temporary negative monetary shock ($\delta < 0$). To see what is the optimal adjustment of firms to this shock, we compare the profit of each mode (equations (17) to (19) and equation (21)). If the shock was positive, a similar analysis with similar results could be done with equation (21) replaced by equation (20).

There is full adjustment when $\pi_I > \pi_{II}$, $\pi_I > \pi_{III}$, and $\pi_I > \pi_{IV-}$. These conditions can respectively be written:

$$\frac{(1+\delta)^{1+\gamma-\gamma\eta}}{\eta} - (1+\delta)^{1/\eta} + \left(\frac{\eta-1}{\eta}\right)(1+\delta)^{\gamma} > cq, \tag{22}$$

$$\frac{(1+\delta)^{1+\gamma-\gamma\eta}}{\eta} - (1+\delta) + \left(\frac{\eta-1}{\eta}\right)(1+\delta)^{1+\gamma} > cp, \tag{23}$$

$$\frac{(1+\delta)^{1+\gamma-\gamma\eta}}{\eta} - (1+\delta) + \left(\frac{\eta-1}{\eta}\right)(1+\delta)^{\gamma} > cq + cp, \tag{24}$$

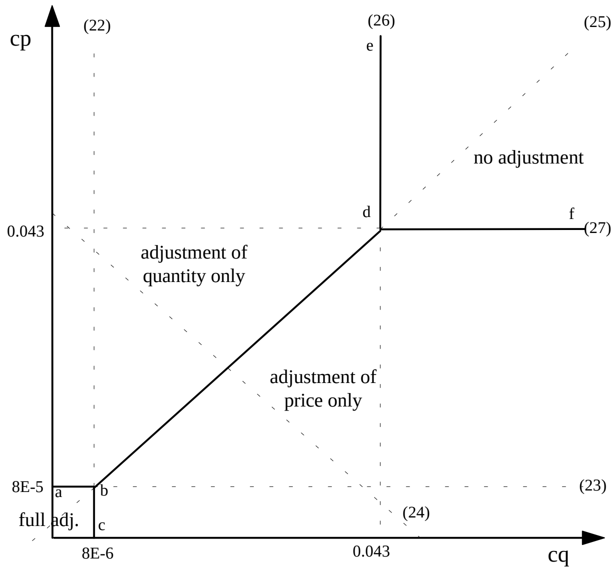

Figure 1:

where cq and cp are the costs of adjusting quantity and price as a percentage of the old value of production. That is,

$$cj \equiv \frac{Cj}{\left(\frac{\eta}{\eta-1}\right)^{\frac{-2}{\gamma}}} \qquad j = q, p.$$

The three conditions can be used to determine the zone of full adjustment in the space (cq, cp) . This zone is shown on Figure 1 as the area a-b-c-o which has been drawn for a 5 percent fall in the money stock, a markup of 15 percent ($\eta = 7.67$), and $\gamma = 0.1$. These values seem quite reasonable (see for example Romer (1990, 1996)). Only relations (22) and (23) are binding. There is full adjustment when the costs of adjusting the price and the quantity are small (of the order 8E-6 for the quantity adjustment cost and 8E-5 for the price adjustment cost); in all other cases, at least one variable is unchanged.

The price is the sole variable to adjust if $\pi_{II} > \pi_I$, $\pi_{II} > \pi_{III}$, and $\pi_{II} > \pi_{IV-}$. These conditions are respectively equivalent to:

(22) with the reverse inequality sign,

$$(1+\delta) - (1+\delta)^{1/\eta} - \left(\frac{\eta-1}{\eta}\right)(1+\delta)^{\gamma}\delta < cq - cp, \tag{25}$$

$$-\left(\frac{\eta-1}{\eta}\right)(1+\delta)^{\gamma}\delta > cq. \tag{26}$$

Thus, the price is the only variable to adjust in the zone delimited by these three restrictions. In Figure 1, this is roughly the right lower part of the figure (area determined by points c-b-d-f) where it is not too expensive to adjust the price but it is expensive to adjust the quantity.

