Foundations of Modern Macroeconomics

Ben J. Heijdra
University of Groningen

January 2002

Solutions for problems to Chapter 5

Question 1

Part (a)

Demand policies in the BGM model can be either in the form of fiscal policy (an increase in G) or in the form of monetary policy (an increase in initial money balances, M_0). In the regime of classical unemployment (CU) there is excess demand for goods and excess supply of labour. Households thus face quantity constraints in both the goods and the labour market and consequently formulate an effective supply of labour and an effective demand for goods. Firms do not face quantity constraints and thus formulate notional plans. In formal terms, in the CU regime we have:

$$\bar{N} = N^D(w) < N^{SE}(w, P, \underset{+}{\bar{C}}, M_0 \underset{-}{+} \Pi_0), \tag{A1}$$

$$\bar{Y} = Y^S(w) < C^{DE}(\underset{+}{w\bar{N}}, P, M_0 \underset{+}{+} \Pi_0) + G. \tag{A2}$$

Since the government is not rationed by assumption, the quantity constraint faced by households in the goods market is:

$$\bar{C} = \bar{Y} - G. \tag{A3}$$

It is clear from (A1)-(A2) that demand policies do not affect $\bar{N}$ or $\bar{Y}$ because these are both determined by the agents on the "short-side of the market," i.e. by the firms whose plans will only change if the real wage changes.

An increase in G will lead to a one-for-one reduction in $\bar{C}$ (see (A3)). This prompts households to cut back their labour supply somewhat (by (A1)) so that unemployment, $N^{SE} - \bar{N}$, falls. At the same time, of course, the excess demand in the goods market, $C^{DE} + G - \bar{Y}$, rises (see (A2)). An increase in M_0 leads to reduction in the effective supply of labour and

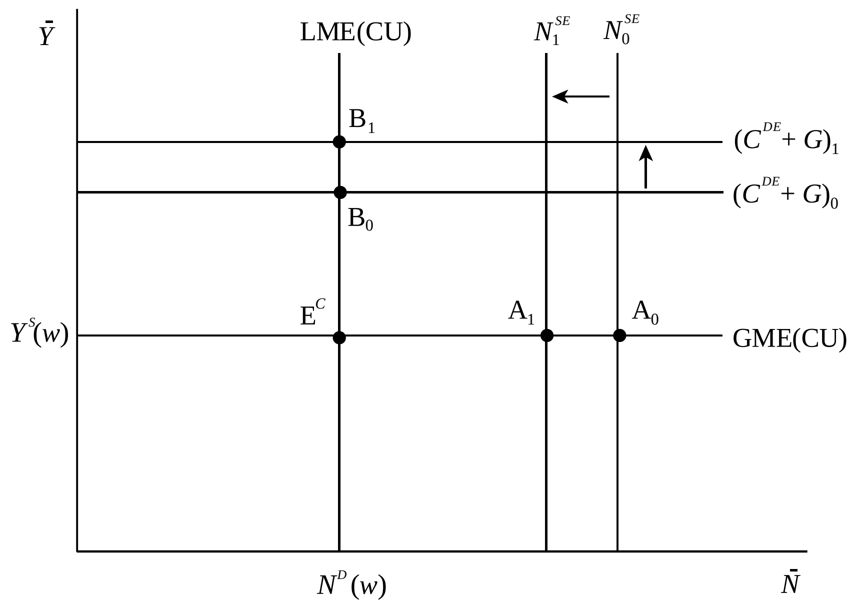

Figure 1: Demand policy under classical unemployment

an increase in the effective demand for goods. Hence unemployment falls but excess demand in the goods market rises.

These effects have been illustrated in Figure 1. In that diagram LME(CU) is defined by $\bar{N} = N^S(w)$ whereas GME(CU) is given by $\bar{Y} = Y^S(w)$. The rationing equilibrium is at E^C. The initial excess supply of labour is represented by the horizontal distance $\mathrm{E}^C\mathrm{A}_0$ and the initial excess demand for goods by the vertical distance $\mathrm{E}^C\mathrm{B}_0$. Demand policy shifts effective goods demand (from $(C^{DE}+G)_0$ to $(C^{DE}+G)_1$) so that excess demand for goods expands by the distance $\mathrm{B}_0\mathrm{B}_1$. Effective labour supply is reduced (from N_0^{SE} to N_1^{SE}) so that excess supply of labour is reduced by the distance $\mathrm{A}_1\mathrm{A}_0$.

Part (b)

Under Keynesian unemployment (KU) there is excess supply of labour and excess supply of goods. Households are rationed in the labour market and formulate an effective demand for goods. Firms are rationed in the goods market and formulate an effective demand for labour. Formally, we have in the KU regime:

$$\bar{N} = N^{DE}(\underset{+}{\bar{Y}}) < N^S(w, P, M_0 \underset{-}{+} \Pi_0), \tag{A4}$$

$$\bar{Y} = C^{DE}(\underset{+}{w\bar{N}}, P, M_0 \underset{+}{+} \Pi_0) + G < Y^S(w). \tag{A5}$$

In Figure 2, the LME(KU) locus is defined by $\bar{N} = N^{DE}(\bar{Y})$. Its slope is given by:

$$d\bar{N} = N^{DE}_{\bar{Y}} d\bar{Y} \quad \Leftrightarrow \quad \left(\frac{d\bar{Y}}{d\bar{N}}\right)_{LME(KU)} = \frac{1}{N^{DE}_{\bar{Y}}} > 0. \tag{A6}$$

An increase in $\bar{Y}$ relaxes the quantity constraint faced by the firms which induces them to increase labour demand and thus employment.

