EE312 Macroeconomics, 2/2015 (Sec. 046402)
Problem Sets 3 : Ch.3 A Closed Economy One-Period Macroeconomic Model
Solution

*** Exam will consist of essay-type questions only.**

1. Suppose the government increases its spending on consumption goods. Use the Closed-Economy, One-Period Macroeconomic Model to determine the effects of the spending increase on aggregate output, consumption, employment and the real wage. Explain the chain of effects among variables correctly. Describe your analysis in words and use diagrams as needed. (If the space provided is not enough, please attach a separate paper.)

Figure 1: Competitive Equilibrium

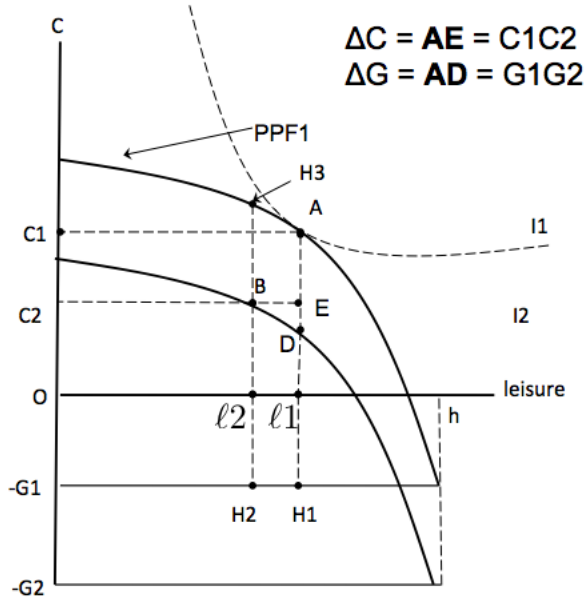
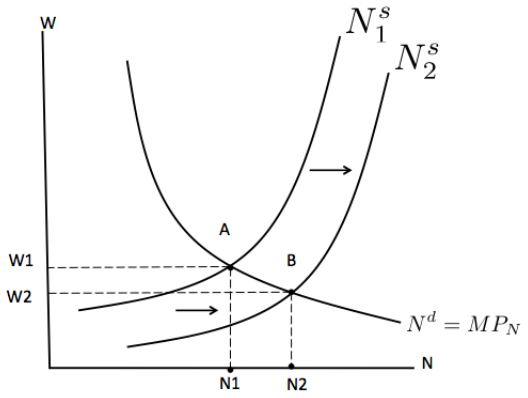


Figure 2: Labor Market Equilibrium



See Figure 1 Competitive Equilibrium.

- Starting with **the initial competitive equilibrium** at point A, the initial competitive equilibrium is at point A where the firm's PPF1 the consumer highest possible indifferece curve I1. At A, the firm maximises profit and the consumer maximizes utility at real wage rate equal to the slope of PPF1 at A (which is equal to the slope of I1 at A). The optimal consumption bundle for consumer is consumption equal to C_1 and leisure equal to ℓ_1. So, the consumer's working time (and labor supply) is $(h - \ell_1)$.
- The government increases spending (G) causing lump-sum tax imposed on the consumer (T) to increase **by the same amount** (Balanced budget constraint: $G = T, \Delta G = \Delta T$).
- **Non-wage income** $(\pi - T)$ and **disposable income** (Y_d) decreases for all ℓ.
- $PPF1$ is illustrated by $C = zF(K, h - \ell) - G_1$. As G increases from G_1 to G_2 , PPF shifts downward by amount of ΔG to PPF2.
- **The new competitive equilibrium** moves from point A to point B. **Consumption drops** from C_1 to C_2 while **leisure decreases** from ℓ_1 to ℓ_2.
- This can be considered as **a pure income effect** which reduces both consumption and leisure since **both are normal goods** by assumption.
- Less leisure is equivalent to **an increase in working time** $(h - \ell\ )$. The consumer **supplies more labour services** (N^s). [Labour supply shifts to the right.]
  - The real wage(w) drops to induce more labor demand by the firm.
  - The real wage decreases because the slope of PPF2 at point B is less steep than the slope of PPF1 at point A.
  - **Employment rises**.
    See **Figure 2** for the equilibrium in the labor market. N^d remains the same because production function has not been changed. N^s shifts to the right from N_1^s to N_2^s . The consumer is willing to supply more labor for all levels of wage because the consumer's non-wage income is decreased by an increase in tax (T). Real wage decreases and employment rises.
- More labour input in production results in **larger total output** (Y). The original
- Y can be represented by the distance $H1A$. The new Y can berepresented by the distance $H2H3$. $(\Delta Y = ED\ )$
- The consumer works more, receives a lower real wage and consume less.
- The **decrease in consumption** (the distance C1C2 = AE) **is smaller than the increase in government spending** (the distance G1G2 = AD).
- $Y \uparrow$ but $C \downarrow$. Private consumption is **crowded out** by government purchases.
- This means that when government increases its spending, the firm produces more. The government's share in total output increases while the consumer's share in total output decreases.
- In sum, The consumer's utility decreases as the governmet expenditure increases.
- As the representative consumer pays higher taxes, his or her disposable income falls, and in equilibrium he or she spends less on consumption goods, and work harder to support a larger government.

