Public Economics

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1 Common Goods

1.1 Background Knowledge

First Fundamental Theorem of Welfare Economics

- The market equilibrium will be Pareto optimal (i.e., reach a Pareto efficient allocation of goods) if,
  - Perfect competition. (All producers and consumers are price takers.)
  - Each sector has complete information.
  - There is no externalities.
- Implications
  - There is little role for government in economy.
  - Nevertheless, efficiency may not be the only goal for society, and we may also have a desire for some sort of equitable distribution of goods.

Different starting points lead to different Pareto optima.

Second Fundamental Theorem of Welfare Economics

- Any Pareto optimum can be achieved in a competitive market equilibrium for some initial set of endowments.
- Implications:
  - Altering the initial endowments of resources will change the final Pareto optimum.
  - The government plays its role by redistributing initial wealth.
  - After redistribution, market will do the rest, no further government interventions needed.
  - In sum, efficiency and equity issues can be addressed separately.

A framework for deciding a trade-off the society should make is needed.

Define a Social Welfare Function (SWF), which behaves as a utility function for society. SWF, combined with the "Utility Possibility Curve" directs us toward the social optimum. (However, mind that the Utility Possibility Curve may not be strictly concave. Therefore, not all "tangent" solutions are maximized ones.)

Government Intervention

Aside from distributional concerns, other reasons, called market failures, rationales government interventions.

- Market Power
  - Monopoly
    * If monopoly, the first Welfare Economics Theorem doesn't hold.
- Nonexistence of Markets
  - Asymmetric Information
  - Externality
  - Public Good

1.2 Public Goods

1.2.1 Definition

Pure public goods are perfectly **non-rival in consumption** and **nonexcludable** goods.

- Non-Rival in Consumption
  - One individual's consumption of a good doesn't affect another's opportunity to consume the good.
- Non-Excludable
  - Individuals cannot deny each other the opportunity to consume a good.
- Impure Public Goods
  - Goods that satisfy the two public-goods conditions just to some extent, not fully.

		Is the good rival in consumption?	
		Yes	No
Is the good excludable?	Yes	Private good (ice cream)	Impure public good (Cable TV)
	No	Impure public good (crowded sidewalk)	Public good (defense)

1.2.2 Optimal Provision for Private Goods

Suppose there are two goods, ice-cream (denoted as ic) with price P_{ic} and cookies (denoted as c) with price P_c, and P_c is normalized to one (i.e., numeraire good). Two individuals, Ben and Jerry, will demand different quantities of the good at the same competitive market price. Let $MRS_{ic.c} = \frac{MU_{ic}}{MU_c}$ denote how many cookies the consumer is willing to give up for 1 ice-cream.

The optimality condition for the consumption of private goods is written as

$$MRS^B_{ic,c} = \frac{P_{ic}}{P_c} = P_{ic} MRS^J_{ic,c} = \frac{P_{ic}}{P_c} = P_{ic}$$

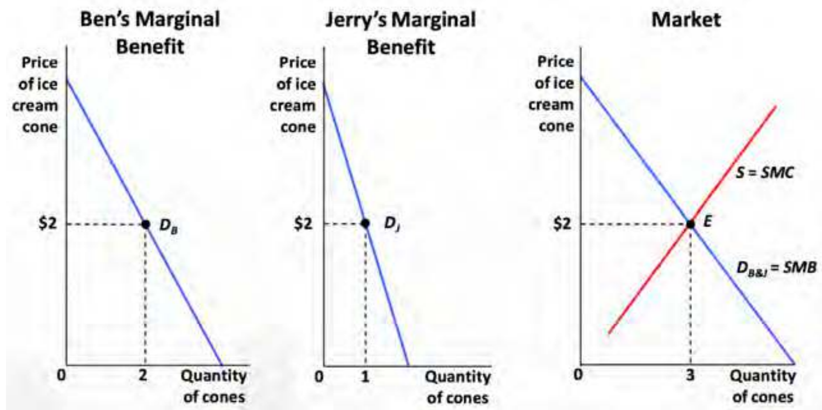
In general equilibrium, the supply side requires

$$MC_{ic} = P_{ic}$$

In equilibrium, it holds that

$$MRS^B_{ic,c} = MRS^J_{ic,c} = MC_{ic}$$

For each individual, she would find the optimization for herself; and from the perspective of the society, the equilibrium should be presented using horizontal summation.



To find social demand curve, add quantity at each price, which is equivalent to sum horizontally.

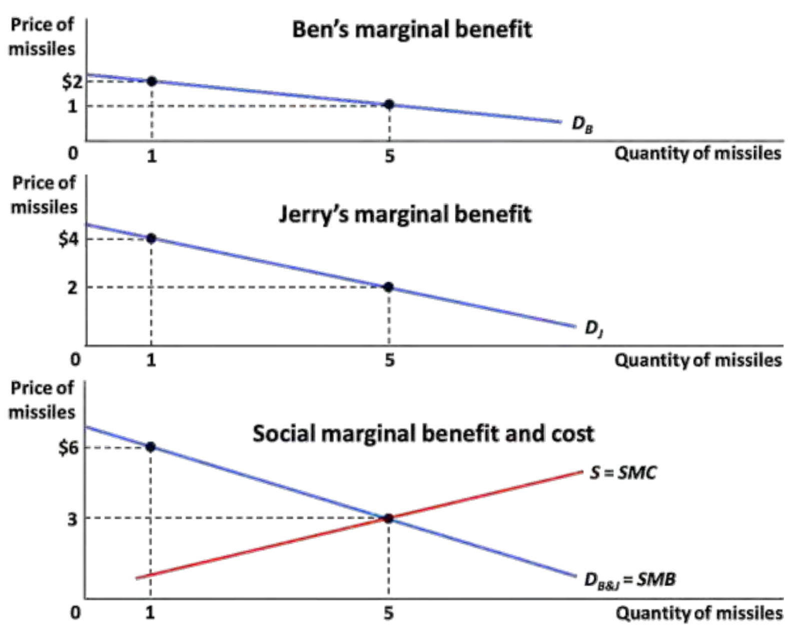
1.2.3 Optimal Provision for Public Goods

This time, we consider the tradeoff between cookies (denoted as c), the private good, and missiles (denoted as m), the public good. Let $MRS_{m,c}$ Denote how many cookies an individual is willing to give up for 1 missile.

In net, the society is willing to give up $(MRS_{m,c}^{B} + MRS_{m,c}^{J})$ cookies for 1 missle. Social-efficiency-maximizing condition for the public good is

$$MRS_{m,c}^{B} + MRS_{m,c}^{J} = MC_m$$

which means social efficiency is maximized when the marginal cost is set equal to the sum of the MRSs, rather than being set equal to each individual's MRS. (which is called the Samuelson rule)



Private sector provision implies $MRS_{m,c}^{i} = MC_m$ for each individual i, while the provision for public goods requires $\sum_i MRS_{m,c}^{i} = MC_m$ for optimization. Apparently, under private sector provision,

$$\sum_i MRS^i_{m,c} > MC_m$$

which implies that the outcome is not efficient, and could be improved in welfare by having more public goods and less private goods.

Free rider Problem describes the situation that, when an investment has a personal cost but a common benefit, selfish individuals will underinvest. Private sector provision induces an inefficient outcome in terms of public goods. Because of the free rider problem, the private market under-supplies public goods. (Private provision of a public good creates a positive externality. However, that part of positive externality isn't traded in the market.)

The free-rider problem is partially remedied by compulsory finance.

- Taxation
- Payment for public survices

The free-rider problem does not lead to a complete absence of private provision of public goods. Private provision works better when:

- Some individuals care more than others.
  - Private provision is particularly likely to surmount the free-rider problem when individuals are not identical, and when some individuals have an especially high demand for the public good.
- Altruism
  - When inidviduals value the benefits and costs to others in making their consumption choices.
- Warm glow
  - The emotional reward of giving to others; so individuals may care about their particular contributions to the public goods.

1.3 Lindahl Tax

Lindahl tax is a decentralized mechanism to achieve Pareto efficiency. Suppose each individual i with income Y hopes to maximize $U_i(X_i, G)$, and both private and public goods have price of 1. And suppose individual i has to pay a personalized share t_i (Lindahl tax) of the public good and can pick her favorite level of the public goods, G_i. The G_i should be set to maximize her utility, $U_i(Y_i - t_i G_i, G_i)$. Apparently, the F.O.C. is that, $MRS_i = t_i$. From the social perspective, $\sum_i t_i = 1$ must hold so that the public good is fully financed.

In equilibrium, all individuals must demand the same quantity of public goods. And luckily, such equilibrium generically exists, since n equations will determine n unknowns (t_i, for $i = 1, 2, ..., n$). Efficiency can be achieved since $\sum_i MRS_i = \sum_i t_i = 1 = MC$.

Limitations of Lindahl equilibrium are, individual preferences must be known to set personalized prices, however, people will nt truthfully reveal their preferences. And there would exist a difference between Lindahl equilibria and standard equlibria, since no market forces that will generate the right price vector.

Lindahl tax is itself a decentralized mechanism to achieve Pareto efficiency, where the government only designs the rule of Lindahl taxes t_i, and the market do the rest to determine the level of G. Each individual i only has to maximize her own utility, wihout caring about others. Lindahl tax internalizes the social welfare $t_i = 1 - \sum_{-i} t_{-i} = 1 - \sum_{-i} MRS_{-i}$ into individual's decision making. It turns out that the chosen G is socially optimal. Yet, there is possibly an alternative way to think about Lindahl tax, where the *government* chooses G, the set of tax $\{t_i\}_{i\in N}$ and try to

$$\max_{\{t_i\}_{i\in N},G,\lambda} \sum_{i=1}^{N} U_i(Y_i - t_iG, G) + \lambda(\sum_{i=1}^{N} t_i - 1)$$

With $n+2$ equations and $n+2$ unknowns, the maximization problem has its unique solution. This logic will reach the same result as the decentralized solution, but more of a centralized allocation.

1.4 VCG Mechanism

VCG mechanism is designed to make it each agent's dominant strategy to reveal her preference truthfully.

Assume that there are n individuals, each with $U_i(X_i, G) = X_i + V_i(G)$, where individual's valuation of G, $V(\cdot)$ is privately known, but it is crucial for optimal provision of G. All prices are set to 1 for simplicity.

VCG mechanism works as follows:,

- Each individual reports $v_i(\cdot)$ to the social planner.
- Based on all individuals' reports of valuation function $v(\cdot)$, the social planner sets $\hat{G} = \arg\max_G \sum_i (v_i(G) - G)$ and $\hat{G}_{-i} = \arg\max_G (\sum\limits_{j\neq i} v_j(G) - G)$.
- Each individual is required to pay $t_i(v) = (\sum_{j\neq i} v_j(\hat{G}_{-i}) - \hat{G}_{-i}) - (\sum_i v_i(\hat{G}) - \hat{G})$.
  - Intuitively, each agent pays for her "harm" to the rest of the society.
  - Generally speaking, the more $v_i(\cdot)$ deviates from $V_i(\cdot)$. the more $\hat{G}$ deviates from $\hat{G}_{-i}$, making $t_i(v)$ larger.

Under VCG mechanism, the dominant strategy for each individual is to truthfully report her valuation function of the public good, i.e., $v_i(\cdot) = V_i(\cdot)$. (Formal prove is skipped.) Thus, VCG mechanism will achieve Pareto optimal level of G, since it is satisfied that $\sum_i MRS_i = MC_G = 1$.

Assume that all other individuals report truthfully, then for individual i, her payoff would be

$$U_i(X_i, G) = V_i(G) - Y_i - [(\sum_{j\neq i} v_j(\hat{G}_{-i}) - \hat{G}_{-i}) - (\sum_i v_i(\hat{G}) - \hat{G})]$$

where individual i can indirectly choose $\hat{G}$, simply by reporting a particular $v_i(\cdot)$. Thus, we can turn the table and convert the maximization problem of individual i's choosing G.

$$\max_G \; U_i(X_i, G) = V_i(G) - Y_i - [(\sum_{j\neq i} v_j(\hat{G}_{-i}) - \hat{G}_{-i}) - (\sum_i v_i(G) - G)]$$

$$\text{F.O.C.}: \sum_i V_i'(G) = 1 \Longrightarrow \sum_i MRS_i = 1$$

Therefore, i will choose the socially optimal G, which implies she will report truthfully with $v_i(\cdot) = V_i(\cdot)$.

2 Externality

Market failure describes a problem that violates one of the assumptions of the 1st welfare theorem and causes the market economy to deliver an outcome that does not maximize efficiency for society. In other word, the outcome is not socially optimal, or is not first-best.

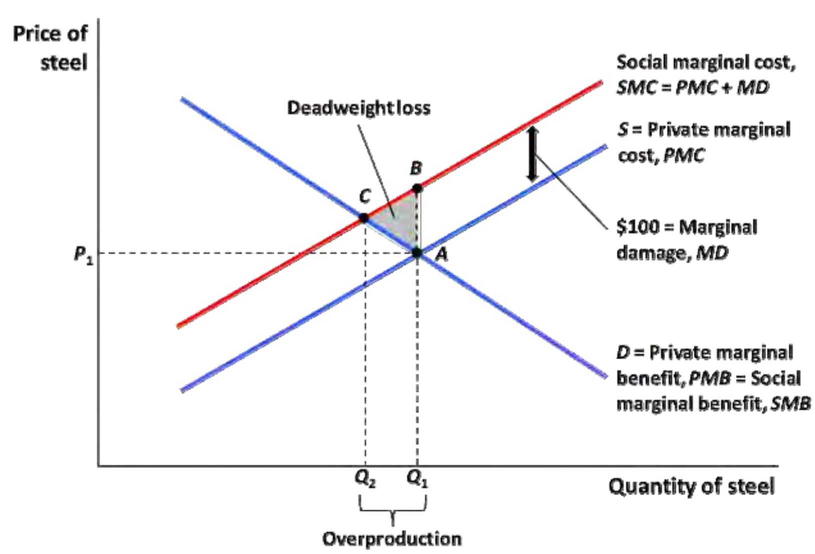
Externalities arise whenever the actions of one economic agent **directly** affect another economic agent **outside** the market mechanism. The first party neither bears the costs nor receives the benefits of doing so. Externalities are one important case of market failure.

According to the definition of externality, the effect of certain action spills over to another party, and this process is finished outside the market mechanism. A steel plant that pollutes the river nearby is a vivid example. However, a Bitcoin plant that uses more electricity and bids up the price of electricity for other electricity customers shouldn't be attributed to externality. The electricity price's bidding up is realized through market mechanism, and the Bitcoin plant also pays for the higher price.

Under the setting of externalities, we discuss externalities from either the production side or the consumption side.

2.1 Negative Production Externality

- Negative production externality: generated when a firm's production reduces the well-being of others who are not compensated by the firm.
- Private marginal cost (PMC): the direct cost to producers of producing an additional unit of a good, which corresponds to the Supply Curve on plot.
- Marginal damage (MD): any additional costs associated with the production of the good that are imposed on others outside the market for the produced good, but the producers do **not** bear or internalize such cost.
- Social marginal cost (SMC): sum of private marginal cost and marginal damage, i.e., $SMC = PMC + MD$.
  - Considering producers and consumers in the market and the "affected others", holding "unaffected others" constant.

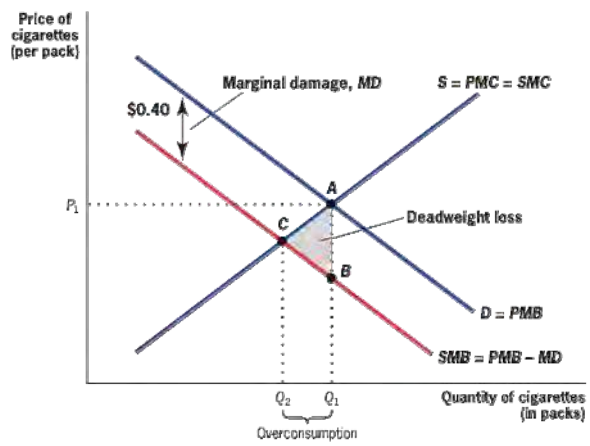


The grey-filled triangle corresponds to the deadweight loss for the society. This means if the outcome is determined simply by private marginal cost (PMC) and demand curve, from the perspective of society, private markets do not produce Pareto efficient outcome, since the firms did not take into account the social cost of pollution when making quantity decision, or say the externality was not fairly traded.

