Ch.7 A Closed-Economy One-Period Macroeconomic Model: Optimizing-agent decision

EE312 Topic 5, 6 (for Section 046402)

Read: Williamson Ch.4 - 5

March 2019

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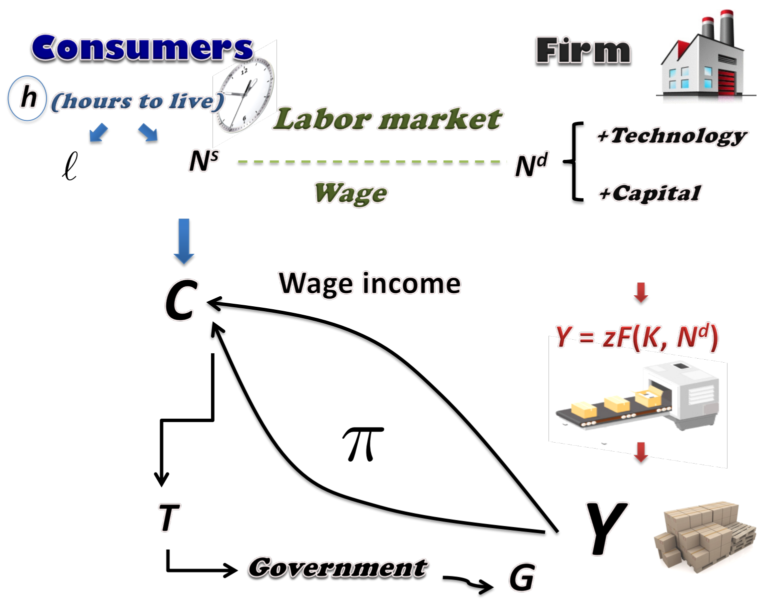
2 One-period decisions

- ptimization by consumers and firms.
- One period decisions; static analysis:
  - Consumers: consumption demand and labor supply.
  - Firms: supply of goods and demand for labor.
  - No investment, no saving.
- Government collects taxes and spends (G = T).
- No foreign trade; a barter economy.
- The foundation of all macro analysis.



3 Consumer: work-leisure decision and labor supply

3.1 Representative Consumer

- Preference over consumption and leisure represented by indifference curves.
- A budget constraint of wage and non-wage incomes.
- Combination of consumption and leisure which maximizes utility, given the budget constraint.
- Effects of an increase in non-wage income and the real wage rate.

3.2 The utility function

$$U = U(C, \ell),$$

where U = the utility function;
C= amount of consumption;
ℓ = amount of leisure

$U = U(C1, \ell 1)$.

= level of utility derived from the consumption bundle of C1 and $\ell 1$.

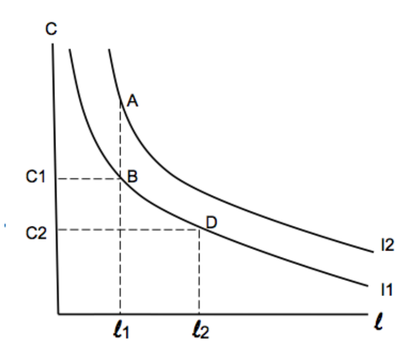
[consumption bundle $(C1, \ell 1)$ is strictly preferred to consumption bundle $(C2, \ell 2)$ if $U(C1, \ell 1) > U(C2, \ell 2)$. consumption bundle $(C2, \ell 2)$ is strictly preferred to consumption bundle $(C1, \ell 1)$ if $U(C2, \ell 2) > U(C1, \ell 1)$. and the consumer is indifferent between the two consumption bundles if $U(C1, \ell 1) = U(C2, \ell 2)$.]

3.2.1 Properties of consumer preference

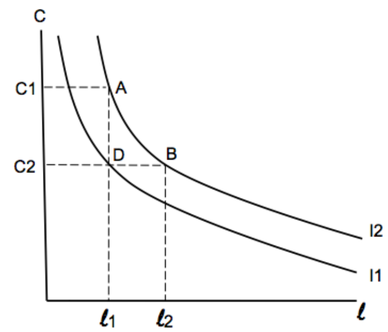
- **'More is preferred to less.'**
  - If $U(C2, \ell 2) > U(C1, \ell 1)$, then consumption bundle $(C2, \ell 2)$ is strictly preferred to consumption bundle $(C1, \ell 1)$.
- '**The consumer has preference for diversity in his/her consumption bundle.'**
  - $(C2, \ell 1)$ is preferred to $(C3, 0)$
- **'Consumption and leisure are normal goods'**.
  - The consumer will demand more as income increases.

3.2.2 The indifference curves

- The indifference curve (IC) gives different bundles of the two goods which the consumer is indifferent (equal utility).
  - (1) 'More is preferred to less.': ICs slope downwards.
  - (2) 'Preference for diversity': ICs are convex towards the origin.
- The indifference map: a set of ICs for the representative consumer.



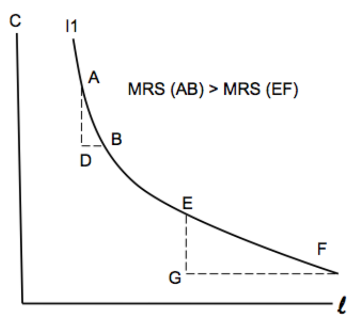
- A is strictly preferred to B.
- The consumer is indifferent between B and D.



(1) "More is preferred to less"

- If C1 (at A) drops to C2 with the same $\ell 1$, the consumer is on a lower I1.
- To get the initial I2 (with the same C2, raise $\ell 1$ to $\ell 2$ (at B).
- Same C, more ℓ is preferred.
- Same ℓ, more C is preferred.

- ***Marginal rate of substitution (MRS)***
  - The marginal rate of substitution of leisure for consumption ($MRS_{\ell,C}$) is the rate at which the consumer is willing to substitute leisure for consumption goods.
  - The slope of the IC passing through a given (C, ℓ).
  - Willingness to sacrifice given consumption for more leisure.
  - $MRS_{\ell,C}$ is decreasing as the consumer moves from consumption to more leisure.



(2) "Preference for diversity"

- From A to B, a small amount of L (BD) is needed for a given sacrifice (AD) of C to make the consumer indifferent.
- From E to F, larger leisure (FG) is needed for the same (EG=AD) amount of consumption.

