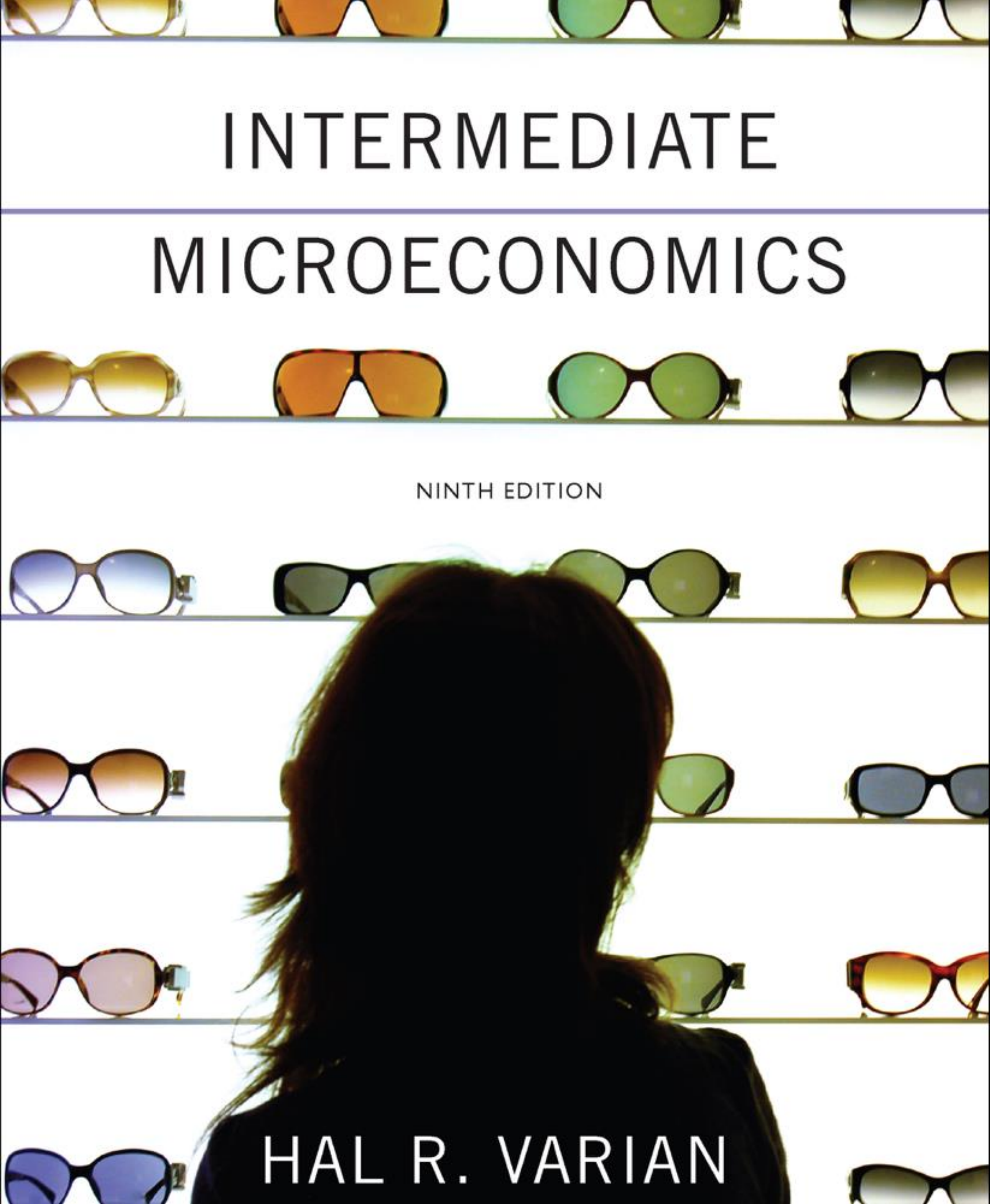

CHAPTER 37

Public Goods

Public Goods

A good is a pure **public good** if it is both **nonexcludable** and **non-rival** in consumption.