The GME(KU) locus is defined by $\bar{Y} = C^{DE}(w\bar{N}, P, M_0 + \Pi_0) + G$. Its slope is given by:

$$d\bar{Y} = C^{DE}_{\bar{N}} d\bar{N} \quad \Leftrightarrow \quad \left(\frac{d\bar{Y}}{d\bar{N}}\right)_{GME(KU)} = C^{DE}_{\bar{N}} > 0. \tag{A7}$$

Although both GME(KU) and LME(KU) slope upwards, it is not hard to show that LME(KU) is steeper than GME(KU) for the Cobb-Douglas case studied in the book. We note from equation (5.28) in the book that the slope of GME(KU) for the Cobb-Douglas case is:

$$\left(\frac{d\bar{Y}}{d\bar{N}}\right)_{GME(KU)} = C^{DE}_{\bar{N}} = \left(\frac{\alpha}{\alpha + \gamma}\right) w < w. \tag{A8}$$

Next we note that in the KU regime $\bar{Y} = F(N^{DE})$ and $N^{DE} = \bar{N}$ so that the slope of LME(KU) is equal to:

$$\left(\frac{d\bar{Y}}{d\bar{N}}\right)_{LME(KU)} = F_N(\bar{N}) > w. \tag{A9}$$

Since $\bar{N} = N^{DE}$ is strictly less than N^D (for which $w = F_N(N^D)$) it follows that $F_N(\bar{N}) > w$. Hence, LME(KU) is steeper than GME(KU). This has been illustrated in Figure 2.

In Figure 2, the reduction in G (or M_0) shifts the GME(KU) locus down (from GME(KU)$_0$ to GME(KU)$_1$) and shifts the rationing equilibrium from E^K_0 to E^K_1. The policy measure sets in motion a negative demand multiplier. The fall in G (or M_0) reduces effective demand for goods and makes the constraint faced by firms worse. As a result the firms cut back employment which leads to a reduction in household income and a further decrease in effective goods demand.

Part (d)

In the repressed inflation (RI) regime there is excess demand for goods and excess demand for labour. Households are constrained in the goods market and formulate an effective labour supply decision. Firms are constrained in the labour market and formulate an effective supply of goods. Formally, we have in the RI regime:

$$\bar{N} = N^{SE}(w, P, \underset{+}{\bar{Y} - G}, M_0 + \Pi_0) < N^D(w), \tag{A10}$$

$$\bar{Y} = Y^{SE}(\bar{N}) < C^D(w, P, \underset{+}{M_0 + \Pi_0}) + G, \tag{A11}$$

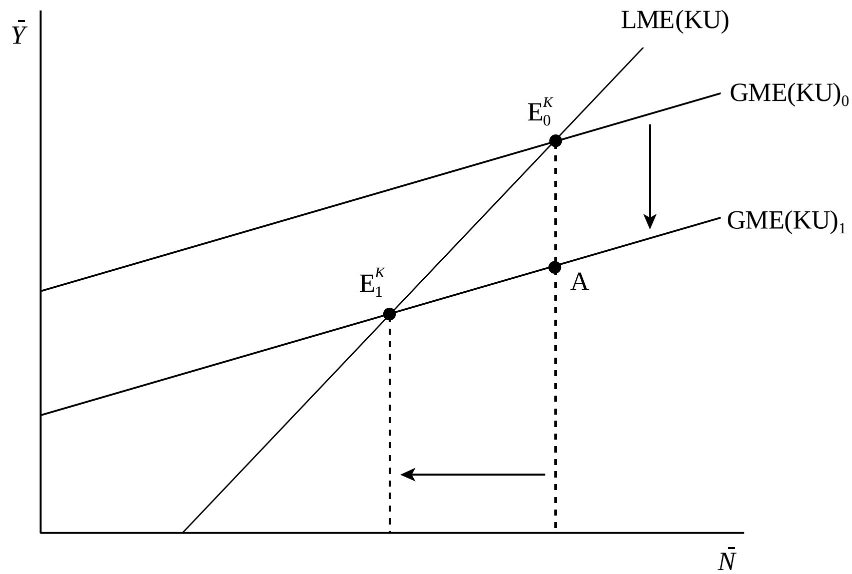

Figure 2: Contractionary demand policy under Keynesian unemployment

where we have used the expression for $\bar{C}$ (given in (A3)) in equation (A10). A decrease in G or M_0 leads to an increase in the effective supply of labour. Firms are happy to employ the additional workers (as there is excess demand for labour) so employment and output increase. In terms of Figure 3, the GME(RI) locus, which is defined as $\bar{Y} = Y^{SE}(\bar{N})$, has a slope equal to:

$$d\bar{Y} = Y_{\bar{N}}^{SE} d\bar{N} \qquad \Leftrightarrow \qquad \left(\frac{d\bar{Y}}{d\bar{N}}\right)_{GME(RI)} = Y_{\bar{N}}^{SE} > 0. \tag{A12}$$

