Makroøkonomi 2   Note 3

22.10.2015   Christian Groth

Back to short-run macroeconomics

In this lecture note we shift the focus from long-run macroeconomics to short-run macroeconomics. The *long-run* models concentrated on mechanisms that are important for the economic evolution over a time horizon of at least 10-15 years. With such a horizon it is the development on the supply side (think of capital accumulation, population growth, and technical progress) that is the primary determinant of cumulative changes in output and consumption − the trend. The demand side and monetary factors are important for the fluctuations about the trend. In a long-run perspective these fluctuations have limited quantitative importance. But within a short horizon, say up to four years, the demand-side, monetary factors, nominal rigidities, and expectation errors are quantitatively important. The present note re-introduces these *short-run* factors and aims at suggesting how short-run and long-run theory are linked. This also implies a few remarks about theory dealing with the *medium run,* say 4 to 15 years.[1] The purpose of medium-run theory is to explain the regularities in the fluctuations (business cycles) about the trend and to study what can be accomplished by monetary and fiscal stabilization policy. In that context the *dynamic interaction* between demand and supply factors and the time-consuming adjustment in relative prices play an important role. In this way medium-run theory bridges the gap between the long run and the short run.

1 Stylized facts about the short run

The idea that prices of most goods and services are sticky in the short run rests on the empirical observation that in the short run firms in the manufacturing and service industries typically let output do the adjustment to changes in demand while keeping prices unchanged. In industrialized societies firms are able to do that because under "normal circumstances" there is "abundant production capacity" available in the economy. Three of the most salient short-run features that arise from macroeconomic time series

[1] These number-of-years declarations should not be understood as more than a rough indication. Their appropriateness will depend on the specific historical circumstances and on the problem at hand.

analysis of industrialized market economies are the following (cf. Blanchard and Fischer, 1989, Christiano et al., 1999):

1) Shifts in aggregate demand (induced by sudden changes in the state of confidence, exports, fiscal or monetary policy, or other events) are largely accommodated by changes in quantities rather than changes in nominal prices – *nominal price insensitivity.*

2) Even large movements in quantities are often associated with little or no movement in relative prices – *real price insensitivity.* The real wage, for instance, exhibits such insensitivity in the short run.

3) Nominal prices are *sensitive* to general changes in *input costs.*

These stylized facts pertain to final goods and services. It is not the case that *all* nominal prices in the economy are in the short run insensitive vis-a-vis demand changes. One must distinguish between production of most final goods and services on the one hand and production of primary foodstuff and raw materials on the other. This leads to the associated distinction between "cost-determined" and "demand- determined" prices.

Final goods and services are typically differentiated goods (imperfect substitutes). Their production takes place under conditions of imperfect competition. As a result of existing reserves of production capacity, generally speaking, the *production is elastic w.r.t. demand.* An upward shift in demand tends to be met by a rise in production rather than price. The price changes which do occur are mostly a response to general changes in costs of production. Hence the name "cost-determined" prices.

For *primary foodstuff* and many *raw materials* the situation is different. To increase the supply of most agricultural products requires considerable time. This is also true (though not to the same extent) with respect to mining of raw materials as well as extraction and transport of crude oil. When production is *inelastic* w.r.t. demand in the short run, an increase in demand results in a diminution of stocks and a rise in price. Hence the name "demand-determined prices". The price rise may be enhanced by a speculative element: temporary hoarding in the expectation of further price increases. The price of oil and coffee – two of the most traded commodities in the world market – fluctuate a lot. Through the channel of *costs* the changes in these demand-determined prices spill over to the prices of final goods. Housing is also an area where, apart from regulation, demand-determined prices is the rule in the short run.

In industrialized economies manufacturing and services are the main sectors, and the general price level is typically regarded as cost-determined rather than demand determined. Two further aspects are important. First, many wages and prices are set in nominal terms by *price setting agents* like craft unions and firms operating in imperfectly competitive output markets. Second, these wages and prices are in general deliberately kept unchanged for some time even if changes in the environment of the agent occurs; this aspect, possibly due to pecuniary or non-pecuniary costs of changing prices, is known as *nominal price stickiness.* Both aspects have vast consequences for the functioning of the economy as a whole compared with a regime of perfect competition and flexible prices.

2 A simple short-run model

The simple model presented below is close to what Paul Krugman named the *World's Smallest Macroeconomic Model.*[2] The model is crude but nevertheless useful in at least three ways:

- the model demonstrates the fundamental difference in the *functioning* of an economy with flexible prices and one with sticky prices;
- by addressing spillovers across markets, the model is a suitable point of departure for a definition of the Keynesian concept of *effective demand;*
- the model displays the logic behind the Keynesian *refutation* of *Say's law.*

2.1 Elements of the model

We consider a monetary closed economy which produces a consumption good. There are three sectors in the economy, a production sector, a household sector, and a public sector with a consolidated government/central bank. Time is discrete. There is a current period, of length a quarter of a year, say, and "the future", compressing the next period and onward. Labor is the only input in production. To simplify notation, the model presents its story as if there is just one representative household and one representative firm owned by the household, but the reader should imagine that there are numerous agents of each kind.

[2] Krugman (1999). Krugman tells he learned the model back in 1975 from Robert Hall. As presented here there is also an inspiration from Barro and Grossman (1971).

The production function has CRS,

$$Y = AN, \qquad A > 0, \tag{1}$$

where Y is aggregate output of a consumption good which is perishable and therefore cannot be stored, A is a technology parameter and N is aggregate employment in the current period. In short- and medium-run macroeconomics the tradition is to use N to denote labor input ("number of hours"), while L is typically used for either money demand ("liquidity demand") or supply of bank loans. We will follow this tradition.

The price of the consumption good in terms of money, i.e., the *nominal* price, is P. The wage rate in terms of money, the *nominal* wage, is W. We assume that the representative firm maximizes profit, taking these current prices as given. The nominal profit, possibly nil, is

$$\Pi = PY - WN. \tag{2}$$

There is free exit from the production sector in the sense that the representative firm can decide to produce nothing. Hence, an equilibrium with positive production requires that profits are non-negative.

The representative household lives only one period, but leaves a bequest for the next generation. The household supplies labor inelastically in the amount $\bar{N}$ and receives the profit obtained by the firm, if any. The household demands the consumption good in the amount C^d in the current period (since we want to allow cases of non-market clearing, we distinguish between consumption *demand,* C^d, and realized consumption, C. Current income not consumed is saved for the future. As the output good cannot be stored, the only non-human asset available in the economy is fiat money, which is thus the only asset on hand for saving. There is no private banking sector in the economy. So "money" means the "currency in circulation" (the monetary base) and is on net an asset in the private sector as a whole. Until further notice the money stock is constant.

The preferences of the household are given by the utility function,

$$U = \ln C^d + \beta \ln \frac{\hat{M}}{P^e}, \qquad 0 < \beta < 1, \tag{3}$$

where $\hat{M}$ is the amount of money transferred to "the future", and P^e is the expected future price level. The utility discount factor β (equal to $(1+\rho)^{-1}$ if ρ is the utility discount rate) reflects "patience".

