Macroeconomic Analysis
Lecture notes (5.1) on:
New Keynesian Macroeconomics: imperfect competition and nominal rigidities

(F. Bagliano, 2017)

The traditional "keynesian" literature has often assumed the existence of rigidities in the price and/or wage setting process in order to justify the real effects (on output and employment) of fluctuations in aggregate demand, due for example to changes in money supply. The need to provide rigorous theoretical underpinnings to the hypothesis of nominal rigidities is the main motivation of several strands of the more recent "*new keynesian macroeconomics*" literature.

Those efforts to build keynesian macroeconomics on sound microeconomic foundations are based on two important beliefs:

a) fluctuations in some *nominal* variables (e.g. money) have important effects on real dynamics in the short- to medium-run (therefore, over those horizons, the classical "dichotomy" between the "real" and the "monetary" sector of the economy does not hold);

b) various *imperfections* on several markets (for labor, goods, capital) play a key role in explaining macroeconomic fluctuations, in contrast with the "Walrasian" paradigm of perfect competition, absence of externalities, and perfect information.

In particular, in order to provide a microeconomic rationale to the price rigidity necessary for changes in aggregate demand to have real effects, two conditions must be met:

1. prices have to be set by economic agents (*price makers*) with market power, and not determined on perfectly competitive markets populated by atomistic agents;

2. price makers find it convenient to keep prices unchanged (adjusting only the quantity supplied) in the face of macroeconomic shocks.

The first condition leads naturally to consider markets where sellers with some *monopoly power* choose the price on the basis of the slope of the demand curve for their product. In this setting, price is higher than marginal cost, and the second condition can be justified: if it is costly to adjust prices, an increase of the quantity sold at an unchanged price will not entail losses at the margin. Indeed, it is often observed that producers willingly sell more at the "market price", whereas in a perfectly competitive market (where price is equal to marginal cost) the possibility to sell more at unchanged prices would be much less attractive.

In these notes, this insight is illustrated in a *partial equilibrium* framework (following Mankiw 1985) and then in a *general equilibrium* setting (Blanchard and Kiyotaki 1987).

1. Microeconomic foundations of nominal rigidities: the costs of price adjustment

Consider a producer in a *monopolistically competitive* market facing a demand function

$$p = f(q)$$

where p is the price of the good produced expressed in *real* terms (i.e. relative to an index of the economy-wide price level), q is the quantity sold, and $f'(q) < 0$. Marginal cost in real terms is a constant k. To maximize *real* profits $f(q)q - kq$, the producer chooses price p^* such that marginal revenue is equal to marginal cost ($MR = k$); consequently, the output sold is q^* such that $p^* = f(q^*)$. The case of a linear demand function is displayed in Figure 1.

The *social welfare* generated by producing and exchanging a quantity q can be measured by the sum of the producer's surplus and the consumers' surplus, corresponding to the area below the demand cruve and above marginal cost. Due to market power, the firm's choice q^* does not maximize social welfare. The welfare-maximizing output is q^{**}, such that $k = f(q^{**})$; however, the producer (having to sell all units of the good at the same price) is not willing to sell output at k with no profits (note that, from basic microeconomics, a subsidy -financed with lump-sum taxes- could induce the producer to increase production beyond q^*).

Let us now set up the producer's problem in *nominal* terms: with N denoting an index of the general price level, the nominal price P is given by

$$P = pN = f(q)N$$

and nominal costs (assuming no fixed costs) are

$$C = kqN$$

In our partial equilibrium setting, N is an exogenous measure of the nominal demand which shifts the (nominal) demand curve for the firm's output; in a general equilibrium framework (as in the Blanchard-Kiyotaki model below) it would depend, for instance, on the money supply in the whole economy. If N is *known* when the nominal price P is chosen, then the maximization of *nominal* profits $Pq - C = [f(q)q - kq]N$ yields the same result as the maximization of *real* profits (output q^* and price p^* as above). Instead, if the producer sets the price *before* observing the actual level of N (therefore on the basis of its expected value N^e), the chosen price will not be at the optimal level any time $N \neq N^e$. In this case, the firm has to choose whether to adjust the price to the new (and now known) demand conditions, paying a fixed cost z, or to keep it at the level set previously. In the former case, output remains at the (unique) profit-maximizing level q^*; in the latter, with P fixed, p changes and also the quantity supplied q changes along the demand curve.