The LME(RI) locus is formally defined as $\bar{N} = N^{SE}(.)$ and has the following slope:

$$d\bar{N} = N_{\bar{C}}^{SE} d\bar{Y} \qquad \Leftrightarrow \qquad \left(\frac{d\bar{Y}}{d\bar{N}}\right)_{LME(RI)} = \frac{1}{N_{\bar{C}}^{SE}} > 0. \tag{A13}$$

In the book we assume that the LME(RI) is steeper than GME(RI). It must be stressed that this is not guaranteed even for the Cobb-Douglas case discussed in the book. Indeed, we know from equation (5.40) that:

$$\frac{1}{N_{\bar{C}}^{SE}} = \left(\frac{\beta+\gamma}{\beta}\right) w > w. \tag{A14}$$

We also know that in the RI regime $\bar{Y} = F(N^{SE})$ and $N^{SE} = \bar{N}$ so that the slope of GME(RI) is equal to:

$$\left(\frac{d\bar{Y}}{d\bar{N}}\right)_{GME(RI)} = Y_{\bar{N}}^{SE} = F_N(\bar{N}) > w. \tag{A15}$$

Since $1/N_{\bar{C}}^{SE}$ and $Y_{\bar{N}}^{SE}$ are both larger than w, it is ambiguous whether the former exceeds the latter (as we assume).

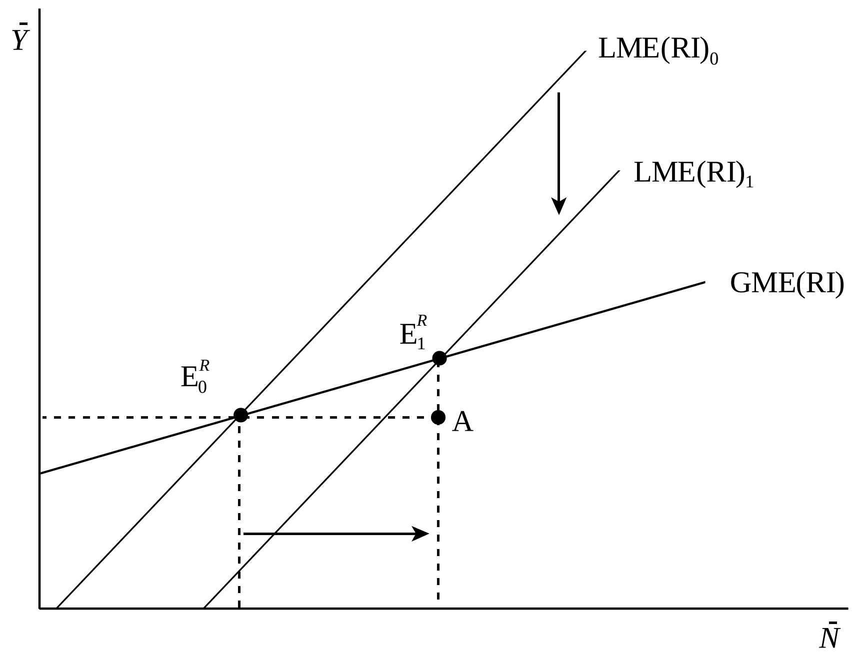

Figure 3: Contractionary demand policy under repressed inflation

Part (d)

By wage moderation we mean a reduction in the real wage. We find from Table 5.3 in the book that a reduction in w leads to a reduction in employment and output under the Keynesian unemployment regime. The real wage cut leads to a reduction in effective demand (as C^{DE} falls with $w\bar{N}$). Output falls as does employment. The drop in employment prompts a further fall in effective demand. See equations (A4)-(A5) above.

A reduction in w increases output and employment in the Classical unemployment regime. In that regime the real wage cut stimulates the demand for labour and the supply of output. See equations (A1)-(A2) above.

Part (e)

In the underconsumption (UC) regime, there is excess supply of goods so firms express an effective demand for labour (N^{DE}) and there is excess demand for labour so firms express an effective supply of goods (Y^{SE}). This regime is represented by the region in between the GME(EDL) line and the LME(ESG) line. It is easy to show, however, that these two lines coincide, so that the UC regime vanishes. Recall that the GME(EDL) and LME(ESG) lines are defined as follows:

$$Y^{SE}(\bar{N}) = C^D + G, \quad \bar{N} = N^S, \qquad \text{(GME(EDL))}$$
$$N^S = N^{DE}(\bar{Y}), \quad \bar{Y} = C^D + G. \qquad \text{(LME(ESG))}$$

But we know that the firm is always on its production function, i.e. $Y^{SE}(\bar{N}) = F(\bar{N})$ and $N^{DE}(\bar{Y}) = F^{-1}(\bar{Y})$. Furthermore, $N^{DE}(\bar{Y}) = \bar{N}$ and $Y^{SE}(\bar{N}) = \bar{Y}$. Using these results, GME(EDL) and LME(ESG) can be rewritten as:

$$F\left[N^S(.)\right] = C^D(.) + G, \quad \text{(GME(EDL))}$$
$$N^S(.) = F^{-1}\left[C^D(.) + G\right]. \quad \text{(LME(ESG))}$$

It follows that the two lines coincide.