Consider the household's choice problem. Facing P and W and expecting that the future price level will be P^e, the household chooses C^d and $\hat{M}$ to maximize U s.t.

$$PC^d + \hat{M} = M + WN + \Pi \equiv B, \qquad N \leq \bar{N}. \tag{4}$$

Here, $M > 0$ is the stock of money held at the beginning of the current period and is predetermined. The actual employment is denoted N and equals the minimum of the amount of employment offered by the firm and the labor supply $\bar{N}$ (the principle of voluntary trade). The sum of initial financial wealth, M, and nominal income, $WN + \Pi$, constitutes the budget, B.[3] Nominal financial wealth at the beginning of the next period is $\hat{M} = M + WN + \Pi - PC^d$, i.e., the sum of initial financial wealth and planned saving where the latter equals $WN + \Pi - PC^d$. The benefit obtained by transferring $\hat{M}$ depends on the expected purchasing power of $\hat{M}$, hence it is $\hat{M}/P^e$ that enters the utility function. Presumably the household expects some labor and profit income also in the future and seemingly ownership rights to the firms' profit are non-negotiable. How the decision making is related to such matters is not specified in this minimalist way of representing that there is a future.

Substituting $\hat{M} = B - PC^d$ into (3), we get the first-order condition

$$\frac{dU}{dC^d} = \frac{1}{C^d} + \beta \frac{P^e}{B - PC^d}(-\frac{P}{P^e}) = 0,$$

which gives

$$PC^d = \frac{1}{1+\beta}B. \tag{5}$$

We see that the marginal (= average) propensity to consume is $(1+\beta)^{-1}$, hence inversely related to the patience parameter β. The planned stock of money to be held at the end of the period is

$$\hat{M} = (1 - \frac{1}{1+\beta})B = \frac{\beta}{1+\beta}B.$$

So, the expected price level, P^e, in the future does not affect the demands, C^d and $\hat{M}$. This is a special feature caused by the additive-logarithmic specification of the utility function in (3). Indeed, with this specification the substitution and income effects of a rise in the expected real gross rate of return, $(1/P^e)/(1/P)$, on savings exactly offset each other, and there is no wealth effect in this model.

Inserting (4) and (2) into (5) gives

$$C^d = \frac{B}{P(1+\beta)} = \frac{M + WN + \Pi}{P(1+\beta)} = \frac{\frac{M}{P} + Y}{1+\beta}, \tag{6}$$

[3] As time is discrete, expressions like $M + WN + \Pi$ are legitimate. Although it is meaningless to add a stock and a flow (since they have different denominations), the sum $M + WN + \Pi$ should be interpreted as $M + (WN + \Pi)\Delta t$, where Δt is the period length. With the latter being the time unit, we have Δt = 1.

In our simple model output demand is the same as the consumption demand C^d. So *clearing* in the output market, in the sense of equality between demand and actual output, requires $C^d = Y$. So, *if* this clearing condition holds, substituting into (6) gives the relationship

$$Y = \frac{M}{\beta P}. \tag{7}$$

This is only a *relationship* between Y and P, not a solution for any of them since both are endogenous variables so far. Moreover, the relationship is *conditional on clearing* in the output market.

We have assumed that agents take prices as given when making their demand and supply decisions. But we have said nothing about whether nominal prices are flexible or rigid as seen from the perspective of the system as a whole.

2.2 The case of fully flexible W and P

What Keynes called "classical economics" is nowadays also often called "Walrasian macro-economics" (sometime just "pre-Keynesian macroeconomics"). In this theoretical tradition both wages and prices are assumed fully flexible and all markets perfectly competitive.

Firms' ex ante output supply conditional on a hypothetical wage-price pair (W, P) and the corresponding labor demand will be denoted Y^s and N^d, respectively. As we know from microeconomics, the pair (Y^s, N^d) need not be unique, it can easily be a "set-valued function" of (W, P). Moreover, with constant returns to scale in the production function, the range of this function may for certain pairs (W, P) include (∞, ∞).

The distinguishing feature of the Walrasian approach is that wages and prices are assumed fully flexible. Both W and P are thought to adjust immediately so as to clear the labor market and the output market like in a centralized auction market. Clearing in the labor market requires that W and P are adjusted so that actual employment, N, equals labor supply, N^s, which is here inelastic at the given level $\bar{N}$. So

$$N = N^s = \bar{N} = N^d, \tag{8}$$

where the last equality indicates that this employment level is willingly demanded by the firms.

We have assumed a constant-returns-to-scale production function (1). Hence, the clearing condition (8) requires that firms have zero profit. In turn, by (1) and (2), zero profit requires that the real wage equals labor productivity:

$$\frac{W}{P} = A. \tag{9}$$

With clearing in the labor market, output must equal full-employment output,

$$Y = A\bar{N} \equiv Y^f = Y^s, \tag{10}$$

where the superscript "f" stands for "full employment", and where the last equality indicates that this level of output is willingly supplied by the firms. For this level of output to match the demand, C^d, coming from the households, the price level must be

$$P = \frac{M}{\beta Y^f} \equiv P^c, \tag{11}$$

in view of (7) with $Y = Y^f$. This price level is the *classical equilibrium price*, hence the superscript "c". Substituting into (9) gives the *classical equilibrium wage*

$$W = AP^c \equiv W^c. \tag{12}$$

For general equilibrium we also need that the desired money holding at the end of the period equals the available money stock. By *Walras' law* this equality follows automatically from the household's *Walrasian* budget constraint and clearing in the output and labor markets. To see this, note that the *Walrasian* budget constraint is a *special case* of the budget constraint (4), namely the case

$$PC^d + \hat{M} = M + WN^s + \Pi^c, \tag{13}$$

where Π^c is the notional profit associated with the hypothetical production plan (Y^s, N^d), i.e.,

$$\Pi^c \equiv PY^s - WN^d. \tag{14}$$

The Walrasian budget constraint thus *imposes* replacement of the term for *actual* employment, N, with the households' desired labor supply, $N^s (= \bar{N})$. It also *imposes* replacement of the term for *actual* profit, Π, with the hypothetical profit Π^c ("c" for "classical") calculated on the basis of the firms' aggregate production plan (Y^s, N^d).