3.3 Consumer's budget constraint

- The consumer is subject to competition.
  - The consumer is a price-taker.
  - The market prices are given.
  - Individual action has no influence on the market price.
- The consumer allocates time between leisure and work.
  - He/She receives wages from work and non-wage incomes from non-labor services.

3.3.1 The consumer's time constraint

h = hours of time available;
ℓ= time allotted to leisure;
N^S= time spent working (labor supply)

$$\ell + N^s = h$$

3.3.2 Real disposable income

$$Y^d = WN^S + \pi - T$$

- The real disposable income is the sum of wage and dividend incomes minus taxes.
  - Y^d = Disposable Income
  - W= the real wage in the units of consumption goods;
  - π= real dividend income (profits) in the unit of consumption goods received from the firm;
  - T = a lump-sum tax.

3.3.3 The consumer's budget constraint

- The consumer's disposable income is spent on consumption goods.
- Disposable income (Y^d) = consumption expenditure (C);

$$C = wN^S + \pi - T$$

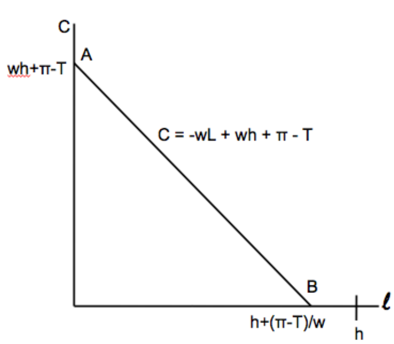
$$C = w(h - \ell) + \pi - T$$

$$C = w(h - \ell) + \pi - T$$

$$C = -w\ell + wh + \pi - T$$

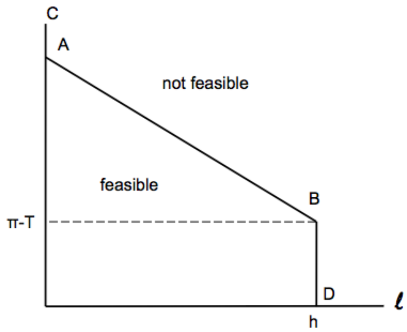
$$C + w\ell = wh + \pi - T$$

- The implicit real disposable income ($wh + \pi - T$) is split into expenditures on consumption goods and leisure ($C + w\ell$).
- W = the market price of leisure.
- The slope = – w; the intercept = ($wh + \pi - T$)



(1) The budget constraint ($T > \pi$)

- AB = the budget line.
- The vertical intercept is ℓ = 0;
- The horizontal intercept is C = 0. Slope = -w

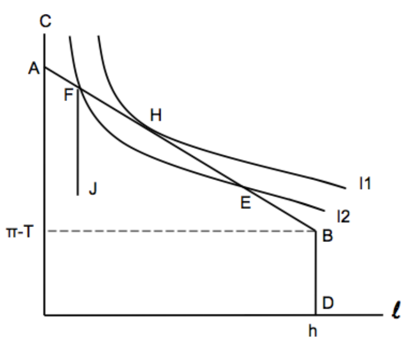


(2) **The budget constraint** ($T < \pi$)

- The budget line is kinked at B.
- Along BD, works = 0;
- $\ell = h$, and $C \geq \pi - T > 0$.

3.4 Consumer optimization

- The consumer is rational.
  - Knowledge of his/her own preferences and budget constraint.
  - Combination of consumption and leisure (consumption bundle) which maximizes utility.
- The consumer chooses the consumption bundle that is on his/her highest indifference curve subject to his/her budget constraint.



- H = optimal consumption bundle;
- E and F are feasible but not optimal.

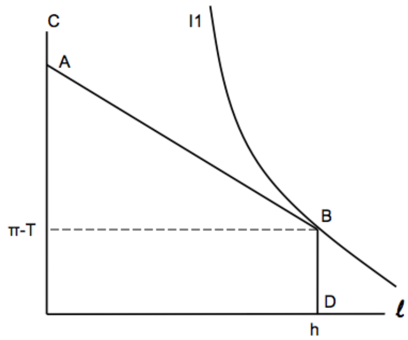
(J lies inside the budget constraint.
Point F is clearly preferred by consumer to J.)

- Optimization condition
  - The rate of marginal substitution of leisure for consumption is equal to the real wage.
  - The real wage is the relative price of leisure in terms of consumption goods.

$$MRS_{\ell,C} = w$$

Marginal Rate of Substitution of leisure for consumption = the real wage

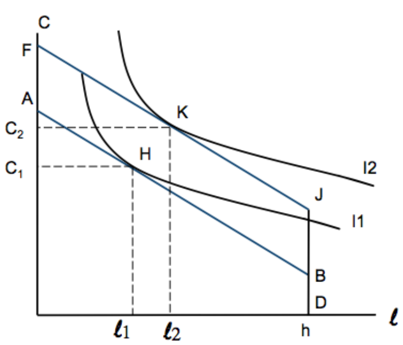
- Corner solution



- The consumer chooses not to work at B.
- $\ell = h$
- This is a situation that cannot happen, taking into account consistency the actions of the consumer and of firms.
- "A rentier is a person or entity that receives income derived from economic rents, which can include income from patents, copyrights, brand loyalty, real estate ..."

- Corner solution: impossible
  * The consumer may choose not to work and consume only leisure.
  * Impossible solution:
    · No labor service to the firm, no incomes.
    · No production by the firm, no consumption goods.
    · The consumer's preference for diversity.
  * Real life? Consumers do not repeat their mistakes.

- Changes in dividends or taxes
  - Assuming consumption and leisure are both normal goods.
  - An increase in dividends or a decrease in taxes $(\pi - T)$
  - causes the consumer to increase both consumption and leisure (and to reduce the quantity of labor supply).
  - The pure income effect.



An increase in π−T

- An increase in π−T (by JB) causes the consumer to increase both C and L.