Figure 1 shows the effects of a unanticipated *decrease* of N (due, for example, to a restrictive monetary policy). If P is kept unchanged, p rises from p^* to p^0 and output decreases from q^* to q^0: profits are lower. However, the reduction in profits (given by the difference between the areas named B and A in the figure) is relatively "small"; the producer could choose not to adjust the nominal price P if only a small cost of adjustment z (a "*menu cost*") is present. In contrast, the change in social welfare is relatively "large": the overall (producer's and consumers') surplus decreases by $B + C$. More precisely, if the (real) adjustment cost is $z < B - A$, then the firm will adjust his nominal price to bring the price in real terms equal to the profit-maximizing level p^*, and the ensuing reduction in profits (limited to the adjustment cost z only) will coincide with the loss in social welfare. Instead, if $z > B - A$, the producer will not change price, and will accept a reduction in profits of $B - A$, with a larger reduction in social welfare, $B + C$; in this case, then, the price rigidity due to the cost of adjusting prices is undesirable from the perspective of social welfare.

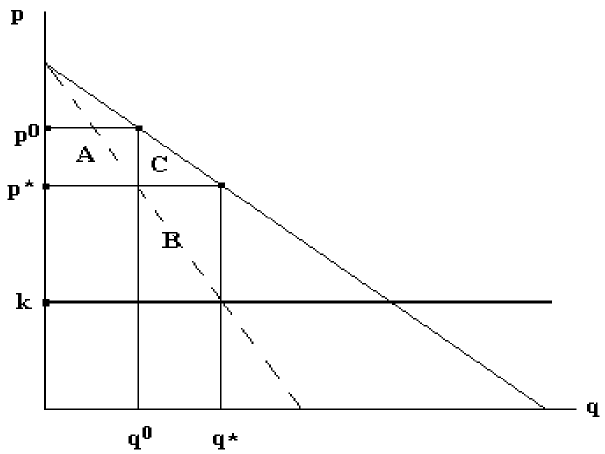

Figure 1: Decrease of N.

Symmetrically, Figure 2 illustrates the effects of an unanticipated *increase* of N (e.g. due to an expansionary monetary policy). If P is unchanged, the price in real terms p decreases to p^1 (assumed higher than marginal cost k) and output increases from q^* to q^1. Again, the reduction of profits is relatively small (equal to the difference $A' - B' > 0$), and total surplus increases by $B' + C'$. If the price adjustment cost is high enough to induce the producer to keep P unchanged (i.e. if $z > A' - B'$), then output and social welfare increase, with a transfer of resources from the producer to consumers. In contrast, if $z < A' - B'$, then the firm brings the real price back to the optimal level p^*, generating a reduction of profits and social welfare equal to the price adjustment cost z. Therefore, in the face of an increase in N, it is always socially optimal to keep the price unchanged, and to increase output: price rigidities due to menu costs positively affect social welfare.

We can note here that, if we start from a perfectly competitive situation (where $p = k$), then:

i) it would not be possible to increase social welfare (already maximized under perfect competition);

ii) if it were impossible (or not convenient) to change prices, sellers would prefer to ration demand instead of increase output, since selling the product at a price lower than k would entail losses at the margin.