2.2 Negative Consumption Externality

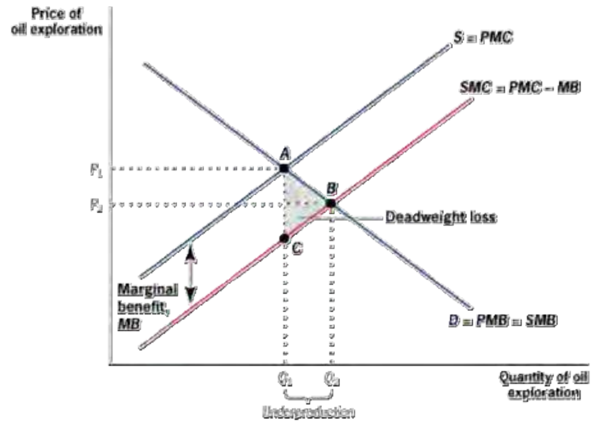
Similarly, introduce some basic terms.

- Negative consumption externality: when an individual's consumption reduces the well-being of others who are not compensated by the individual.
- Private marginal benefit (PMB): The direct benefit to consumers of consuming an additional unit of a good.
- Social marginal benefit (SMB): The private marginal benefit to consumers plus any costs associated with the consumption of the good that are imposed on others (outside the market for consuming the good).
- Marginal damage (MD): any additional costs associated with the consumption of the good that are imposed on others outside the market for the produced good, but the consumers do **not** bear or internalize such cost.



2.3 Positive Externality

- Positive production externality
  - When a firm's production increases the well-being of others but the firm is not compensated by those others.
  - Example: Beehives of honey producers have a positive impact on pollination and agricultural output.
- Positive consumption externality
  - When an individual's consumption increases the well-being of others but the individual is not compensated by those others.
  - Example: Beautiful private garden that passers-by enjoy seeing.



In sum, with a free market, the equilibrium is set such that

$$PMB = PMC$$

However, social optimum is realized only when

$$SMB = SMC$$

Therefore, private market leads to an inefficient outcome. The first welfare theorem hence does not work when externalities exist and are not fairly "traded" in the market.

- Negative production externalities lead to over-production.
- Positive production externalities lead to under-production.
- Negative consumption externalities lead to over-consumption.
- Positive consumption externalities lead to under-consumption.

2.4 Private-Sector Solution

Coase proposed, externalities emerge because property rights are not well defined. If the property rights are clearly defined, the competitive market mechanism will help internalize the externalities, positive or negative.

Coase Theorem (Part I)

> When there are well-defined property rights and costless bargaining, then negotiations between the party creating the externality and the party affected by the externality can bring about the socially optimal market quantity.

Coase Theorem (Part II)

> The efficient quantity for a good producing an externality does not depend on which party is assigned the property rights, as long as someone is assigned those rights.

Implication: a particular and limited role for government – define, assign and protect the property rights.

2.4.1 Problems with Coasian Solution

- The assignment problem
  - When externalities affect many agents (e.g. global warming), assigning property rights is difficult.
  - Coasian solutions are likely to be more effective for **small, localized** than for larger, more global externalities involving large number of people and firms.
  - Only a "government" can potentially successfully aggregate the interests of all individuals suffering from externality.
- Transaction costs and negotiating problems
  - Hard to negotiate when there are large numbers of individuals on one or both sides of the negotiation.
  - This problem is amplified for an externality such as global warming, where the potentially divergent interests of billions of parties on one side must be somehow aggregated for a negotiation.
- Asymmetric information problem
  - Resource owners need to be able to identify source of damage.
  - First welfare theorem fails when information is not complete.

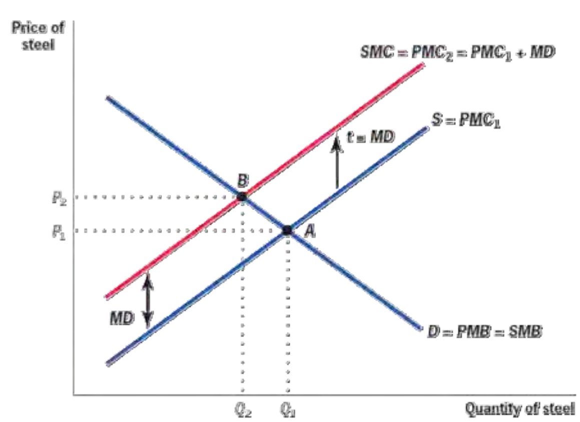
2.5 Public Sector Remedies for Externalities

Public policy makers employ two types of remedies to resolve the problems associated with negative externalities:

- Corrective taxation: corrective tax or subsidy equal to marginal damage per unit (internalization)
  - Example: Carbon tax to fight global warming due to CO2 emissions
- Quantity regulation: government limits use of externality producing chemicals.
  - Example: CFCs [chlorofluorocarbons] that deplete ozone layer banned in 1990s

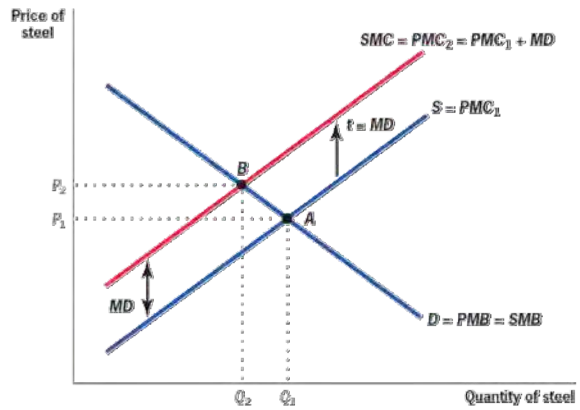
Corrective taxation and quantity regulation can be combined with tradable emissions permits to firms that can then be traded (cap-and-trade for carbon emissions).

2.5.1 Pigouvian Corrective Taxation



The tax collected is used to compensate the externality-induced loss. However, an apparent limitation is that, you have to know the MD function before setting up the optimal tax. Moreover, if MD is not constant, the tax may fail.

2.5.2 Quantity Regulation



In the simple model, Pigouvian tax and regulation produce exactly the same outcome.

- Advantages of regulation
  - Easy to enforce and administer
  - Useful to quickly reduce pollution if you want to meet a certain salient target.
- Disadvantages of regulation
  - Dynamics: discourage innovation; no monetary incentives to discover new technologies to reduce pollution further.If with a tax, the firm will have a strong incentive to cut such burden.
  - Heterogeneity: inefficient allocation when there is heterogeneity in costs of pollution abatement across firms.

2.5.3 Permits (Cap-and-Trade)

The governemnt can cap total amount of socially desirable pollution level and allow firms to sort out between themselves who pollutes more and less using tradable permits. In equilibrium, firms with the highest MC of reducing pollution will end up buying the most permits; firms that can easily reduce pollution will sell. If total number of permits is set to achieve the social optimum, both productive and allocative efficiency will be achieved, Additionallu, cap-and-trade will induce dynamic incentives to innovate , because firms are bearing the MC of pollution

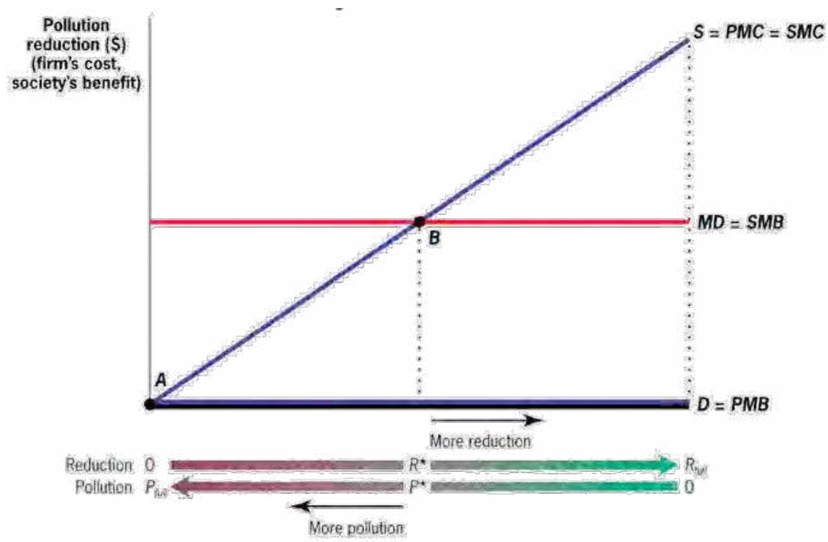
Initial allocation of permits matters. If the government sells them to firms, this is equivalent ot the tax; if the government gives them to current firms for free, this is like the tax with large lump-sum transfer to initial polluting firms. The trade system for permits will expose each firm's wililngness to pay and marginal cost to reduce pollution, and this property outbeats the tax mechanism greatly, where uncertainty in costs of cutting off pollution will make such system fail.

2.6 Price v.s. Quantity

2.6.1 Basic Model

Let R denote the amount of pollution reduction starting from private market equilibrium ($R = 0$); let $SMB(R)$ denote social MB of pollution reduction and $SMC(R)$ denote social MC. You can map any externality model into a model of costs and benefits of externality reduction, where

- $PMB(R)$ of abatement (private demand for abatement) is 0;
- $SMB(R) = MD$, where MD is assume to be flat here, but can be downward sloping due to diminishing returens;
- MC of abatement is increasing and $PMC = SMC$.



where $PMB = PMC \Longrightarrow R = 0; SMB = SMC \Longrightarrow R = R^*$.

If there is no uncertainty, we can obtain optimum with either a quantity policy (impose P^* perimits) or a price policy (set $t = MB = PMB$). Two approaches are equivalent.

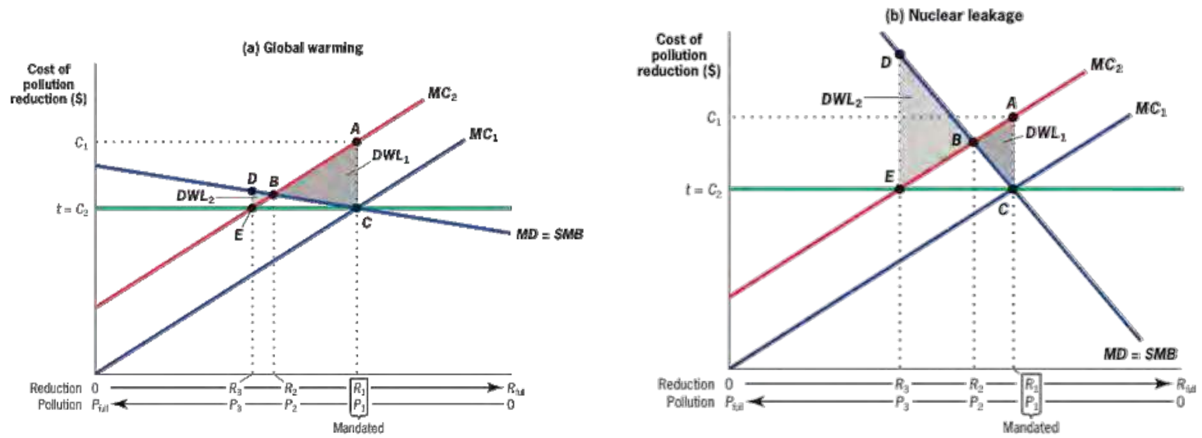
2.6.2 Heterogeneous Abatement Costs

If firms differ in marginal cost of abatement, the optimal condition for each firm is its MC of abatement equals to SMB. One equivalent way to think about this issue is, horizontally summing up MC curves and getting the total marginal cost of abatement curve of society MC_T, the intersection of MC_T and SMB determines the optimal abatement level for society.

In order to achieve such goal, you can either exert quantity regulation for each firm (cannot treat them equally), or take price regulation through a corrective tax set at $t = MD = SMB$. Another comprehensive design is exert quantity regulation with tradable permits.

2.6.3 Uncertainty of Costs

Now suppose that we are uncertain about MC of reducing pollution (also assume homogeneous firms). Specifically, regulators use MC_1 to set the tax at $t = C_2$; however, the actual marginal cost is given by MC_2, higher than MC_1, then the firms should have been taxed higher at $t = C_1$. With uncertainty of costs, quantity-policy and price-policy are not equivalent and will land at different effects.



With a flat MD curve, the tax is likely to play its role with less DWL. The intuition is that, since pollution cost is modest or gradual, reducing distortion using price mechanism rather than administrative intervention to the economy may be more important. With steeep MD curve, then quantity regulation is likely to work well, because steep MD implies the case of a very risky outcome.

2.7 Measuring Externality

Measuring externalities is hard, because there is by definition no direct market that can be used to recover willingness-to-pay. If there were a market, there would be no externality. Two prevalent approaches are applied in practice: indirect market-based methods and contingent valuation.

- Indirect Market-Based Method
  - Use quasi-experiment and DiD to estimate price change related to the level change of such externality.
    - e.g. *Clean Air Act 1970*
- Contingent Valuation
  - Put respondents in a hypothetical scenario through statement, and ask how much people would be willing to pay for it.
  - Sometimes impossible to have a market value for some outcomes.
  - Problems with this method
    - No resource cost to respondents, thus noisy answers and upward biased.
      - Warm glow: people feel having the idea that they are supporters of good causes.
    - People do not have well-defined preferences over these type of hypothetical choices.
      - Farming effect: people think you may want to receive this answer.
      - Timing of question matters: not same answers each time.

3 Taxation

Typically, there are two types of sales taxes:

- Ad-valorem tax: in percentage terms

- Unit tax: in dollar terms

  where ad-valorem tax are more common, but we are going to go through the machanics of unit tax, because it is easier.

3.1 Tax Incidence

Tax incidence: Analysis of how taxes affect the prices paid for goods; Critical for knowing who actually bears the burden of the tax.

Distinction: **statutory** incidence v.s. **economic** incidence

- Statutory (or legislative): who by law has to remit the tax to govt
- Economic: how does the tax affect prices, analysing how tax is shared among producers and consumers.

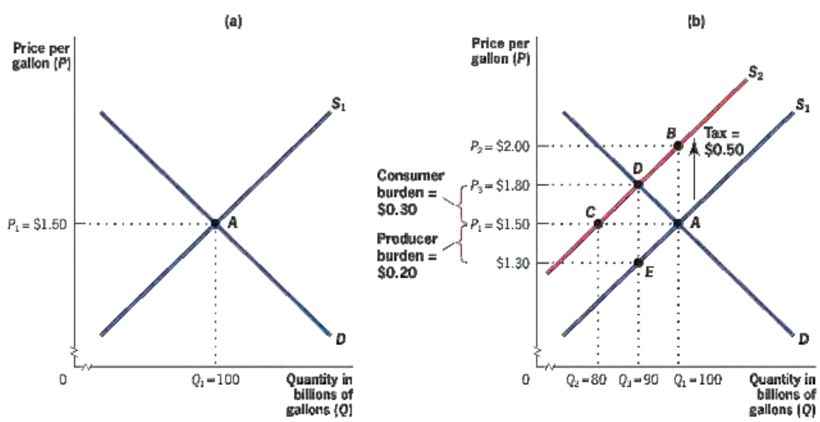
Key insight: we need to keep track of two prices, seller price and consumer price:

$$p_B - t = p_S$$

where p_B is the price buyers receive, and p_S is the price sellers receive.

3.1.1 Tax on Sellers

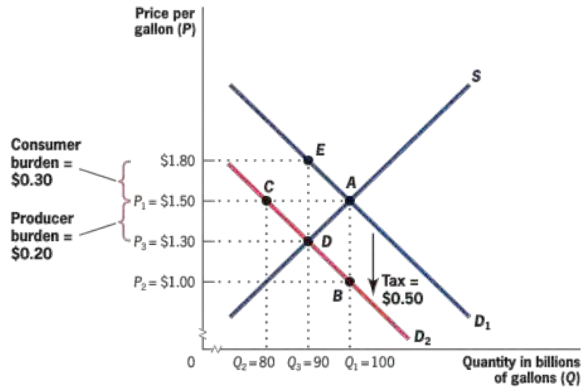
If tax is levied directly on sellers, the supply curve itself has not changed. But we have to track the S curve to track the two prices (p_B, p_S). In this case, p_B is the price consumers paid, and correpsondingly, the sellers are going to get $p_B - t$ as p_S. On graph, the tax will result the S curve to move up by the amount of tax per unit.



In equilibrium, the quantity declines; the price paid by buyers p_B increases, and the price received by the seller $p_S = p_B - t$ decreases. Here, the incidence of the tax is shared by both sellers and buyers, and both parties are "worse off", if we just limit our analysis on price paid.