- A higher π−T raises C and ℓ

$$\pi\uparrow \searrow \quad (\pi - T)\uparrow \;\rightarrow\; Y^d\uparrow \text{ (implicit)} \nearrow C\uparrow$$
$$T\downarrow \nearrow \qquad\qquad\qquad\qquad \searrow \ell\uparrow$$
$$\ell\uparrow \;\downarrow\; (h-\ell)\downarrow \;\leftarrow\; N^s\downarrow$$

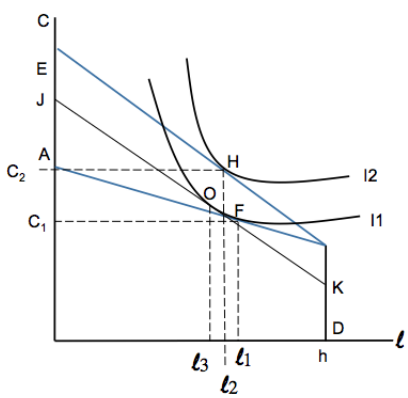
An increase in the market real wage

- **Substitution effect**: an increase in the real wage (the price of leisure) causes the consumer to substitute consumption for leisure.
- **Income effect**: the consumer's income increases, causing both consumption and leisure to increase.
- Consumption increases, but leisure may rise or fall.

  A higher wage raises C

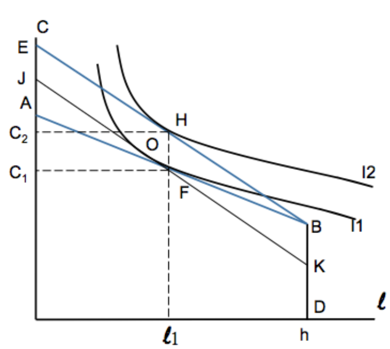
$$w\uparrow \begin{cases} \nearrow & \begin{array}{l}\text{income effect}=C\uparrow \\ \text{substitution effect}=C\uparrow\end{array} \Rightarrow C\uparrow \\ \searrow & \begin{array}{l}\text{income effect}=\ell\uparrow \\ \text{substitution effect}=\ell\downarrow\end{array} \Rightarrow \ell ? \end{cases}$$

$$w\uparrow \begin{cases} \nearrow & \begin{array}{llll}\text{income effect}=\ell\uparrow & < & \Rightarrow & \ell..... \\ \text{substitution effect}=\ell\downarrow & & \Rightarrow & (h-\ell)..... \\ \text{[Stronger Substitution Effect]} & & \Rightarrow & N^s......\end{array} \\ \searrow & \begin{array}{llll}\text{income effect}=\ell\uparrow & > & \Rightarrow & \ell..... \\ \text{substitution effect}=\ell\downarrow & & \Rightarrow & (h-\ell)..... \\ \text{[Stronger Income Effect]} & & \Rightarrow & N^s......\end{array} \end{cases}$$



Stronger substitution effect

- Substitution effect = FO.
- Income effect = OH.
- FO > OH, C increases and ℓ decreases.
- So N increases.



Equal effect

- Substitution effect = FO.
- Income effect = OH.
- FO = OH, C increases; but ℓ (and N) is the same.

3.5 The labor supply function

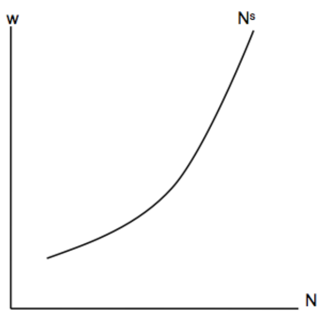
- $\ell(w)$ is a function that tells us how much leisure the consumer wishes to consume, given the real wage rates.
- Then, the labor supply curve is given by

$$N^S(w) = h - \ell(w)$$
$$\frac{\partial N^S}{\partial w} > 0$$

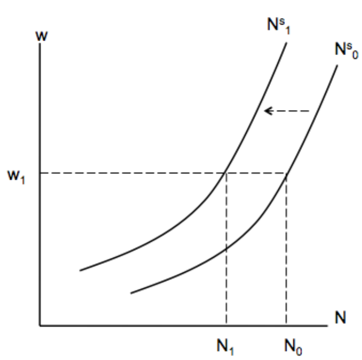
- $N^S =$ the labor supply function
- h = the maximum hours avaiable
- $\ell(w)$ = the leisure function, given the real wage. Assuming the stronger substitution effect.

[We typically assumes that the substitution effect of an increase in real wage dominates the income effect, so that the labor supply curve is upward-sloping.]

The labor supply curve



- The quantity of labor supply is a positive function of the real wage.
- Assuming the stronger substitution effect.



Effect of an increase in $(\pi - T)$.

- A rise in $(\pi - T)$ causes the consumer to reduce labor supply, given the real wage (positive income effect).

4 Firm: profit maximization and labor demand

4.1 Representative firm

- The firm demands labor and supplies consumption goods.
  - Source of wage and dividend incomes for the consumer.

- The production function combines labor service to produce consumption goods.

- Profit maximization and labor demand function.

4.2 The firm's production function

$$Y = zF(K, N^d)$$

where:

- Y = output of consumption goods;
- K = capital input;
- N^d= labor input (hours);
- z = total factor productivity (TFP).

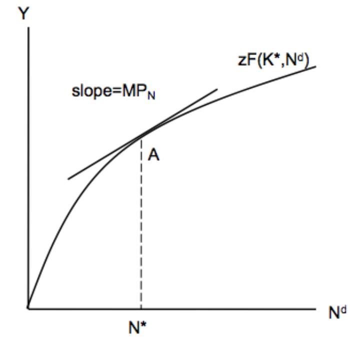
4.2.1 Total factor productivity (TFP)

- z = the degree of sophistication of the production process.
- A production function with the same K and Nd as another but with a larger z will produce more output.
  - Production organization;
  - Managerial input;
  - Social and physical infrastructures.

4.2.2 Properties of the production function

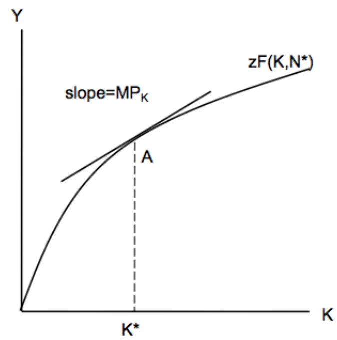
- Constant returns to scale:
  - $zF(xK, xN^d) = xzF(K, N^d)$
  - Increase each input by x times will raise the total output by x times.
- Output increases if either labor or capital increases.
  - $MP_N = \frac{\partial Y}{\partial N^d} > 0$;
  - $MP_K = \frac{\partial Y}{\partial K} > 0$.
  - Upward slope of the production function.
- The marginal product of labor (MP_N) decreases as the labor input increases, given the capital input.
  - The production function is concave; the slope is decreasing as output increases.
- The marginal product of capital (MP_K) decreases as the capital input increases, given the labor input.