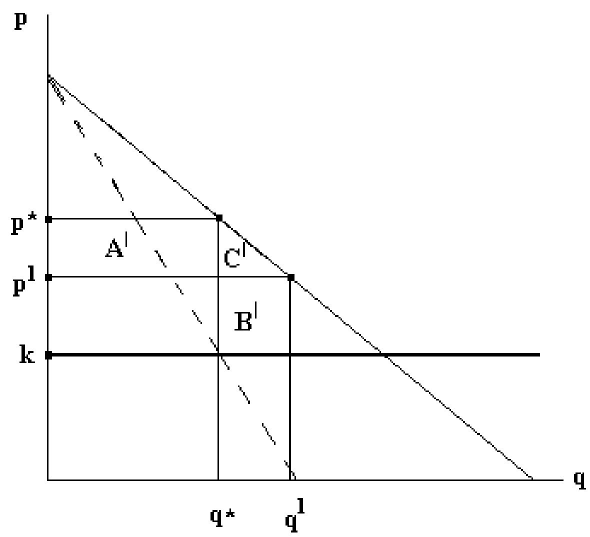

Figure 2: Increase of N.

Though stylized, this model provides a formal microeconomic foundation to some basic macroeconomic insights. A "boom" (i.e. an increase in output at fixed prices) enhances social welfare, whereas an increase in output accompanied by a price increase has a negative effect on welfare (due to costly price changes for sellers, as in the model, and also to the greater effort that consumers must devote to the search process for the best prices). On the contrary, a reduction in output has always negative welfare effects, due to the distorsion of supply in a monopolistically competitive market, and due to costly price reduction that may occur.

Those results are based on the fact that changes in the welfare of agents with monopolistic power who do not adjust prices to optimal values are smaller than welfare changes for the society as a whole.

2. A general equilibrium model of monopolistic competition

After the partial equilibrium model of the previous section, we outline here a more complete model of an economy where *monopolistic competition* prevails in goods markets. A simplified version of Blanchard and Kiyotaki (1987) is presented; in the original paper, imperfect competition is present also on the labor market.

Consider an economy where n monopolistically competitive firms produce n differentiated goods (indexed by $i = 1, ..., n$). Consumers are identical under all respects and their behavior can be analyzed by focusing on a "representative consumer" who chooses optimal consumption of the n goods and how much labor to supply to producers. For simplicity, we assume that, differently from the monopolistically competitive goods markets, the labor market operates under perfect competition, with a market-clearing level of the (perfectly flexible) nominal wage W that is considered as given by producers and consumers when solving their respective maximization problems.

2.1. Consumers

Let us begin by formalizing the *consumer's* choice problem. He chooses optimal consumption of each of the n goods (C_i), the optimal quantity of money to hold M, and the amount of labor N to supply to firms by maximizing the following objective function:

$$\max_{(C,N,M)} \quad U = C^{\gamma}\left(\frac{M}{P}\right)^{1-\gamma} - \frac{1}{\beta}N^{\beta} \qquad 0<\gamma<1\ ,\ \beta>1 \tag{2.1}$$

where

$$C = \left(n^{-\frac{1}{\theta}}\sum_{i=1}^{n} C_i^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}} \qquad \theta>1 \tag{2.2}$$

$$P = \left(\frac{1}{n}\sum_{i=1}^{n} P_i^{1-\theta}\right)^{\frac{1}{1-\theta}} \tag{2.3}$$

under the budget constraint

$$\sum_{i=1}^{n} P_i C_i + M = M_0 + WN + \sum_{i=1}^{n} \Pi_i \equiv I \tag{2.4}$$

The utility function (2.1) is separable in N, therefore ruling out any income effect on labor supply. We also assume that $0 < \gamma < 1$ e che $\beta > 1$; the latter assumption imposes an increasing marginal disutility of labor ($\beta - 1$ is the elasticity of the marginal disutility of labor with respect to N). C and P are aggregate indices (of the *constant elasticity of substitution* variety) of the consumption bundle and of the corresponding price level, defined by (2.2) and (2.3) (it can be checked that if $C_i = \overline{C}$ and $P_i = \overline{P}$ for all goods i, then $C = n\overline{C}$ and $P = \overline{P}$). The parameter θ measures the (constant) elasticity of substitution between any pair of goods; to ensure the existence of equilibrium, it is assumed that $\theta > 1$. Consumers' resources are composed of initial money balances M_0, labor income WN, and profits from the n firms (under the assumptions that firms are owned by consumers and firms' profits are entirely distributed as dividends). In maximizing utility, nominal wage W and all goods prices P_i (and therefore the aggregate price level P) are taken as given by consumers.