3.1.2 Tax on Buyers

If tax is levied on buyers, similarly, the demand curve itself has not changed, but hte D curve will shift due to the inconsistency of p_B and p_S. Suppose sellers receive a price p_S, considering the tax, the price paid by the consumer is $p_S + t$ as p_B. On graph, the tax will result the D curve to move down by the amount of tax per unit.



The equilibrium analysis is as before, the equilibrium quantity falls, with lower seller price and higher buyer price. The incidence of tax is also shared by both sellers and buyers, and they are made "worse off" on prices received.

Interestingly, the two results with tax either levied on buyers or sellers will reach the same result: same equilibrium quantity, same incidence of tax. We can safely conclude that statutory incidence does not tell us about economic incidence; but under either scenario, the incidence analysis is identical. Moreover, in both cases, the exact incidence of tax is shared among sellers and buyers according to their relative elasticity. The party with less elasticity will suffer more.

3.1.3 Math of Taxation

Assume unit tax of t on suppliers. Note that it does not matter statutory incidence is attributed to which party. Then, the consumer pay p_B and producers receive $p_S = p_B - t$.

In equilibrium, the intersection is set by $S(p_S)$ and $D(p_B)$, which satisfies

$$S(p_B - t) = D(p_B)$$

Notice that p_B is a function of t, since the tax will change the equilibrium price, so the equilibrium condition can be further specified as

$$D\left(p_B(t))\right) = S\left((p_B(t) - t)\right)$$

Take derivative with regard to t,

$$\begin{aligned}
\frac{\mathrm{d}D}{\mathrm{d}p}\frac{\mathrm{d}p_B}{\mathrm{d}t} &= \frac{\mathrm{d}S}{\mathrm{d}p}\frac{\mathrm{d}(p_B(t)-t)}{\mathrm{d}t} = \frac{\mathrm{d}S}{\mathrm{d}p}\left(\frac{\mathrm{d}p_B}{\mathrm{d}p} - 1\right) \\
\iff \frac{\mathrm{d}p_B}{\mathrm{d}t} &= \frac{\frac{\mathrm{d}S}{\mathrm{d}p}}{\frac{\mathrm{d}S}{\mathrm{d}p} - \frac{\mathrm{d}D}{\mathrm{d}p}} \\
\iff \frac{\mathrm{d}p_B}{\mathrm{d}t} &= \frac{\frac{\mathrm{d}S}{\mathrm{d}p}\frac{P}{Q}}{\frac{\mathrm{d}S}{\mathrm{d}p}\frac{P}{Q} - \frac{\mathrm{d}D}{\mathrm{d}p}\frac{P}{Q}} = \frac{\varepsilon_S}{\varepsilon_S - \varepsilon_D}
\end{aligned}$$

Note that $\varepsilon = \frac{\frac{\mathrm{d}Q}{Q}}{\frac{\mathrm{d}P}{P}} = \frac{\mathrm{d}Q}{\mathrm{d}P}\frac{P}{Q}$, and $\varepsilon_S > 0, \varepsilon_D < 0$.

Similarly, we can write the equilibrium condition as

$$D(p_S(t) + t) = S(p_S(t))$$

Take derivative with regard to t, and get

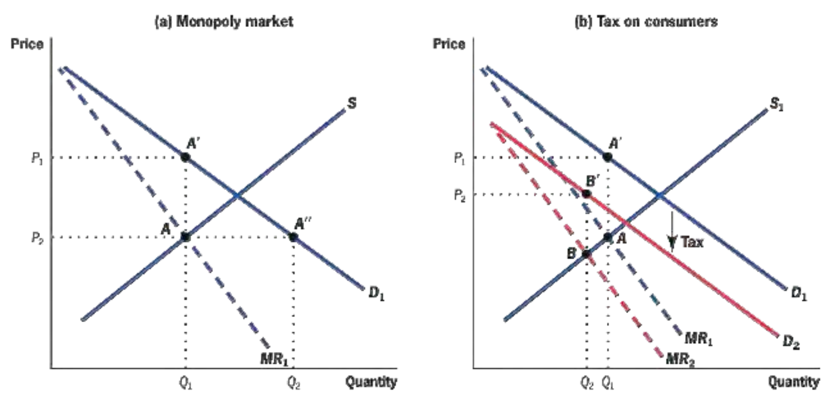
$$\frac{\mathrm{d}p_S}{\mathrm{d}t} = \frac{\varepsilon_D}{\varepsilon_S - \varepsilon_D}$$

Therefore, tax incidence depends on relative elasticities.

- The relatively smaller the demand elasticity [in absolute value] (i.e., more inelastic) the larger the change in p_B, the smaller the change in p_S.
  - $\varepsilon_D = 0$, i.e., inelastic demand
  - $\varepsilon_S = +\infty$, i.e., perfectly elastic supply
- The smaller the supply elasticity (i.e., more inelastic) the smaller the change in p_B, the greater the change in p_S.
  - $\varepsilon_S = 0$, i.e., inelastic supply
  - $\varepsilon_D = -\infty$, i.e., perfectly elastic supply

In sum, statutory incidence is not equal to economic incidence, and equilibrium is independent of who nominally pays the tax. The bottomline for economic incidence is that, larger burden of tax goes to less elastic side of the market.

We have discussed the taxation in perfectly competitive market, which is the simplest case to analyse. In extension, the tax incidence in the monopioly market would be more complicated. In monopoly market, the optimum output level for the producer is determined via the intersection of MC and MR curves, instead of simply the S and D curves.



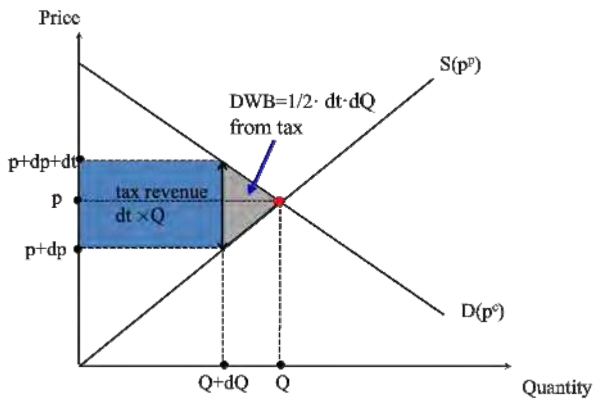
3.2 Efficiency Costs of Taxation

The inefficiency of any tax is determined by the extent to which consumers and producers change their behavior to avoid the tax. Or on the other hand, the inefficiency is caused because taxation will distort the free market mechanism and some trades that could have possibly deal are now "prohibited" due to taxation. Such inefficiency, or distortion, will cause deadweight loss. But note that if there is no change in quantities consumed, the tax has no efficiency costs, which means no such trades are "limited".

The taxes are levied on sellers and buyers, and then collected by the government as revenue for socially welfare-improving activities. Thus, from the perspective of society, the definition of surplus should be modified as

$$\begin{aligned}\text{Total Surplus} &= \text{Consumer Surplus} + \text{Producer Surplus} + \text{Government Revenue} \\ &= \text{Consumer Surplus} + \text{Producer Surplus} + \text{Tax}\end{aligned}$$

Deadweight loss, or excess burden of taxation, is the welfare loss created by tax over and above the tax revenue generated by the tax. Note that welfare consists of consumer surplus and producer surplus.



Consider a small tax $\mathrm{d}t$ starting from tax-free equilibrium, the DWL of such tax $\mathrm{d}t$ is measured by the Harberger Triangle.

$$DWL = \frac{1}{2}\mathrm{d}Q\mathrm{d}t$$

where $\mathrm{d}Q < 0, DWL < 0$.

In equilibrium, $Q = S(p_S)$, and hence $\mathrm{d}Q = \frac{\mathrm{d}S}{\mathrm{d}p_S}\mathrm{d}p_S$.

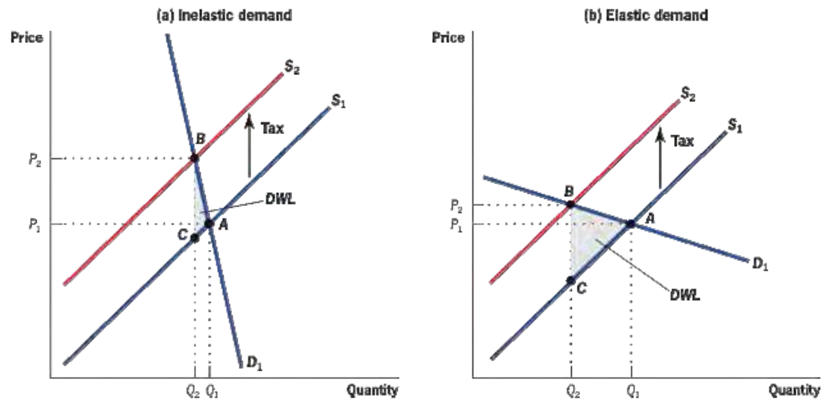
$$DWL = \frac{1}{2}\mathrm{d}Q\mathrm{d}t = \frac{1}{2}\frac{\mathrm{d}S}{\mathrm{d}p_S}\mathrm{d}p_S\mathrm{d}t = \frac{1}{2}\frac{\mathrm{d}S}{\mathrm{d}p_S}\frac{p_S}{S}\frac{Q}{P}\frac{\mathrm{d}p_S}{\mathrm{d}t}(\mathrm{d}t)^2$$

where $\varepsilon_S = \frac{\mathrm{d}S}{\mathrm{d}p_S}\frac{p_S}{S}$, and $\frac{\mathrm{d}p_S}{\mathrm{d}t} = \frac{\varepsilon_D}{\varepsilon_S - \varepsilon_D}$. Therefore

$$DWL = \frac{1}{2}\mathrm{d}Q\mathrm{d}t = \frac{1}{2}\frac{Q}{P}\frac{\varepsilon_S\varepsilon_D}{\varepsilon_S - \varepsilon_D}(\mathrm{d}t)^2 = \frac{1}{2}\frac{Q}{P}\frac{1}{\frac{1}{\varepsilon_D} - \frac{1}{\varepsilon_S}}(\mathrm{d}t)^2$$

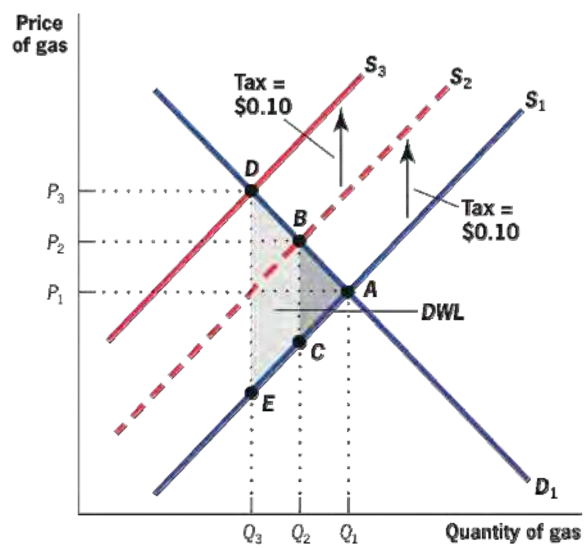
DWL's expression enlightens us that

- DWL increases with the absolute size of elasticities. ($\varepsilon_S > 0, \varepsilon_D < 0$)
  - More efficient to tax relatively inelastic goods.

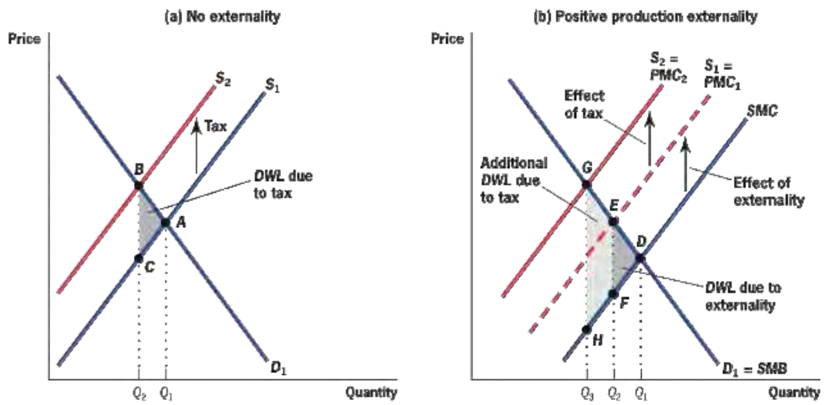


- DWB increases with the square of the tax rate.
  - Small taxes have relatively small efficiency costs; large taxes have relatively large efficiency costs.
  - Better to spread taxes across all goods to keep each tax rate low.
  - Better to fund large one time govt expense (such as a war) with debt and repay slowly afterwards than have very high taxes only during war.

Note that our induction of DWL starts from tax-free equilibrium. Pre-existing distortions (e.g. an existing tax) makes the cost of taxation higher. On graph, the effect of tax (DWL) moves from the triangle to trapezoid. Marginal DWL rises with tax rate.



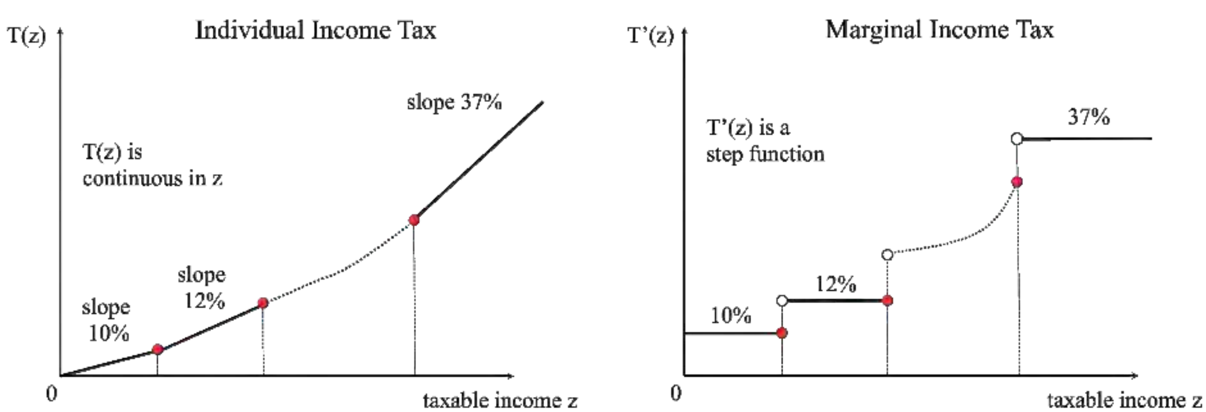
Similarly, the externality is a form of latent tax. Sometimes, the effect of externalities and taxes may overlap and create an even greater effect, like the case of marginal DWL with increasing tax rate.



3.3 Taxation and Behavior

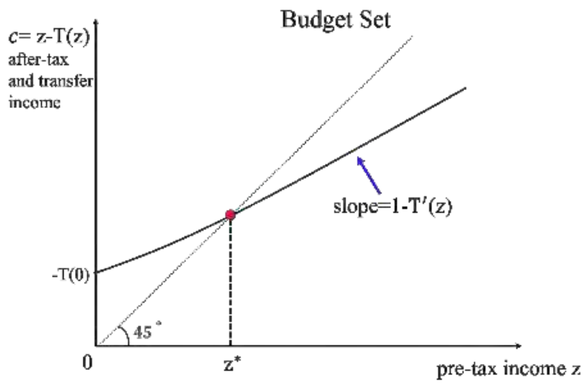
Generally, the government use taxes and transfers to reduce inequity. Specifically, taxes are collected by the government to raise revenue, and then this revenue funds transfer programs. Moreover, the transfers can be categorized into two kinds.

- Universal Transfers
  - Public education, health care benefits, retirement and disability benefits, unemployment benefits.
- Means-tested Transfers
  - In-kind (public housing, food stamps in the US) & in-cash benefits (minimum income).



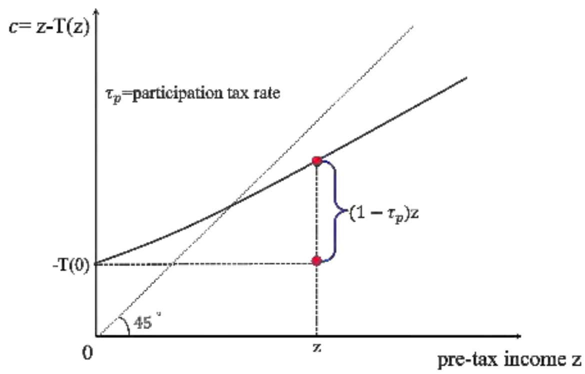
Individual income tax is the amount of tax the person is levied. The tax rates in different ranges may differ, taking derivatives for individual income tax and get the marginal income tax (i.e., tax rates for each income range).