There cannot be simultaneous rationing of firms in both markets if there is no inventory accumulation, i.e. the simultaneous occurrence of $N^{DE} > N^S$ and $Y^{SE} > C^D + G$ is impossible. Intuitively this is because a firm that faces a constraint in one market only has a single choice left in the other market, so only one constraint can be binding at the same time. In the absence of inventories it makes no sense to demand more labour than $\bar{N}$ because the supply of goods is already too large. It is not feasible to produce in the current period for future sales. In the absence of inventories, the production function is the unique link between the goods market and the labour market for the producer.

In contrast, the household operates in three markets, namely the goods market, the labour market, and the money market. If it faces a constraint in one of the first two markets it can still make two choices (i.e. money and labour or money and goods).

Question 2

Part (a)

We use Figure 4 to answer this question. The economy is initially in point E_0^C which is in the regime of classical unemployment (CU). In this regime, the following holds:

$$\bar{N} = N^D(\underset{-}{w}) < N^{SE}(\underset{+}{w}, \underset{+}{P}, \bar{Y} \underset{+}{-} G, M_0 \underset{-}{+} \Pi_0), \quad \text{(A1)}$$
$$\bar{Y} = Y^S(\underset{-}{w}) < C^{DE}(\underset{+}{w\bar{N}}, \underset{-}{P}, M_0 + \Pi_0) + G. \quad \text{(A2)}$$

The following adjustments take place over time:

- w falls because there is ESL. $\bar{N} = N^D$ rises, $\bar{Y} = Y^S$ rises, C^{DE} rises and N^{SE} falls on this account. Because $\bar{Y}$ rises, the consumption ration, $\bar{C}$, becomes larger so N^{SE} rises on that account.

- P rises because there is EDG. No effect on $\bar{N}$ and $\bar{Y}$ on this account, C^{DE} falls and N^{SE} rises on this account.

In terms of Figure 4, the economy moves gradually from E_0^C to point A on the GME(ESL) locus. Since there is still ESL in point A, the real wage continues to fall and the economy

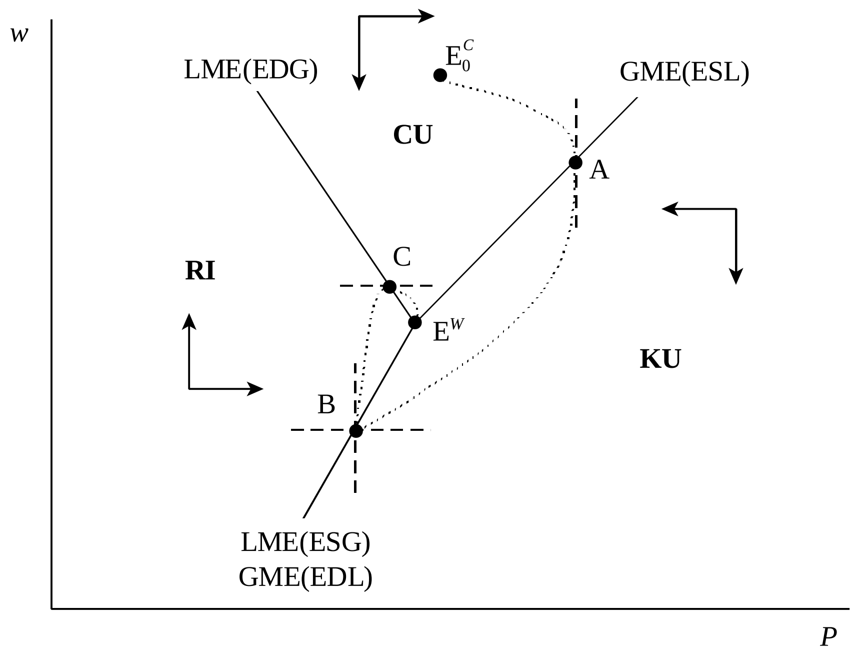

Figure 4: Dynamic adjustment in the disequilibrium model

moves below the GME(ESL) locus where there is ESG. Hence, the economy enters the regime of Keynesian unemployment (KU).

In the regime of Keynesian unemployment, the following holds:

$$\bar{N} = N^{DE}(\underset{+}{\bar{Y}}) < N^S(\underset{+}{w}, \underset{+}{P}, M_0 + \Pi_0), \tag{A3}$$

$$\bar{Y} = C^{DE}(\underset{+}{w\bar{N}}, \underset{-}{P}, M_0 + \Pi_0) + G < Y^S(\underset{-}{w}). \tag{A4}$$

The following adjustments take place over time:

- P falls because there is now ESG. C^{DE} rises, $\bar{Y}$ rises, $\bar{N} = N^{DE}$ rises, (multiplier effect) C^{DE} rises.
- w continues to fall because there is still ESL. C^{DE} falls somewhat, $\bar{Y}$ falls somewhat.

In terms of Figure 4, the economy moves from A to B on the LME(ESG) line. In point B, there is ESG and EDL. Hence, the wage and price both start to rise and the economy moves into the regime of repressed inflation (RI).