The quantity is the sole variable to adjust if $\pi_{III} > \pi_I$, $\pi_{III} > \pi_{II}$, and $\pi_{III} > \pi_{IV-}$. These conditions are respectively equivalent to:

(23) with the reverse inequality sign,

(25) with the reverse inequality sign,

$$(1+\delta)^{1/\eta} - (1+\delta) > cp. \tag{27}$$

Thus, quantity adjusts in the zone delimited by these three restrictions. In Figure 1, this is roughly the left upper part of the figure where it is not too expensive to adjust the quantity but it is expensive to adjust the price (area determined by points a-b-d-e).

In all other cases, it is optimal neither to adjust the price nor the quantity; this determines the last zone in the right upper part of the figure (area determined by points e-d-f). In this zone there is unsold commodities in the case of a negative shock and a rationing of demanders in the case of a positive shock.

One noteworthy feature is that (25) always lies above the 45°-degree line. This reflects an asymmetry in the sense that price adjustment costs have to be larger than quantity adjustment costs for the "menu-cost"-case to arise.

Of course the figure depends on the value taken by the parameters. Table 1 provides a sensitive analysis. A value of η equal to 21 implies a markup of 5 percent, when it is equal to 3 or 2, the markup is respectively 50 and 100 percent. Since the most important points i Figure 1 are points b and d, Table 1 presents the coordinates of these points ($b1$, $b2$) and ($d1$, $d2$). What is interesting to note is that these points roughly lie on the main diagonal. Moreover, the coordinates of b are always (with one exception) lower than 1 percent and the coordinates of d always varies between 2.3 and 4.7 percent. The results thus seem robust to variations in the underlying parameters.

Table 1. Sensitivity analysis

η	γ	b_1	b_2	d_1	d_2
21	0.1	7.325E-05	0.0002583	0.0473754	0.0475604
7.667	0.1	8.043E-06	8.413E-05	0.0432561	0.0433322
3	0.1	0.0001403	2.504E-05	0.0331628	0.0330476
2	0.1	0.0002052	1.25E-05	0.0248721	0.0246794
21	0.5	0.0062616	0.0074087	0.0464133	0.0475604
7.667	0.5	0.0012339	0.0021885	0.0423776	0.0433322
3	0.5	0.0012339	0.0006303	0.0324893	0.0330476
2	0.5	7.205E-05	0.0003124	0.024367	0.0246794
21	1	0	0.0357159	0.0452381	0.0475604
7.667	1	0.0071876	0.0092152	0.0413046	0.0433322
3	1	0.001163	0.0025439	0.0316667	0.0330476
2	1	0.0003206	0.00125	0.02375	0.0246794

The literature on menu cost has spurred an interest in evaluating the cost of adjusting the price (the menu cost). The aim is to show that this cost may be high enough to induce the firms to keep their price unchanged in the face of a monetary shock. Thus, this literature focuses on the difference between π_I and π_{II}, and aims to show that π_{II} can be greater than π_I even with minor costs of adjusting price. If so, nominal prices are rigid and the adjustment burden to changes in the money stock is entirely taken by the quantities. This result is interesting in macroeconomics since it both has implications for business cycles theory, and implies that the monetary policy has real effects. However, the reasonning underlying menu-cost models is incomplete as we can see from Figure 1: there is a large zone in which the quantity does not adjust to the monetary shock. On the right of the upward sloping line determined by condition (25), and with a sufficient cost of adjusting quantity (a cost of the order of 8E-6 only), quantities are not adjusted to a monetary shock. Moreover if the menu cost of adjusting the price is lower than 4.3 percent (of output), then it is the price that entirely bears the cost of adjustment to the money shock. On the other hand, if the cost of adjusting the price is higher than 4.3 percent (of output) neither the price nor the quantity is adjusted; the profit entirely bears the adjustment to the monetary shock.