Suppose an individual has the pre-tax income z, and $T(z)$ denotes net tax for her, which integrates taxes and transfers. For individuals with zero earnings, the after-tax income is $0-T(0)$. The break-even earnings point z^* is set at $T(z^*) = 0$, where tax equals to transfer.



When it comes to tax rate, distinguish from two concepts.

- Marginal tax rate $T'(z)$: individual keeps $1 - T'(z)$ for an additional \$1 of earnings from z.
  - This describes "intensive margin".
- Participation tax rate $\tau_p(z) = \frac{T(z)-T(0)}{z}$: individual keeps fraction $1-\tau_p$ of earnings when moving form not working (and then has zero earnings) to working (and then has earnings of z).
  - This describes "extensive margin".



Suppose in an economy, there are N individuals with fixed income $z_1 < z_2 < ... < z_N$. where income z is fixed for each individual, exogenous to $T(\cdot)$. $T(z)$ as before, is the net tax on income z, which means tax if $T(\cdot) > 0$, transfer if $T(\cdot) < 0$. After considering the net tax, the after-tax income c is therefore $c = z - T(z)$. The individual's utility $u(\cdot)$ is built upon her after-tax income c, which is strictly increasing and concave, and same for everyone in the economy. The government in the economy hopes to maximize Utilitarian objective, the social welfare function:

$$SWF = \sum_{i=1}^{N} u(c_i) = \sum_{i=1}^{N} u(z_i - T(z_i))$$

subject to government's budget constraint

$$\sum_{i=1}^{N} T(z_i) = 0$$

i.e, taxes need to fund transfers.

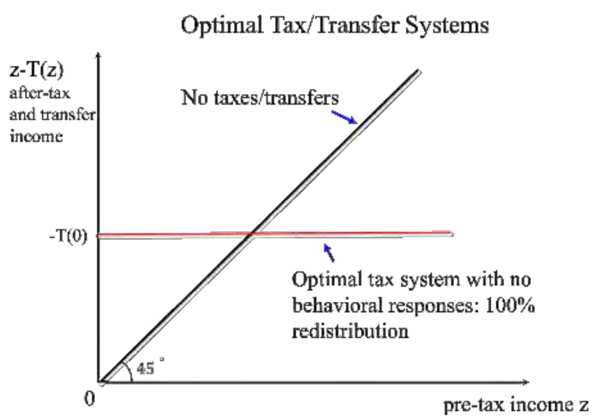
Start from focusing on individual $i = 1$. Replace $T(z_1) = -\sum_{i=2}^{N} T(z_i)$ from government's budget constraint, the social welfare function is like

$$SWF = u(c_1) + \sum_{i=2}^{N} u(c_2) = u\left(z_i + \sum_{i=2}^{N} T(z_i)\right) + \sum_{i=2}^{N} u(z_i - T(z_i))$$

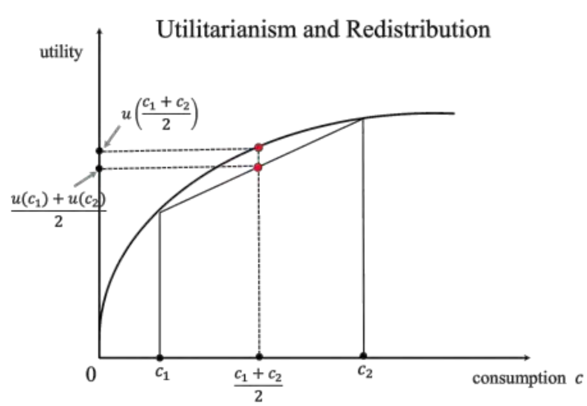
F.O.C. in $T(z_j)$ for a given $j = 2, ..., N$:

$$\begin{aligned} &\frac{\partial SWF}{\partial T(z_j)} = u'\left(z_i + \sum_{i=2}^{N} T(z_i)\right) - u'(z_j - T(z_j)) = 0 \\ \Longleftrightarrow &\frac{\partial SWF}{\partial T(z_j)} = u'(z_1 - T(z_1)) - u'(z_j - T(z_j)) = 0 \\ \Longrightarrow &u'(z_1 - T(z_1)) = u'(z_j - T(z_j)), \forall j = 2, ..., N \end{aligned}$$

Therefore, $z_j - T(z_j)$ is constant for all $j = 1, 2, ..., N$, since $u(\cdot)$ is strictly increasing and concave. This result of Utilitarian object indicates a perfect equalization of after-tax income; in other words, 100% tax rate and redistribution. Utilitatianism with decreasing marginal utility leads to perfect egalitarianism.



This egalitarianism result seems surprising at first glance, however, it is also straightforward from a two-person economy. All that mechanism goes to the strictly increasing and concave form of utility function.



Issues with the simple model:

1. No behavioral responses:
   - Obvious missing piece: 100% redistribution would destroy incentives to work and thus the assumption that is exogenous is unrealistic.
   - Optimal income tax theory incorporates behavioral responses.
2. Issue with Utilitarianism:
   - Even absent behavioral responses, many people would object to 100% redistribution.
   - Citizens' views on fairness impose bounds on redistribution government can do.

3.3.1 Behavior Response

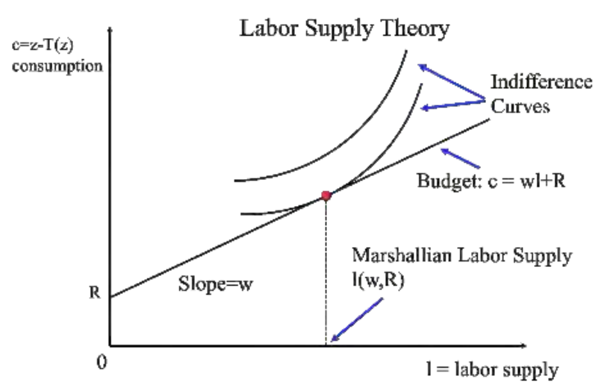
After considering the behavior responses to the taxes or transfers, the "appropriate" amount of taxes or transfers is a matter of equity and efficiency tradeoff.

If the society feels that inequality is so severe that taxes should be used to raise revenue for transfer programs to reduce inequality in disposable income, then taxes are more desirable. However, taxes and transfers would form a distortion to people's incentives to work. High tax rates will probably create economic inefficiency, because the poor can ease with the free-meal transfer, and the rich would step back from work due to shrinked profits. Thus, size of behavioral response limits the ability of government to redistribute with taxes and transfers, which generates an equity-efficiency tradeoff.

Labor Supply Theory Suppose individual has utility $u(c, l)$ over labor supply l (in hour) and consumption c, and her wage is $\bar{w}$ per hour. The utility function behaves well that $u(c, l)$ is increasing in c and decreasing in l (equivalent to increasing in leisure). For convenience, denote $w = (1-\tau)\bar{w}$ as the after-tax wage rate. Additionally, the individual has a non-labor income of R. Her objective for maximizing her utility is

$$\max_{c,l} u(c, l) \text{s.t. } c = wl + R \Longrightarrow \text{F.O.C } [l]: \quad \frac{\partial u}{\partial c} w + \frac{\partial u}{\partial l} = 0$$

where the F.O.C. of l defines the Marshallian labor supply $l = l(w, R)$.



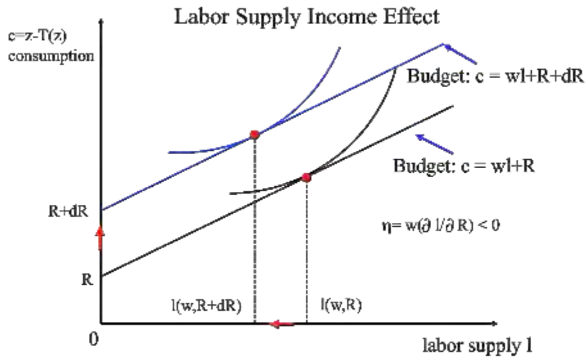
Uncompensated labor supply elasticity (with regard to after-tax wage rate w) is defined as

$$\varepsilon^u = \frac{\partial l}{\partial w} \frac{w}{l}$$

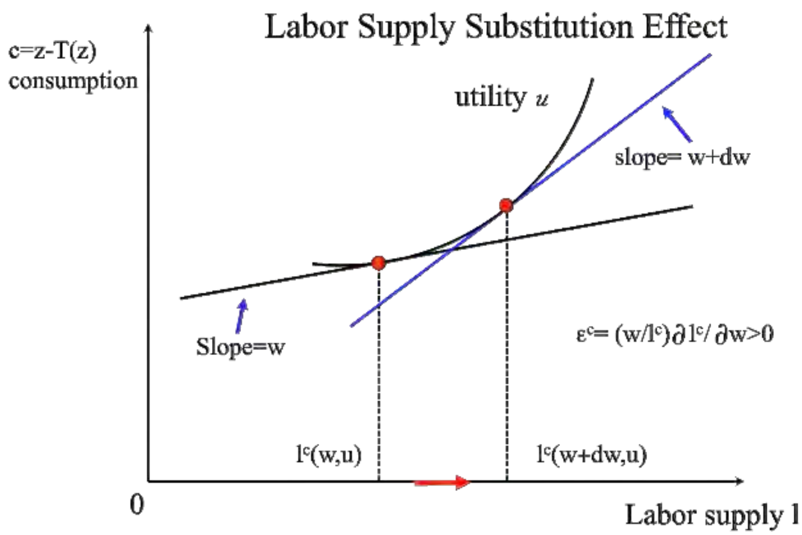
Income effect is defined as

$$\eta = \frac{\partial l}{\partial R} w$$

where leisure is assumed to be a normal good, and $\eta < 0$.



For substitution effects, consider Hicksian labor supply: $l^c(w,u)$ minimizes cost dR needed to reach u given slope w.



In other words, keeping the same utility level, find the tangent budget constraint for the indifference curve.

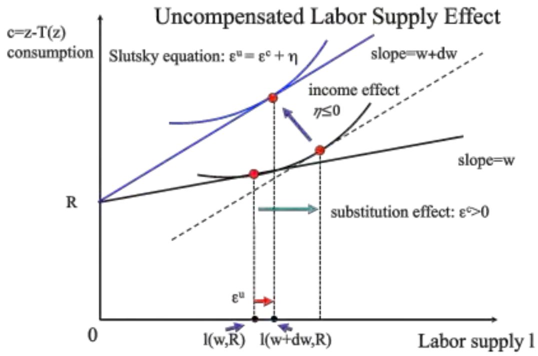
Compensated labor supply elasticity is defined as

$$\varepsilon^c = \frac{\partial l^c}{\partial w} \frac{w}{l}$$

where $\varepsilon^c > 0$.

Combine the income and substitution effect together, Slusky decomposition on the effect of w on labor supply is as follows,

$$\frac{\partial l}{\partial w} = \frac{\partial l^c}{\partial w} + \frac{\partial l}{\partial R} l \iff \varepsilon^u = \varepsilon^c + \eta$$



Application of Labor Supply Theory to Tax Starting from no tax or transfer at all, i.e., $T(\cdot) = 0$.

- Income effects
  - Tax $T(z) > 0$ reduces disposable income and thus increases labor supply;
  - Transfer $T(z) < 0$ increases disposable income and decreases labor supply.
- Substitution effects
  - Marginal tax $T'(z) > 0$ reduces net wage rate and reduces labor supply.

<table>
<tr><th>$z < z^*$</th><th>$z > z^*$</th></tr>
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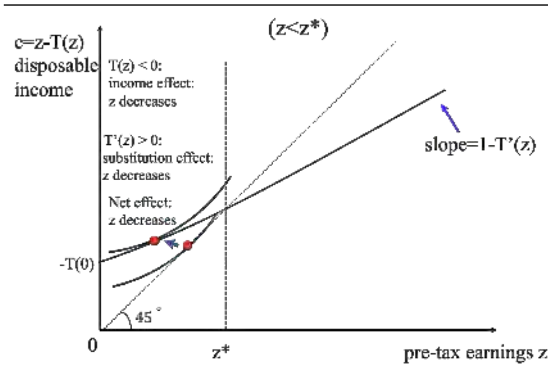

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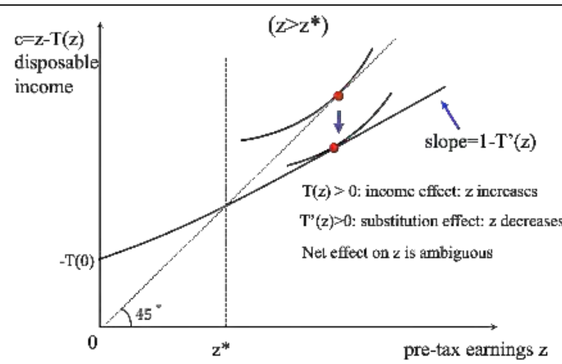

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- When $z < z^*$,
  - $T(z) < 0$: income effect causes z to decrease;
  - $T'(z) > 0$: substitution effect causes z to decrease either.
  - Net effect: z is sure to decrease.
- When $z > z^*$,
  - $T(z) > 0$: income effect causes z to increase;
  - $T'(z) > 0$: substitution effect causes z to decrease.
  - Net effect on z is ambiguous.

Interestingly, from the labor supply theory, the relatively poor who receive transfer from the government loaf from work.

Tax Revenue Suppose individual has disposable income $c = (1-\tau)z + R$, where z is her pre-tax income with τ as the linear tax rate, and R is the fixed universal transfer, fully funded by taxes, i.e., $R = \tau\bar{z}$. Based on all that, individual i chooses l_i to maximize $u_i((1-\tau)w_i l_i + R, l_i)$, where labor supply choices l_i will then determine individual earnings $z_i = w_i l_i$. The average earnings $Z = \frac{\sum_i z_i}{N}$ will respond to the net-of-tax rate $1-\tau$. Therefore, the average earnings Z can be written as $Z = Z(1-\tau)$.

Tax revenue TR collected from each individual is

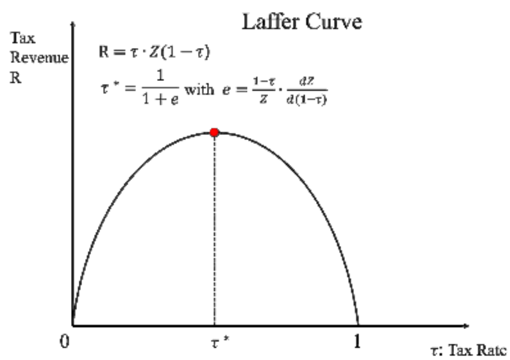
$$TR = \tau \cdot Z(1-\tau)$$

Laffer rate τ^* is set to maximize tax revenue TR, the F.O.C. is

$$TR'(\tau) = Z - \tau \cdot \frac{\mathrm{d}Z}{\mathrm{d}(1-\tau)} = 0 \iff \frac{\tau}{1-\tau}\left(\frac{1-\tau}{Z}\frac{\mathrm{d}Z}{\mathrm{d}(1-\tau)}\right) = 1$$

Define $e = \frac{1-\tau}{Z}\frac{\mathrm{d}Z}{\mathrm{d}(1-\tau)}$ with practical meanings as the elasticity of average income Z with respect to the net-of-tax rate $1-\tau$. Then

$$\tau^* = \frac{1}{1+e}$$



Tax Revenue per person $TR = \tau Z$ is hump-shaped (inverse U-shape) with τ, which is the so-called Laffer Curve. Laffer Curve enlightens us that, it is inefficient to have $\tau > \tau^*$, because decreasing τ would make taxpayers better off, with increasing tax revenue for the government. All in all, the Laffer Curve depicts the tradeoff between tax base (determined by labor supply) and tax rate (proportion of the base).

Considering behavioral responses, the government again chooses τ to maximize utilitarian social welfare

$$SWF = \sum_{i=1}^{N} u_i\left((1-\tau)w_i l_i + \tau \cdot Z(1-\tau), l_i\right)$$

The difference lies in the utility function here has taken labor supply l_i into account, i.e., behavioral responses to tax rate. And the response will affect the tax revenue per person $\tau \cdot Z(1-\tau)$ that is redistributed back as transfer to everyone.