In the repressed inflation regime we have:

$$\bar{N} = N^{SE}(\underset{+}{w}, \underset{+}{P}, \underset{+}{\bar{Y} - G}, M_0 + \Pi_0) < N^D(\underset{-}{w}), \tag{A5}$$

$$\bar{Y} = Y^{SE}(\underset{+}{\bar{N}}) < C^D(\underset{+}{w}, \underset{-}{P}, M_0 + \Pi_0) + G. \tag{A6}$$

The following adjustments take place over time:

- w rises because there is EDL. $\bar{N} = N^{SE}$ rises on this account as does $\bar{Y}$. The consumption ration, $\bar{C}$, rises on this account.
- P rises because there EDG. This causes N^{SE} to rise.

In terms of Figure 4, the economy moves from B to C on the LME(EDG) locus. In point C, there is EDG (so the price continues to rise) but there is LME(EDG) so the real wage no longer rises. The economy moves into the CU regime again.

In the discussion we have assume that adjustment in cyclical. This is not the only possible adjustment pattern. Depending on the magnitudes of λ_1 and λ_2, it may very well be the case that the adjustment is non-cyclical, e.g. that the economy moves directly from point A to the Walrasian equilibrium at E^W.

Question 3

Part (a)

In the Dixit model there are no inventories, labour is immobile internationally, the good is internationally tradeable, and transport costs are abstracted from. The economy is small relative to the world market which means that it can always buy and sell all the goods it wants to at the given world price. Hence, there is never rationing on the goods market. It follows from the assumptions underlying the model that the price of the domestic good is determined in the world market:

$$P = EP^*, \tag{A1}$$

where P is the domestic currency price, P^* is the foreign currency price, and E is the nominal exchange rate (dimension domestic currency per unit of foreign currency, e.g. Euro's per \$).

Part (b)

Since there is never rationing on the goods market, notional demand and supply on the labour market are relevant. Since the real wage is rigid, it may however, be the case that there is ESL or EDL. So effective demand and supply are relevant in the goods market. If there is ESL, so that $N^S > N^D = \bar{N}$, we have for the trade balance:

$$X = F(\bar{N}) - C^{DE}(w\bar{N}, EP^*, M_0 + \Pi_0) - G, \qquad \bar{N} = N^D(w) < N^S. \tag{A2}$$

The trade balance equals the difference between domestic production ($F(\bar{N})$) and domestic absorption ($C^{DE} + G$). If there is EDL, so that $N^D > N^S = \bar{N}$, then the trade balance is:

$$X = F(\bar{N}) - C^D(w, EP^*, M_0 + \Pi_0) - G, \qquad \bar{N} = N^S(.) < N^D. \tag{A3}$$

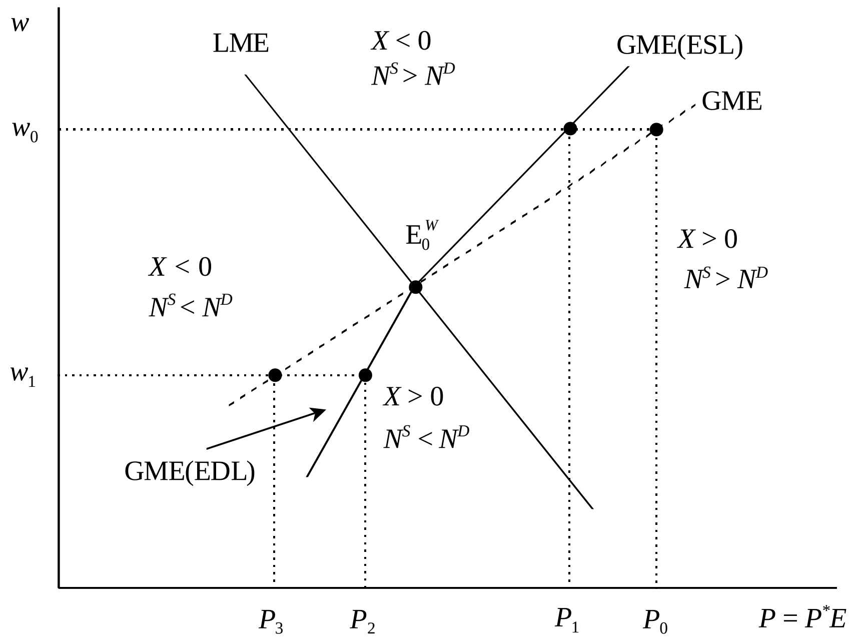

Figure 5: The Dixit model

Again, the trade balance is the difference between domestic production ($F(\bar{N})$) and domestic absorption ($C^{DE}+G$). In Figure 5 we illustrate the different regimes that exist in the model. Note that the line for which $X = 0$ is referred to as the GME locus.

The LME locus is formally defined as:

$$N^D(w) = N^S(w, EP^*, M_0 + \Pi_0). \tag{A4}$$

Its slope is given by:

$$N_w^D dw = N_w^S dw + N_P^S dP \qquad \Leftrightarrow \qquad \left(\frac{dw}{dP}\right)_{LME} = -\frac{N_P^S}{N_w^S - N_w^D} < 0, \tag{A5}$$

where the sign follows from the fact that $N_P^S > 0$, $N_w^S > 0$, and $N_w^D < 0$. For points above (below) the LME line, the real wage is too high (low) and there is ESL (EDL).