- The marginal product of labor increases as the quantity of the capital input increases.



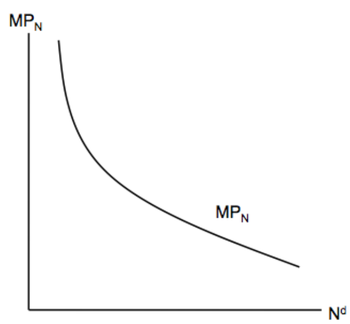
Production function, fixed capital

- The slope at A is MP_N when N = N*.
- MP_N is falling as the labor input increases, given the capital input.



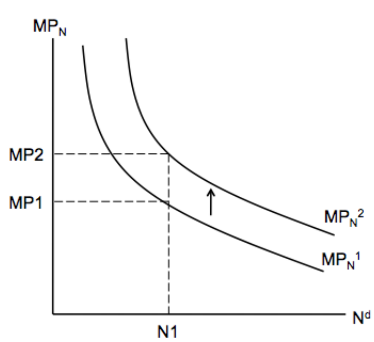
Production function, fixed labor

- The slope at A is MP_K when K = K*.
- MP_K is falling as the capital input increases, given the labor input.



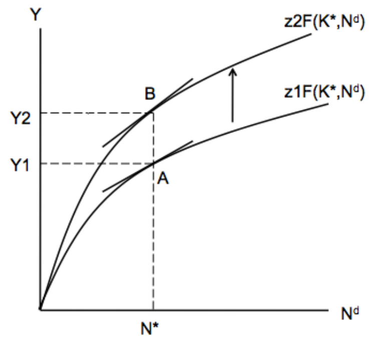
Marginal Product of Labor (MP_N)

- The marginal product of labor decreases as the labor input increases.
- Downward slope MP_N.



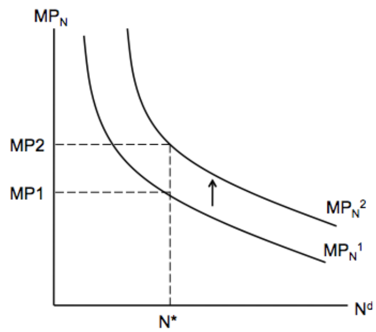
MP_N **increases as K increases.**

- The marginal product of labor increases as the capital input increases.



Increases in total factor productivity (z)

- An increase in z causes MP_N and output (Y) to rise at N^*.

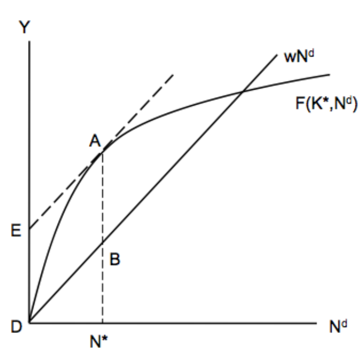


Effect of rising z on MP_N

- An increase in z causes MP_N at N^* to rise.

4.2.3 The firm's profit maximization

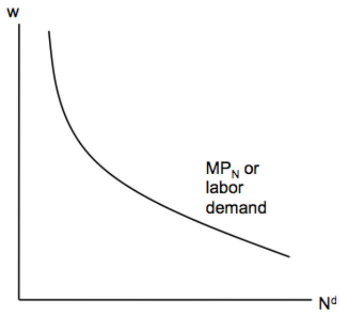
- Y = total revenue = $zF(K, N^d)$;
- wN^d = total variable cost;
- $\pi = zF(K, N^d) - wN^d$
- Maximized profit where
  - Slope of Y = slope of wN^d;
  - MR = MC
  - $MP_N = w$ or the firm's labor demand function.
  - The MP_N is the firm's labor demand curve.



Profit Maximization

- Y = revenue;
- MP_N = marginal revenue;
- wN^d = variable cost;
- w = marginal cost;
- Profit = $Y - wN^d$;
- Max profit = AB where $MP_N = w$.

4.2.4 The firm's labor demand curve



- Profit-max: the firm hires labor up to the point where $N^d = w$.

Labor input (workers)	Total product (number of goods)	Marginal product of labor
0	0	—
1	9	9
2	17	8
3	22	5
4	25	3
5	26	1

5 Government Sector

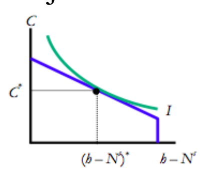
- The only action of the government is to implement "fiscal policy".
- Fiscal policy refers to the government's choices over its expenditures, taxes, transfers and borrowing.
- Suppose the government wishes to purchase a given quantity of consumption good, G.
- Since there is only one period, the government cannot borrow to finance G.
- Thus G is paid by taxing the representative consumer.
- The government must observe the **balanced budget constraint**, G = T.
- G is exogenous.
- Exogenous variables: values are determined outside the model.
- Endogenous variables: values are determined inside the model.

6 Competitive equilibrium and Pareto Optimality

6.1 Competitive Equilibrium

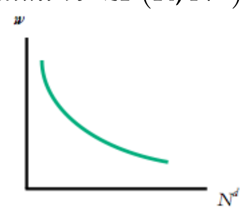
- The values of endogenous variables (C, Y, N^d, N^S, w, T). at which, given z, K and G:
  - The representative consumer chooses C and N^s so that utility is maximized, given w, T and π.
  - The representative firm chooses Y and Nd so that profit is maximized, given w, z and K.
  - Competitive refers to the fact that all consumers and firms are price-takers.
  - Equilibrium refers to the state when the actions of all consumers and firms are consistent.
  - The labor market clears: $N^d = N^s$..
  - The government budget constraint: G = T.

1. C and N^S solves the consumer's problem. $maxU(C, \ell)$ subject to $C = N^s w + \pi - T$.



$MRS_{\ell,C} = w, \; N^S = h - \ell$

2. N^d solves the firm's problem given z , K and w.
$max \; \pi = zF(K, N^d) - wN^d$



$MP_N = w \Rightarrow N^d = MP_N = w$

3. Labor Market Clears: $N = N^S = N^d$

4. Good Market Clears: $Y = C + G$

5. Government balance budget constraint: $G = T$

Income-expenditure identity

$$Y = C + G$$

- In a competitive equilibrium, the goods market clears:
  Y = total output or income; C = consumption expenditure; G = government expenditure.
  The consumer's budget constraint

$$\begin{aligned} C &= N^s w + \pi - T \\ \text{as } \pi &= Y - wN^d \\ G &= T \\ C &= N^s w + \pi - G \end{aligned}$$

- In equilibrium, $N^S = N^d$ and the equation is reduced to Y = C + G.