Government's F.O.C. with respect to τ is

$$\frac{\mathrm{d}SWF}{\mathrm{d}\tau} = \sum_{i=1}^{N} \frac{\partial u_i}{\partial c} \cdot \left(-z_i + Z - \tau \frac{\mathrm{d}Z}{\mathrm{d}(1-\tau)} \right) = 0$$

where the envelope theorem is used since l_i has already maximized u_i. (deduction of Laffer Curve)

Hence, we have the following optimal linear income tax formula

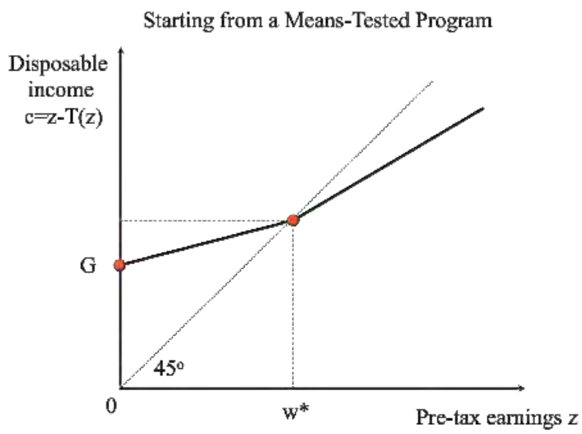
$$\tau = \frac{1-\bar{g}}{1-\bar{g}+e}, \text{with } \bar{g} = \frac{\sum_i z_i \frac{\partial u_i}{\partial c}}{Z \sum_i \frac{\partial u_i}{\partial c}}, e = \frac{1-\tau}{Z} \frac{\mathrm{d}Z}{\mathrm{d}(1-\tau)}$$

where $\bar{g}$ is kind of a measure of equity, and e, the elasticity, is a symbol of efficiency.

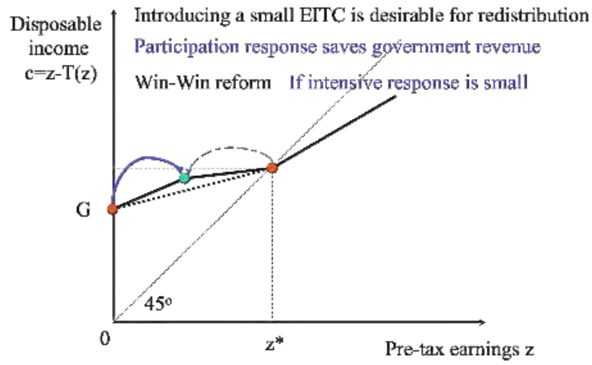
τ decreases with elasticity e and $\bar{g}$. This relationship further describes the equity-efficiency tradeoff. When $\bar{g}$ is low, τ should increase for redistribution, but that may hurt efficiency.

τ is close to Laffer rate $\tau^* = \frac{1}{1+e}$ when $\bar{g}$ is low, which means inequality is high, and marginal utility decreases fast with income.

3.3.2 Behavioral Responses & Labor Participation



Starting from a means-tested program, where the marginal tax rate before the break-even point is lower, and higher after break-even. If \$1 to low-paid workers values more than \$1 distributed to all, then introducint a small EITC (Earned Income Tax Credit, a tax break) is desirable for redistribution. Moreover, it is a win-win reform, since the participation response of the low-income workers will further in return save the government revenue. However, those medium-income workers may jump back and quit working due to the increased intensive margin. Therefore, the win-win scenario is reached when intensive response is small.



4 Social Insurance

- Social insurance: government intervention in providing insurance against adverse shocks to individuals.
  - Examples
    - Health insurance;
    - Retirement and disability insurance (social security);
    - Unemployment insurance.
    -
- Insurance premium ( ): **Money paid** to an insurer so that an individual will be insured against adverse events.

$$\text{Insurance} \Longleftarrow \text{Uncertainty}$$

4.1 Model Uncertainty

Suppose there are multiple $n \geq 2$ outcomes, and each outcome i is assigned with a monetary value $x_i \in \mathbb{R}$,

$$\vec{x} = (x_1, ..., x_n) \in \mathbb{R}^n$$

and is realized with probability

$$\vec{p} = (p_1, ..., p_n) \in [0, 1]^n, p_i \in [0, 1], \sum_{i=1}^{n} p_i = 1$$

Note that one method to evaluate lottery $(\vec{p}, \vec{x})$ is through its expected payoff, $\mathbb{E}[\tilde{x}] = \sum_{i=1}^{n} p_i x_i$.

4.1.1 Expected Utility Model

The Expected Utility (EU) model: people **maximize expected utility**, instead of maximizing expected payoff.

$$\mathbb{E}[u(\tilde{x})] = \sum_{i=1}^{n} p_i u(x_i)$$

where $u : \mathbb{R} \to \mathbb{R}$, a Bernoulli utility function mapping from monetary outcome to utility.

$\forall \mathcal{L} = (\vec{p}, \vec{x}), \mathcal{L}' = (\vec{p}', \vec{x}'), \mathcal{L} \succeq \mathcal{L}'$ if and only if

$$\mathbb{E}[u(\mathcal{L})] = \sum_{i=1}^{n} p_i u(x_i) \geq \sum_{i=1}^{n} p_i' u(x_i') = \mathbb{E}[u(\mathcal{L}')]$$

Axioms for Expected Utility Theorem

- Completeness: $\forall \mathcal{L}, \mathcal{L}'$, either $\mathcal{L} \succeq \mathcal{L}'$ or $\mathcal{L}' \succeq \mathcal{L}$.
- Transitivity: $\forall \mathcal{L}, \mathcal{L}', \mathcal{L}''$, if $\mathcal{L} \succeq \mathcal{L}'$ & $\mathcal{L}' \succeq \mathcal{L}''$, then $\mathcal{L} \succeq \mathcal{L}''$.
- Continuity: If $\mathcal{L} \succeq \mathcal{L}' \succeq \mathcal{L}''$, then $\exists \alpha \in [0,1]$, s.t. $\alpha\mathcal{L} + (1-\alpha)\mathcal{L}'' \sim \mathcal{L}'$
- Independence: $\forall \mathcal{L}''$ and $\alpha \in [0,1]$, $\mathcal{L} \succeq \mathcal{L}' \Leftrightarrow \alpha\mathcal{L} + (1-\alpha)\mathcal{L}'' \succeq \alpha\mathcal{L}' + (1-\alpha)\mathcal{L}''$

Expected Utility Theorem

vNM expected utility representation

Suppose that "$\succeq$ "satisfies Axioms 1~4, there must exist a function $U(.)$, s.t.

$$\mathcal{L} \succeq \mathcal{L}' \iff U(\mathcal{L}) \succeq U(\mathcal{L}')$$

Remarks

- $U(.)$ is mapping from a lottery to a utility; $u(.)$ is mapping from a monetary outcome to a utility.
- The theorem holds for continuous outcome spaces as well. If $F : \mathbb{R} \to [0,1]$ is the c.d.f. representing the lottery, $U(\mathcal{L}) = \int u(x)\mathrm{d}F(x)$.

4.1.2 Certainty Equivalent & Risk Attitude

For a utility function u and a lottery $\mathcal{L}$ with c.d.f. F, the certainty equivalent is the amount of money such that

$$u(c(F,u)) = \int u(x)\mathrm{d}F(x)$$

Moreover, risk attitude is defined through $c(F,u)$,

- Risk-Neutral: $c(F,u) = \int x\mathrm{d}F(x)$;
- Risk-Loving: $c(F,u) > \int x\mathrm{d}F(x)$;
- Risk-Averse: $c(F,u) < \int x\mathrm{d}F(x)$.
  - Risk-averse is assumed most of the time.

For any strictly increasing utility function u, the following two statements are equivalent.

1. $c(F,u) < \int x\mathrm{d}F(x)$, for all non-degenerate distribution F.
2. u is strictly concave.

Remarks

Shape of utility function is a convenient way to categorize risk attitude.

- Strictly Convex ⇔ Risk-Averse
- Strictly Concave ⇔ Risk-Loving
- Linear ⇔ Risk-Neutral

4.2 Demand for Insurance

Consider an individual with initial wealth $w > 0$. She is sick with probability $q > 0$, which incurs a loss $d > 0$. To buy an amount α (in percentage of the loss) of insurance contracts, the individual pays premium of $p\alpha$ always, and receives payout αd only if sick. Individual will choose α to maximize $U(\alpha)$, expected utility would be

$$U(\alpha) = (1-q) \cdot u(w - p\alpha) + q \cdot u(w - p\alpha - d + \alpha d)$$

where $u' > 0, u'' < 0$.

For the insurer, the (pre-unit) expected profit is $\Pi(p) = p - qd$. And if $\Pi(p) = 0 \Leftrightarrow p = qd$, the insurance is **actuarially fair** (　　). Such concept can be extended that a game is actuarially fair if its entry cost equals to its expected payoff. Also note that since the individual is risk-averse, she is at least willing to pay qd to insure her wealth against the lost.

One way to think about individual's choice on α is think of such insurance as a contingent plan. Correspondingly, the person has two state in the future, and has w_s of wealth if sick, w_h otherwise. Then, the problem is what we have been quite familiar with - to weight your choice between two options, subject to a budget constraint.

$$U(\alpha) = U(w_s, w_h) = (1-q) \cdot u(w_h) + q \cdot u(w_s) \text{with } w_h = w - p\alpha, w_s = w - p\alpha - d + \alpha d$$

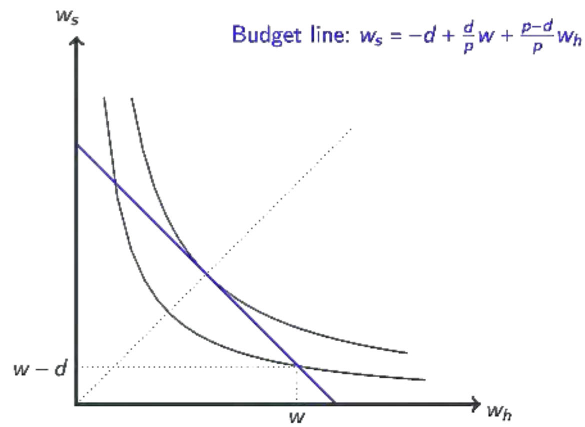
where we have to further work out the relationship of w_h and w_s to represent the budget constraint. Since α is unknown and endogenous, eliminate α in expressions above and get that

$$w_s = -d + \frac{d}{p}w + \frac{p-d}{p}w_h$$

Another way to view the choice on α is to consider α as the unique unknown parameter in $U(\alpha)$, and solve the optimal α^* **without** constraint.

Theorem

> If the premium is actuarially fair, it's optimal for a risk-averse individual to choose $\alpha^* = 1$, i.e. buy the full insurance.



Intuition is that, with concave utility, it's always desirable to reallocate consumption from good states to bad states, in order to wipe out uncertainty and risks.

4.3 Market Mechanism for Insurance

There are three mechanisms by which insurance can operate:

- Risk pooling
- Risk spreading
- Risk transfer

4.3.1 Risk Pooling

Risk Pooling is the main mechanism underlying most private insurance markets, which relies on the Law of Large Numbers. If $x_1, ..., x_n$ are i.i.d. trails with $\mathbb{E}[x_i] = \mu$,

$$\text{plim } \bar{X}_n = \mu$$

Therefore, by pooling amounts of independent risks, insurance company can effectively make risks "disappear" (vanishingly small).

4.3.2 Risk Spread

When risks are *not* independent, LLN does not hold any more, and the risk-pooling mechanism does not work.

- Example: catastrophes are likely to affect many people simultaneously, and the risks are non-diversifiable and correlated.
- This explains that many insurance policies has an escape clause regarding catastrophic events.

Risk Spread works because some of the population are likely to be unaffected, though some co-affected. Since u is concave, if the burden is shared by the body, it is still much better than shouldered by a few. In all kinds of disaster relief, the government is effectively spreading risks to increase social welfare.

4.3.3 Risk Transfer

The key idea of risk transfer is to exploit the heterogeneity in people's risk attitude. For example, if the poor are more risk-averse, it's Pareto efficient to pay the rich to bear risks. The extent to which an individual is risk averse is measured by absolute risk aversion,

$$A(w) = -\frac{u''(w)}{u'(w)}$$

which is decreasing in w. The wealthier you are, the lower the utility cost of risk. Intuitively, a concave utility function is more "linear" when wealth is larger, and exhibits more risk-averse when wealth is smaller.

Take a concrete example. Suppose each indivial has a utility function u over wealth w, $u(w) = \ln w$, which satisfies decreasing absolute risk aversion (DARA). Each person has a 50% chance of losing \$100,000. For someone who is poor and has an initial wealth of \$200,00, $EU = \frac{1}{2}\ln(200000) + \frac{1}{2}\ln(100000) \approx 11.86, \text{Expected Wealth} = \$150000, c(F,u) = \$141421$; and she would be willing to pay \$8579 to defray the risk. For someone who is rich with an initial wealth of \$2,000,000, $EU = \frac{1}{2}\ln(2000000) + \frac{1}{2}\ln(1900000) \approx 14.45, \text{Expected Wealth} = \$1950000, c(F,u) = \$1949359$; and she would be willing to pay only \$641 to avoid the risk. Hence, the poor can pay the rich to bear the risk at any price p, such that $p \in (\$641, \$8570)$, which is a Pareto improvement.

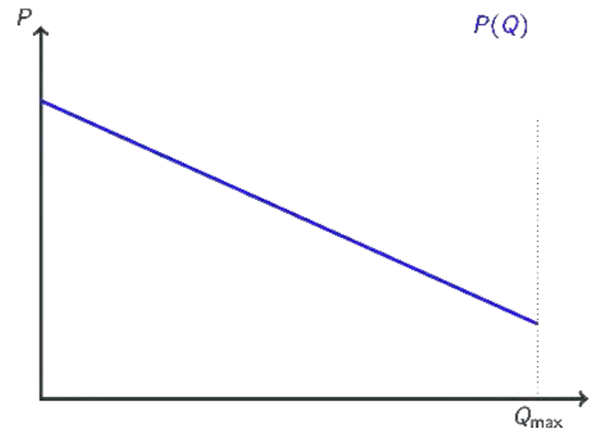
4.4 Adverse Selection

Previously, a rationale for publicly-provided insurance is to spread correlated risks. However, there are government intervention in markets where risks do not seem to be highly correlated, such as health insurance and auto insurance.

- Paternalism and individual optimization failures (e.g. myopia).
- Physical externalities, especially infectious diseases (e.g. mandatory vaccines).
- Redistribution (ex ante insurance behind the "veil of ignorance").
- Samaritan's dilemma.
  - Government cannot commit not to help out uninsured individuals, a form of government failure.

Apart from all those, government intervention may also increase welfare when insurance markets are affected by adverse selection, which comes down to asymmetric information. Asymmetric information can have serious ramifications for market outcomes.

Consider a single insurance contract that covers some probabilistic loss. For the consumer side, consumers are equally risk-averse, different only in their ***privately*** known probabilities of incurring the loss, $\pi \in [0, 1]$. Each consumer only makes a binary choice of whether or not to purchase the insurance contract. Hence, for a given price P of the contract, only individuals with sufficiently high risks will buy it, i.e., $\pi \geq \bar{\pi}(P)$, where as $\bar{\pi}(P)$ is increasing in P. So, the demand function is $Q(P) = 1 - \bar{\pi}(P)$. Let $P(Q) = \bar{\pi}^{-1}(1 - Q)$ be the inverse demand function. Apparently, $P(Q)$ is decreasing in Q.



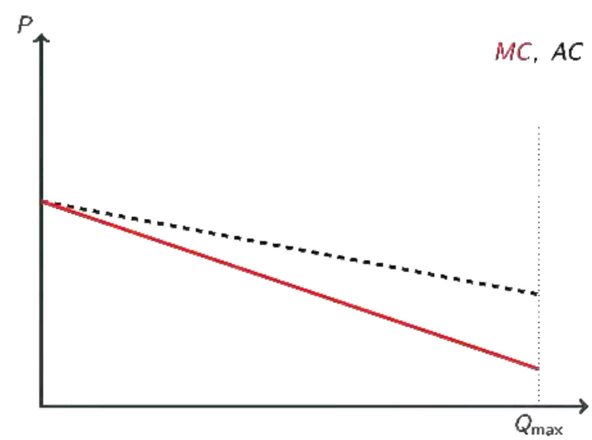
For the insurance companies, they compete only over what price to charge for the market. Let $C(\pi)$ be the firms' costs associated with prividing insurance to the type-π individual. Since firms are risk-neutral, $C(\pi)$ is equal to the expected insurance claim, and is increasing in π. Because the consumers who are most likely to incur the loss have the highest willingness-to-pay, we assume the insurance will be first bought by those will highest willingness. (Even if not, the individuals can trade with each other and reach Pareto improvement.) Therefore, the firms' marginal cost is

$$MC(Q) = C(\bar{\pi}(P(Q)))$$

and the average cost is

$$AC(Q) = \mathbb{E}[C(\pi)|\pi \geq \bar{\pi}(P(Q))]$$

Clearly, Marginal Cost is lower than Average Cost.