The GME locus (the dashed line in Figure 5) is defined as:

$$Y^S(w) = C^D(w, EP^*, M_0 + \Pi_0) + G. \tag{A6}$$

Its slope is given by:

$$Y_w^S dw = C_w^D dw + C_P^D dP \qquad \Leftrightarrow \qquad \left(\frac{dw}{dP}\right)_{GME} = -\frac{C_P^D}{C_w^D - Y_w^S} > 0, \tag{A7}$$

where the sign follows from the fact that $Y_w^S < 0$, $C_w^D > 0$, and $C_P^D < 0$.

The GME(ESL) locus is formally defined by:

$$Y^S(w) = C^{DE}(wN^D(w), EP^*, M_0 + \Pi_0) + G, \tag{A8}$$

where we have used the fact that $\bar{N} = N^D(w)$ on the right-hand side of (A8). The slope of the GME(ESL) locus is:

$$\begin{aligned} Y_w^S dw &= C_{w\bar{N}}^{DE}\left[wN_w^D + N^D\right] dw + C_P^{DE} dP \\ \left[Y_w^S - (1-\epsilon_w)\,\bar{N}C_{w\bar{N}}^{DE}\right] dw &= C_P^{DE} dP \qquad \Leftrightarrow \\ \left(\frac{dw}{dP}\right)_{GME(ESL)} &= -\frac{C_P^{DE}}{(1-\epsilon_w)\,\bar{N}C_{w\bar{N}}^{DE} - Y_w^S} > 0, \end{aligned} \tag{A9}$$

where $\epsilon_w \equiv -wN_w^D/N^D$ is the (absolute value of the) wage elasticity of labour demand. The sign in (A9) follows from the fact that $C_P^{DE} < 0$, $C_{w\bar{N}}^{DE} > 0$, $Y_w^S < 0$, and $0 < \epsilon_w < 1$ (for the Cobb-Douglas case discussed in the book). Hence, both GME and GME(ESL) are upward sloping in Figure 5. It is not difficult to demonstrate that GME(ESL) is steeper GME. Consider a particular value for the real wage, say $w = w_0$. It follows that for that value of w, the left-hand sides of (A6) and (A8) are the same. But that means that the right-hand sides of (A6) and (A8) must also be the same, i.e.

$$C^D(w_0, P_0, M_0 + \Pi_0) = C^{DE}(w_0 N^D(w_0), P_1, M_0 + \Pi_0), \tag{A10}$$

where P_0 is the price level on the notional demand curve and P_1 is the price level on the effective demand curve. We know that, for a given wage-price combination, (w_0, P_0), effective demand is less than notional demand because the labour market rationing causes the households to cut back consumption, i.e.:

$$C^D(w_0, P_0, M_0 + \Pi_0) > C^{DE}(w_0 N^D(w_0), P_0, M_0 + \Pi_0). \tag{A11}$$

By combining the results in (A10) and (A11) and noting that $C_P^{DE} < 0$ it follows that P_1 must be lower than P_0, i.e. GME(ESL) lies to the left of GME.

The GME(EDL) line is formally defined as:

$$Y^{SE}(N^S(w, EP^*, M_0 + \Pi_0)) = C^D(w, EP^*, M_0 + \Pi_0) + G, \tag{A12}$$

where we have used the fact that $\bar{N} = N^S(w, EP^*, M_0 + \Pi_0)$ on the left-hand side of (A12). The slope of GME(EDL) is easily found:

$$\begin{aligned} Y_{\bar{N}}^{SE}\left[N_w^S dw + N_P^S dP\right] &= C_w^D dw + C_P^D dP \qquad \Leftrightarrow \\ \left(\frac{dw}{dP}\right)_{GME(EDL)} &= \frac{C_P^D - Y_{\bar{N}}^{SE} N_P^S}{C_w^D - Y_{\bar{N}}^{SE} N_w^S} > 0, \end{aligned} \tag{A13}$$

where we have used the fact that $Y_{\bar{N}}^S > 0$, $N_w^S > 0$, $N_P^S > 0$, $C_w^D > 0$, and $C_P^D < 0$. (Note that $C_w^D - Y_{\bar{N}}^{SE} N_w^S > 0$ can also be proved for the Cobb-Douglas case.) Hence, both GME and GME(EDL) are upward sloping in Figure 5.

It is easy to show that GME(EDL) is steeper than GME. Take a given value for the real wage rate, say $w = w_1$. Deducting (A12) from (A6) we find:

$$Y^S(w_1) - Y^{SE}(.) = C^D(w_1, P_3, M_0 + \Pi_0) - C^D(w_1, P_2, M_0 + \Pi_0), \tag{A14}$$

where P_2 and P_3 are the prices associated with, respectively, GME and GME(EDL). We know that firms are rationed due to the labour market constraint, i.e. $Y^{SE} < Y^S$ and the left-hand side of (A14) is positive. For a given real wage, this can only be the case if P_3 is less than P_2 (since C^D depends negatively on the price level). Hence, GME(EDL) lies to the right of GME.

To the right of the GME(x) line demand falls short of domestic production so there is surplus on the trade account ($X > 0$). The opposite holds to the left of the GME(x) line.