- **Step 1:** Derive the production possibilities frontier (PPF), which describes the technological possibilities for the entire economy, in terms of the production of C and l.

  Production Function : $Y = zF(K, N^d)$

  Economy produces 2 goods : Consumption Goods (Y) and Leisure (ℓ)

  $\ell \downarrow \Rightarrow N \uparrow \Rightarrow zF(K,\ N) \uparrow \rightarrow Y \uparrow$.

  There is a trade-off between leisure and consumption goods. **PPF** (Y, ℓ) slopes downward

  $MP_N \downarrow$ as $N \uparrow$. PPF is concave to the origin.

  $Y = C + G$; $G =$a constant, exogenously given

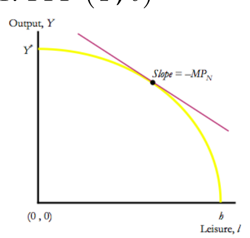
  $C = Y - G. \Rightarrow$ **PPF** $(C, \ell\ )$

- **Step 2:** Put the **PPF** $(C, \ell\ )$ **together with the consumer's indifference curves**, so that we can analyze a competitive equilibrium in a single diagram.

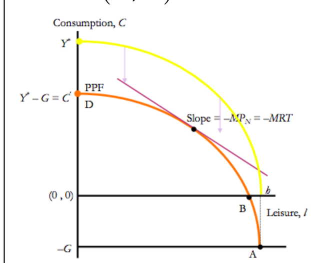
  Consumer optimization : $U(C, \ell)$, $MRS_{\ell,C} = w$

  $MRS_{\ell,C} = w = MP_N$

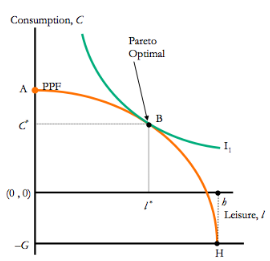
1. PPF (Y, ℓ)



2. PPF $(C,\ \ell)$



3. Put the PPF $(C, \ell\ )$ together with the consumer's indifference curve.

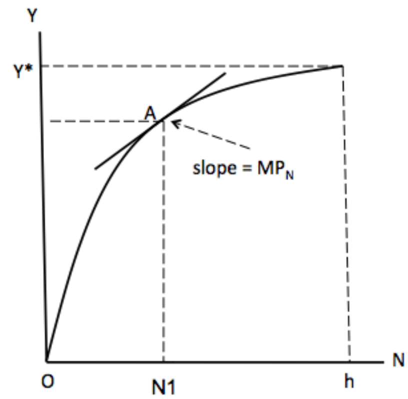


6.1.1 Step 1 : Derive the production possibilities frontier (PPF), which describes the technological possibilities for the entire economy

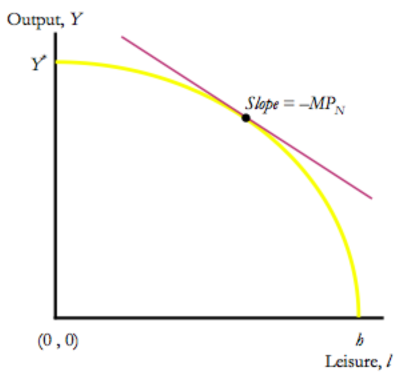
The production function

$$Y = zF(K, N)$$

- In equilibrium, $N = h - \ell$, so: $Y = zF(K, h - \ell)$



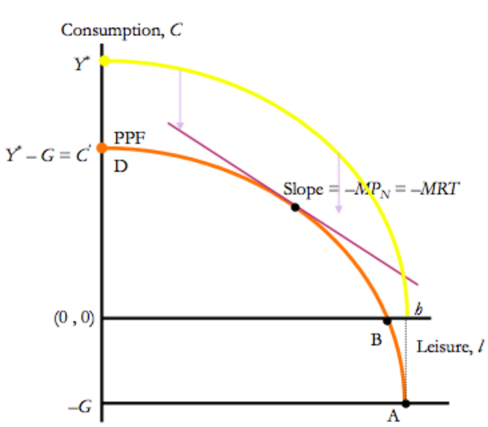
- Y = zF(K, N).
- h = maximum labor supply available.
- ON1 = labor input.
- N1h = leisure.



Output as a function of leisure

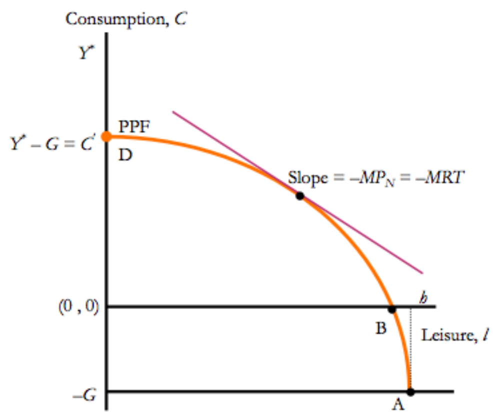
- In equilibrium, we have $N^d = N^s = N = h - \ell$.
- Y = zF(K, h-ℓ), which is a relationship between output and leisure.
- Y* is the level when l = 0, and it is the maximum output level.
- Y* = zF(K , h)
- The relation between Y and L is a mirror image of the production function with slope = - MP_N.

- Y = C + G.
- So, In equilibrium, C = Y – G = $zF(K, h - \ell)$ – G.
- The equation shows a relationship between C and ℓ, given the exogenous variables z , K and G.
- Total output is deducted by G to give the net amount available for consumption — the PPF.
- This is the PPF which captures the trade-off between leisure and consumption given the production technology.
- Graphical Illustration, next page.



Production Possibility Frontier

- PPF gives the trade-off between consumption and leisure, given technology.
- DB is feasible ($C \geq 0$); AB is not feasible (C is negative).