The first order conditions of the problem (referred to C_i, M and N, respectively) are:

$$\gamma \left(\frac{M}{PC}\right)^{1-\gamma} \left(\frac{C}{nC_i}\right)^{\frac{1}{\theta}} = \lambda P_i \tag{2.5}$$

$$(1-\gamma)\left(\frac{M}{PC}\right)^{-\gamma} = \lambda P \tag{2.6}$$

$$N^{\beta-1} = \lambda W \tag{2.7}$$

where λ is the Lagrange multiplier associated to the budget constraint. In order to obtain the demand functions for the n consumption goods and money and the labor supply function, we combine the first two conditions and get

$$P_i = \frac{\gamma}{1-\gamma} \frac{M}{C} \left(\frac{C}{nC_i}\right)^{\frac{1}{\theta}} \tag{2.8}$$

Using (2.8) into the definition of the price level (2.3) yields:

$$\begin{aligned} P &= \left(\frac{1}{n}\sum_{i=1}^{n} P_i^{1-\theta}\right)^{\frac{1}{1-\theta}} \\ &= \frac{\gamma}{1-\gamma}\frac{M}{C}\left(\frac{C}{n}\right)^{\frac{1}{\theta}} \underbrace{\left(\frac{1}{n}\sum_{i=1}^{n} C_i^{\frac{\theta-1}{\theta}}\right)^{\frac{1}{1-\theta}}}_{=\left(\frac{C}{n}\right)^{-\frac{1}{\beta}} \text{ from (2.2)}} \\ &= \frac{\gamma}{1-\gamma}\frac{M}{C} \end{aligned} \tag{2.9}$$

Substituting from (2.9) $\frac{M}{C} = \frac{1-\gamma}{\gamma}P$ into (2.8) we then get the demand for each good i as a function of its relative price:

$$C_i = \left(\frac{P_i}{P}\right)^{-\theta}\frac{C}{n} \tag{2.10}$$

The demand for C_i depends on its relative price with a constant price elasticity given by $-\theta$. In order to express goods and money demand as functions of the overall consumer's resources (I), we employ the budget constraint (2.4):

$$I = \sum_{i=1}^{n} P_i C_i + M \tag{2.11}$$

From (2.8) the consumption expenditure can be written as

$$\begin{aligned} \sum_{i=1}^{n}\frac{P_i}{P}C_i &= \sum_{i=1}^{n}\left(\frac{C}{n}\right)^{\frac{1}{\theta}} C_i^{\frac{\theta-1}{\theta}} = C^{\frac{1}{\theta}}\left(n^{-\frac{1}{\theta}}\sum_{i=1}^{n} C_i^{\frac{\theta-1}{\theta}}\right) \\ &= C^{\frac{1}{\theta}} C^{\frac{\theta-1}{\theta}} = C \\ \Rightarrow \sum_{i=1}^{n} P_i C_i &= PC \end{aligned} \tag{2.12}$$

Using (2.9), (2.11) and (2.12) we get:

$$C = \gamma\frac{I}{P} \tag{2.13}$$

$$M = (1-\gamma)I \tag{2.14}$$

Aggregate consumption and money holdings are now expressed as functions of the consumer's overall wealth.

Noting that since in this economy aggregate *output* Y coincides with the production of consumer goods C, we get a relation linking output to real money balances:

$$C = Y = \frac{\gamma}{1-\gamma}\frac{M}{P} \tag{2.15}$$

Labor supply is obtained by combining the conditions for M and N into (2.7):

$$\begin{aligned} N^{\beta-1} &= \frac{W}{P}(1-\gamma)\left(\frac{M}{PC}\right)^{-\gamma} = \frac{W}{P}(1-\gamma)\left(\frac{1-\gamma}{\gamma}\right)^{-\gamma} \\ &= \frac{W}{P}(1-\gamma)^{1-\gamma}\gamma^{\gamma} \end{aligned}$$

where (2.9) has been used. Labor supply can then be written as

$$N = \left[(1-\gamma)^{1-\gamma}\gamma^{\gamma}\right]^{\frac{1}{\beta-1}}\left(\frac{W}{P}\right)^{\frac{1}{\beta-1}} \tag{2.16}$$

As previously noticed, labor supply depends only on the real wage and not also on real money balances (i.e. the income effect is absent). The wage elasticity of labor supply is given by $\frac{1}{\beta-1} > 0$, since we assumed $\beta > 1$.