- **Nonexcludable**: it is costly or impossible to exclude agents from consuming the good.
- **Non-rival**: when one agent consumes the good, it does not prevent another agent from consuming the good.

Public Goods: Examples

- Broadcast radio and TV programs
- National defense
  - Military
  - Dikes
- Air quality
- Fireworks
- Public highways
- National parks

Public Goods and Externalities

Public goods are strongly related to **externalities**.

Whenever a good creates an externality that is non-excludable and non-rivalrous, it becomes a public good.

Hence, all public goods create externalities, but not all goods that create externalities are public goods.

In other words, whenever the externality affects many people, it may be seen as a public good.

Two Important Concepts

Our plan for discussing public goods:

- The free rider problem
  - Government intervention
- Optimal "provision" of public good

Free Riding

Free riding: an agent who uses the public good without paying for it.

Imagine two agents, A and B, that consider buying shampoo for their joint travels.

A and B each have two actions: individually buy shampoo, or not. And:

- r_A is the reservation price for shampoo of agent A
- r_B is the reservation price for shampoo of agent B
- p is the price of shampoo

Consider that the shampoo is a pure public good.

Free Riding

Suppose $r_A > p$ and $r_B < p$.

What would be the **Nash equilibrium** in terms of shampoo provision?

- Given that B does not buy shampoo, A's **best response** is to buy shampoo
- Given that A buys shampoo, B's **best response** is to not buy shampoo

Hence, the Nash equilibrium entails **free riding**: B enjoys the public good for free.

Free Riding: Example 1

A and B each have two actions: individually buy shampoo, or not. And:

- $r_A = \$120$
- $r_B = \$65$
- $p = \$100$

$\$120 + \$65 > \$100$, so suppling the shampoo is welfare improving.

However, what is the Nash equilibrium?

Free Riding: Example 1

		Player B	
		Buy	Don't Buy
Player A	Buy	\$20 , -\$35	\$20 , \$65
	Don’t Buy	\$120 , -\$35	\$0 , \$0

(Buy, Don’t Buy) is the unique NE.

Free Riding

Suppose $r_A < p$ and $r_B < p$.

Neither A and B will buy shampoo alone.

Yet, if $r_A + r_B > p$, then it is welfare improving for shampoo to be bought.

A Nash equilibrium may be that A and B try to **free ride** on each other, which causes the public good not to be supplied at all.

Free Riding: Example 2

A and B each have two actions: individually buy shampoo, or not. And:

- $r_A = \$80$
- $r_B = \$65$
- $p = \$100$

$\$80 + \$65 > \$100$, so suppling the shampoo is welfare improving.

However, what is the Nash equilibrium?

Free Riding: Example 2

		Player B	
		Buy	Don't Buy
Player A	Buy	-\$20 , -\$35	-\$20, \$65
	Don't Buy	\$80 , -\$35	\$0, \$0

(Don't Buy, Don't Buy) is the unique NE. But, this is also inefficient.

Free Riding

Until so far, A and B each had two actions: individually buy shampoo, or not

In this case, the public good may not be supplied at all, or it may be supplied by one player while the other player free rides. This can generate welfare loss.

Now allow A and B to each make **contributions** c to supplying shampoo.

One Nash equilibrium may be that A and B each make a positive contribution to the public good, which causes the good to be supplied.

Free Riding: Example 3

A and B can each make contributions c to supplying the good.

For example, A contributes $c_A = \$60$ and B contributes $c_B = \$40$, so that:

- Payoff $= r_A - c_A = \$20$
- Payoff $= r_B - c_B = \$25$
- $p = \$100$

Free Riding: Example 3

		Player B	
		Contribute	Don't Contribute
Player A	Contribute	\$20, \$25	-\$60, \$0
	Don't Contribute	\$0, -\$40	\$0, \$0

Two NE: (Don't Contribute, Don't Contribute) and (Contribute, Contribute).

