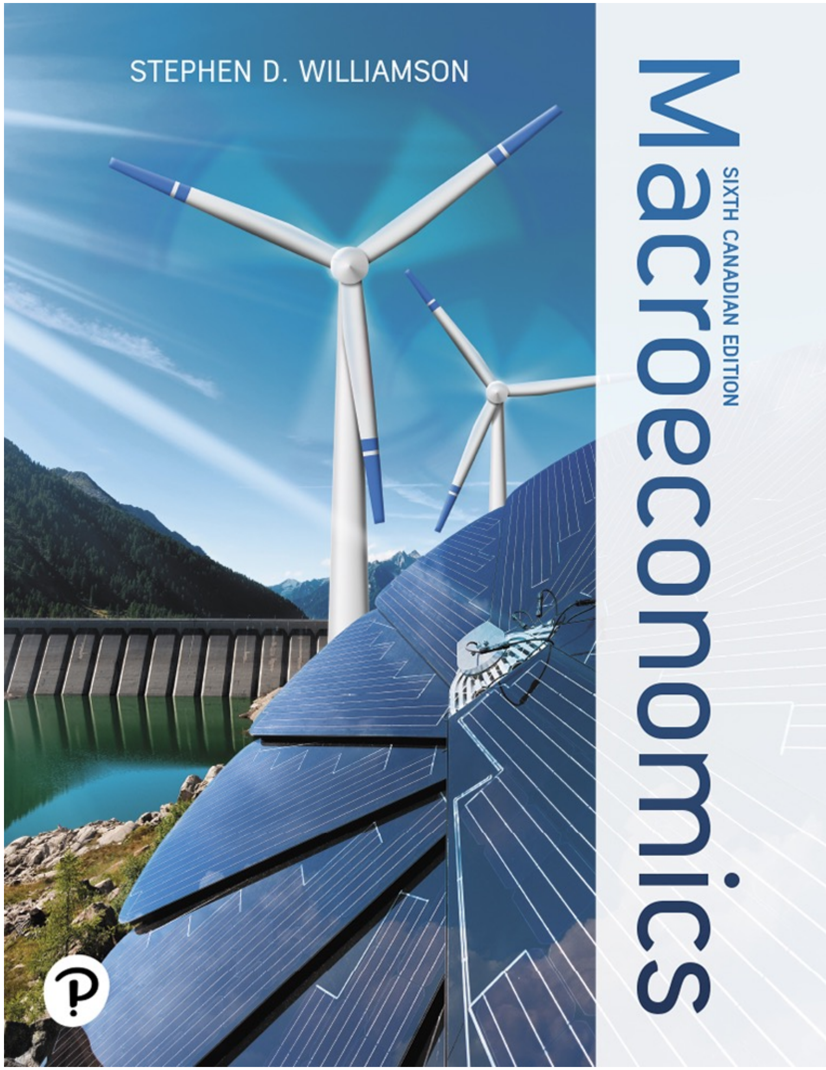
Macroeconomics

Sixth Canadian Edition



Chapter 5

A Closed-Economy One-Period Macroeconomic Model

Pearson

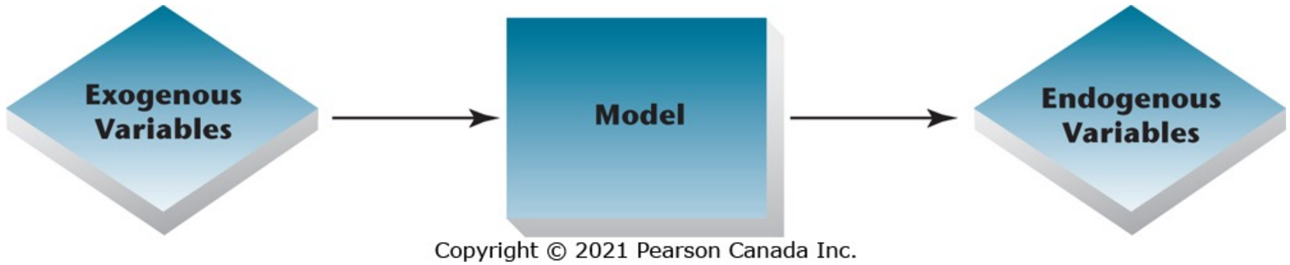
Outline

- Introduce the government. $Y = C + G$, but still one-period model
- Construct closed-economy one-period macroeconomic model, which has: (i) representative consumer; (ii) representative firm; (iii) government.
- Economic efficiency and Pareto optimality.
- Experiments: Increases in government spending and total factor productivity.
- Consider a distorting tax on wage income and study the Laffer curve.

Closed-Economy One-Period Macro Model

- Representative Consumer
- Representative Firm
- Competitive Equilibrium
- Experiments: What does the model tell us are the effects of changes in government spending and in total factor productivity?

Figure 5.1
A Model Takes Exogenous Variables and Determines Endogenous Variables



- Exogenous variables: are determined outside a macroeconomic model. e.g. G, z, and K
- Endogenous variables: given the exogenous variables, the model determines the endogenous variables. e.g. C, N^s, N^d, Y, w, T
- Experiments, we are interested in how the endogenous variables change when there are changes in exogenous variables.
  - For example: the effects of change in government spending on consumption, employment, aggregate output, and real wage.

Competitive Equilibrium

- Consistency means that, given market prices, demand is equal to supply in each market in the economy which refers to as competitive equilibrium.
- Representative consumer optimizes given market prices.
- Representative firm optimizes given market prices.
- The labour market clears; $\underset{\text{supply}}{N^s} = \underset{\text{demand.}}{N^d}$
- The government budget constraint is satisfied, or $G = T$.
- In our model economy:
  - there is only one price, which is the real wage w.
  - there is only one market, in which labour time is exchanged for consumption goods.

Income-Expenditure Identity

- In a competitive equilibrium, the income-expenditure identity is satisfied, so

$$Y = C + G$$

The representative consumer's budget constraint:

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

In equilibrium, dividend income, $\pi = Y - wN^d$

and the government budget constraint is satisfied, $G = T$

then, $C = wN^s + Y - wN^d - G$

In equilibrium, labor market clears, $N^s = N^d$

So, $C = wN^s + Y - wN^s - G$

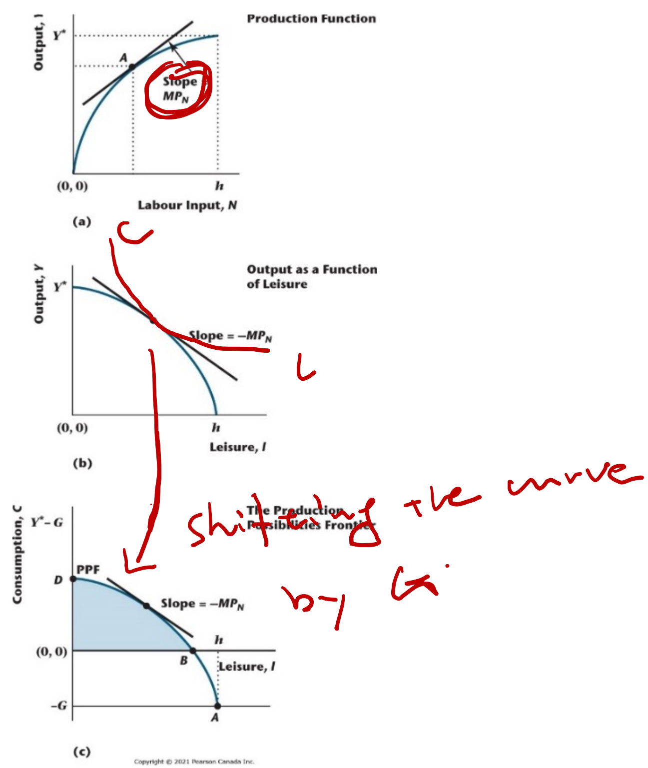
$$Y = C + G$$

The Production Function

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

$C + G = zF(K, N)$

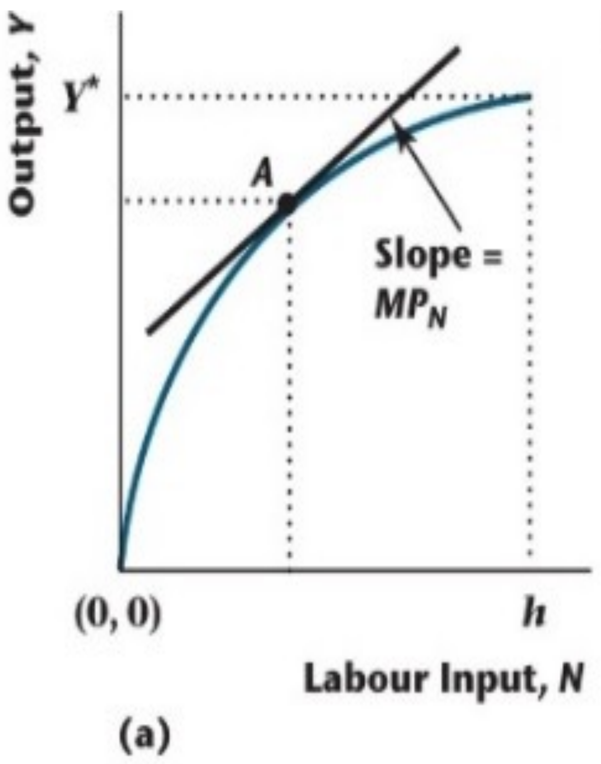
Figure 5.2
The Production Function and the Production Possibilities Frontier



Panel (a) shows the production function of the representative firm, while panel (b) shows the equilibrium relationship between the quantity of leisure consumed by the representative consumer and aggregate output. The relationship in (b) is the mirror image of the production function in (a). In (c), we show the production possibilities frontier (PPF), which is the technological relationship between *C* and *l*, determined by shifting the relationship in (b) down by the amount *G*. The shaded region in (c) represents consumption bundles that are technologically feasible to produce in this economy.

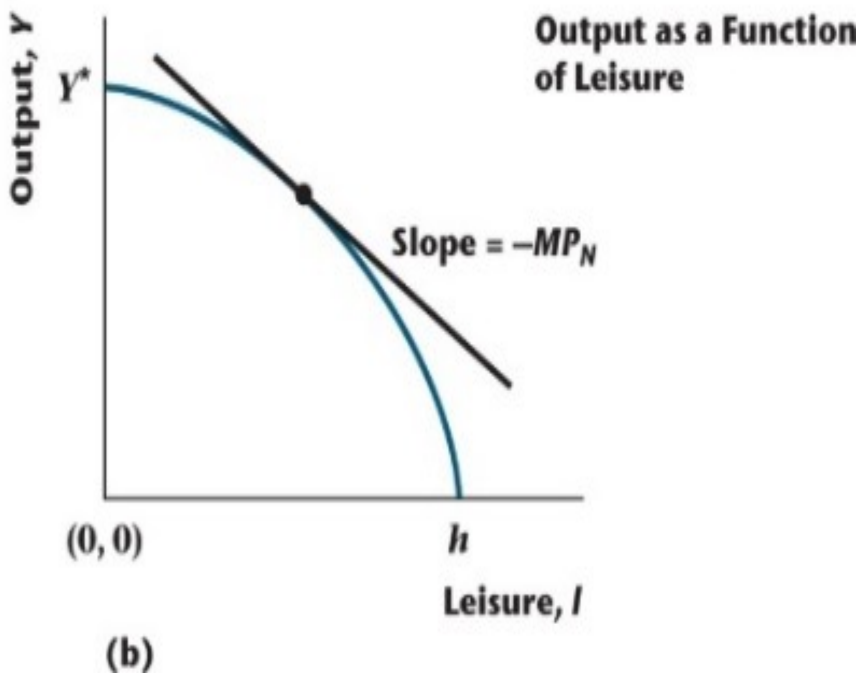
Figure 5.2
The Production Function and the Production Possibilities Frontier

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



- In equilibrium, $N = N^s = N^d$
- Since representative Consumer has a maximum of h hours to spend working, N can be no larger than h, and maximum output that could be produced in this economy is Y^*

Figure 5.2
The Production Function and the Production Possibilities Frontier

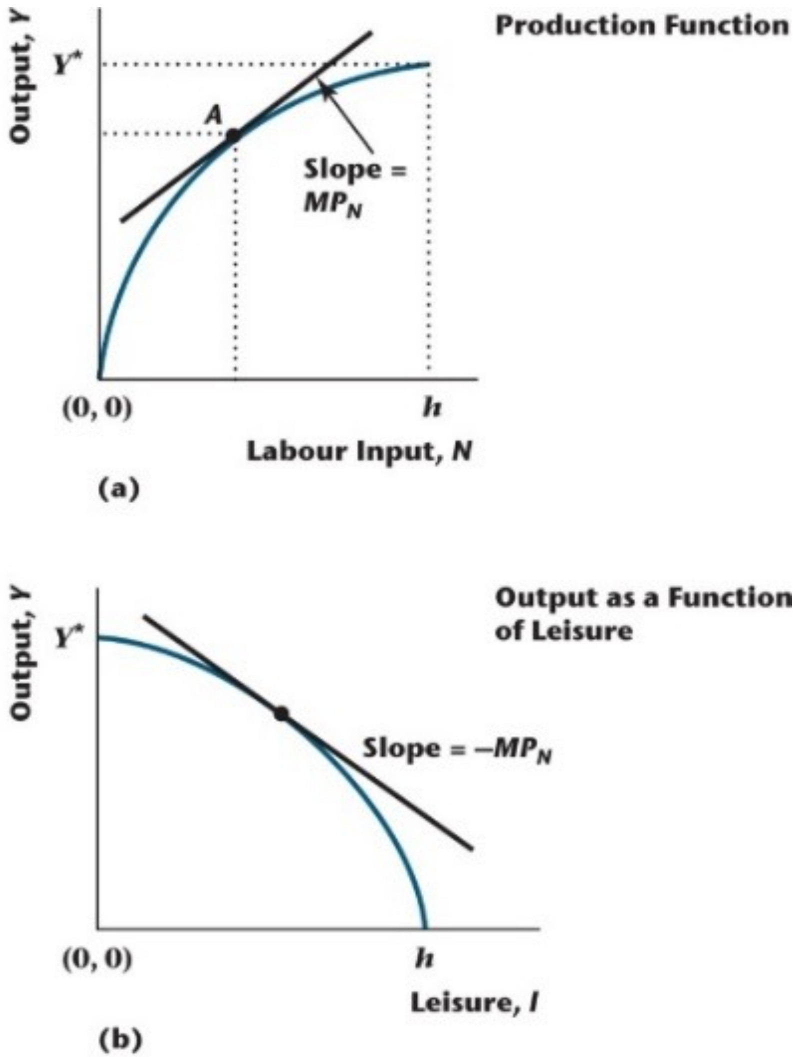


- The equilibrium relationship between the quantity of leisure and aggregate output.
- Substituting for N in the production function:

$$Y = zF(K, h - l)$$

Figure 5.2

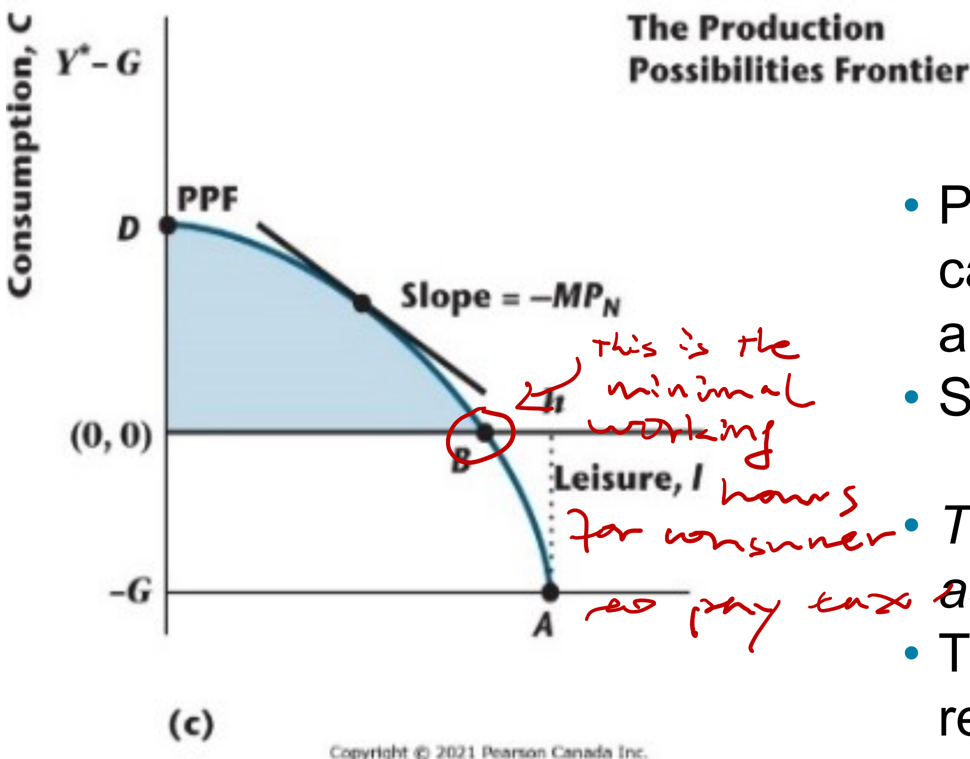
The Production Function and the Production Possibilities Frontier



- The relationship in (b) is the mirror image of the production function in (a).
- If l = h then nothing gets produced and N & Y = 0
- As leisure falls in (b) from h, employment increases in (a) from zero and output increases.
- The slope of production function in (a) is MPN , the slope in panel (b) is -MPN

Figure 5.2

The Production Function and the Production Possibilities Frontier

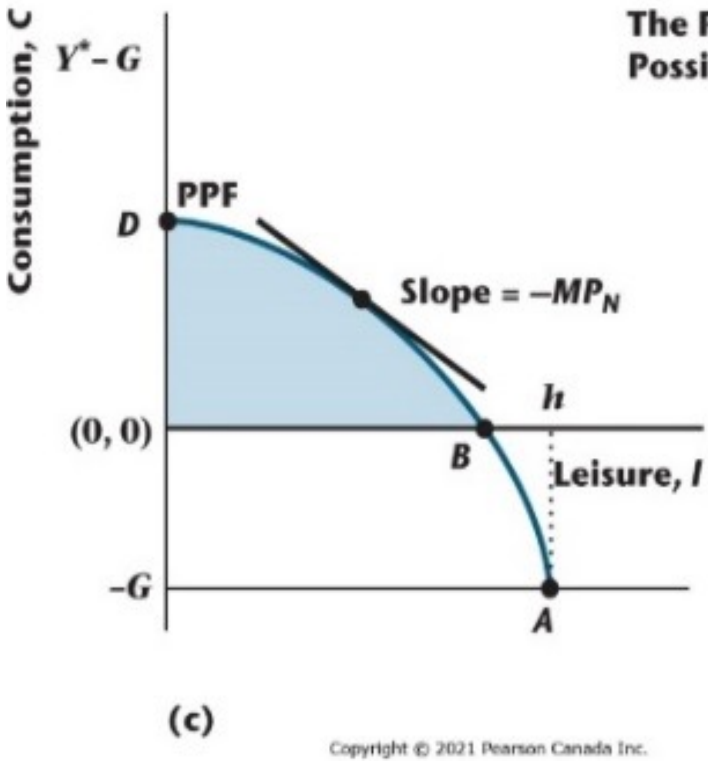


this is the minimal working hours for consumer to pay tax

- Panel (c), shows the PPF, which captures the tradeoff between *C* and *l*
- Since in equilibrium C = Y – G,

  C = zF(K, h – l) – G
- *The points on BA are not feasible as consumption is negative*.
- The shaded region in (c) represents consumption bundles that are technologically feasible to produce in this economy.

Figure 5.2
The Production Function and the Production Possibilities Frontier

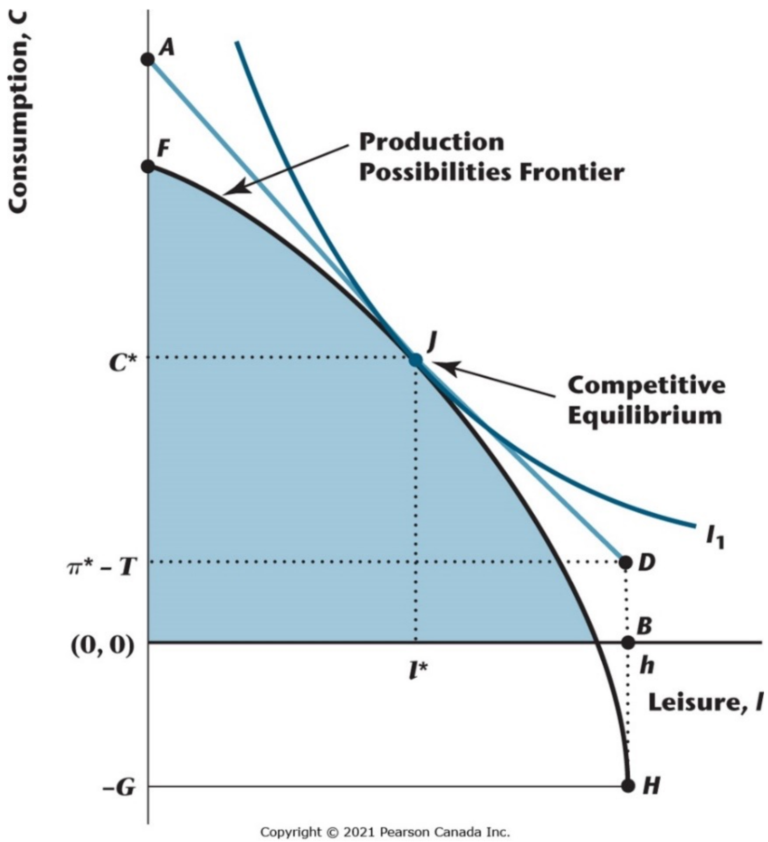


MRT = MRS = w

- The slope of the PPF is Marginal Rate of Transformation, rate at which l can be converted in into C through work.
- $MRT_{l,C} = MP_N$ = -(slope of PPF)
- Only the points on the PPF on DB are feasible, because here enough consumption goods are produced so that the government can take some of these goods and still leave something for private consumption.

Figure 5.3

Competitive Equilibrium: putting IC and PPF together



- Firm chooses $N^d = h - l^*$, given w; $N^d = w$
- $MRT_{l,c}$ (- the slope of PPF) must be equal to w;

$$MRS_{l,c} = MRT_{l,c} = MP_N$$

- If w is an equilibrium wage rate, we can draw a line AD that has slope – w and is tangent to PPF at point j

This figure brings together the representative consumer's preferences and the representative firm's production technology to determine a competitive equilibrium. Point *J* represents the equilibrium consumption bundle. *ADB* is the budget constraint faced by the consumer in equilibrium, with the slope of *AD* equal to minus the real wage and the distance *DB* equal to dividend income minus taxes.