Now, let the Walrasian auctioneer announce an arbitrary price vector $(W, P, 1)$, with $W > 0$, $P > 0$, and 1 being the price of the numeraire, money. Then the values of excess demands add up to

$$\begin{aligned}
& W(N^d - N^s) + P(C^d - Y^s) + \hat{M} - M \\
= \; & WN^d - PY^s + PC^d + \hat{M} - M - WN^s \quad \text{(by rearranging)} \\
= \; & WN^d - PY^s + \Pi^c \quad \text{(by (13))} \\
= \; & WN^d - PY^s + \Pi^c \equiv 0. \qquad \text{(from definition of } \Pi^c \text{ in (14))}
\end{aligned}$$

This exemplifies *Walras' law,* saying that with Walrasian budget constraints the aggregate value of excess demands is *identically* zero. Walras' law reflects that when households satisfy their Walrasian budget constraint, then as an arithmetic necessity the economy as a whole has to satisfy an aggregate budget constraint for the period in question. It follows that the equilibrium condition $\hat{M} = M$ is ensured as soon as there is clearing in the output and labor markets. And more generally: if there are n markets and $n - 1$ of these clear, so does the n'th market.

Consequently, when $(W, P) = (W^c, P^c)$, all markets clear in this flexwage-flexprice economy with perfect competition and a representative household with the "endowment"-pair $(M, \bar{N})$. Such a state of affairs is known as a *classical* or *Walrasian equilibrium.*[4] A key feature is expressed by (8) and (10): output and employment are *supply-determined*, i.e., determined by the supply of production factors, here labor.

The intuitive mechanism behind this equilibrium is the following adjustment process. Imagine that in an ultra-short sub-period $W/P - A \neq 0$. In case $W/P - A > 0$ (< 0), there will be excess supply (demand) in the labor market. This drives W down (up). Only when $W/P = A$ and full employment obtains, can the system be at rest. Next imagine that $P - P^c \neq 0$. In case $P - P^c > 0$ (< 0), there is excess supply (demand) in the output market. This drives P down (up). Again, only when $P = P^c$ *and* $W/P = A$ (whereby $W = W^c$), so that the output market clears under full employment, will the system be at rest.

This adjustment process is fictional, however, because outside equilibrium the Walrasian supplies and demands, which supposedly drive the adjustment, are artificial constructs. Being functions only of initial resources and price signals, the Walrasian supplies and demands are mutually inconsistent outside equilibrium and can therefore not tell what quantities will be traded during an adjustment process. The story needs a considerable refinement unless one is willing to let the mythical "Walrasian auctioneer" enter the scene and bring about adjustment toward the equilibrium prices without allowing trade until these prices are found.

Anyway, assuming that Walrasian equilibrium has been attained, by comparative statics based on (11) and (12) we see that in the classical regime: (a) P and W are proportional to M; and (b) output is at the unchanged full-employment level whatever the level of M. This is the *neutrality of money* result of classical macroeconomics.

[4] To underline its one-period nature, it may be called a Walrasian *short-run* or a Walrasian *temporary equilibrium.*

The neutrality result also holds in a quasi-dynamic context where we consider an actual change in the money stock occurring in historical time. Suppose the government/central bank at the beginning of the period brings about lump-sum transfers to the households in the total amount $\Delta M > 0$. As there is no taxation, this implies a budget deficit which is thus fully financed by money issue.[5] So (134) is replaced by

$$PC^d + \hat{M} = M + \Delta M + W\bar{N} + \Pi^c. \tag{15}$$

If we replace M in the previous formulas by $M' \equiv M + \Delta M$, we see that money neutrality still holds. As *saving* is income minus consumption, there is now positive nominal private saving of size $S^p = \Delta M + W\bar{N} + \Pi^c - PC^d = M' - M = \Delta M$. On the other hand the government dissaves, in that its saving is $S^g = -\Delta M$, where ΔM is the government budget deficit. So national saving is and remains $S \equiv S^p + S^g = 0$ (it *must* be nil as there are no durable produced goods).

2.3 The case of W and P fixed in the short run

In standard Keynesian macroeconomics nominal wages are considered predetermined in the short run, fixed in advance by wage bargaining between workers (or workers' unions) and employers (or employers' unions). Those who end up unemployed in the period do not try to – or are not able to – undercut those employed, at least not in the current period.

Likewise, nominal prices are set in advance by firms facing downward-sloping demand curves. It is understood that there is a large spectrum of differentiated products, and Y and C are composites of these. This heterogeneity ought of course be visible in the model – and it will become so in Section 19.3. But at this point the model takes an easy way out and ignores the involved aggregation issue.

Let W in the current period be given at the level $\bar{W}$. Because firms have market power, the profit-maximizing price involves a mark-up on marginal cost, $\bar{W}N/Y = \bar{W}/A$ (which is also the average cost). We assume that the price setting occurs under circumstances where the chosen mark-up becomes a *constant* $\mu > 0$, so that

$$P = (1 + \mu)\frac{\bar{W}}{A} \equiv \bar{P}. \tag{16}$$

[5] Within the model this is in fact the only way to increase the money stock. As money is the only asset in the economy, a change in the money stock can not be brought about through open market operations where the central bank buys or sells another financial asset.

While $\bar{W}$ is considered exogenous (not determined within the model), $\bar{P}$ is endogenously determined by the given $\bar{W}$, A, and μ. There are barriers to entry in the short run.

Because of the fixed wage and price, the distinction between *ex ante* (also called *planned* or *intended*) demands and supplies and the *ex post* carried out purchases and sales are now even more important than before. This is because the different markets may now also *ex post* feature excess demand or excess supply (to be defined more precisely below). According to the principle that no agent can be forced to trade more than desired, the actual amount traded in a market must equal the minimum of demand and supply. So in the output market and the labor market the actual quantities traded will be

$$Y = \min(Y^d, Y^s) \quad \text{and} \tag{17}$$

$$N = \min(N^d, N^s), \tag{18}$$

respectively, where the superscripts "*d*" and "*s*" are now used for demand and supply in a *new* meaning to be defined below. This principle, that the short side of the market determines the traded quantity, is known as the *short-side rule.* The other side of the market is said to be *quantity rationed* or just *rationed* if there is discrepancy between Y^d and Y^s. In view of the produced good being non-storable, intended inventory investment is ruled out. Hence, the firms try to avoid producing more than can be sold. In (17) we have thus identified the traded quantity with the produced quantity, Y.

But what exactly do we mean by "demand" and "supply" in this context where market clearing is not guaranteed? We mean what is appropriately called the *effective demand* and the *effective supply* ("effective" in the meaning of "operative" in the market, though possibly frustrated in view of the short-side rule). To make these concepts clear, we need first to define an agent's *effective* budget constraint:

DEFINITION 1 An agent's (typically a household's) *effective budget constraint* is the budget constraint conditional on the perceived price and quantity signals from the markets.

It is the last part, "and quantity signals from the markets", which is not included in the concept of a Walrasian budget constraint. The perceived quantity signals are in the present context the *actual* employment constraint faced by the household and the profit expected to be received from the firms and determined by their *actual* production.[6] So the household's effective budget constraint is given by (4). In contrast, the Walrasian

[6] We assume the perceived quantity signals are deterministic.

budget constraint is not conditional on quantity signals from the markets but only on the "endowment" $(M, \bar{N})$ and the perceived price signals and profit.