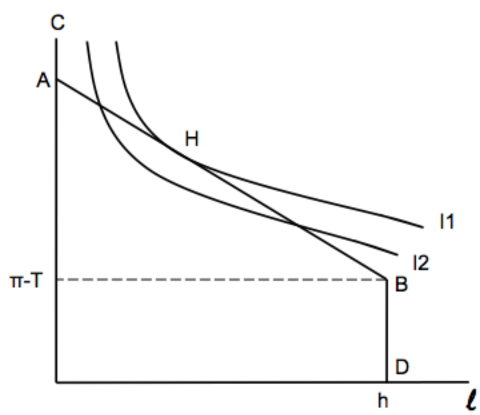


- The slope of PPF is **the marginal rate of transformation (MRT)** of ℓ to C, the rate at which leisure is converted to consumption through work, given technology.

$$MRT_{\ell,C} = MP_N = -\text{slope of PPF}$$

- This helps us determine the equilibrium values C* and ℓ*.

6.1.2 Step 2. Put the PPF $(C, \ell\,)$ together with the consumer's indifference curves



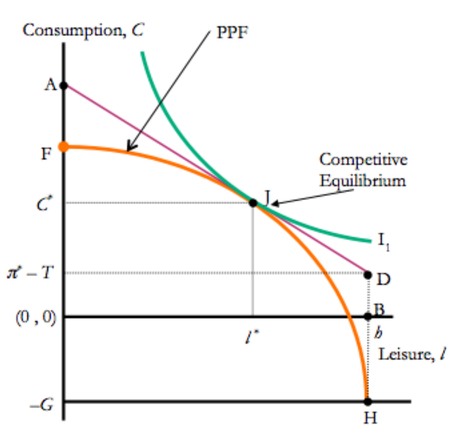
The consumer's max. utility

- The consumer trades off between C and ℓ, given w.

PPF and the Consumer

- The firm chooses the point on PPF which maximizes profits. $MRT_{\ell,C} = MPN = w$.
- The consumer's budget constraint has a slope $MRS_{\ell,C} = -w$.
- That point is on the firm's PPF and on the consumer's budget constraint — tangent point.
- In equilibrium, C* and ℓ * are chosen by the representative consumer.

Competitive equilibrium



The consumer's max. utility

- Note that ADB is the budget constraint.
- J is the equilibrium consumption bundle (C*, ℓ*) where

$$MRS_{\ell,C} = w$$

- In equilibrium,

$$\begin{aligned} MP_N &= w = MRT_{\ell,C} \\ &= MRS_{\ell,C} \end{aligned}$$

- The firm and the consumer both optimize at J.

Properties of competitive equilibrium

- The values of C, Y, N^d, N^s, , w and T at which, given z, K and G:
- The representative consumer chooses C and N^s so that utility is maximized, given w, T and π.
- The representative firm chooses Y and N^d so that profit is maximized, given w, z and K.
- The labor market clears: $N^d = N^s$. The government budget constraint: G = T.

The firm's optimization

- The firm maximizes profits at J, given technology: $MP_N = w = MRT_{\ell,C}$ = slope of the budget line AD.
- The firm pays the real wage = w = the real wage received by the consumer.
- The firm demands labor equal to $h - \ell^*$ and produces $Y* = zF(K, h - \ell)$.
- Max. profit: $\pi^* = zF(K, h - \ell) - w(h - \ell^*) = DH$.
- DB = $\pi^* - G = \pi^* - T$.

The consumer's optimization

- The consumer maximizes utility at J subject to the budget constraint:
- ADB is the budget constraint; the slope = –w.
- DB = the consumer's dividend income minus taxes = $\pi^* - T = \pi^* - G$ = the firm's max. profit minus G.
- C* = consumption goods demanded by the consumer = quantity of consumption goods produced by the firm.
- h-ℓ* = quantity of labor supplied by the consumer = quantity of labor demanded by the firm;
- ℓ*= leisure desired by the consumer.
- Point J on AD is also tangent to the consumer's highest indifference curve where $MRS_{\ell,C} = W$.

Equilibrium in production and consumption
$MRS_{\ell,C} = w = MRT_{\ell,C} = MP_N$

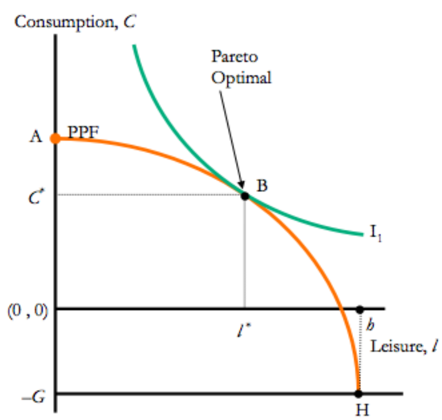
- A competitive equilibrium is achieved when both the consumer and the firm optimize, given z, G and K.
- The real wage (w) is the price signal for both parties to adjust and achieve a simultaneous equilibrium.

6.2 Pareto optimality

- Questions: *Is the competitive equilibrium efficient? Are there any other ways to obtain a better outcome?*
- A competitive equilibrium is **Pareto optimal** if there is no way to rearrange production or to reallocate goods so that someone is made better off and no one is made worse off.
- Since there is only one consumer, we can ignore how consumption goods are allocated among consumers.
- Rather, we focus on how production is arranged.
- An allocation of C, ℓ (and Y) at which an increase in the utility of one agent cannot be made without reducing the utility of another agent.
- The maximum efficiency is achieved as the competitive outcome.

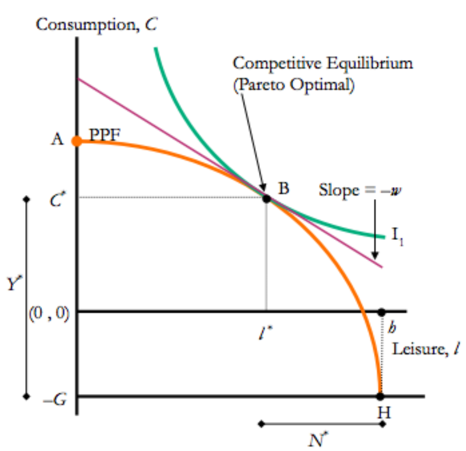
$$MRS_{\ell,C} = w = MRT_{\ell,C} = MP_N$$

6.2.1 Social Planner's Problem



- Consider a social planner who runs the representative firm and chooses the quantities C and ℓ so as to maximize consumer's utility.
- Graphically, the social planner chooses a consumption bundle that is on the PPF and is on the highest possible indifference curve for the consumer.