Free Riding

Hence, allowing A and B to make contributions makes the supply of the public good possible when no individual will supply the good alone.

However, free riding can persist even with contributions, so that it is also possible the public good is not supplied (i.e., there are two Nash equilibria).

Government Intervention

The **government can provide the public good** to make sure the public good is supplied and to prevent free riding.

For instance, the government can tax both players their contributions proposed previously. That is, $\tau_A = \$60$ and $\tau_B = \$40$.

With the tax revenue $= \$60 + \$40 = 100$, the government can provide the public good. Recall that providing the public good was welfare improving.

Optimal Provision of Public Good

So far, we assumed that only one unit of the public good (i.e., one bottle of shampoo) could be supplied.

However, in reality $G \geq 0$ units of the public good can be supplied

- Military and dikes
- National park
- Public high-ways

What is the *optimal* level of G for society as a whole? In practice, this boils down to: What is the level of G the government should provide?

Optimal Provision of Public Good

Finding the optimal level of public good G is a similar problem to finding the optimal individual consumption bundle.

- **Optimal individual consumption bundle**: maximize individual utility subject to the individual budget constraint.
- **Optimal level of public good**: maximize the *sum* of individuals' utilities subject to the *joint* budget constraint.

Optimal Provision of ~~Public~~ Private Goods

Let's act as if G is a private good. **Optimal individual consumption bundle:** maximize individual utility subject to the individual budget constraint.

$$\max_{x,G} \; u(x, G)$$

Subject to

$$x + c(G) = w$$

The solution is that

$$MRS = -mc(G),$$

where $MRS = \frac{\partial x(G)}{dG} = -\frac{MU_G}{MU_x}$

Optimal Provision of ~~Public~~ Private Goods

Imagine $MRS = 2$ and $mc(G) = 1$, so that MRS $> mc(G)$

- Substitute two x for one G, this would keep *individual* utility the same (since $MRS = 2$), but we would still have *$1* extra to spend (since $mc(G) = 1$)
- Cannot be optimal

Imagine $MRS = 1$ and $mc(G) = 2$, so that MRS $< mc(G)$

- Substitute one G for one x, this would keep *individual* utility the same (since $MRS = 1$), but we would still have *$1* extra to spend (since $mc(G) = 2$)
- Cannot be optimal

Optimal Provision of Public Good

Now G is a public good. **Optimal level of public good:** maximize the *sum* of individuals' utilities subject to the *joint* budget constraint

$$\max_{x_A, x_B, G} u_A(x_A, G) + u_B(x_B, G)$$

Subject to

$$x_A + x_B + c(G) = w_A + w_B$$

The solution is that

$$MRS_A + MRS_B = -mc(G),$$

where $MRS_i = \frac{\partial x_i(G)}{dG} = -\frac{MU_{i_G}}{MU_{i_x}}$

Optimal Provision of Public Good

Imagine $MRS_i = 1$ and $mc(G) = 1$, so that $MRS_A + MRS_B > mc(G)$

- Substitute one x for both A and B for one G, this would keep *everybody's* utility the same (since $MRS_i = 1$) but we would still have *\$1* extra to spend (since $mc(G) = 1$)
- Cannot be optimal

Imagine $MRS_i = 1$ and $mc(G) = 3$, so that $MRS_A + MRS_B < mc(G)$

- Substitute one G for one x for both A and B, this would keep *everybody's* utility the same (since $MRS_i = 1$) but we would still have *\$1* extra to spend (since $mc(G) = 3$)
- Cannot be optimal

Free Riding Revisited

When is free riding individually rational?

Agents **maximize individual utility**, not the sum of all individuals' utilities.

An agent maximizing *individual* utility may free ride given that another agent (also maximizing individual utility) already provides the public good:

- A maximizes individual utility, and considering that B does not contribute to the public good, the **best response** is to contribute
- B maximizes individual utility, and considering that A contributes to the public good, the **best response** is not to contribute

Hence, the **Nash equilibrium** may entail **free riding**: B enjoys the public good for free.