2.2. Firms

The solution of the consumer's problem yields the demand function for each consumption good (2.10). This function is the constraint in the profit maximization problem of the n firms. Formally, each firm i solves the following problem:

$$\max_{P_i, N_i, Y_i} \Pi_i = P_i Y_i - W N_i$$

where N_i is the amount of labor employed by firm i. The constraints are given by the production function (with decreasing returns to labor) and the market demand:

$$\begin{aligned} Y_i &= N_i^{\alpha} \qquad \alpha < 1 \\ Y_i &= C_i = \left(\frac{P_i}{P}\right)^{-\theta}\frac{C}{n} \end{aligned}$$

Substituting the constraints into the objective function we can write the problem as

$$\max_{P_i} \ \Pi_i = P_i \left(\frac{P_i}{P}\right)^{-\theta} \frac{C}{n} - W \left[\left(\frac{P_i}{P}\right)^{-\theta} \frac{C}{n}\right]^{\frac{1}{\alpha}} \tag{2.17}$$

If the number of firms n is sufficiently large, we can plausibly assume that no individual firm can substantially affect the general price level. Therefore, firms take P as given in maximizing profits with respect to P_i. Moreover, perfect competition on the labor market makes the nominal wage W a given for firms. From the first-order condition for P_i we get:

$$\frac{P_i}{P} = \left(\frac{\theta}{\theta - 1} \frac{1}{\alpha} \frac{W}{P} \left(\frac{C}{n}\right)^{\frac{1-\alpha}{\alpha}}\right)^{\frac{\alpha}{\alpha+\theta(1-\alpha)}} \tag{2.18}$$

(2.18) is the rule followed by firm i in setting the relative price for its product P_i/P (the "*price rule*"), given the general price level. The relative price is increasing in the real wage, which determines marginal costs of production. The relative price also depends on aggregate demand (C): with increasing marginal costs ($\alpha < 1$), an increase in demand causes an increase in both output and price, whereas the latter would not increase under constant marginal costs ($\alpha = 1$).

2.3. Equilibrium

We can now characterize the economy's equilibrium. With perfectly identical firms, all relative prices will be unity in equilibrium:

$$P_i = P \qquad \forall i \tag{2.19}$$

From (2.10), using (2.19), we get the equilibrium output for each firm:

$$C_i = Y_i = \frac{C}{n} \qquad \forall i \tag{2.20}$$

Under perfect competition, the ***labor market equilibrium*** is obtained by equating the demand for and supply of N. Combining (2.20) with the firms' production function we get the aggregate demand for labor N^D:

$$N^D = \sum_{i=1}^{n} N_i^D = nY_i^{\frac{1}{\alpha}} = n\left(\frac{C}{n}\right)^{\frac{1}{\alpha}}$$

Using (2.15) we can write labor demand as a function of real money balances:

$$N^D = n^{\frac{\alpha-1}{\alpha}} \left(\frac{\gamma}{1-\gamma} \frac{M}{P} \right)^{\frac{1}{\alpha}} \tag{2.21}$$

Now, equating labor demand (2.21) and labor supply (2.16) we obtain an equilibrium relationship between the real wage W/P and money balances M/P:

$$\frac{W}{P} = \left[n^{\frac{(\alpha-1)(\beta-1)}{\alpha}} \left(\frac{\gamma}{1-\gamma} \right)^{\frac{\beta-1}{\alpha}-\gamma} \frac{1}{1-\gamma} \right] \left(\frac{M}{P} \right)^{\frac{\beta-1}{\alpha}} \tag{2.22}$$