DEFINITION 2 An agent's *effective demand* in a given market is the amount the agent *bids for* in the market, conditional on the perceived price and quantity signals that constrains its bidding. By "bids for" is meant that the agent is both *able* to buy that amount and *wishes* to buy that amount, given the effective budget constraint. Summing over all potential buyers, we get the *aggregate effective demand* in the market.

DEFINITION 3 An agent's *effective supply* in a given market is the amount the agent *offers for sale* in the market, conditional on perceived price and quantity signals that constrains its offering. By "offers for sale" is meant that the agent is both *able* to bring that amount to the market and *wishes* to sell that amount, given the set of opportunities available. Summing over all potential sellers, we get the *aggregate effective supply* in the market.

When $P = \bar{P}$, the aggregate effective output demand, Y^d, is the same as households' consumption demand given by (6) with $P = \bar{P}$, i.e.,

$$Y^d = C^d = \frac{\frac{M}{P} + Y}{1 + \beta}. \tag{19}$$

In view of the inelastic labor supply, households' aggregate effective labor supply is simply

$$N^s = \bar{N}.$$

Firms' aggregate effective output supply is

$$Y^s = Y^f \equiv A\bar{N}. \tag{20}$$

Indeed, in the aggregate the firms are *not able* to bring more to the market than full-employment output , Y^f. And every individual firm is not able to bring to the market than what can be produced by "its share" of the labor force. On the other hand, because of the constant marginal costs, every unit sold at the preset price adds to profit. The firms are therefore happy to satisfy any output demand forthcoming – which is in practice testified by a lot of sales promotion.

Firms' aggregate effective demand for labor is constrained by the perceived output demand, Y^d, because the firm would loose by employing more labor. Thus,

$$N^d = \frac{Y^d}{A}. \tag{21}$$

By the short-side rule (17), combined with (20), follows that actual aggregate output (equal to the quantity traded) is

$$Y = \min(Y^d, Y^f) \leqq Y^f.$$

So the following three mutually exclusive cases exhaust the possibilities regarding aggregate output:

$$\begin{aligned} Y &= Y^d < Y^f \quad \text{(the Keynesian regime)}, \\ Y &= Y^f < Y^d \quad \text{(the repressed inflation regime)}, \\ Y &= Y^d = Y^f \quad \text{(the border case)}. \end{aligned}$$

2.3.1 The Keynesian regime: $Y = Y^d < Y^f$.

In this regime we can substitute $Y = Y^d$ into (19) and solve for Y:

$$Y = Y^d = \frac{M}{\beta \bar{P}} \equiv Y^k < Y^f \equiv \frac{M}{\beta P^c} = Y^s. \tag{22}$$

where we have denoted the resulting output Y^k (the superscript "k" for "Keynesian"). The inequality in (22) is required by the definition of the Keynesian regime, and the identity comes from (11). Necessary and sufficient for the inequality is that $\bar{P} > P^c \equiv W^c/A$. In view of (16), the economy is thus in the Keynesian regime if and only if

$$\bar{W} > W^c/(1+\mu). \tag{23}$$

Since $Y < Y^s$ in this regime, we may say there is "excess supply" in the output market or, with a perhaps better term, there is a "buyers' market" situation (sale less than desired). The reservation regarding the term "excess supply" is due to the fact that we should not forget that $Y - Y^s < 0$ is a completely voluntary state of affairs on the part of the price-setting firms.

From (1) and the short-side rule now follows that actual employment will be

$$N = N^d = \frac{Y}{A} = \frac{M}{A\beta\bar{P}} < \bar{N} = N^s. \tag{24}$$

Also the labor market is thus characterized by "excess supply" or a "buyers' market" situation. Profits are $\Pi = \bar{P}Y - \bar{W}N = (1 - \bar{W}/(\bar{P}A))\bar{P}Y = (1-(1+\mu)^{-1})\beta^{-1}M > 0$, where we have used, first, $Y = AN$, then the price setting rule (16), and finally (22).

This solution for (Y, N) is known as a *Keynesian equilibrium* for the current period. It is named an *equilibrium* because the system is "at rest" in the following sense: (a) agents do the best they can given the constraints (which include the preset prices and the quantities offered by the other side of the market); and (b) the chosen actions are *mutually compatible* (purchases and sales match). The term equilibrium is here not used in the Walrasian sense of market clearing through instantaneous price adjustment but in the sense of a *Nash equilibrium* conditional on perceived price and quantity signals. To underline its temporary character, the equilibrium may be called a Keynesian *short-run* (or *temporary*) equilibrium. The flavor of the equilibrium is *Keynesian* in the sense that there is unemployment and at the same time it is aggregate demand in the output market, not the real wage, which is the binding constraint on the employment level. A higher propensity to consume (lower discount factor β) results in higher aggregate demand, Y^d, and thereby a higher equilibrium output, Y^k. In contrast, a lower real wage due to either a higher mark-up, μ, or a lower marginal (= average) labor productivity, A, does *not* result in a higher Y^k. On the contrary, Y^k becomes *lower*, and the causal chain behind this goes via a higher $\bar{P}$, cf. (16) and (22). In fact, the given real wage, $\bar{W}/\bar{P} = A/(1+\mu)$, is consistent with unemployment as well as full employment, see below. It is the sticky nominal price at an excessive level, caused by a sticky nominal wage at an "excessive" level, that makes unemployment prevail through a too low aggregate demand, Y^d. A lower nominal wage would imply a lower $\bar{P}$ and thereby, for a given M, stimulate Y^d and thus raise Y^k.

In brief, the Keynesian regime leads to an equilibrium where output as well as employment are *demand-determined.*

The "Keynesian cross" and effective demand The situation is illustrated by the "Keynesian cross" in the (Y, Y^d) plane shown in Fig. 19.1, where $Y^d = C^d = (1+\beta)^{-1}(Y + M/\bar{P})$. We see the vicious circle: Output is below the full-employment level because of low consumption demand; and consumption demand is low because of the low employment. The economy is in a *unemployment trap.* Even though at Y^k we have $\Pi > 0$ and there are constant returns to scale, the individual firm has no incentive to increase production because the firm already produces as much as it rightly perceives it can sell at its preferred price. We also see that here money is *not neutral.* For a given $W = \bar{W}$, and thereby a given $P = \bar{P}$, a higher M results in higher output and higher employment.

Although the microeconomic background we have alluded to is a specific "market power story" (one with differentiated goods and downward sloping demand curves), the Keynesian cross in Fig. 19.1 may turn up also for other microeconomic settings. The key point is the fixed $\bar{P} > P^c$ and fixed $\bar{W} < A\bar{P}$.