$$
\begin{array}{lllllllll}
G\uparrow & \rightarrow & (\pi - T)\downarrow & \rightarrow & Y_d\downarrow & \rightarrow & \ell\downarrow & \rightarrow & (h-\ell)\uparrow \\
 & & & \swarrow & & & & & \downarrow \\
 & & C\downarrow & & & & & & N^S\uparrow \\
 & & & \nwarrow & & & & & \\
 & & & & Y\uparrow & & & & \text{(shift right)} \\
 & & & \nearrow & & & & & \downarrow \\
 & & zF(K,N^d) & \leftarrow & N^d\uparrow & & \leftarrow & & w^*\downarrow \\
 & & & & \text{(move along)} & & & &
\end{array}
$$

$$
\begin{aligned}
|\Delta C| &< |\Delta G| \\
\Delta C &= \Delta Y - \Delta G
\end{aligned}
$$

2. Use the closed-economy, one period macroeconomic model to determine the effects of a decrease in total factor productivity on the aggregate output, consumption, employment and real wage. Explain the chain of effects among variables correctly. Describe your analysis in words and use diagrams as needed. (If the space provided is not enough, please attach a separate sheet.)

Figure 3: Production Function

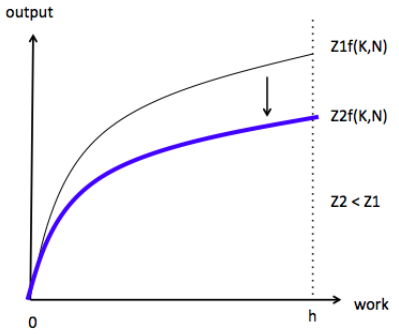


Figure 4: Competitive Equilibrium

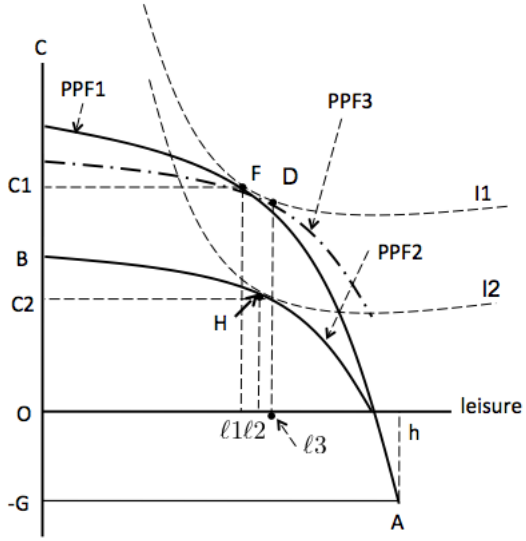
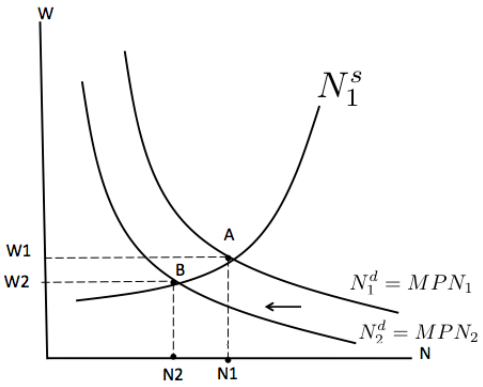