Letting K_L be the constant term in square brackets and taking logarithms, we finally get:

$$\ln \left(\frac{W}{P} \right) = \ln K_L + \frac{\beta-1}{\alpha} \ln \left(\frac{M}{P} \right) \qquad (LME) \tag{2.23}$$

The equilibrium relation on the labor market (LME) links positively the real wage to real money balances through the coefficient $\frac{\beta-1}{\alpha}$, that measures the elasticity of the marginal disutility of labor with respect to output.[1]

The ***goods market equilibrium*** is described by a second relation between W/P and M/P, obtained by setting relative prices equal to unity into the price rule (2.18) capturing firms' price-setting behavor, and using (2.15):

$$\begin{aligned} \frac{W}{P} &= \frac{\theta-1}{\theta} \alpha \left(\frac{\gamma}{1-\gamma} \frac{M}{nP} \right)^{\frac{\alpha-1}{\alpha}} \\ &= \left[\frac{\theta-1}{\theta} \alpha \left(\frac{\gamma}{1-\gamma} \right)^{\frac{\alpha-1}{\alpha}} n^{-\frac{\alpha-1}{\alpha}} \right] \left(\frac{M}{P} \right)^{\frac{\alpha-1}{\alpha}} \end{aligned} \tag{2.24}$$

Letting K_P be the constant term in square brackets and taking logarithms, we get:

$$\ln \left(\frac{W}{P} \right) = \ln K_P - \frac{1-\alpha}{\alpha} \ln \left(\frac{M}{P} \right) \qquad (APR) \tag{2.25}$$

The equilibrium relation on the goods market, called the "*aggregate price rule*" (APR) describes a positive link between the price to wage ratio (the reciprocal of

[1] In fact, this coefficient is the product of two elasticities: $\beta - 1$ is the elasticity of the marginal disutility of labor with respect to N, and $\frac{1}{\alpha}$ is the elasticity of labor with respect to output (from the -inverted- production function).

the real wage) and aggregate demand, captured by real money balances. Under constant returns to scale in production ($\alpha = 1$), P/W would be independent of aggregate demand, being determined only by the degree of producers' market power (the coefficient $\frac{\theta}{\theta-1}$ measures the excess of price on marginal labor costs, capturing the degree of firms' monopoly power).[2]

The general equilibrium of the economy can be described graphically in Figure 3 by means of the two relationships LME and APR, both defining a (log) relation between real wage W/P and output Y (proportional to real money balances, according to (2.15): $\ln Y = \ln\left(\frac{\gamma}{1-\gamma}\right) + \left(\ln \frac{M}{P}\right)$). The overall equilibrium under monopolistic competition in the goods market is found where the two curves cross. If the goods market tends to perfect competition conditions (which occurs as $\theta \to \infty$), the APR curve shifts upwards along an unchanged LME curve: output and the real wage increase.[3]

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[2]In fact, we can equivalently write (2.24) in terms of P/W as:

$$\frac{P}{W} = \frac{\theta}{\theta-1}\frac{1}{\alpha}\left(\frac{\gamma}{1-\gamma}\frac{1}{n}\right)^{\frac{1-\alpha}{\alpha}}\left(\frac{M}{P}\right)^{\frac{1-\alpha}{\alpha}}$$

In general, the ratio P/W (mark-up) depends on aggregate demand (M/P); if $\alpha \to 1$ then $P/W \to \frac{\theta}{\theta-1}$.

[3]If monopolistic competition prevailed *also* on the labor market (in addition to the goods markets), the LME curve would be placed at the left of that depicted in Figure 3 (valid under the assumption of perfect competition). In this case, a generalized decrease of the market power (on both the goods and the labor market) would shift *both* curves to the right, reinforcing the positive effect on output but making the effect on the real wage (a priori) ambiguous.