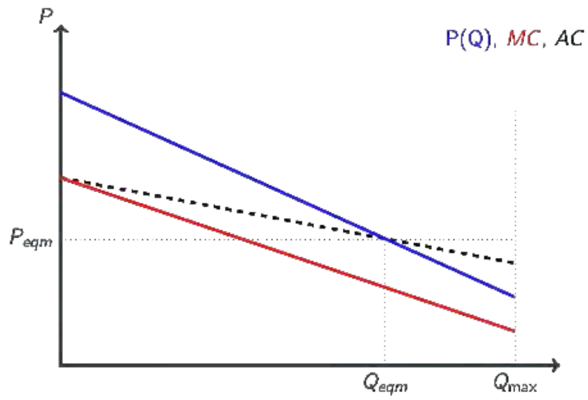
The *downward sloping* MC has represented the adverse-selection property of the insurance market, which is driven by the demand-side customer selection. And this is what makes selection markets special, as in most other contexts, demand curves and cost curves are independent objects.

In a competitive equilibrium, firms' expected profits are zero.

$$P(Q) = AC(Q)$$

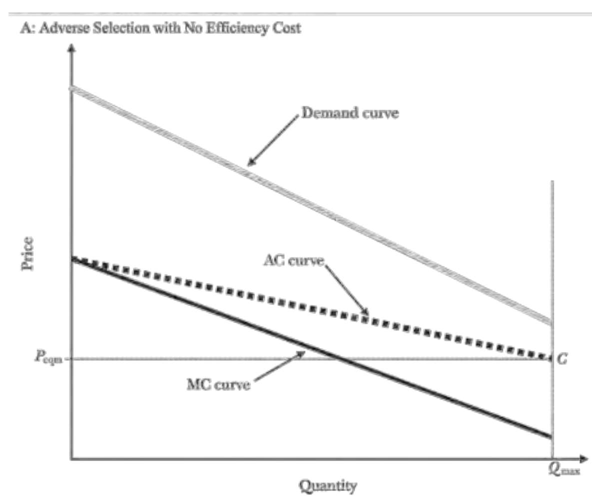
which implies the following equilibrium price

$$P = \mathbb{E}[C(\pi)|\pi \geq \bar{\pi}(P)]$$

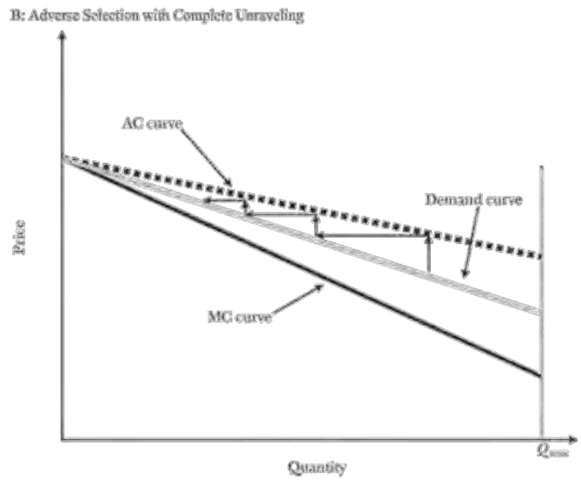


If we assume all consumers are risk-averse, and no other market frictions. Explicitly, the demand curve is always above the MC curve. For the society, it's efficient for all individuals to be insured, say $Q_{eff} = Q_{max}$. However, the equilibrium allocation is determined by the relationship between average cost and demand, but the AC curve is not always below the demand curve! This is the fundamental inefficiency created by the asymmetric information between the two sides of the market.

The amount of under-insurance and its associated welfare loss of adverse selection can vary greatly. For one extreme, the efficient outcome ($Q_{eff} = Q_{eqm} = Q_{max}$) may arise despite adverse selection, if the heterogeneity in unobserved risks is small.



For another extreme, a competitive equilibrium may involve no insurance at all, i.e., the market unravels.



Critique of such model of insurance is that, the model just focus on one single contract and price competition. In fact, firms can compete over both price and coverage. This makes it possible for insurance companies to screen the risk type of consumer by offering different contracts.

4.5 Risk Types and Insurance Contracts

4.5.1 Settings

There is a unit mass of consumers, a fraction $\lambda \in [0,1]$ of whom are low risk (denoted by L), and the remaining $1-\lambda$ are high risk (denoted by H). Denote the probability of monetary loss as π_H and π_L, respectively.

The market is competitive and firms are risk-neutral. Each firm can offer one insurance contract, specifying coverage $C \in [0, D]$ as premium P. All consumers are risk-averse expected-utility maximizesrs. Competition makes all insurance contracts actuarially fair, say $P = \bar{\pi}C$, where $\bar{\pi}$ is the "average risk" of the insurance buyers.

A set of contracts S is a Rothschild-Stiglitz (RS) equilibrium if

- Each contract in S makes non-negative profits;
- There does not exists a contract (C, P) outside of S that earns strictly positive profits when offered in addition to S.

For each risk type $k = H, L$, the expected utility is

$$EU = (1-\pi_k)\cdot u(W_1) + \pi_k \cdot u(W_2)$$

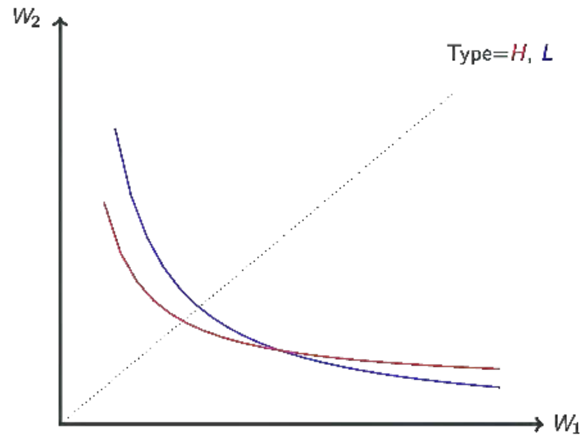
where $W_1 \equiv W_0 - P, W_2 \equiv W_0 - P - D + C$.

Let $\mathrm{d}EU = 0$, we obtain the slope of the indifference curve (or, the marginal rate of substitution) in the (W_1, W_2)-space.

$$\frac{\mathrm{d}W_2}{\mathrm{d}W_1} = -\frac{1-\pi_k}{\pi_k}\cdot\frac{u'(W_1)}{u'(W_2)}$$

Every point in the space of (W_1, W_2) implicitly corresponds to a pair of (C, P).

Since $\pi_L < \pi_H$, the slope of type-L's indifference curve is **steeper** than that of type-H at any (W_1, W_2), which induces the single-crossing property of the indifference curves.



The two indifference curves will cross and cross only once.

The expected profit from a contract is

$$\begin{aligned}\Pi &= P - \bar{\pi}C = P - \bar{\pi}(W_2 - W_0 + P + D)\\ &= (W_0 - W_1) - \bar{\pi}(W_2 - W_0 + W_0 - W_1 + D)\\ &= -(1-\bar{\pi})W_1 - \bar{\pi}W_2 + W_0 - \bar{\pi}D\end{aligned}$$

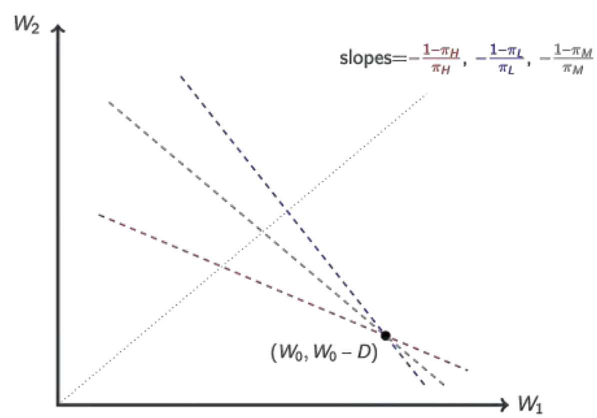
where $W_1 \equiv W_0 - P, W_2 \equiv W_0 - P - D + C$.

So the slope of the isoprofit curves in the (W_1, W_2)-space is

$$\frac{\mathrm{d}W_2}{\mathrm{d}W_1} = -\frac{1-\bar{\pi}}{\bar{\pi}}$$

Note that the isoprofit curve is also the line defining the *budget constraint* for type-$\bar{\pi}$ individuals if actuarially fair insurance is offered.

A key observation is that, any zero-isoprofit curve must pass through $(W_0, W_0 - D)$, which corresponds to consumers buying no fraction of insurance and the firm earning zero profit.

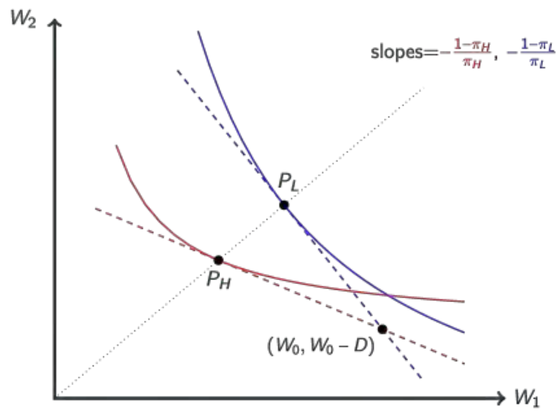


4.5.2 Complete Information

Consider the case of complete information as a benchmarke. If the risk-types of the consumers are **publicly known**, then each type can get separate contract with fair premium. In addition, the

equilibrium contracts must provide full coverage to the buyers (with zero-profit), which is the first-best allocation.

$$P_k = \pi_k D, \quad C_k = D, \quad \forall k = H, L$$



However, with asymmetric information about individual risk types, $\{(\pi_k D, D)\}_{k=H,L}$ is no longer an equilibrium. The problem is that the high-risk type would clearly have the incentive to claim that they are low-risk. Hence, the contract $(P_L, C_L) = (\pi_L D, D)$ would actually attract both risk types, resulting a loss in expectation.

4.5.3 Incomplete Information

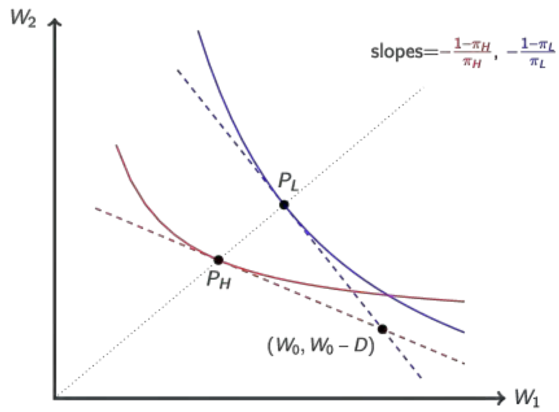
With incomplete information, we are interested in pooling equilibria and separating equilibria.

Separating Equilibria To obtain a separating equilibrium, it's necessary that H-types do not want to take up the contract offered to L-types. With fair premium, the incentive compatibility (IC) of H can only be achieved by restricting the coverage of available to L. Moreover, the single-crossing property of the indifference curves implies that the incentive campatibility (IC) of the$L$-type follows from the H-type. Therefore, the insurance for L-type should be designed to be less atractive so that the H-type do not prefer it anymore and stick with H-type customized insurance. If this is realized, we achieve the separating equilibrium.

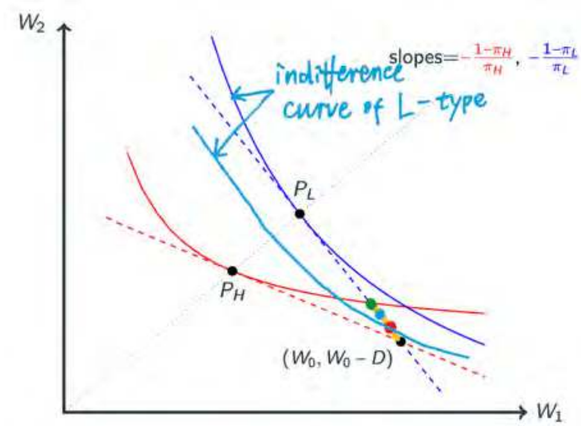
The redesigned constract selling to L, denoted as P'_L, should be located such that

1. Contract at P'_L is purchased by L only. Zero-profit condition implies that P'_L must be located on the zero-isoprofit curve for L.
2. For the H-type, it must be that $P_H \succeq P'_L$. So P'_L should be located on or below the indifference curve of H.

The only region satisfying these two conditions is the yellow-highlighted line in the graph below.



However, not all points in the yellow line hold in equilibrium. Look at the *red* point in the graph below. If the re-designed insurance is provided at the red point, another company will instead sell at the *blue* point because it's above the indifference curve of L crossing the red point so L will purchase blue instead of red. Then P'_L cannot be located at the red point. By the same logic, P'_L cannot sustain at the blue point, until the market competition pushes the insurance product to the green point, which is the intersection between the zero-isoprofit line for L and the indifference curve of H crossing P_H.



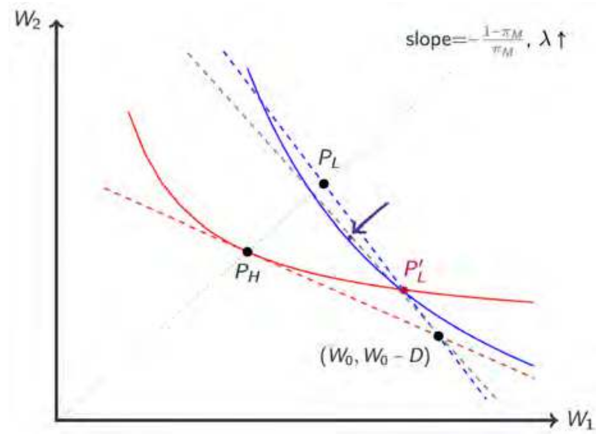
So now (P_H, green) is a candidate for separating equilibrium. The last thing we need to verify is that L will prefer the insurance at the green point over P_H. The single-crossing property of the indifference curves in fact implies that the IC of -types is automatically met if the IC of -types holds. Look at the indifference curve of L crossing the green point. Since it's steeper everywhere than the indifference curve of H and cross only once, it must be located above the P_H, so L prefer the green over P_H. Thus, we find the P'_L at the green point, and (P_H, P'_L) is the only separating equilibrium in this case. At this equilibrium:

1. Insurace contracts P_H and P'_L are sold in the market;
2. Type-H purchases P_H and type-L purchases P'_L;
3. Both contracts generate zero profit for insurance companies.

Let's look at some properties of this separating equilibrium. First, *the high risk types are fully insured*, while the *low risk types are only partly insured*, which is especially ironic since they should be easier to insure. But if a company offered a contract that fully insured L, it would also attract the H and cannot sustain. Second, notice that H are not better off for the hard they do to L. The externality is entirely *dissipative*, meaning that one group loses but on group gains. This is the opposite of Pareto improvement and potentially a large social cost.

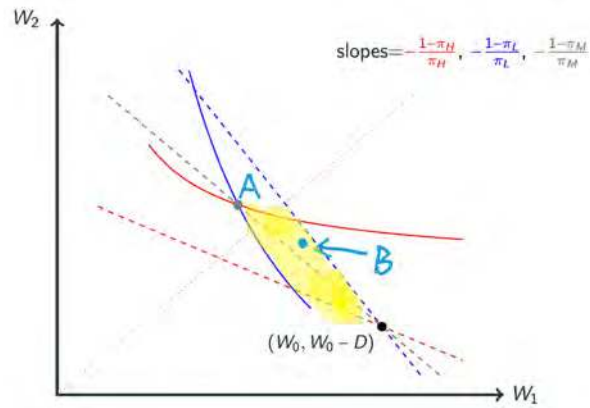
Separating Equilibrium May NOT Exist

The next thing we consider is whether the derived separating equilibrium above always exist, and the answer is **not**. Consider the case where the share of the low-risk type among the population, , increases. Then if selling insurance to both types, the zero-isoprofit line (the grey dashed line in the graph below) moves closer to the one for L.
Now consider the purple point in the graph below. If a new company offers insurance in this point, who would deviate from (P_H, P_L') and buy this insurance? Both types would buy the purple one because it lies above each of their indifference curves when originally purchasing P_H and P_L'. Will any new companies offer the purple contract? Yes because it attracts both types and lies below the grey zero-isoprofit curve so they can earn *positive* profit. So the sole candidate for separating equilibrium, (P_J, P_L'), breaks down and doesn't form an equilibrium anymore.