Key Properties of a Competitive Equilibrium

$$MRS_{l,c} = MRT_{l,c} = MP_{N'}$$

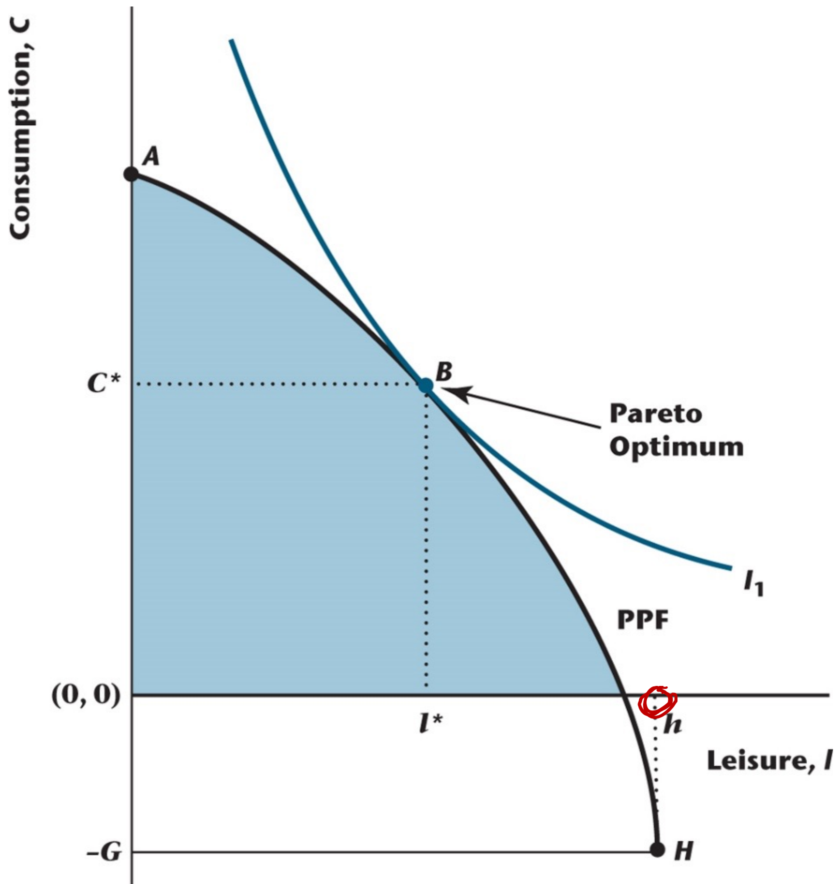
- The marginal rate of substitution of leisure for consumption is equal to the marginal rate of transformation, which is equal to the marginal product of labor.
- That is, because the consumer and the firm face the same market real wage in equilibrium; the rate at which the consumer trades leisure for consumption and at which leisure can be converted into consumption goods by using the production technology is the same rate .

Pareto Optimality

- An important part of economics is analyzing is comparing markets' outcome in terms of production and consumption activities with some ideal or efficient arrangement.
- Typically, the efficiency criterion that economists use in evaluating market outcomes is Pareto-optimality named after a nineteenth-century Italian economist.
- 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 without making someone else worse off.

Figure 5.4
Pareto Optimality

Q. In this model, whether competitive equilibrium is pareto-optimal?



- The Pareto optimum is the point that a social planner would choose, where the representative consumer is as well off as possible given the technology for producing consumption goods by using labour as an input.
- Here, the Pareto optimum is *B*, where an indifference curve is tangent to the PPF.

Key Properties of a Pareto Optimum

- In this model, the competitive equilibrium and the Pareto optimum are identical.
- We know this as, at the Pareto optimum,

$$MRS_{l,c} = MRT_{l,c} = MP_N,$$

First and Second Welfare Theorems

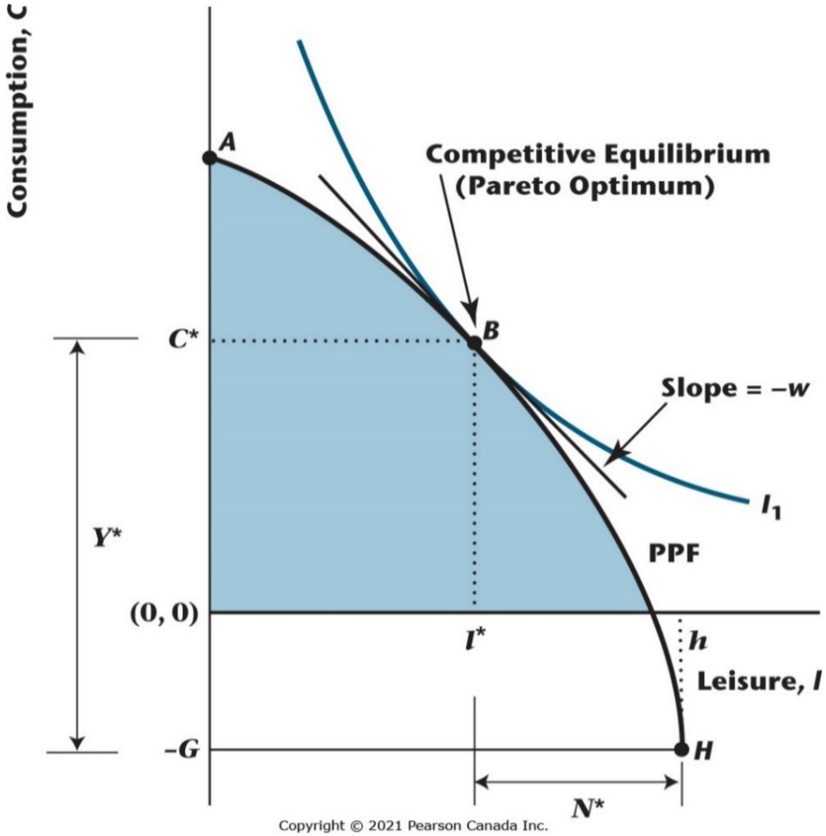
- These theorems apply to any macroeconomic model.
- First Welfare Theorem: Under certain conditions, a competitive equilibrium is Pareto optimal.
- Second Welfare Theorem: Under certain conditions, a Pareto optimum is a competitive equilibrium.

Sources of inefficiency

- Externalities; pollution
- Distortions; proportional wage tax
- Market imperfections; firms are not price takers; Monopolies

Figure 5.5

Using the Second Welfare Theorem to Determine a Competitive Equilibrium

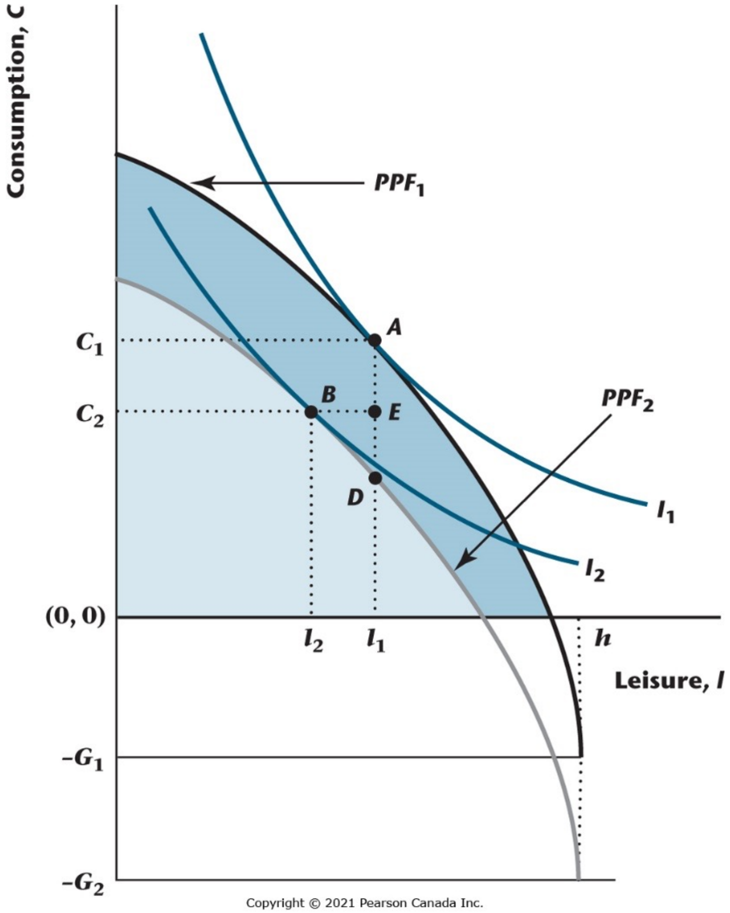


Key concept:

- consumption and production in the economy is determined entirely by the interaction of consumer's preferences (Indifference curve) and the technology (PPF) available to firms.
- So a change in either of these will affect what is produced and consumed.