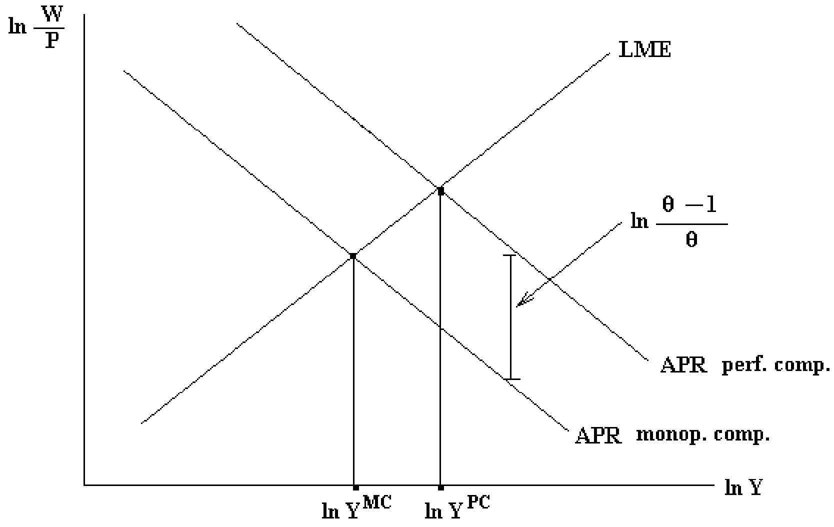


Figure 3

The model yields two fundamental conclusions:

1. The equilibrium with monopolistic competition is *inefficient* if compared with the equilibrium under perfect competition: output Y^{MC} is lower than Y^{PC} and, for given nominal money balances M, the price level is higher under monopolistic competition than under perfect competition.[4] This inefficiency is due to the presence of an *aggregate demand externality.* In fact, if an individual firm decides to decrease its own price, there are two effects. On the one hand, the *relative* price changes, and the demand for the firm's product increases. On the other hand, the reduction of the firm's price has a (limited) effect on the *general* price level, causing a (small) decrease in P, with a consequent increase in the demand for the goods produced by

[4]From the two equilibrium conditions, using the relationship $Y = \frac{\gamma}{1-\gamma}\frac{M}{P}$, we get output under monopolistic competition relative to the perfect competition level as:

$$\frac{Y^{MC}}{Y^{PC}} = \left(\frac{\theta - 1}{\theta}\right)^{\frac{\alpha}{\beta-\alpha}}$$

This ratio is increasing in θ.

all firms. The latter effect would allow to increase output and welfare in the economy as a whole, but is *not* taken into account by the individual producer when setting his (optimal) price, whereas the former effect is zero at the profit-maximizing price. As a consequence, there is no incentive for producers to cut prices, even if a generalized cut would determine an overall gain in terms of output and welfare.

2. The existence of a macroeconomic inefficiency is not enough to determine a “keynesian” effect of aggregate demand on equilibrium output: even in a monopolistically competitive economy, changes in the nominal money supply have no effect on real variables (monetary neutrality holds). However, if even relatively "small" price adjustment costs are introduced (e.g. the *menu costs* of Mankiw’s model) such as to induce producers not to adjust prices in the face of increases of aggregate demand (due, for example to an increase of M), then an overall increase in output and welfare can occur. Therefore, monopolistic competition is not sufficient to yield real effects of changes in money; however, it plays a key role when a potential source of rigidity such as *menu cost* is also introduced: when marginal revenue is higher than marginal cost (as in the monopolistic competition equilibrium) producers will be willing to increase output at unchanged prices when an increase in aggregate demand occurs.

References

[1] Blanchard O.J. and N. Kiyotaki (1987) "Monopolistic competition and the effects of aggregate demand", *American Economic Review*, 77, 4

[2] Mankiw N.G. (1985) "Small menu costs and large business cycles: a macroeconomic model of monopoly", *Quarterly Journal of Economics*, 100