Thinking about this a bit more and we can get the condition for when the separating equilibrium exists. The condition is that is low enough so that the aggregate zero-isoprofit curve (grey one) is flat enough and never intersect with the L's indifference curve crossing P_L' anywhere.

Pooling Equilibira First, we can immediately see that the purple point cannot be an equilibrium because insurance company there makes positive profit, so new firm entry under market competition will break that down until profit is zero. In other words, any potential pooling equilibrium must lie on the grey zero-isoprofit line, as shown in the graph above.
Consider one (any) point on that line and draw indifference curves for both types in the graph below. We know it satisfies the zero-profit condition, but how about the no market entry condition for equilibrium exist? Consider a new company sells another insurance at point B. Given its location relative to two indifference curves, this new insurance will be preferred by the L-type but not by the H-type. So the L-types all move to B while all H-types stay with A. But when only H-types purchase the A insurance, companies will lose money since A lies above the H's zero-isoprofit line (red dashed line), so no matter where the original pooling insurance contract A is located (within the aggregate zero-isoprofit line), it cannot sustain. As a result, pooling equilibrium never exist.



Why is that? Well, for any pooling insurance at A, it lies above the H's zero-isoprofit line and below the L's zero-isoprofit line. This means the insurance company loses money from H and earns profit from L when both purchases this insurance. In other words, insurance company uses the profit from L to subsidize H and keep the zero profit. This is really not optimal for any profit-maximizing firms; they will want to abandon the unprofitable H and only serve the L, so pooling equilibrium doesn't exist.

4.5.4 Design of Separating Equilibirum in Reality

Insurance companies have designed two features of annuity contracts:

- Degree of back-loading. (higher payments in later periods v.s. constant)
- Payment to estate in the event of death. (e.g., repay beneficiary if die too early)

Competitive markets can function very poorly in the presence of adverse selection. In extreme cases, the market may even unravel completely. In reality, insurance companies may also use **statistic discrimination** to limit who can buy.

- Discrimination itself is neutral, just a description of screening and classifying.
- The public policy, in order to support the market, statistic discrimination is allowed.
- This provides a rationale for public policy interventions in insurance markets.

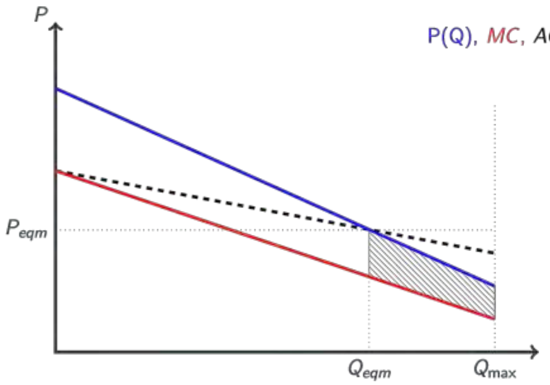
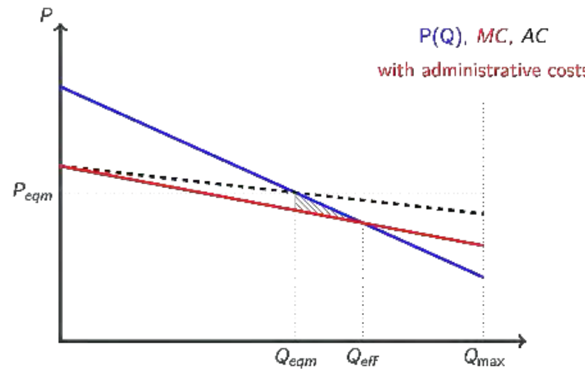
4.6 Public Policy Intervention

- Theoretically, the assumptions are that
  - Everyone is equally risk-averse;
  - No other market frictions exist.

  And a mandatory insurance policy is always efficient.
- The magnitude of the welfare gain, however, will depend on the specifics of the market.
  - Administrative costs
  - Preference heterogeneity
    * Preference heterogeneity may not be independent of risk types.
    * People differ not only in their risk types.

4.6.1 Administrative Costs

Administrative costs, a form of market friction, will deviate the equilibrium and affect the social welfare level.

Without Administrative Costs	With Administrative Costs
	

4.6.2 Adverse Selection & Moral Hazard

One interesting and natrual question when it comes to social insurance is that, are those who buy more insurance more likely to file claims. Specifically, say

$$\text{Insurance} = \beta X + \varepsilon \text{Claims} = \Gamma X + \eta$$

where X defines the characteristics that determine individual insurance prices.

Hence, we are to carry a **positive correlation test**, see if $Cov(\varepsilon, \eta) > 0$. However, it is noteworthy that $Cov(\varepsilon, \eta)$ could be generated by both *adverse selection* and *moral hazard*.

- Adverse Selection: Individuals with private information that they have high expected cost (risks) self-select into insurance markets.
  - Ex-ante. Information before buying is unknown.
- Moral Hazard: Individuals with greater coverage have less incentive to take actions to reduce their expected costs (risks).
  - Ex-post. Behavior after buying is unknown.
  - Intuition suggests that moral hazard can be quite prevalent. For policy implications, government tends not to have comparative advantage with moral hazard.

In order to distinguish adverse selection from moral hazard, we need exogenous variation in contracts. For example, quasi-exogenous variation in premioms (over time, or regression discontinuity in geography), or field experiment.

4.7 Advantageous Selection

Advantageous Selection describes the phenomenon that those who are *less* risky than other observably similar people have *higher* demand for insurance.

Consider a population with two risk types, H and L, and two risk-preference types, C and R (for Cautious and Reckless, respectively). Risk types are private information, and insurance companies cannot tell them apart.

(Marginal) distribution of types are

$$\Pr(H) = \lambda_H, \Pr(L) = 1 - \lambda_H \Pr(C) = \delta_C, \Pr(R) = 1 - \delta_C$$

Assume that, on average, type-H individuals are morel likely to require mediacl service than the type-L.

$$\Pr(M|H) = p_H > p_L = \Pr(M|L)$$

Suppose the likelihood of buying insurance satisfy:

$$Pr(I|H,C) > Pr(I|L,C) \Pr(I|H,R) > \Pr(I|L,R) \Pr(I|H,C) > \Pr(I|H,R) \Pr(I|L,C) > \Pr(I|L,R)$$

In other words, we have both adverse selection on H/L (the first two inequalities) and advantageous selection on C/R (the last two inequalities) operating simultaneously.

Wr are then interested in whether the insured consumers will be more likely than average to require medical service. The overall probability of requiring medical service in the population is

$$\bar{p} = p_H \lambda_H + p_L \lambda_L$$

And the probability for an insured individual to require medical service is

$$p_I = p_H \Pr(H|I) + p_L \Pr(L|I)$$

Then if the insured consumers are more likely than average to require medical service, where adverse selection dominates advantageou selection, the condition is

$$p_I > \bar{p} \iff \Pr(H|I) > \lambda_H$$

where in general, the conditional probability $\Pr(H|I)$ is a function of both λ_H and δ_C and their correlation.

4.8 Exercise for Insurance

There are two states G and B, where G is the no-loss state and B the loss state. The customer has initial wealth $W_0 = 4$, and will suffer loss $\ \ = 3$if state B occurs. The customer is an expected utility maximizer with log function over wealth, so her final wealth levels (consumption) in the two states are W_G and W_B, and the probability of loss is $\ \ $, his expected utility is

$$EU = (1 - \pi) \ln W_G + \pi \ln W_B$$

The insurance company is risk-neutral and wants to maximize expected profit, but perfect competition in the insurance market keeps its expected profit equal to zero. All insurance contracts will be characterized by the amounts of wealth (W_G, W_B) that the consumer will end up with in the two states. Denote P as the premium and C as the coverage.

4.8.1 Moral Hazard

Luckily, the customer can exert effort to affect the probability of loss. A bad effort has zero cost to the consumer in utility ters, and then $\pi = 0.5$; a good effort has cost k to the customer in utility terms, and then $\pi = 0.25$.

> **Q1. Find the inequality linking W_G, W_B, k such that the customer will make good effort if the inequality holds, and bad efforts if the opposite inequality holds. (Fine to assume that the customer will make good effort in the borderline case where the relation holds with exact equality.)**

Simply compare the expected utilities net of effort cost in the two situations. The customer will make good efforts if

$$\frac{1}{4}\ln W_B + \frac{3}{4}\ln W_G - k \geq \frac{1}{2}\ln W_B + \frac{1}{2}\ln W_G \Longrightarrow W_G \geq W_B \cdot e^{4k}$$

Note that this is not only the incentive condition for the customer to make good effort, but also the constraint for insurance company's available zero-profit insurace products. On the zero-isoprofit line, if such inequality does not hold, the customers buying insurance designed for the good-effort and low-risk ones will commit moral hazard and only exert bad efforts, eventually making the company to earn negative profits.

> **Q2: Find the equation for the insurance company's zero-isoprofit line when the customer makes bad effort and when the customer makes good effort, respectively.**

When earning zero profit, it must be that

$$P = \pi C$$

The wealth of the customer in two states can be written as

$$\begin{cases} W_G = W_0 - P \\ W_B = W_0 - P - L + C \end{cases} \Longrightarrow \begin{cases} L = C + W_G - W_B \\ P = W_0 - W_G \end{cases} \overset{P=\pi C}{\Longrightarrow} \pi W_B + (1-\pi)W_G = W_0 - \pi L$$

Therefore, the zero-isoprofit lines for each type of customers are

$$\begin{cases} W_B + W_G = 5, & \text{Bad Effort} \\ W_B + 3W_G = 13, & \text{Good Effort} \end{cases}$$

And note that the two lines intersect at point $(4, 1)$, where the customer is not insured.

> **Q3: Find the local optimum, namely the values of (W_G, W_B) that maximizes the customer's expected utility subject to the insurance company's zero-profit constraint, when the customer is making bad and good effort respectively. Together, find the customer's expected utility under each scenario.**

- If making bad effort, based on the standard model, the customer will buy full insurance at the fair price. Therefore, $W_G = W_B$. Along with the zero-isoprofit line $W_G + W_B = 5$, we can get that $W_B = W_G = \frac{5}{2}$, corresponding utility is $\ln\frac{5}{2} = 0.916$.

- If making good effort, it must be primarily met that $W_G \geq W_B \cdot e^{4k}$. Combined with the zero-profit condition, $W_G = \frac{13 \cdot e^{4k}}{1+3 \cdot e^{4k}}, W_B = \frac{13}{1+3 \cdot e^{4k}}$. The utility level is $\ln 13 - \ln(1 + 3 \cdot e^{4k}) + 2k$.

Q4: Find the value range of k when making good effort is globally optimal.

Simply compare two utility level when making good or bad efforts,

$$\ln 13 - \ln(1 + 3 \cdot e^{4k}) + 2k \geq \ln \frac{5}{2} \Longrightarrow k \leq 0.207$$

Q5: Now suppose $k = 0.1$. Find the customer's expected utility in two situations.

1. **where she gets no insurance at all;**
2. **where effort is observable, and the company sells full insurance at the statistically fair price conditional on customer making good effort.**

1. Note that the non-insured point is located in the region where it is optimal for the customer to *exert good effort*:

$$W_G = 4 > W_B \cdot e^{4k} = e^{0.4} = 1.49$$

Thus, the customer's expected utility where she gets no insurance at all is

$$\frac{1}{4} \ln 1 + \frac{3}{4} \ln 4 - 0.1 = 0.9397$$

2. This time, since effort can be observed, there is no room for moral hazard. The difference between this and the previous setting is that, since competitive firms have to keep zero profit, they will surely not sell those insurances that do not satisfy $W_G \geq W_B \cdot e^{4k}$, which is also the incentive compatibility for the customer to exert good effort. But if effort can be observed by the firm, such commitment will make *all* points on zero-isoprofit line of low-risk type available. Because good effort is ”committed”, the cost of effort is kind of ”sunk cost”, instead of marginal cost for the customer, and will not further influence her behavior like loafing or paying effort. Thus, the incentive compatibility (IC) does not play a role here.

If the customer exert good effort and then buy the insurance, it is sure that she will buy full insurance to maximize her utility, $W_G = W_B$. Along with the zero-isoprofit line $W_B + 3W_G = 13$, we can get $W_B = W_G = \frac{13}{4}$, and the expected utility is

$$\frac{1}{4} \ln \frac{13}{4} + \frac{3}{4} \ln \frac{13}{4} - 0.1 = 1.0787 > 0.9397$$

which is greater than non-insured scenario. So she will buy the insurance

Q7: Quantify the social cost of the information asymmetry.

Fistly, calculate the expected utility of global optimum under information asymmetry:

$$\ln 13 - \ln(1 + 3e^{0.4}) =).2 = 1.0647$$

So the gain with insurance is $1.0647 - 0.9397 = 0.125$.

If the information asymmetry does not exist, the customer should receive full insurance and make good effort, gaining $1.0787 - 0.9397 = 0.139$.

Therefore, the social cost is $\frac{0.139-0.125}{0.139} \approx 10\%$.

4.8.2 Adverse Selection

The basic settings are the same as before, expect that there is no good or bad effort anymore, and the customer's type is exogenous and fixed, also privately known.

> **Q1: Find the equation for the insurance company's zero-isoprofit lines for the customer being the high risk type and the low risk type, respectively.**
>
> **Q2: What insurance contract intended for the high risk type will be offered in the equilibrium? What is the resulting expected utility?**
>
> **Q3: What insurance contract intended for the low risk type will be offered in the equilibrium? What is the resulting expected utility?**
>
> **Q4: Compare the low risk type customer's expected utility in three situations:**
>
> - **first where he gets no insurance at all**
> - **second where he gets the Rothschild-Stiglitz separating equilibrium contract**
> - **third, the hypothetical ideal optimum where type is observable, and the customer is given full insurance at the actuarially fair price for the low type.**
>
> **Q5: How much (in percentage of utility) does the H-type and L-type suffer from the information asymmetry in the insurance market, respectively?**

The body is the same with the previous part of moral hazard.

$$\begin{cases} W_B + W_G = 5, & \text{High Risk} \\ W_B + 3W_G = 13, & \text{Low Risk} \end{cases}$$

In the separating equilibrium, the insurance contract available to be selected by the high risk type will offer them *full* insurance at the fair price. Easy to get $W_G = W_B = \frac{5}{2}, EU_H = \ln\frac{5}{2} = 0.9163$.

The insurance contract available to be selected by the low risk type will be on the zero-isoprofit line $W_B + 3W_G = 13$, and such that the high risk type finds it exactly indifferent to take this contract or the previous one. The equation for this indifference is

$$\frac{1}{2}\ln W_B + \frac{1}{2}\ln W_G = \ln\frac{5}{2} \iff W_B W_G = 6.25 \overset{W_B+3W_G=13}{\Longrightarrow} (W_{G,L1}, W_{B,L1}) \Longrightarrow EU_{L1} = 1.1234$$

When the low-risk type customer gets no insurance,

$$EU_{L0} = \frac{1}{4}\ln 1 + \frac{3}{4}\ln 4 = 1.0397$$

When she gets the Rothschild-Stiglitz separating equilibrium contract, $EU_{L1} = 1.1234$.

Under observable risk type, the customer is given full insurance at the actuarially fair price, so

$$\begin{cases} W_B = W_G \\ W_B + 3W_G = 13 \end{cases} \Longrightarrow W_{B,L2} = W_{G,L2} = \frac{13}{4} \Longrightarrow EU_{L2} = 1.1787$$

Jointly speaking,

$$EU_{L0} < EU_{L1} < EU_{L2}$$

Compared to no insurance at all, insurance can improve the low-risk type customer's expected utility. But RS equilibrium contract is less favorable than the hypothetical ideal optimum without information asymmetry.

$$\begin{cases} \Delta EU_1 = EU_{L1} - EU_{L0} = 0.0837 \\ \Delta EU_2 = EU_{L2} - EU_{L0} = 0.139 \end{cases} \Longrightarrow \frac{\Delta EU_2 - \Delta EU_1}{\Delta EU_2} = 40\%$$

Therefore, the low risk type suffer by 40% of utility compared to the hypothetical ideal optimum.

And for the high risk type, there's zero utility loss caused by information asymmetry.

4.9 Unemployment Insurance

The unemployment insurance aims to insure the risk of consumption loss when temporarily out of work and looking for a new job. Potential benefits are smooth path of consumption, and better job matches. Potential distortions are less job search, higher unemployment rate, and shrinking on the job.