6.2.2 Comparison between Social Planner's solution and Competitive Equilibrium



- Comparison:
  - Representative consumer faces a linear or kinked budget constraint.
  - Social planner faces a concave PPF.
- The Pareto optimum is at B where the equality holds

$$MRS_{\ell,C} = MRT_{\ell,C} = MP_N$$

- Note that we have the same condition for a competitive equilibrium.

6.2.3 Fundamental theorems in welfare economics

- Assuming convex and monotone preferences and technologies.
  - **First welfare theorem**:
    - Under certain conditions, a competitive equilibrium is Pareto optimal. Competition results in a socially efficient outcome.
    - Adam Smith's 'the Wealth of Nations' (1776).

    A competitive market economy with self-interested consumers and firms could achieve the allocation of resources and goods which is socially efficient.

    Competition is 'the invisible hand' which guides individuals to act in the way which benefit both themselves and society.
  - **Second welfare theorem**:
    - Under certain conditions, a Pareto optimum is a competitive equilibrium
- Remark: Pareto optimality ignores the distribution issue among individuals and is thus a narrow concept of social optimality.

6.3 Sources of Social Inefficiencies

A competitive equilibrium may not be Pareto optimal due to:

- **Externalities**
  - An externality is any activity for which an individual firm or consumer does not take account of all associated costs and benefits.
  - All the benefits or costs are not captured by the price of the goods.
  - Positive externalities: social benefit > private benefit (e.g., education, innovation, health care).
  - Negative externalities: social cost > private cost (e.g., pollution, noise).
  - The root cause of an externality is that it is too costly, if not impossible, to set up a market to trade for the benefits and costs associated with the externalities (Market Failure).
- **Distorting taxes**, e.g., proportional income tax (t) on wages:

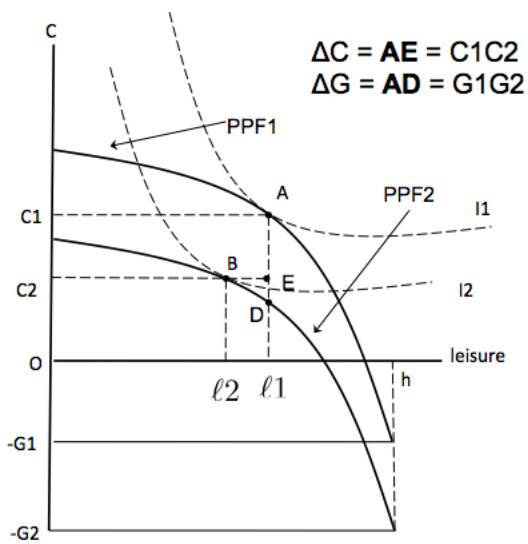
$$W(1-t) = MRS_{\ell,C} < MP_N = MRT_{\ell,C}$$

- **Imperfect competition**: firms which are not price-takers.
  - Undersupply of the goods: P > MR = MC.
- But government intervention to solve market failure may make the inefficiency worse.
- **The competitive model** is still very powerful.
  - A large number of real-world markets are close to perfect competition.
  - Benchmark for analysis of inefficiency and possible private solutions.

7 Model Applications

7.1 Effects of an increase in G

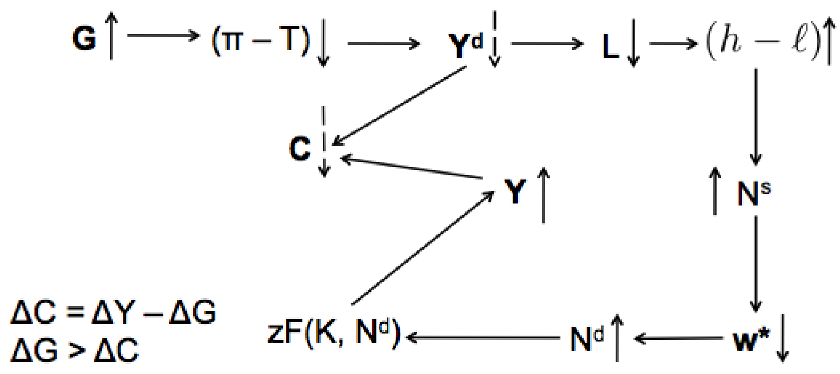
- Dividend income $(\pi - T)$ and disposable income fall;
- C and ℓ decrease (normal goods).
- Employment (N = h-ℓ) increases.
- Output Y = zF(K,N) rises;
- C increases.
- $\Delta C = \Delta Y - \Delta G$; C does not drop as much as ΔG.
- Private consumption is partially **crowded out** by the increase in G, but not completely.



- Consider an ↑ in G from G_1 to G_2 .
- Since G = T, G ↑ must be followed by T ↑ of the same amount.
- G ↑, the PPF shifts from PPF_1 to PPF_2.
- This shift leaves the slope of the PPF constant for each ℓ.
- The new Pareto optimum is at B.
- Thus, G ↑ leads to a negative income effect on C and ℓ.

- $G \uparrow \Rightarrow C \downarrow$
  - Private consumption is **crowded out** by government purchases.
  - The decrease in C is smaller than the increase in G.
- $\ell \downarrow \Rightarrow N \uparrow \Rightarrow Y \uparrow \Rightarrow w \downarrow$
- What happens to the real wage?
  - The slope of PPF_2 at B is less steep than PPF_1 at A.
  - So the real wage fall. The consumer supplies more labor (N=h-ℓ increases).
  - Given K, more labor input causes MP_N to fall.
  - The firm optimizes by paying lower $w = MP_N$.
  - The lower real wage (w) induces the firm to raise employment (N).
- The consumer works more, receives a lower real wage and consume less.

- Higher G crowds out C.



- Note on business cycle :
- Model prediction

  $G \uparrow \quad \Rightarrow \quad Y^{*}$.......