Since the competitive equilibrium and the Pareto optimum are the same thing, we can analyze a competitive equilibrium by working out the Pareto optimum, which is point *B* in the figure. At the Pareto optimum, an indifference curve is tangent to the PPF, and the equilibrium real wage is equal to minus the slope of the PPF and minus the slope of the indifference curve at *B*.

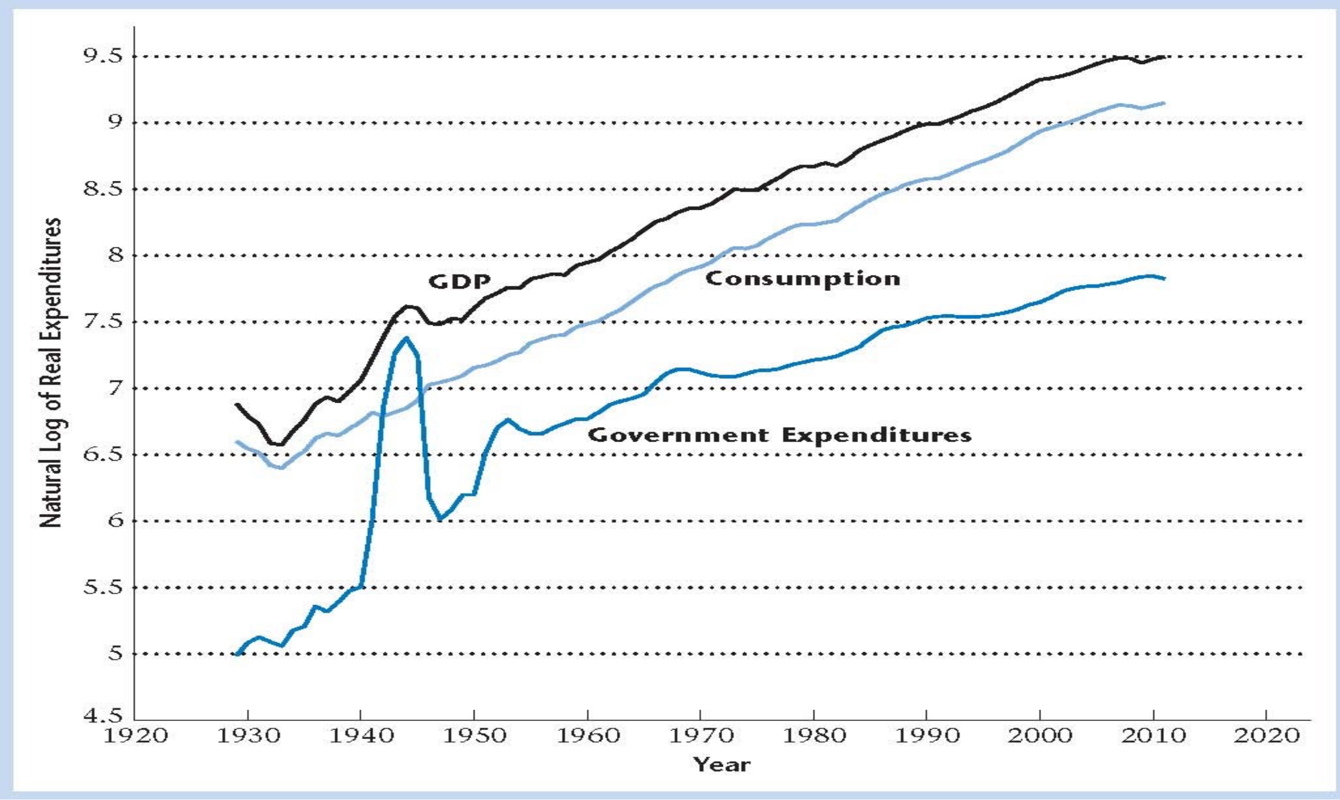
Experiments: Equilibrium Effects of an Increase in Government Spending



- Essentially a pure income effect
- C decreases, *l* decreases
- Y increases; since Y = C + G
- Employment increases and w falls

An increase in government spending shifts the PPF down by the amount of the increase in *G*. There are negative income effects on consumption and leisure, so that both *C* and *l* fall, and employment rises, while output (equal to *C* + *G*) increases; Y = C + G.

Equilibrium Effects of an Increase in Government Spending



Pearson

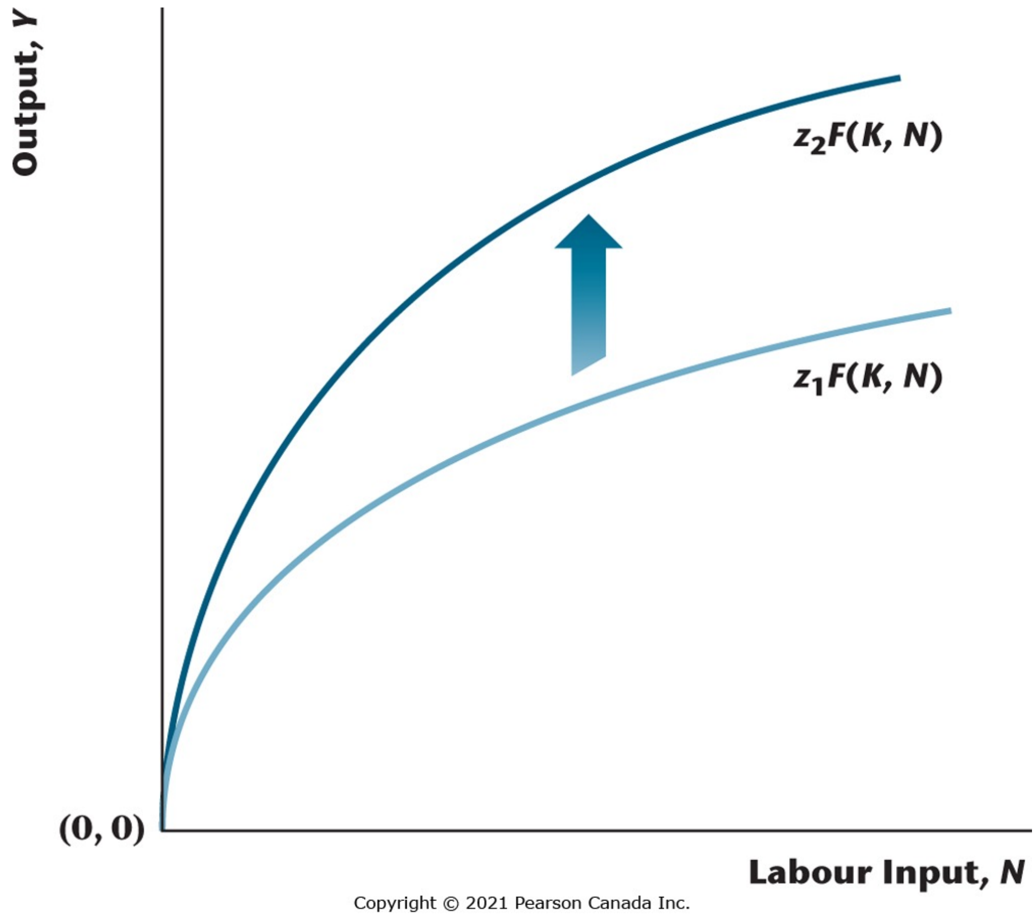
Is a change in G a likely cause of Business Cycle?