Figure 5: Labor Market Equilibrium



See figure 4. Let assume **a stronger substitution effect** so that labour supply has a postitive slope.

- Starting with **the initial competitive equilibrium** at point F, the initial competitive equilibrium is at point F where the firm's PPF1 the consumer highest possible indifferece curve I1. At A, the firm maximises profit and the consumer maximizes utility at real wage rate equal to the slope of PPF1 at F (which is equal to the slope of I1 at F). The optimal consumption bundle for consumer is consumption equal to C_1 and leisure equal to ℓ_1. So, the consumer's working time (and labor supply) is $(h - \ell_1)$.
- A decrease in total factor productivity causes a decrease in MPN. The **PPF rotates downwards** from PPF1 to PPF2.
- The new PPF is less steeper (flatter) than the original one.
- **The new competitive equilibrium** moves from point F to point H. Consumption drops from C_1 to C_2 while leisure increases from ℓ_1 to ℓ_2.
- This means that wage decreases for all N , ℓ
- **substitution effect and income effect :** $w \downarrow$
  substitution effect : $\ell \uparrow$ and $C \downarrow$
  leisure is less costly.
  income effect : $\ell \downarrow$ and $C \downarrow$
  lower wage implies lower income.
- Consumption declines for sure.
- As we assume **a stronger substitution effect** , leisure increases. (See note*)
- **To separate income effect and substitution effect**, we draw an imaginary PPF (PPF3) which has the same slope as the new PPF (PPF2).
  - Point D is the point where the imaginary PPF (PPF3) touches the initial IC (I1).
  - FD is therefore the substitution effect (the effect due only to the relative price change, controlling for the change in real income). Leisure inceases from $\ell 1$ to $\ell 3$.
  - DH is then the income effect (the effect due to only the income change, controlling for the change in the relative price). Leisure decreases from $\ell 3$ to $\ell 2$.
  - Since Substitution Effect (SE) > Income Effect (IE), $\ell 1 \ell 3 > \ell 3 \ell 2$. Leisure increases from from ℓ_1 to ℓ_2.
  - More leisure is equivalent to **an decrease in working time** $(h - \ell\ )$. The consumer **supplies less labour services** (N^s). **Employment decreases.**
  - The original real wage is the slope of PPF1 at point F.
  - The new real wage is the slope of PPF2 at point H.
  - **Real wage decreases.**

- **See figure 5** for the equilibrium in the labor market. N^d shifts to the left (From N_1^d to N_2^d) because the decrease in z causing MPN to decrease for all N. Real wage decreases..
- Less labour input in production results in **smaller total output** ($Y \downarrow$).
- The consumer works less, consumes less, and receives a lower real wage.
- The consumer utility is decreased.

$$
\begin{array}{lllllllll}
z, K \downarrow & \rightarrow & MP_N \downarrow & \rightarrow & N^d \downarrow & \rightarrow & & w \downarrow & \\
 & & & & & & \swarrow & & \searrow \\
 & & & & & \text{Substitution Effect} & & & \text{Income Effect} \\
 & & & & & \ell \uparrow C \downarrow & & & \ell \downarrow C \downarrow \\
 & & & & & & \searrow & & \swarrow \\
 & & & & & & & C \downarrow & \\
 & \rightarrow & Y \downarrow & & & & & N^S \text{depends} & \\
 & & \downarrow & & & & SE > IE & & : C \downarrow, \ell \uparrow \\
 & & C \downarrow & & & & SE = IE & & : C \downarrow, \overline{\ell} \\
 & & & & & & SE < IE & & : C \downarrow, \ell \downarrow
\end{array}
$$

* Note: A student may analyze all the three possible cases; a stronger income effect, an equal effect and a stronger income effect. Please make sure you understand all cases especially the stronger substitution effect case. Later, we will always assume a stronger substitution effect.