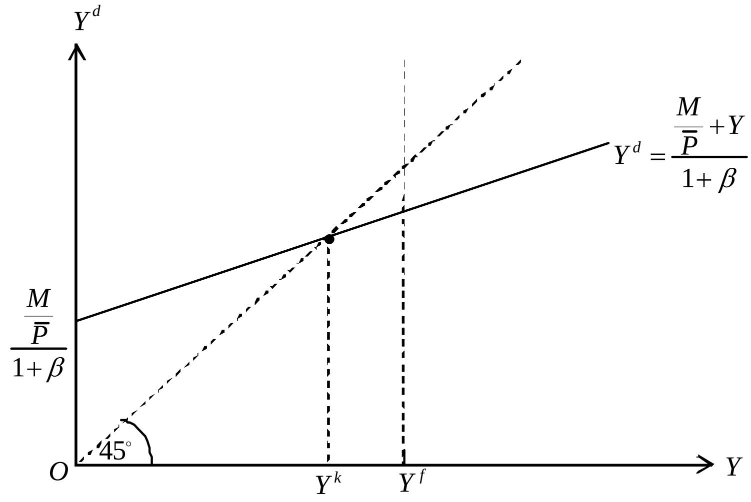

Figure 1: The Keynesian regime ($\bar{W} > W^c/(1+\mu)$; M and Y^f given, $\bar{P}$ fixed).

The fundamental difference between the Walrasian and the present framework is that the latter allows trade outside Walrasian equilibrium. In that situation the households' consumption demand depends *not* on how much labor the households would *prefer* to sell at the going wage, but on how much they are *able* to sell, that is, on a *quantity signal* received from the labor market. Indeed, it is the *actual* employment, N, that enters the operative budget constraint, (4), not the desired employment as in classical or Walrasian theory.

2.3.2 The repressed-inflation regime: $Y = Y^f < Y^d$.

This regime represents the "opposite" case of the Keynesian regime and arises if and only if the opposite of (23) holds, namely

$$\bar{W} < W^c/(1+\mu).$$

In view of (16), this inequality is equivalent to $\bar{P} < W^c/A \equiv P^c$. Hence $M/(\beta\bar{P}) > M/(\beta P^c) = Y^f = A\bar{N}$. In spite of the high output demand, the shortage of labor hinders the firms to produce more than Y^f. With $Y = Y^f$, output demand, which in this model is always the same as consumption demand, C^d, is, from (6),

$$Y^d = \frac{\frac{M}{\bar{P}} + Y^f}{1+\beta} > Y = Y^s = Y^f. \tag{25}$$

As before, effective output supply, Y^s, equals full-employment output, Y^f.

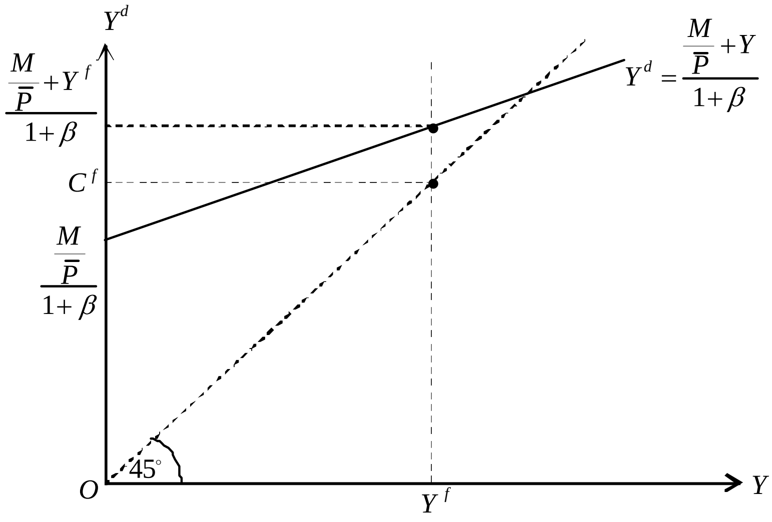

Figure 2: The repressed inflation regime ($\bar{W} < W^c/(1+\mu)$; M and Y^f given, $\bar{P}$ fixed).

The new element here in that firms perceive a demand level in excess of Y^f. As the real-wage level does not deter profitable production, firms would thus prefer to employ people up to the point where output demand is satisfied. But in view of the short side rule for the labor market, actual employment will be

$$N = N^s = \bar{N} < N^d = \frac{Y^d}{A}.$$

So there is excess demand in both the output market and the labor market. Presumably, these excess demands generate pressure for wage and price increases. By assumption, these potential wage and price increases do not materialize until possibly the next period. So we have a *repressed-inflation equilibrium* $(Y, N) = (Y^f, \bar{N})$, although possibly short-lived.

Fig. 19.2 illustrates the repressed-inflation regime. In the language of the microeconomic theory of quantity rationing, consumers are quantity rationed in the goods market, as realized consumption $= Y = Y^f < Y^d =$ consumption demand. Firms are quantity rationed in the labor market, as $N < N^d$. This is the background for the parlance that in the repressed inflation regime, output and employment are not demand-determined but *supply-determined*. Both the output market and the labor market are *sellers' markets* (purchase less than desired). Presumably, the repressed inflation regime will not last long unless there are wage and price controls imposed by the government, as for instance may be the case for an economy in a war situation.[7]

[7] As another example of repressed inflation (simultaneous excess demand for consumption goods and

2.3.3 The border case between the two regimes: $Y = Y^d = Y^f$.

This case arises if and only if $\bar{W} = W^c/(1+\mu)$, which is in turn equivalent to $\bar{P} = (1+\mu)\bar{W}/A = W^c/A \equiv P^c \equiv M/(\beta Y^f)$. No market has quantity rationing and we may speak of both the output market and the labor market as *balanced markets*.

There are two differences compared with the classical equilibrium, however. The first is that due to market power, there is a wedge between the real wage and the marginal productivity of labor. In the present context, though, where labor supply is inelastic, this does not imply inefficiency but only a higher profit/wage-income ratio than under perfect competition (where the profit/wage-income ratio is zero). The second difference compared with the classical equilibrium is that due to price stickiness, the impact of shifts in exogenous variables will be different. For instance a lower M will here result in unemployment, while in the classical model it will just lower P and W and not affect employment.

2.3.4 In terms of effective demands and supplies Walras' law does not hold

As we saw above, with *Walrasian* budget constraints, the aggregate value of excess demands in the given period is zero for any given price vector, $(W, P, 1)$, with $W > 0$ and $P > 0$. In contrast, with *effective* budget constraints, effective demands and supplies, and the short-side rule, this is no longer so. To see this, consider a pair (W, P) where $W < PA$ and $P \neq P^c \equiv M/(\beta Y^f)$. Such a pair leads to either the Keynesian regime or the repressed-inflation regime. The pair *may*, but need not, equal one of the pairs $(\bar{W}, \bar{P})$ considered above in Fig. 19.1 or 19.2 (we say "need not", because the particular μ-markup relationship between W and P is not needed). We have, *first*, that in both the Keynesian and the repressed-inflation regime, effective output supply equals full-employment output,

$$Y^s = Y^f. \tag{26}$$

The intuition is that in view of $W < PA$, the representative firm *wishes* to satisfy any output demand forthcoming but it is only able to do so up to the point of where the availability of workers becomes a binding constraint.