- Model predictions: (increased G)
- Aggregate output and employment increases
- Consumption and real wages decreases
- Business cycles facts:
- Employment and aggregate output procyclical
- Consumption and real wage also procyclical
- Model suggest that consumption and real wages are countercyclical
- Govt. spending shock do not appear to be a good candidate as a cause of business cycle

Effects of an Increase in z (or an increase in K)

- PPF shifts out, and becomes steeper – income and substitution effects are involved.
- C increases, I may increase or decrease, Y increases, w increases.

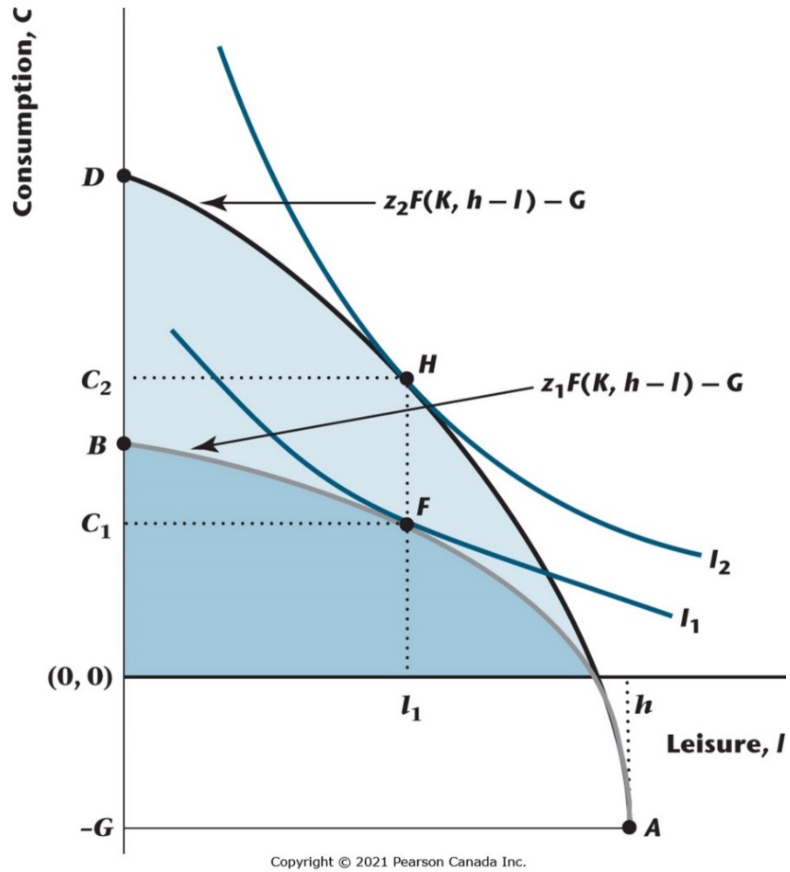
Figure 5.7
Increase in Total Factor Productivity



An increase in total factor productivity shifts the production function up and increases the marginal product of labour for each quantity of the labour input.

Figure 5.8

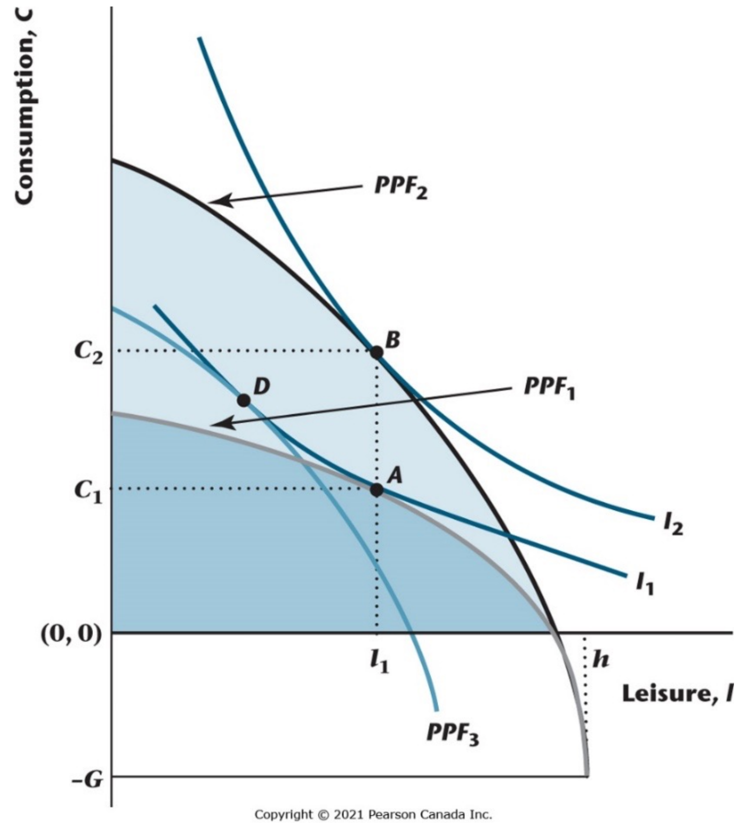
Competitive Equilibrium Effects of an Increase in Total Factor Productivity



An increase in total factor productivity shifts the PPF from *AB* to *AD*. The competitive equilibrium changes from *F* to *H* as a result. Output and consumption increase, the real wage increases, and leisure may rise or fall. Since employment is $N = h - l$, employment may rise or fall.

Figure 5.9

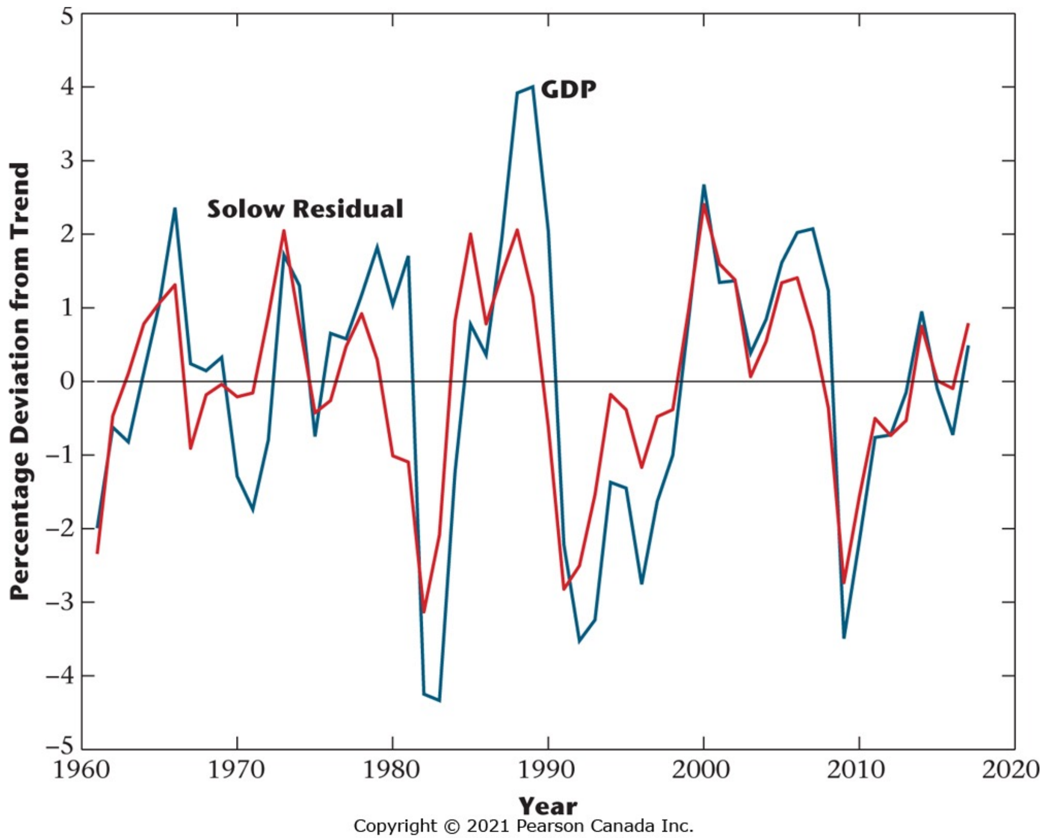
Income and Substitution Effects of an Increase in Total Factor Productivity



Here, the effects of an increase in total factor productivity are separated into substitution and income effects. The increase in total factor productivity involves a shift from PPF_1 to PPF_2. The curve PPF_3 is an artificial PPF, and it is PPF_2 with the income effect of the increase in z taken out. The substitution effect is the movement from A to D, and the income effect is the movement from D to B.