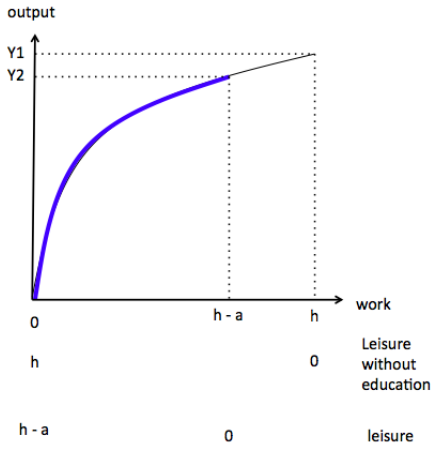
* Note: In my opinion, the graph for labour market is a little tricky. We analyze a general equilibrium where the consumer is the owner of the firm. When TFP(total factor productivity) changes, firm's profit changes. This must affect labour supply somehow. When we analyze the model by using graphical illustration, the effect on the labour market is unclear. However, the mathematical appendix of the textbook shows us how the model is derived. When it becomes sequence of equations, all the solutions are clear. It can be proved that real wage decreases when TFP decreases (real wage increases when TFP increases).

3. In one-period model, education can be represented as time spent by the representative consumer that is neither leisure nor time applied to producing output. What the economy gains in the future is that the representative consumer then has more time available, as measured in terms of effective units of labour time (adjusted for skill level, or what economists call human capital).

   (a) Using the one-period model, show what effects additional education has in the present on consumption, leisure, employment, aggregate output, and the real wage.

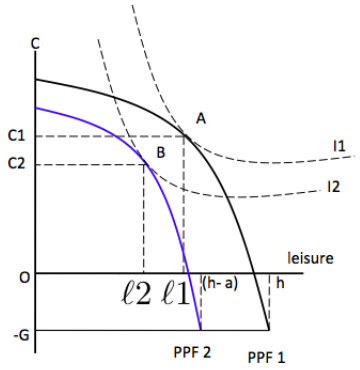
   Ans. If households dedicate a hours to education today, it reduces the hours available for leisure and work fro h to $h - a$.

Figure 6: production function



- The production function is truncated at $(h - a)$ instead of h. Note that to derive PPF, the relation between Y and ℓ is a mirror image of the production function with slope = -MPN.
- Without education, at 0 unit of leisure, MPN is the slope of production function where $N = h$. With education, at 0 unit of leisure, MPN is the slope of production function where $N = h - a$. Therefore, the slope of PPF with education at zero unit of leisure is higher than the the slope of PPF withour education at zero unit of leisure. This is true for all levels of leisure. PPF with education is steeper (same leisure, with education, lower hours work, higher MPN).
- In addition, at zero unit of leisure, without education the economy can produce Y_1 units of output. Then, consumption is equal to $Y_1 - G$. At zero unit of leisure, with education the economy can produce Y_2 units of output. Then, consumption is equal to $Y_2 - G$, which is lower than $Y_1 - G$. This is true for all levels of leisure, consumption with education is lower than consumption without education (same leisure, with education, lower hours work, lower Y, hence lower C).
- The PPF with education (PPF2) has to start form point $(-G, h - a)$ instead of $(-G, h)$. Graphically, this corresponds to the figure 7.