From the previous discussion, it is clear that it is important to evaluate the size of the cost of adjusting the quantity relative to the cost of adjusting prices. When the former is greater, then the standard result of menu cost models that the price is unchanged while the quantity bears all the adjustment to monetary shock does not hold.

There is a number of reasons which makes it plausible that the cost of adjusting output is higher than the cost of adjusting prices. That the latter is small is already recognized in the "menu-cost" literature, "almost surely much less than 1 percent of revenue. A menu cost of a few hundredths of a percent of revenue, on the other hand, does not seem unreasonable." writes Romer (1996, p.280). Levy et al. (1997) report a menu cost of 0.70 percent of revenues for multistore supermarket chains[8]. Thus, a menu cost of 1 percent of revenue seems to be an upper bound.

Is there any evidence on the cost of adjusting output? It is plausible that it is higher than 1 percent given that output changes in general require changes in the labour force, which is known to be costly. There is a large literature on the effects of these costs on the employment level (see for example Hamermesh (1993) and Hamermesh and Pfann (1996)) but there is relatively few empirical studies on the size of such costs. Bresnahan and Ramey (1994) present evidence on the costs of adjusting the output in the U.S. automobile industry. The firm has different possibilities to adjust its production depending on whether it want to increase it or decrease it.

- It can use overtime hours but labour laws mandate that workers be paid a 50 percent premium for hours in excess of 40 hours per week.

[8]Costs at the same level are found in a study of chain drugstores, Levy et al. (1998).

- It can close the plant for less than a week but in this case it must roughly pay 80 percent of the wage to the workers who are not working.

- It can close the plant for one week or more in which case it does not pay the workers. Workers however receive unemployment benefits which are financed by the firms. The cost to the firm of unemployment insurance varies from state to state but normally depends on the degree of experience rating. The exact method of financing unemployment benefits is explained in Topel (1983). For New York for example, Topel reports an increase of 71 cents of taxes paid by employers per dollar of benefits received by workers. However the tax cannot go beyond some threshold; it is therefore possible that an additional layoff does not increase future taxes, but this is not the case for most firms; the cost of closing the plant for more than 1 week is therefore not trivial.

- It can add a shift or increase the line speed. These solutions involves changing the number of workers, reorganizing the assembly line and redefining jobs. The costs of such changes are difficult to assess. However, as Bresnahan and Ramey (1994) notice, these solutions are used only when the change in production is expected to be long because they generate high costs of adjustment. When the change in production is expected to be short, the firm prefers using overtime hours and shutdowns even though these solutions imply that the cost of producing an additional output is high.

These arguments suggest that the cost of adjusting quantities are substantial and could well be above 1 percent (of output). In terms of Figure 1, this depreciates considerably the likelihood of encountering the case of observing only quantity adjustment to monetary shocks. The case where the price is the only variable to adjust to a money shock is more likely to prevail.

5 Conclusion

This analysis shows that allowing for both price and quantity adjustment costs erodes the “small cost” argument underlying menu-cost models. For empirically plausible values of adjustment costs it is more likely that monetary shocks induce price adjustments rather than quantity adjustments. The question why nominal shocks have real effects has not been satisfactorily resolved by menu-cost models.

A Appendix

From the first-order conditions to the household problem we have

$$\frac{M_t}{P_t C_t} = \theta + \beta E_t \left(\frac{M_{t+1}}{P_{t+1} C_{t+1}} \right)$$

by use of the fact that $\lambda_t^i = \frac{1}{C_t^i}$ and $\mu_t M_t^i = M_{t+1}^i$ and imposing the symmetry condition. Therefore,

$$\frac{M_t}{P_t C_t} = \frac{\theta}{1-\beta}$$

and using $C_t = Y_t$ yields (15). Notice that the symmetry implies that $B_t = 0$ in equilibrium.

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