Figure 5.11

Deviations from Trend in the Solow Residual and Real GDP, 1961–2017



The figure shows the percentage deviations from trend in the Solow residual, a measure of total factor productivity, and in real GDP. The two time series track each other very closely, consistent with the view that total factor productivity fluctuations are an important cause of business cycles.

A Simplified Model with a Proportional Income Tax

- Now, we consider a proportional tax on wage income
- This captures some features of income taxation in Canada and other countries
- Competitive equilibrium is no longer Pareto-Optimal
- Allows to discuss some fiscal policy issues
- Use the model to study the incentive effects of the income tax, and to derive the “Laffer curve.”

Production Function Without Capital

- Labour is the only input, but there is still constant returns to scale (linear production function).

$$Y = zN$$

Production Possibilities Frontier

In competitive equilibrium, labor demand equals labor supply:

$$N^d = N^s = h - l \text{ and since,}$$

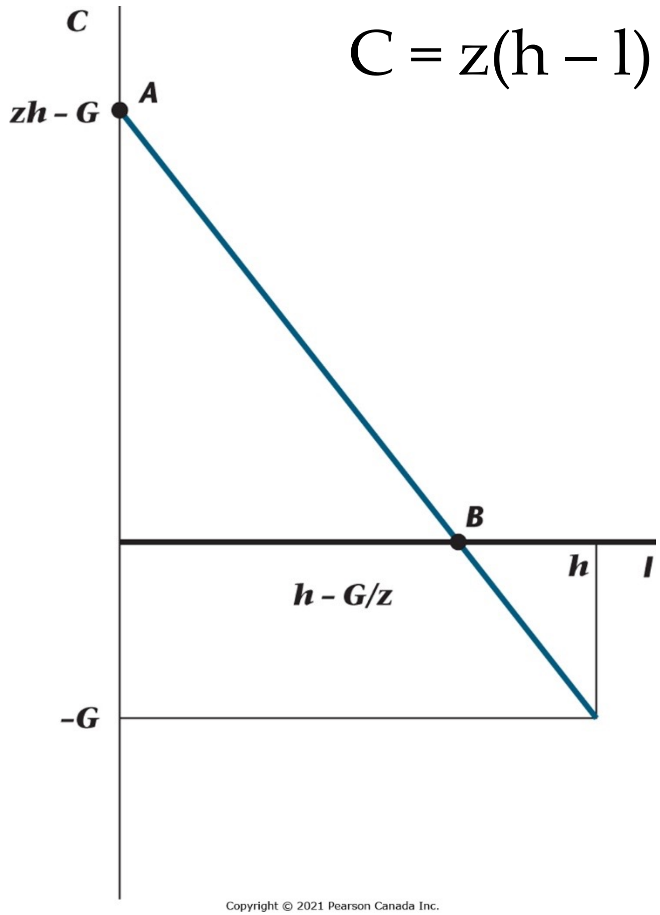
$$Y = C + G \text{ or } C = Y - G$$

Then using $Y = zN^d$

$$C = z(h - l) - G$$

Figure 5.12

The Production Possibilities Frontier in the Simplified Model



$$C = z(h - l) - G$$

Maximum consumption
when l = 0
C = zh – G (Point A)

At point B, C = 0, and
works G/z units of time
(l = h – G/z)
to supply the government
with G units of goods

The production possibilities frontier is linear. The maximum quantity of consumption (when the quantity of leisure is zero) is *zh* - *G*.

Consumer's Budget Constraint

- To purchase G units, proportional tax (t) is imposed on wage income. Assume T = 0,
- Consumer budget constraint take the form:

$$C = w(1 - t)\,(h - l) + \pi$$

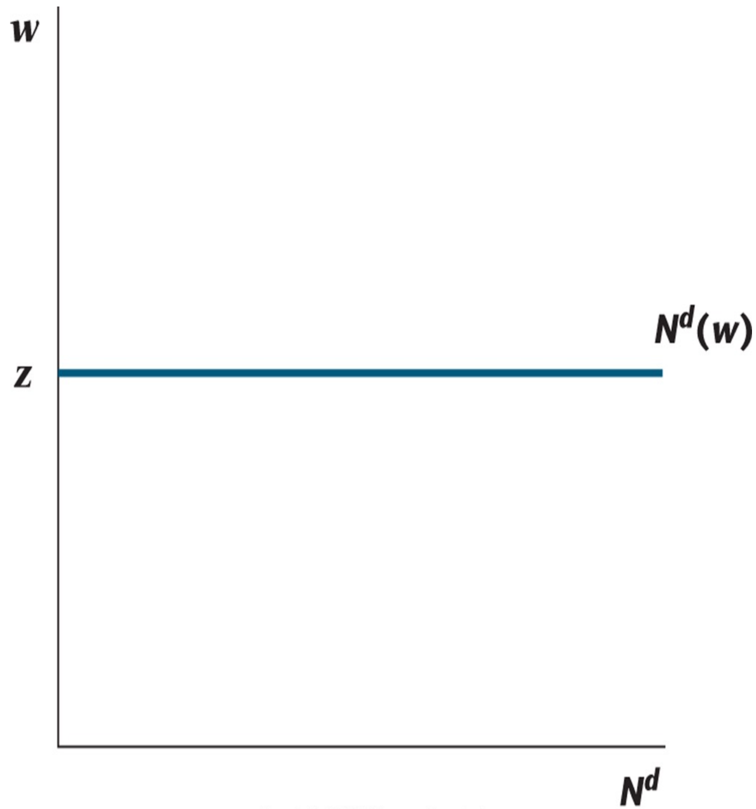
Profits for the Firm

- Profits for the firm are given by:

$$\Pi = Y - w N^d = (z - w) N^d$$

- Firm chooses N^d to make Π as large as possible, given z and w
- Firm makes z – w profit for each unit of labor input. The profit is indépendant from quantity of labor input

Figure 5.13
The Labour Demand Curve in the Simplified Model



Firm's demand curve for labor is perfectly elastic at w = z

If z – w > 0, firm makes profit and would like to hire an infinité quantity of labor

If z = w, profits are zero and firm is indifferent concerning how much labor to hire

If z – w < 0 , firm makes negative profit and would hire no labor

Since productivity is constant at *z*, the representative firm's demand curve for labour is infinitely elastic at *w* = *z*.