Part (c)

Under flexible exchange rates, the domestic price is fully flexible also (as $P = EP^*$), and is such that EDG is zero, i.e. the economy is on the $X = 0$ line. The (rigid) real wage rate determines where exactly the economy will be on the GME(x) locus. Consider point A in Figure 6. In this point there is ESL and $X > 0$, i.e. exports exceed imports. There is an excess demand for domestic currency on the foreign exchange market and, since the exchange rate is flexible, the domestic currency appreciates, i.e. E falls. Since the foreign price level is given, EP^* falls, and the economy moves from point A to point B on the GME(ESL) locus. By assumption the real wage is rigid.

Part (d)

The situation under fixed exchange rates is depicted in Figure 7. The economy is initially in point A, where there is EDL and the trade balance is positive ($X > 0$). The following adjustments occur over time:

- At impact nothing happens to w and EP^* because the real wage is rigid and the exchange rate is fixed by the central bank (and P^* is given).
- During transition the positive trade balance causes foreign exchange reserves to enter the country and the nominal money supply to increase (because the central bank keeps the exchange rate unchanged). So over time, M_0 rises, which causes:
  - an increase in C^D and a shift to the right of the GME(EDL) curve
  - a decrease in N^S and a downward shift in the LME schedule
- Ultimately, the equilibrium is restored in point A. This point lies on the new LME line and thus features equilibrium in the labour market. It also lies on the new GME(EDL) line and thus features a zero trade balance ($X = 0$).

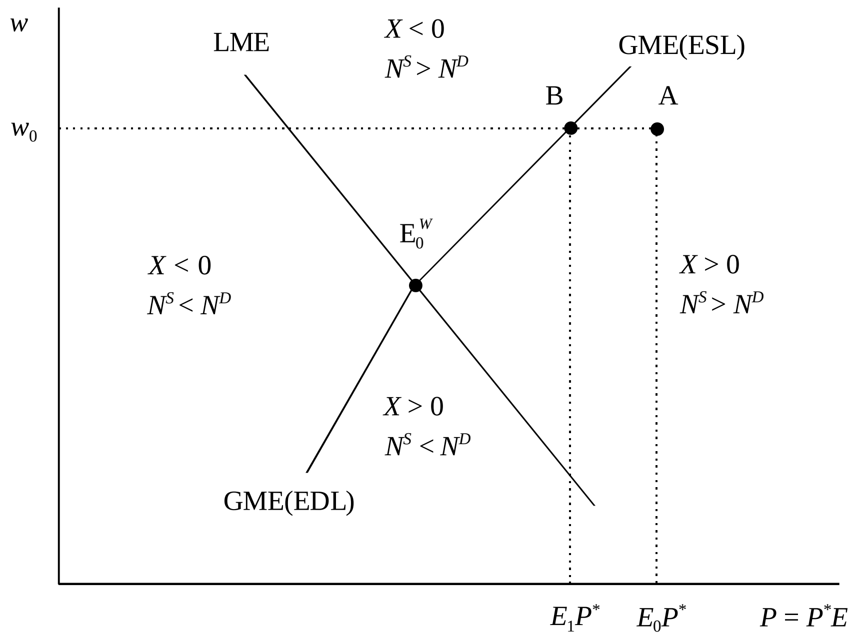

Figure 6: Flexible exchange rates

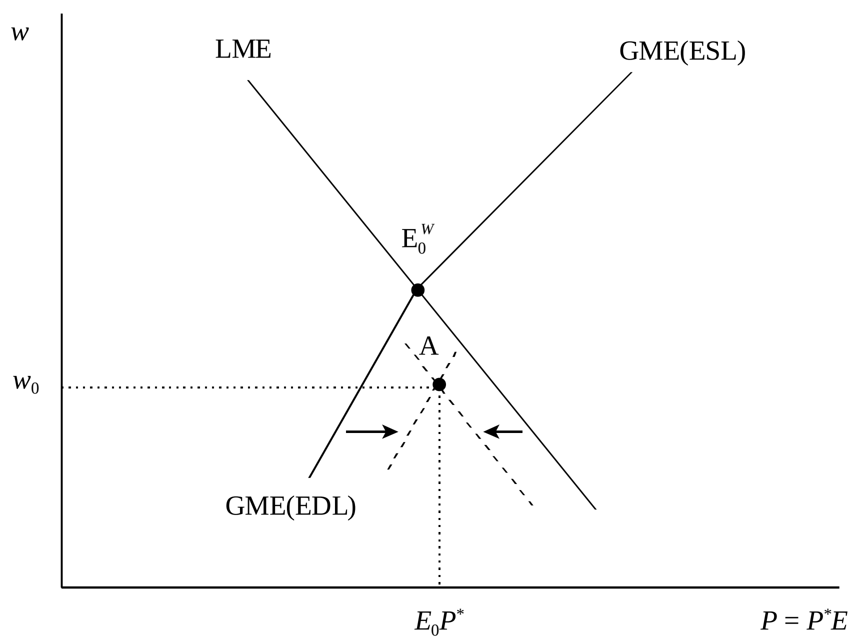

Figure 7: Fixed exchange rates

So nothing happens to the wage-price combination but M_0 rises during adjustment. This means that labour supply (and thus employment and production) is lower than before. Household consumption is higher than before. This is how the initial trade balance surplus vanishes in the long run.