Second, the aggregate value of excess effective demands is, for the considered price

labor) we may refer to Eastern Europe before the dissolution of the Soviet Union in 1991. In response to severe and long-lasting rationing in the consumption goods markets, households tended to decrease their labor supply (Kornai, 1979). This example illustrates that if labor supply is elastic, the *effective* labor supply may be less than the Walrasian labor supply due to spillovers from the output market.

vector $(W, P, 1)$, equal to

$$\begin{aligned}
& W(N^d - N^s) + P(C^d - Y^s) + \hat{M} - M \\
= \; & W(N^d - \bar{N}) + PC^d + \hat{M} - M - PY^f \\
= \; & W(N^d - \bar{N}) + WN + \Pi - PY^f \quad \text{(by (4))} \\
= \; & W(N^d - \bar{N}) + PY - PY^f \quad \text{(by (2))} \\
= \; & W(N^d - \bar{N}) + P(Y - Y^f) \begin{cases} < 0 \text{ if } P > M/(\beta Y^f), \text{ and} \\ > 0 \text{ if } P < M/(\beta Y^f) \text{ and } W < PA. \end{cases}
\end{aligned} \tag{27}$$

The aggregate value of excess effective demands is thus not identically zero. As expected, it is negative in a Keynesian equilibrium and positive in a repressed-inflation equilibrium.[8] The reason that Walras' law does not apply to effective demands and supplies is that outside Walrasian equilibrium some of these demands and supplies are not realized in the final transactions.

This takes us to Keynes' refutation of Say's law and thereby what Keynes and others have regarded as the core of his theory.

2.3.5 Say's law and its refutation

The classical principle "supply creates its own demand" (or "income is automatically spent on products") is named Say's law after the French economist and business man Jean-Baptiste Say (1767-1832). In line with other classical economists like David Ricardo and John Stuart Mill, Say maintained that although mismatch between demand and production can occur, it can only occur in the form of excess production in some industries at the same time as there is excess demand in other industries.[9] General overproduction is impossible. Or, by a classical catchphrase:

> Every offer to sell a good implies a demand for some other good.

By "good" is here meant a produced good rather than just any traded article, including for instance money. Otherwise Say's law would be a platitude (a simple implication of the definition of trade). So, interpreting "good" to mean a produced good, let us evaluate

[8] At the same time, (27) together with the general equations $N^d = \bar{N}$ and $Y^s = Y^f$, shows that we have $\hat{M} = M$ in a Keynesian equilibrium (where $Y = C^d$) and $\hat{M} < M$ in a repressed-inflation equilibrium (where $Y = Y^f$).

[9] There were two dissidents at this point, Thomas Malthus and Karl Marx, two classical economists that were otherwise not much aggreeing.

Say's law from the point of view of the result (27). We first subtract $W(N^d - N^s) = W(N^d - \bar{N})$ on both sides of (27), then insert (26) and rearrange to get

$$P(C^d - Y) + \hat{M} - M = 0, \tag{28}$$

for any $P > 0$. Consider the case $W < AP$. In this situation every unit produced and sold is profitable. So any Y in the interval $0 < Y \leq Y^f$ is profitable from the supply side angle. Assume further that $P = \bar{P} > P^c \equiv M/(\beta Y^f)$. This is the case shown in Fig. 19.1. The figure illustrates that aggregate demand *is* rising with aggregate production. So far so well for Say's law. We also see that if aggregate production is in the interval $0 < Y < Y^k$, then C^d $(= Y^d) > Y$. This amounts to excess demand for goods and in effect, by (28), excess supply of money. Still, Say's law is not contradicted. But if instead aggregate production is in the interval $Y^k < Y \leq Y^f$, then C^d $(= Y^d) < Y$; now there is *general overproduction.* Supply no longer creates its own demand. There is a general shortfall of demand. By (28), the other side of the coin is that when $C^d < Y$, then $\hat{M} > M$, which means excess demand for money. People try to hoard money rather than spend on goods. Both the Great Depression in the 1930s and the Great Recession 2008- can be seen in this light.[10]

The refutation of Say's law does not depend on the market power and constant markup aspects we have adhered to above. All that is needed for the argument is that the agents are price takers within the period. In addition, the refutation does not hinge on *money* being the asset available for transferring purchasing power from one period to the next. We may imagine an economy where M represents *land* available in limited supply. As land is also a non-produced store of value, the above analysis goes through − with one exception, though. The exception is that ΔM in (15) can no longer be interpreted as a policy choice. Instead, a positive ΔM could be due to discovery of new land.

We conclude that general overproduction is possible and Say's law thereby refuted. It might be objected that our "aggregate reply" to Say's law is not to the point since Say had a disaggregate structure with many industries in mind. Considering an explicit disaggregate production sector makes no essential difference, however, as a simple example will now show.

[10] Paul Krugman stated it this way:

> "When everyone is trying to accumulate cash at the same time, which is what happened worldwide after the collapse of Lehman Brothers, the result is an end to demand [for output], which produces a severe recession" (Krugman, 2009).

Many industries Suppose there is still one labor market, but m industries with production function $y_i = An_i$, where y_i and n_i are output and employment in industry i, respectively, $i = 1, 2, \ldots, m$. Let the preferences of the representative household be given by

$$U = \sum_i \gamma_i \ln c_i + \beta \ln \frac{\hat{M}}{P^e}, \qquad \gamma_i > 0, i = 1, 2, \ldots, m, \quad 0 < \beta < 1.$$

In analogy with (4), the budget constraint is

$$\sum_i P_i c_i + \hat{M} = B \equiv M + W \sum_i n_i + \sum_i \Pi_i = M + \sum_i P_i y_i,$$

where the last equality comes from

$$\Pi_i = P_i y_i - W n_i.$$

Utility maximization gives $P_i c_i = \gamma_i B/(1 + \beta)$.

As a special case, consider $\gamma_i = 1/m$ and $P_i = P$, $i = 1, 2, \ldots, m$. Then

$$c_i = \frac{B/m}{(1 + \beta)P}, \tag{29}$$

and

$$B = M + P \sum_i y_i \equiv M + PY.$$

Substituting into (29), we thus find demand for consumption good i as

$$c_i = \frac{\frac{M/m}{P} + Y/m}{1 + \beta} \equiv y^d, \quad \text{for all } i.$$

Let $P > \min\left[W/A, M/(\beta Y^f)\right]$, where $Y^f \equiv A\bar{N}$. It follows that every unit produced and sold is profitable and that

$$my^d = \frac{\frac{M}{P} + Y}{1 + \beta} \leq \frac{\frac{M}{P} + Y^f}{1 + \beta} < Y^f,$$

where the weak inequality comes from $Y \leq Y^f$ (always) and the strict inequality from $P > M/(\beta Y^f)$.