Figure 7: PPF-today, the effect of education



- Originally, without education, the initial competitive equilibrium is at point A where the firm's PPF1 the consumer highest possible indifferece curve I1. At A, the firm maximises profit and the consumer maximizes utility at real wage rate equal to the slope of PPF1 at A (which is equal to the slope of I1 at A). The optimal consumption bundle for consumer is consumption equal to C_1 and leisure equal to ℓ_1.
- After households dedicate a hours to education, PPF shifts downward from PPF1 to PPF2. **Consumption decreases for all levels of leisure**. This is **income effect**.
- The consequence is thus a **reduction in consumption** (from $C1$ to $C2$), leisure (from $\ell 1$ to $\ell 2$), **aggregate output** (since employment is lower and production function remain the same, output is lowered). **Employment** is changed from from $h - \ell 1$ to $h - a - \ell 2$. Change in employment depends on the size of a relative to $\ell_1 - \ell_2$. Assuming that $a > \ell_1 - \ell_2$, employment decreases. Thus, the real wage increases (lower employment, production function remain the same, higher MPN and wage as a consequence) . [Assuming that $a < \ell_1 - \ell_2$, employment increases. Thus, the real wage decreases (lower employment, production function remain the same, lower MPN and wage as a consequence. If $a = \ell_1 - \ell_2$, employment and real wage remains the same.]

(b) Similarly, show the effects of the additional education that people acquire today will have in the future consumption, leisure, employment, aggregate output, and the real wage.

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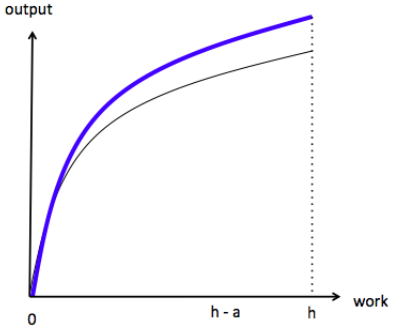
- In the future, workers will be more efficient, which corresponds to an increase in total factor productivity. Production function rotates couterclockwise (upwards) and in the future people do not dedicate time for education anymore. Therefore, they have h hours available for work and leisure. Graphically, this corresponds to the figure 8.

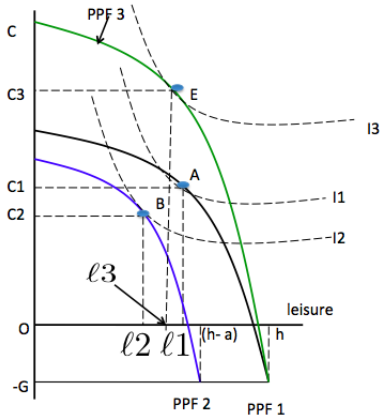
Figure 8: Production function- in the future, the effect of education



- Note that to derive PPF, the relation between Y and ℓ is a mirror image of the production function

with slope = -MPN. Graphically, PPF moves from PPF1 to PPF3. See figure 9.

Figure 9: PPF - in the future, the effect of education



- An increase in total factor productivity causes a increase in MPN. The **PPF rotates downwards** from PPF1 to PPF3.
- The PPF3 is steeper than PPF1.
- Then, there are substitution effect and income effect.
- **substitution effect and income effect :** $w \uparrow$
  substitution effect : $\ell \downarrow$ and $C \uparrow$
  leisure is more costly.
  income effect : $\ell \uparrow$ and $C \uparrow$
  higher wage implies higher income.
- Assume that **substitution effect is greater than income effect**. [You may assume **an equal** effect.]
- The new competitive equilibrium to point E. Consumption increases from C_1 to C_3 while leisure decreases from ℓ_1 to ℓ_3.
- This means that wage increases for all N , ℓ
- [You may separate income effect and substitution effect by drawing an imaginary PPF, the same way as stated in the book]
- **[**You may draw a graph to indicate labour market equilibrium**]**
- [You may explain the chain effect]
- There is an increase in future consumption, aggregate output, employment and the real wage. Leisure is decreased.

(c) What does your analysis in parts (a) and (b) have to say about trade offs society makes between the present and the future in investing in education.

- An increase in education leads to an immediate loss in welfare, as both leisure and consumption are reduced (question a). But this is compensated by an increase in future consumption. If education technology is highly effective, it is possible that the economy become much more productive. Future welfare gain from educaiton (question b) could be higher than welfare loss from education (question a). Therefore, whether the policy to invest time in education is worth doing depends on the effectiveness of the education technology and the preferences of households over current and future utility