Part (e)

In order to study the effect of a productivity shock we must first introduce an index of general technology into the model. Let us assume that the production function is written as follows:

$$Y = \gamma_0 F(N) = \gamma_0 N^{\epsilon}, \tag{A15}$$

where γ_0 is the index of general technology. The notional demand for labour is in this case:

$$w = \gamma_0 F_N = \epsilon\gamma_0 N^{\epsilon-1} \qquad \Leftrightarrow \qquad N^D(w,\gamma_0) \equiv \left(\frac{\epsilon\gamma_0}{w}\right)^{1/(1-\epsilon)}.$$

Labour demand depends positively on the technology index γ_0.

The trade balance under ESL is now:

$$X = \gamma_0 F(\bar{N}) - C^{DE}(w\bar{N}, EP^*, M_0 + \Pi_0) - G, \qquad \bar{N} = N^D(\gamma_0, w) < N^S. \tag{A16}$$

The trade balance under EDL is:

$$X = \gamma_0 F(\bar{N}) - C^D(w, EP^*, M_0 + \Pi_0) - G, \qquad \bar{N} = N^S(.) < N^D. \tag{A17}$$

It is easy to show that a negative productivity shock (a fall in γ_0) shifts the GME(x) lines to the right. By differentiating (A16) with respect to γ_0 we find:

$$\frac{\partial X}{\partial \gamma_0} = F(\bar{N}) + \gamma_0 F_N \left(\frac{\partial \bar{N}}{\partial \gamma_0}\right) > 0. \tag{A18}$$

Similarly, by differentiating (A17) with respect to γ_0 we find:

$$\frac{\partial X}{\partial \gamma_0} = F(\bar{N}) > 0. \tag{A19}$$

It follows from (A18)-(A19) that any given wage-price combination for which $X = 0$ before the shock is consistent with a trade balance deficit ($X < 0$) after the shock, i.e. the GME(x) lines shift to the right.

The LME schedule is defined by:

$$N^D(w,\gamma_0) = N^S(w, EP^*, M_0 + \Pi_0). \tag{A20}$$

By differentiating (A20) with respect to w and γ_0 we find:

$$\left(\frac{dw}{d\gamma_0}\right)_{LME} = \frac{N^D_{\gamma_0}}{N^S_w - N^S_w} > 0. \tag{A21}$$

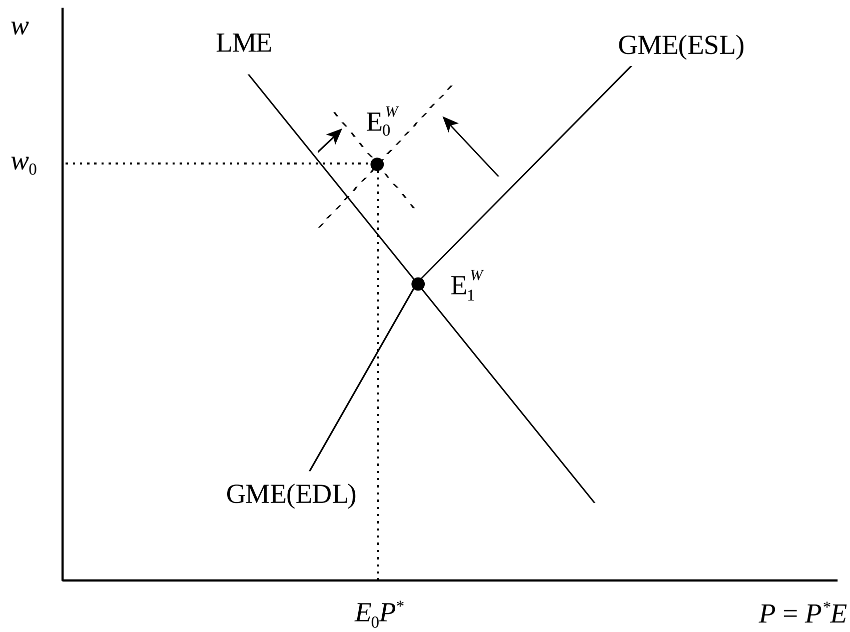

Figure 8: A negative technology shock

It follows from (A21) that the LME schedule shifts down as a result of a negative productivity shock.

In Figure 8 we illustrate the effects of a negative productivity shock. Assume that the economy is initially in a Walrasian equilibrium at E_0^W. Following the negative productivity shock, the new Walrasian equilibrium is at E_1^W. Since both the real wage and the price level are fixed, the economy does not move to the new Walrasian equilibrium but remains in E_0^W. The following adjustments take place over time.

- In E_0^W there is ESL and a deficit on the trade balance ($X < 0$). At impact, production and employment fall as a result of the shock.
- Because $X < 0$, the country loses foreign exchange reserves and the money supply starts to fall over time. The gradual drop in M_0 causes:
  - an increase in N^S and an upward shift in the LME line
  - a decrease in C^{DE} and a shift to the left of the GME(ESL) line
- Ultimately equilibrium is restored in point E_0^W. In that point there is equilibrium on the trade balance ($X = 0$) and equilibrium in the labour market.