Now, suppose good 1 is brought to the market in the amount y_1, where $y^d < y_1 < Y^f/m$. Industry 1 thus experiences a shortfall of demand. Will there in turn necessarily be another industry experiencing excess demand? No. To see this, consider the case $y^d < y_i < Y^f/m$ for all i. All these supplies are profitable from a supply side point of view, and enough labor is available. Indeed, by construction the resource allocation is such that

$$my^d < \sum y_i \equiv Y \leq m\bar{y} < Y^f, \tag{30}$$

where $\bar{y} = \max[y_1, \ldots, y_m] < Y^f/m$. This is a situation where people try to save (hoard money) rather than spend all income on produced goods. It is an example of *general overproduction,* thus falsifying Say's law.

In the special case where all $y_i = Y/m$, the situation for each single industry can be illustrated by a diagram as that in Fig. **??**. Just replace Y^d, Y, Y^k, Y^f, and M in Fig. **??** by y^d, Y/m, $Y^k/m \equiv M/(m\beta P)$, Y^f/m, and M/m, respectively.

Could the evaluation of Say's law be more favorable if we allow for the existence of interest-bearing assets? The answer is no, as we shall see in Chapter **??**.

2.4 Short-run adjustment dynamics

We now return to the aggregate setup. Apart from the border case of balanced markets, we have considered two kinds of "fix-price equilibria", *repressed inflation* and *Keynesian equilibrium.* Most macroeconomists consider nominal wages and prices to be less sticky upwards than downwards. So a repressed inflation regime is typically regarded as having little durability (unless there are wage and price controls imposed by a government). It is otherwise with the Keynesian equilibrium. A way of thinking about this is the following.

Suppose that up to the current period full-employment equilibrium has applied: $Y = Y^d = M/(\beta\bar{P}) = Y^f$ and $\bar{P} = (1+\mu)\bar{W}/A = W^c/A \equiv P^c \equiv M/(\beta Y^f)$. Then, for some external reason, at the start of the current period a *rise* in the patience parameter occurs, from β to β', so that the new propensity to save is $\beta'/(1+\beta') > \beta/(1+\beta)$. We may interpret this as "precautionary saving" in response to a sudden fall in the general "state of confidence".

Let our "period" be divided into n sub-periods, indexed $i = 0, 1, 2, \ldots, n-1$, of length $1/n$, where n is "large". At least within the first of these sub-periods, the preset $\bar{W}$ and $\bar{P}$ are maintained and firms produce without having yet realized that aggregate demand will be lower than in the previous period. After a while firms realize that sales do not keep track with production.

There are basically two kinds of reaction to this situation. One is that wages and prices are maintained throughout all the sub-periods, while production is scaled down to the Keynesian equilibrium $Y^k = M/(\beta'\bar{P})$. Another is that wages and prices adjust downward so as to soon reestablish full-employment equilibrium. Let us take each case at a time.

Wage and price stay fixed: Sheer quantity adjustment For simplicity we have assumed that the produced goods are perishable. So unsold goods represent a complete loss. If firms fully understand the functioning of the economy and have model-consistent expectations, they will adjust production per time unit down to the level Y^k as fast as possible. Suppose instead that firms have naive adaptive expectations of the form

$$C_{i-1,i}^e = C_{i-1}, \qquad i = 0, 1, 2, ..., n.$$

This means that the "subjective" expectation, formed in sub-period $i-1$, of demand next sub-period is that it will equal the demand in sub-period $i-1$. Let the time-lag between the decision to produce and the observation of the demand correspond to the length of the subperiods. It is profitable to satisfy demand, hence actual output in sub-period i will be

$$Y_i = C_{i-1,i}^e = C_{i-1}^d = \frac{M/\bar{P}}{1+\beta'} + \frac{Y_{i-1}}{1+\beta'},$$

in analogy with (19). This is a linear first-order difference equation in Y_i, with constant coefficients. The solution is (see Math Tools)

$$Y_i = (Y_0 - Y^{*\prime}) \left(\frac{1}{1+\beta'} \right)^i + Y^{*\prime}, \qquad Y^{*\prime} = \frac{M}{\beta' \bar{P}} = Y^k < Y^f. \tag{31}$$

Suppose $\beta' = 0.9$, say. Then actual production, Y_i, converges fast towards the steady-state value Y^k. When $Y = Y^k$, the system is at rest. Fig. 19.x illustrates. Although there is excess supply in the labor market and therefore some downward pressure on wages, the Keynesian presumption is that the workers's side in the labor market generally withstand the pressure.[11]

Fig. 19.x about here.

The process (31) also applies "in the opposite direction". Suppose, starting from the Keynesian equilibrium $Y = M/(\beta'\bar{P})$, a *reduction* in the patience parameter β' occurs, such that $M/(\beta'\bar{P})$ increases, but still satisfies $M/(\beta'\bar{P}) < Y^f$. Then the initial condition in (31) is $Y_0 < Y^{*\prime}$, and the greater propensity to consume leads to an upward quantity adjustment.

[11] Possible explanations of downward wage stickiness are discussed in Chapter **??**.

Downward wage and price adjustment Several of Keynes' contemporaries, among them A. C. Pigou, maintained that the Keynesian state of affairs with $Y = Y^k < Y^f$ could only be very temporary. Pigou's argument was that a fall in the price level would take place and lead to higher purchasing power of M. The implied stimulation of aggregate demand would bring the economy back to full employment. This hypothetically equilibrating mechanism is known as the "real balance effect" or the "Pigou effect" (after Pigou, 1943).

Does the argument go through? To answer this, we imagine that the time interval between different rounds of wage and price setting is as short as our sub-periods. We imagine the time interval between households' decision making to be equally short. Given the fixed markup μ, an initial fall in the preset $\bar{W}$ is needed to trigger a fall in the preset $\bar{P}$. The new *classical* equilibrium price and wage levels will be

$$P^{c\prime} = \frac{M}{\beta' Y^f} \text{ and } W^{c\prime} = AP^{c\prime}.$$

Both will thus be lower than the original ones – by the same factor as the patience parameter has risen, i.e., the factor β'/β. In line with "classical" thinking, assume that soon after the rise in the propensity to save, the incipient unemployment prompts wage setters to reduce $\bar{W}$ and thereby price setters to reduce $\bar{P}$. Let both $\bar{W}$ and $\bar{P}$ after a few rounds be reduced by the factor β'/β. Denoting the resulting wage and price $\bar{W}'$ and $\bar{P}'$, respectively, we then have

$$\bar{W}' = \frac{W^{c\prime}}{1+\mu}, \quad \bar{P}' = (1+\mu)\frac{\bar{W}'}{A} = \frac{W^{c\prime}}{A} \equiv P^{c\prime} \equiv \frac{M}{\beta' Y^f}.$$

Seemingly, this restores aggregate demand at the full-employment level $Y^d = M/(\beta'\bar{P}')$ $= Y^f$.

While this "classical" adjustment is conceivable in the abstract, Keynesians question its practical relevance for several reasons:

1. Empirically, it seems to be particularly in the downward direction that nominal wages are sticky. And without an initial fall in the nominal wage, the downward wage-price spiral does not get started.