The Consumer's Budget Constraint in Equilibrium

Consumer budget constraint:

$$C = w(1 - t)(h - l) + \pi$$

with $w = z$, & $\Pi = 0$, budget constraint becomes;

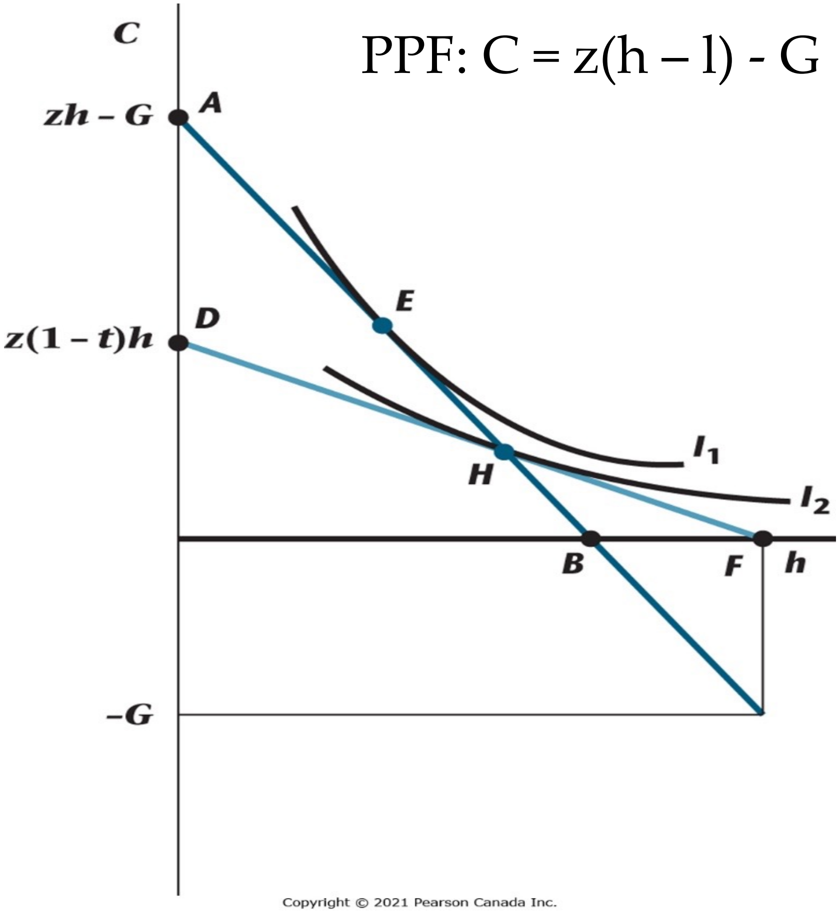
$$C = z(1 - t)(h - l)$$

Point E is pareto-optimal and Point H is competitive equilibrium

Because income tax distorts private decisions, the competitive equilibrium is not socially efficient

Figure 5.14

Competitive Equilibrium in the Simplified Model with a Proportional Tax on Labour Income



- Consumer budget constraint:
  $$C = w(1-t)(h-l) + \pi$$
- with w = z, & Π = 0, budget constraint becomes;
  $$C = z(1-t)(h-l)$$
- Point E is pareto-optimal and Point H is competitive equilibrium
- Because income tax distorts private decisions, the competitive equilibrium is not socially efficient

The competitive equilibrium is point *H*, and the Pareto optimum is point *E*.

Revenue for the Government Given the Tax Rate *t*

The revenue government can generate with tax rate t:

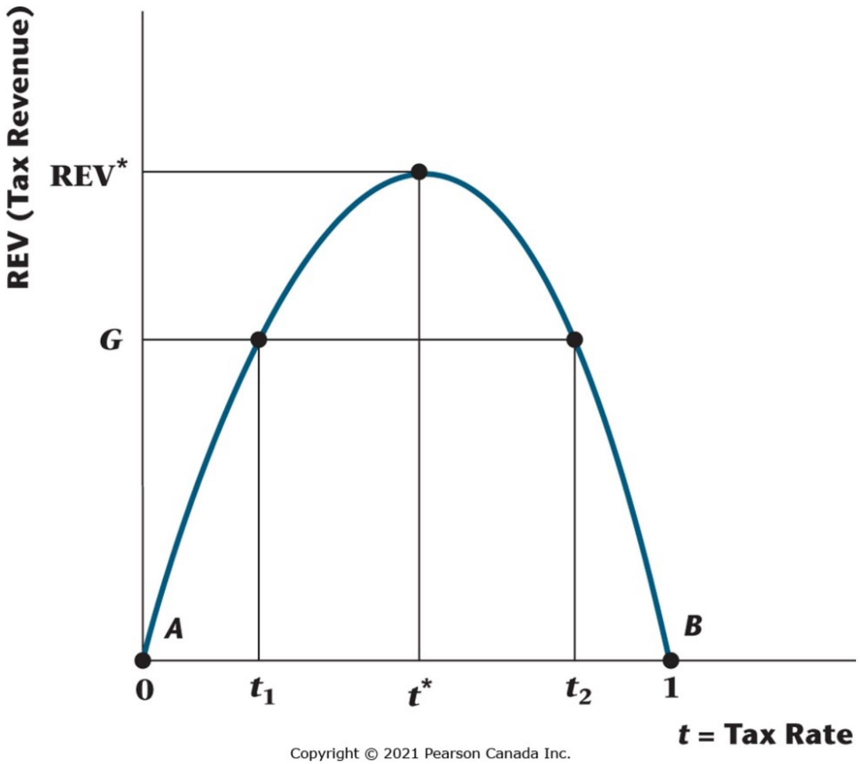
$$REV = tz[h - l(t)]$$

Where:

- REV is total revenue,
- t is the tax rate
- z[h – l(t)] is the **tax base**

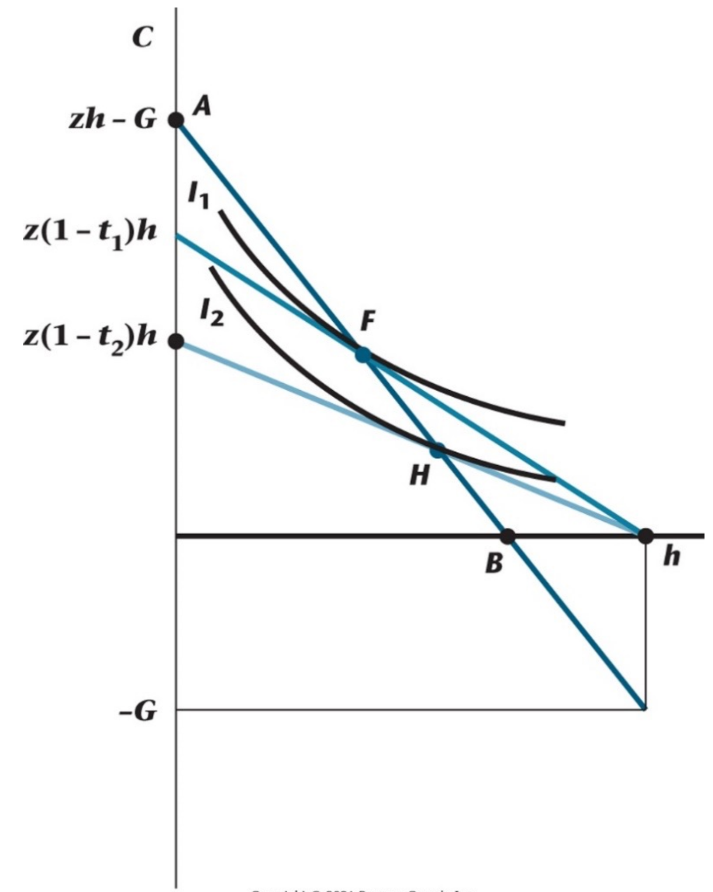
Figure 5.15

A Laffer Curve



- The Laffer curve is the relationship between income tax revenue and the income tax rate.
- Tax revenue must be zero when $t = 0$ (the tax rate is zero) and $t = 1$ (because no one will work if all income is taxed away).
- The government can maximize tax revenue by setting $t = t^*$.
- If the government wishes to finance government spending equal to G, it can set a tax rate of t_1 (on the good side of the Laffer curve) or t_2 (on the bad side of the Laffer curve).

Figure 5.16
Equilibria with High and Low Tax Rates



Given government spending equal to *G*, as in Figure 5.15, there are two equilibrium tax rates. The low-tax-rate (high-tax-rate) equilibrium is at point *F* (*H*). In the low-tax-rate equilibrium, consumption and output are higher and leisure is lower than in the high-tax-rate equilibrium.