N^{*}.......	procyclical
w^{*}.......	countercyclical
C^{*}.......	countercyclical

  - facts

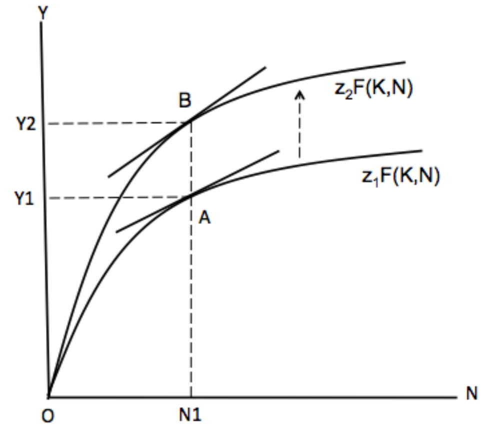
    $Y^{*} \uparrow$

$N^{*} \uparrow$	procyclical
$w^{*} \uparrow$	procyclical
$C^{*} \uparrow$	procyclical

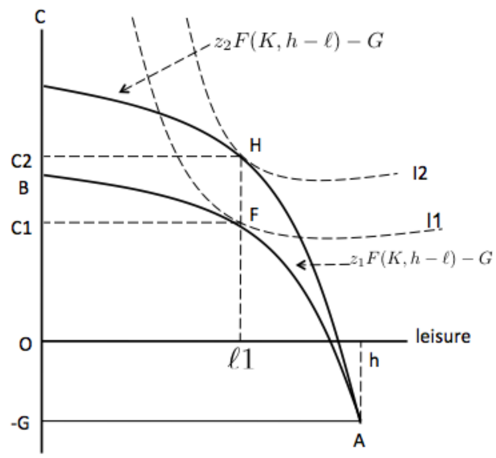
  - Therefore, it is unlikely that governement spending is the primary cause of business cycle fluctuation.

7.2 Effects of an increase in z (or K)

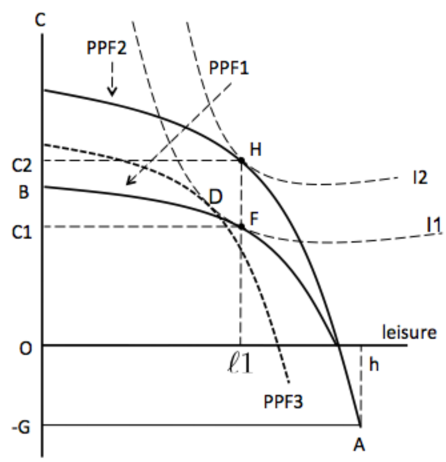
- Increases in z = better technology or organization.
  - The production function and PPF rotate upwards.
  - Higher MP_N, given N with better technology. More demand for labor by the firm. The real wage increases ($MP_N = w$). Employment and leisure ($N = h - \ell$) may rise or fall.
- Output and consumption increase, given G (Y ↑ = C↑ + G); higher social welfare.



- The production function rotates upwards with higher MP_N, given N.
- Not only more Y can be produced given N, but the MP_N i.e. the slope of the production function also increases for each N.
- In next page, we see that the new PPF is steeper than the original one.

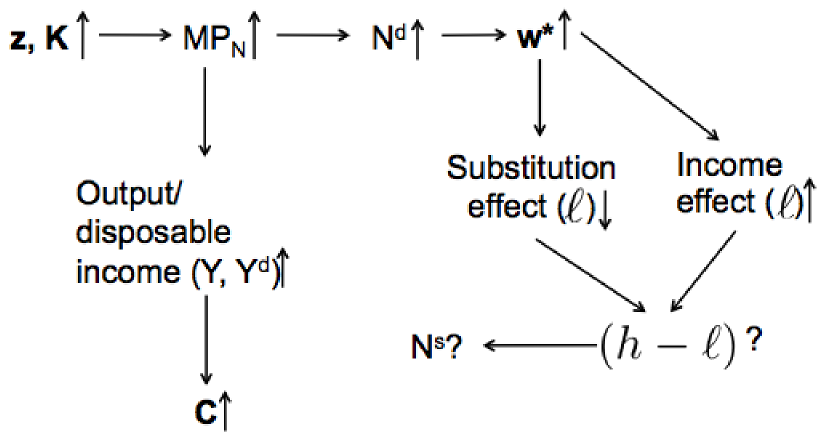


- The PPF rotates upwards.
- C, Y, MP_N and w increase. N and ℓ may rise or fall.



- FD = substitution effect (rising C and N, falling ℓ).
- DH = income effect (rising C and ℓ).
- Equal effects: no change in ℓ and N.

A higher z or K raises w, Y, C



If SE = IE, N^s ....
If SE > IE, N^s ....
If SE < IE, N^s ....

"tells a story about the long-term economic effects of long-run improvement in technology, such as that have occured in the United States since WWII. ... some keys observations from post-WWII US data are that aggregate output has increased steadily, consumption has increased, the real wage has increaed, and the hours worked per employed person has remained roughly constant."

- **Note on business cycle** :
  - Model prediction : assuming a stronger substitution effect or equal effect

$z \uparrow \quad \Rightarrow \quad Y^*$.......

N^*....... procyclical(SE....IE) ,uncertain (SE....IE)
w^*....... procyclical
C^*....... procyclical

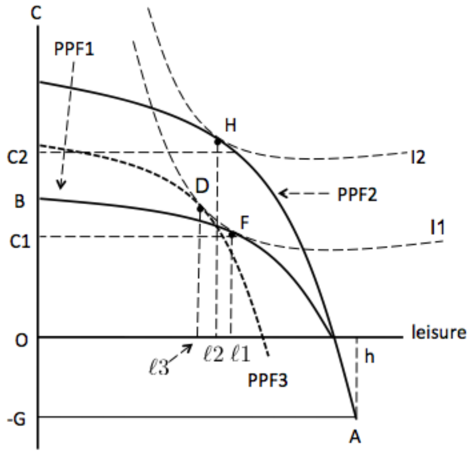
  - facts

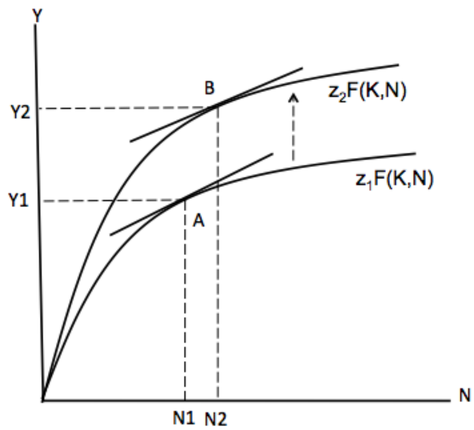
$Y^* \uparrow$

$N^* \uparrow$ procyclical
$w^* \uparrow$ procyclical
$C^* \uparrow$ procyclical

  - Therefore, fluctuations in total factor productivity could be the primary cause of business cycle.

Stronger substitution effect





- FD = substitution effect (rising C, falling ℓ).
- DH = income effect (rising C and ℓ).
- Lower ℓ and larger N.