2. A downward wage-price spiral, i.e., deflation, increases the implicit real interest rate, $(P_t - P_{t+1})/P_{t+1}$, thus tending to dampen aggregate demand rather than the opposite.

3. If we go outside our simple model, there are additional objections:

(a) the monetary base is in reality only a small fraction of financial wealth, and so the real balance effect can not be powerful unless the fall in the price level is drastic;

(b) many firms and households have nominal debt, the real value of which would rise dramatically, thereby leading to bankruptcies and a worsening of the confidence crisis, thus counteracting a return to full employment.

One should be aware that there are two distinct kinds of "price flexibility". It can be "imperfect" or "perfect" (also called "full"). The first kind relates to a *gradual* price process, for instance generated by a wage-price spiral as at item 2 above. The latter kind relates to *instantaneous* and complete price adjustment as with a Walrasian auctioneer, cf. Section 2. It is the first kind that may be destabilizing rather than the opposite.

2.5 Digging deeper

As it stands the above theoretical framework has many limitations:

(a) The wage and price setting should be explicitly modelled and in this connection there should be an explanation of the wage and price stickiness.

(b) It should be made clear how to come from the existence of many differentiated goods and markets with imperfect competition to aggregate output and income which in turn constitute the environment conditioning individual agents' actions.

(c) To incorporate better the role of asset markets, including the primary role of money as a medium of exchange rather than a store of value, at least one alternative asset should enter, an interest-bearing asset.

(d) The model should be truly dynamic with forward-looking endogenous expectations and gradual wage and price changes depending on the market conditions, in particular the employment situation.

We now comment briefly on these points.

3 Price adjustment costs

The classical theory of perfectly flexible wages and prices and neutrality of money seems contradicted by overwhelming empirical evidence. At the theoretical level the theory ignores that the dominant market form is not perfect competition. Wages and prices are usually set by agents with market power. And there may be costs associated with changing prices and wages. Here we consider such costs.

The literature has modelled price adjustment costs in two different ways. *Menu costs* refer to the case where there are *fixed costs* of changing price. Another case considered in the literature is the case of *strictly convex adjustment costs*, where the marginal price adjustment cost is increasing in the size of the price change.

The most obvious examples of *menu costs* are of course costs associated with

1. remarking commodities with new price labels,
2. reprinting price lists ("menu cards") and catalogues.

But the term menu costs should be interpreted in a broader sense, including pecuniary as well non-pecuniary costs of:

3. information-gathering,
4. recomputing optimal prices,
5. conveying the new directives to the sales force,
6. the risk of offending customers by frequent and/or large price changes,
7. search for new customers willing to pay a higher price,
8. renegotiating contracts.

Menu costs induce firms to change prices less often than if no such costs were present. And some of the points mentioned in the list above, in particular point 7 and 8, may be relevant also in the different labor markets.

The menu cost theory is one of the microfoundations provided by modern Keynesian economics for the presumption that nominal prices and wages are sticky in the short run. The main theoretical insight of the menu cost theory is the following. There are menu costs associated with changing prices. Even *small* menu costs can be enough to prevent firms from changing their price. This is because the opportunity cost of not changing price is only of second order, i.e., "small"; this is a reflection of the *envelope theorem* (see

Appendix). But owing to imperfect competition (price > MC), the effect on aggregate output, employment, and welfare of not changing prices is of first order, i.e., "large".

The menu cost theory provides the more popular explanation of nominal price rigidity. Another explanation rests on the presumption of *strictly convex price adjustment costs*. In this theory the price change cost for firm i is assumed to be $k_{it} = \alpha_i(P_{it} - P_{it-1})^2$, $\alpha_i > 0$. Under this assumption the firm is induced to avoid large price changes, which means that it tends to make frequent, but small price adjustments. This theory is related to the customer market theory. Customers search less frequently than they purchase. A large upward price change may be provocative to customers and lead them to do search in the market, thereby perhaps becoming aware of attractive offers from other stores. The implied "kinked" demand curve can explain that firms are reluctant to suddenly increase their price.

4 Adding interest-bearing assets

To incorporate the key role of financial markets for the performance of the macroeconomy, at least one extra asset should enter in a short-run model, an interest-bearing asset. This gives rise to the IS-LM model that should be familiar from Blanchard, *Macroeconomics*.

An extended IS-LM model is presented in the recent editions of the mentioned text by Blanchard (alone) and in Blanchard et al., *Macroeconomics: A European Perspective*, 2010, Chapter 20. The advantage of the extended version is that the commercial banking sector is introduced more explicitly so that the model incorporates both a centralized bond market and decentralized markets for bank loans.

5 Adding dynamics and a Phillips curve

Adding dynamics, expectations formation, and a Phillips curve leads to a *medium-run model*. An introduction is provided in the first-mentioned Blanchard textbook, chapters 8 and 14. Medium-run models describe fluctuations in production and employment around a trend, often considered related to the "natural rate of unemployment". Adding capital accumulation, technical progress, and growth in the labor force to the model, GDP gets a rising trend.

Roughly speaking, this course, Macroeconomics 2, can be interpreted as dealing with an economy moving along this trend. We have more or less ignored the fluctuations, simply by assuming flexible prices and perfect competition. In a realistic model with imperfect competition and price stickiness in both output and labor markets the natural rate of unemployment is likely to be higher than in an economy with perfect competition. And hump-shaped deviations from trend GDP, that is, business cycles, are likely to arise when the economy is hit by large shocks, for instance a financial crisis.

The third macro course, Macroeconomics 3, deals with short and medium run theory and emphasizes issues related to monetary policy.

6 Appendix

ENVELOPE THEOREM Let $y = f(a, x)$ be a continuously differentiable function of two variables, of which one, a, is conceived as a parameter and the other, x, as a control variable. Let $g(a)$ be a value of x at which $\frac{\partial f}{\partial x}(a, x) = 0$, i.e., $\frac{\partial f}{\partial x}(a, g(a)) = 0$. Let $F(a) \equiv f(a, g(a))$. Provided $F(a)$ is differentiable,

$$F'(a) = \frac{\partial f}{\partial a}(a, g(a)),$$

where $\partial f / \partial a$ denotes the partial derivative of $f(\cdot)$ w.r.t. the first argument.

Proof $F'(a) = \frac{\partial f}{\partial a}(a, g(a)) + \frac{\partial f}{\partial x}(a, g(a))g'(a) = \frac{\partial f}{\partial a}(a, g(a))$, since $\frac{\partial f}{\partial x}(a, g(a)) = 0$ by definition of $g(a)$. $\square$

That is, when calculating the total derivative of a function w.r.t. a parameter and evaluating this derivative at an interior maximum w.r.t. a control variable, the envelope theorem allows us to ignore the terms that arise from the chain rule. This is also the case if we calculate the total derivative at an interior minimum.[12]

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[12] For extensions and more rigorous framing of the envelope theorem, see for example Sydsaeter et al. (2006).