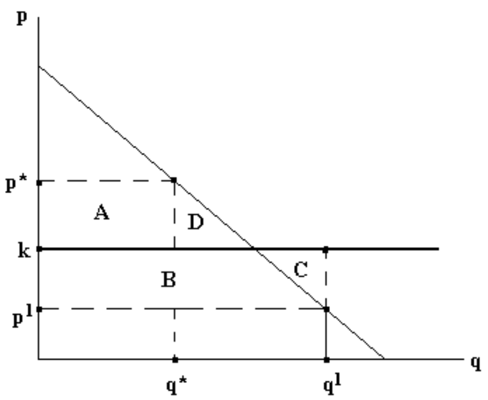
Problems

1. Using Mankiw's (1985) monopoly model, consider the case of an *increase* of nominal aggregate demand (N) such that, at an unchanged price in nominal terms (P), it corresponds a price in real terms (p) *lower* than marginal cost k (assume that the monopolist has necessarily to satisfy the demand for his product). Graphically analyze the effect on *social welfare* in the two cases of *price adjustment* and *no price adjustment* (assuming a *menu cost* z) by the monopolist, specifying for what values of z he chooses not to adjust his price in the face of the increase in demand.

2. Consider a firm operating in a *perfectly competitive* output market with a given productive capacity. Let p^* be the "market price" and p the firm's price. Display graphically the behavior of firms *profits* as a function of its *relative price*: $\frac{p}{p^*}$. What is the key difference with respect to a *monopolistically competitive* firm? what are the implications for the potential relevance of (small) menu costs as a cause of price rigidity in the two cases of perfect and monopolistic competition?

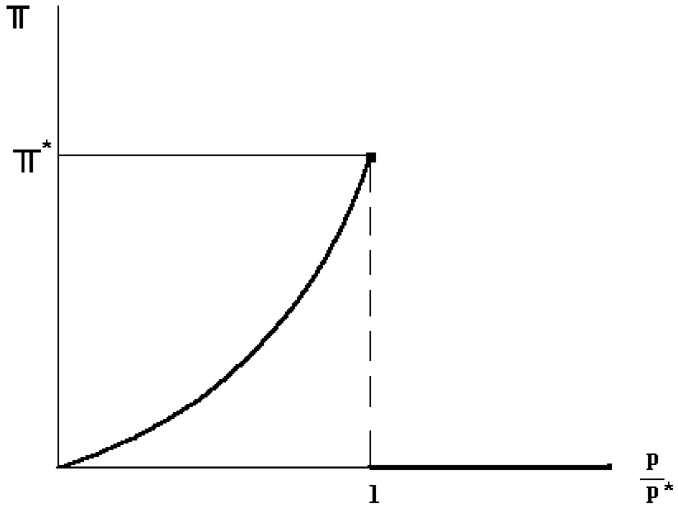
Answers to problems

1. **Answer:**
   Looking at the figure below, let p^* and q^* be the (optimal) price and quantity in case of *price adjustment*, and p^1 and q^1 be the price and quantity in case of *no price adjustment*. If the monopolist adjust his price, private profits and social welfare are reduced by the real adjustment cost z. In contrast, if the nominal price is kept unchanged, the monopolist saves z but loses an amount of profits given by the area $A + B + C$. The producer will then choose to change the price if $A + B + C > z$. From the social welfare perspective, if the price id not adjusted, a loss given by $C - D$ will occur (the sign of which is indetermined in general). It will then be socially optimal to adjust the price if $C - D > z$.



2. **Answer:**
   In the case of *perfect competition* the firm's profit function (giving profits as a function of price) is *not differentiable* at the market price p^*. If the firm sells its output at the market price ($p = p^*$), it will sell the optimal quantity q^* and obtain maximum profits π^*. If the price is lower than the market level ($p < p^*$), the firm will supply only the quantity compatible with the level of its marginal cost, and obtain profits $\pi < \pi^*$. Finally, if the firm's

price is higher than the market price ($p > p^*$), there will be no demand for the firm's products and profits will be zero. Profits π as a function of relative price $\frac{p}{p^*}$ have the following form:



The discontinuity of the profit function is the crucial difference between the perfectly competitive firm and the monopolist in Mankiw's model, the latter having a continuous and differentiable profits function. This implies that deviations of the price from its optimal level would cause "large" (and not "small", or second-order) reduction in profits to a perfectly competitive firm. Therefore, the magnitude of the price adjustment costs needed to justify price rigidities in a perfectly competitive market would be implausibly high.