The structure of UI (unemployment insurance) is typically three-fold.

- Eligibility: reason for being unemployed, and employment history.
- Coverage duration: waiting period and potential benefit duration.
- Benefit level: "replacement rate", typically proportional to previou earnings.

The government intervene into unemployment insurance possibly for

- Credit market failures
- Aggregate shocks and business cycle
- Adverse selection
  - Positive correlation test: correlation between probability of buying supplemental UI coverage in year t and unemployment outcome in year $t+1$.
- Moral hazard
  - Not very likely and difficult to actively become unemployed.
  - More of not actively searching for new jobs once covered by UI.

Baily-Chetty model depicts the tradeoff between insurance (of job loss) and incentive (of job search). It turns out that under a set of parameters in such a static model, an optimal benefit level can be determined, and this also provide a guidance to test the optimality of unemployment insurance.

4.9.1 Setup

Static model with two states: a risk-averse agent is either

- Employed and earns wage $w > 0$, or
- Unemployed and has no income.

The agent is initially employed, with an exogenous probability $p \in (0,1)$ of becoming unemployed.

Once unemployed, she can exert effort $e \in [0,1]$ to search for jobs (in current period).

- The probability of finding a job is e.
- The cost of effort is $c(e)$, where $c' > 0, c'' > 0$.

The UI system pays a constant benefit b to the unemployed.

- Financed via lump sum tax τ paid by the employed agents.
- For simplicity, assume the re-employed doesn't need to pay immediately.

Government's budget constraint is

$$p(1-e)b \leq (1-p)\tau$$

Assume that the government keeps its budget balanced.

Agent's expected utility over consumption is

$$U(e) = (1-p) \cdot u(w-\tau) + p\left[e \cdot u(w) + (1-e) \cdot u(b) - c(e)\right]$$

where $u' > 0, u'' < 0$. Note that if an unemployed person successfully finds a job at this period, she does not need to pay the tax τ to the government, and this is also consistent with our expression of government's budget constraint.

4.9.2 First-Best Optimal

Socially Optimal is achievable under perfect information. Under such assumption, there's no moral hazard. In this setting, e can be perfectly monitored.

The optimization problem of a benevolent government is

$$\max_{b,\tau,e} U(e) \text{ s.t. } (1-p)\tau = p(1-e)b$$

The first-best are characterized by

$$\begin{aligned}
\text{[F.O.C. - b]: } & u'(w-\tau) = u'(b) \\
\text{[F.O.C. - e]: } & bu'(w-\tau) + [u(w) - u(b)] = c'(e) \\
\text{[F.O.C. - } \tau \text{]: } & u'(w-\tau) = \lambda \\
\text{[BC]: } & (1-p)\tau = p(1-e)b
\end{aligned}$$

where

- [F.O.C. - e] internalizes the personal cost. The marginal input to find a job should equate the marginal utility of losing job plus those who are implicitly paying insurance for the unemployed.
- [F.O.C. - b] implies that in the first-best, the agent is fully insured.

$$w - \tau = b$$

which means perfect consumption smoothing. (kind of buying full insurance)

4.9.3 Second-Best with Moral Hazard

More realistically, suppose e is privately chosen by the agent.

Given any government UI policy (b, τ), the agent privately chooses e to maximize $U(e)$.

$$\text{[F.O.C. - e]: } \frac{\mathrm{d}}{\mathrm{d}e}U(e) = 0 \Leftrightarrow u(w) - u(b) = c'(e)$$

Note that both b and τ are exogenous here, and the agent is facing a maximizing problem without constraint.

Compared to the first-best's condition:

$$\text{[F.O.C. - e]: } bu'(w - \tau) + [u(w) - u(b)] = c'(e)$$

Since $c''(\cdot) > 0$, then $e < e^*$. This implies that the agent just searches too little, which is the source of inefficiency. More realistically, agents do not care about their previous co-workers once they are unemployed. The agents will simply get away with receiving b with all employers paying τ to fund it.

4.9.4 Government's Problem

Knowing individuals' reaction under UI policy (b, τ), the government can use *Backward Induction* to solve the maximization problem, taking into account agent's behavioral responses.

$$\begin{aligned} \max_{b,\tau}\ & (1-p)\cdot u(w-\tau) + p\left[e\cdot u(w) + (1-e)\cdot u(b) - c(e)\right] \\ \text{s.t. } & (1-p)\tau = p(1-e)b \qquad (BC) \\ & e = \arg\max_{\tilde{e}} U(\tilde{e}) \qquad\quad (IC) \end{aligned}$$

The last incentive compatibility (IC) follows the individual's problem solution:

$$\text{[F.O.C. - e]: } \frac{\mathrm{d}}{\mathrm{d}e}U(e) = 0 \Leftrightarrow u(w) - u(b) = c'(e)$$

Such problem can be solved, given the government's constrained optimization problem. The second-best (b^*, τ^*, e^*) must satisfy the condition:

$$\frac{u'(b) - u'(w-\tau^*)}{u'(w-\tau^*)} = \frac{\frac{\mathrm{d}(1-e^*)}{1-e^*}}{\frac{\mathrm{d}b^*}{b^*}} = \varepsilon_{1-e^*,b^*}$$

where each side of the equation has practical meanings that

- LHS: **social benefit** of transferring \$1 from high to low state due to increased insurance, which is decreasing in insurance coverage b.
- RHS: **social cost** of transferring \$1 due to decreased search effort, which is non-decreasing with respect to b.

Especially, costs come from the *fiscal externality* from agent's behavioral response to policy on government budget. This would cost every else working agents to fund her longer UI benefits.

Formal derivation of second-best parameters:

The issue of second-best can be addressed by *Backward Induction*. Specifically, given a UI with (τ, b), agents will choose e to maximize her epected utility. Her effort level is determined by (as is shown previously)

$$u(w) - u(b) = c'(e) \Longrightarrow e = e(b)$$

where the effor e, as a response for the agent, is a function of b, say $e = e(b)$. Then, we should treat e as $e(b)$ to incorporate such behavioral response into government's choice.

$$\begin{aligned}
&\max_{b,\tau}\ (1-p)\cdot u(w-\tau) + p\left[e(b)\cdot u(w) + (1-e(b))\cdot u(b) - c(e(b))\right] \\
&\text{s.t. } (1-p)\tau = p(1-e(b))b \qquad (BC) \\
&\qquad u(w) - u(b) = c'(e) \qquad\quad (IC) \\
\Longrightarrow &\begin{cases}
\text{[F.O.C. - b]:} & \frac{\mathrm{d}e}{\mathrm{d}b}u(w) - \frac{\mathrm{d}e}{\mathrm{d}b}u(b) + u'(b)(1-e) - c'(e)\frac{\mathrm{d}e}{\mathrm{d}b} - \lambda(1-e) + \lambda\frac{\mathrm{d}e}{\mathrm{d}b}b = 0 \\
\text{[F.O.C. - } \tau\text{]:} & u'(w-\tau) = \lambda \\
\text{[BC]:} & (1-p)\tau = p(1-e)b
\end{cases}
\end{aligned}$$

where the behavioral response of the agent, $c'(e) = u(w) - u(b)$ should be plugged into [F.O.C. - b] and then have

$$\text{[F.O.C. - b]} \iff u'(b)(1-e) - u'(w-\tau)(1-e) + u'(w-\tau)\frac{\mathrm{d}e}{\mathrm{d}b}b = 0$$

To make this meaningful, do some equivalent transformation to the equation above and then have

$$\text{[F.O.C. - b]} \iff \frac{u'(b) - u'(w-\tau)}{u'(w-\tau)} = \frac{\frac{\mathrm{d}(1-e)}{1-e}}{\frac{\mathrm{d}b}{b}} \equiv \varepsilon_{1-e,b}$$

which is coincidentally linked with unemployment elasticity $\varepsilon_{1-e,b}$. Also, all parameters determined by F.O.C. are optimized ones. (Just for simplicity all parameters were not starred through the proof.)

4.9.5 Test Optimality of Social Insurance

To test the above optimality condition with data, rewrite the marginal utility gap of the LHS using Taylor expansion

$$u'(b) - u'(w-\tau^*) \approx -u''(w-\tau^*)\cdot(w-\tau^*-b^*)$$

Define the coefficient of relative risk aversion (CRRA)

$$\gamma = -\frac{u''(c)\cdot c}{u'(c)}$$

Then, the [F.O.C. - b] can be equivalently written as

$$\begin{aligned}
\text{[F.O.C. - b]} \iff \frac{u'(b) - u'(w-\tau^*)}{u'(w-\tau^*)} &\approx -\frac{u''(w-\tau^*)\cdot(w-\tau^*)}{u'(w-\tau^*)}\cdot\frac{w-\tau^*-b^*}{w-\tau^*} \\
&= \gamma\frac{\Delta c}{c} = \varepsilon_{1-e^*,b^*}
\end{aligned}$$

where $\frac{\Delta c}{c}$ measures the consumption drop during unemployment, and γ is the coefficient of relative risk aversion, and ε_{1-e^*,b^*} is the unemployment elasticity. All those can be estimated from data.

4.9.6 Behavioral Economics & Public Policy

If people fail to choose what is the best for themselves, the government may internene to improve welfare in principle. THere are two behavioral biases that may be particularly relevant for the public policy intervention.

- Exponential-Growth Bias (ERB)
  - e.g. pension, loans, etc.
- Present Bias
  - Time-inconsistency & Procrastination
  - Short-run self is extremely impatient: relative to the current period, all future periods are weighted much less.
  - Long-run self is extremely patient: all future periods are weighted equally.
  - Nudge might help: from opt-in to opt-out.

5 Public Choice

5.1 Majority Voting

Majority voting is a mechanism used to aggregate individuals votes into a social decision, in which individual policy options are put to a vote, and the option that receives the majority of votes is chosen. However, the definition of *majority* may differ. Majority voting can produce a *consistent* aggregation of individual preferences only if preferences are restricted to take a certain form. One such faied example is the tyranny of the majority. Note that instead of majority voting is not equivalent to head-to-head competition matters, the order of which have an influence on the overall winner.

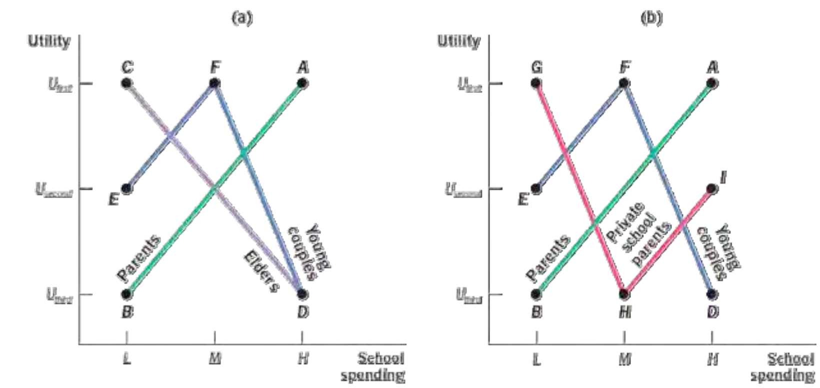
	Parents (33.3%)	**Elders (33.3%)**	**Young Couples (33.3%)**
First choice	*H*	*L*	*M*
Second choice	*M*	*M*	*L*
Third choice	*L*	*H*	*H*

M here is a consistent socially-preferred outcome.

However, under a certain set of preferences, the consistent or stable outcome may not exist. The voting result will cycle with no clear winner, which means majority voting is unable to aggregate preferences in a meaningful way.

	Public school parents (33.3%)	Private school parents (33.3%)	Young Couples (33.3%)
First choice	*H*	*L*	*M*
Second choice	*M*	*H*	*L*
Third choice	*L*	*M*	*H*

If we take the perspective of each voter's peak for her preference, we'll gain a new insight to understand the outcome from the graphic. (Single-Peaked v.s. Non-Single-Peaked)



5.1.1 Median Voter Theorem

Consider choosing along a single dimension.

- Assume that each individual has a single-peaked preference, and peak is the most preferred result for the individual.
- Median voter is the voter whose peak is at the median.
- Voting equilibrium is an outcome that wins in majority voting against any other alternatives.

Median Voter Theorem

Peak of median voter is a voting equilibrium.

Median Voter & Efficiency Efficiency requires

$$\sum \text{Social Marginal Benefits} = \text{Social Marginal Costs}$$

If the sum of social marginal benefits is greater than social marginal costs, the public good is worth providing. What matters for efficiency is the **average** marginal benefit across individuals, instead of the **median** marginal benefit. Median outcome is not efficient, unless Median = Mean, which is not true in general.

Issues with Assumptions

1. Single-dimensional voting:
   - Median voter theorem breaks down with multiple dimensions.
2. Only TWO candidates
   - No stable equilibrium in the model with three or more candidates, because there's always an incentive to move in response to your opponent's positions.
3. No selective voting
   - In the theory all people are assumed to be affected by public goods vote. However, actually only a fraction of citizens vote.
   - In reality, appeal to the base is a way to increase turnout, which in essence is moving away from median voter.
4. No possible deviation
   - Especially the role of money is ignored.
5. Full information
   - Requires perfect information along three dimensions
     – Voter knowledge of the issues and its consequence;
     – Politician knowledge of the issues and its influence on voters;
     – Politician knowledge of voter preferences.

Lobbying Lobbying needs the expending of resources by certain individuals or groups to influence a politician.

- Lobbying could correct the inefficiencies due to median voter theorem, since their value can be achieved by a form of transfer.
- Lobbying can also lead to inefficiencies if public does not have perfect information and hence does not care to pay attention to those who are potentially hurt.

5.1.2 Efficiency of Public or Private sector

- With competition, private production is more innovative and efficient but govt provision or regulation make sense for natural monopolies (e.g. utilities: water, energy, broadband)
- For goods that consumers do not understand well (pensions, health insurance, education), private competition can lead to wasteful advertising or scamming
  – Private firms compete using enticing and costly advertising rather than underlying product quality higher costs than public provision
- In emergency situations (covid), govt command and control beats market to allocate resources (e.g. vaccine distribution)
- Not-for-profit is an intermediate solution (e.g. environment protection) more innovative than govt and not as "predatory" as for-profit

But government may fail even it's selected via voting. Government failure describes the inability or unwillingness of the government to act primarily in the interest of its citizens. Two typical examples are

- Dictatorship: Dictator runs country for his (and family) benefits, not citizens
  - different from Authoritarianism (   )
- Bureaucracies and corruption: Organizations of civil servants that are in charge of carrying out the services of government but follow their self-interest.

5.2 A Model of Regulation & Distrust

5.2.1 Settings

- A continuum of risk-neutral individuals of mass one.
- There are labor and a numeraire good produced with labor.
- Timeline
  1. Individuals are educated to be civic or uncivic during childhood by parents' decision.
     - Denote α as the fraction of the population becomes civic, which is indogenous.
  2. Individuals can become either a routine producer, or an entrepreneur.
     - Productivity of a producer is normalized to 0; an entrepreneur will produce y if uncivic, $y+\varepsilon$ if civic. And $y \sim \mathcal{U}[0,1]$, ε is positive and small.
       * ε is set to break ties but may also capture the fact that production needs cooperation.
       * An entrepreneur, if uncivic, generates a negative externality of $e > 1$ for others.
       * Each individual will know y of yours but not others here.
  3. People vote to regulate entry into entrepreneurship or leave it unrestricted.
     - The voting outcome will be (possibly partly) implemented by officials.
  4. Entrepreneurs produce if entry is authorized. And people work as officials at night.
     - Alternatively, think of it as officials are drawn randomly; it's actually equivalent.
     - If voting to ban, a civic official always bans entry; but an uncivic official demand a bribe to authorize entry regardless of entrepreneur's type, where the bribe is denoted as b.
     - If a civic entrepreneur is denied entry, he returns to routine production; but if he is uncivic, he can still collect bribes when serving as an official at night.

5.2.2 Solution

The model can be solved through backward induction.

Step 4

- If entry is unregulated in voting in step 3, All individuals become entrepreneurs.
- Otherwise, only uncivic entrepreneurs who can bribe will enter.

Step 3 If society decides to regulate entry, every uncivic official sets the bribe to maximize

$$b \cdot (1-\alpha) \cdot (1-b)$$

where $(1-\alpha)$ is the share of uncivic entrepreneurs, and $(1-b)$ is the share (probability) of entrepreneurs with $y > b$. Clearly, optimal $b = \frac{1}{2}$.

The social decision on whether or not to regulate can be written as a function of α.

- Without regulation, all entrepreneurs will enter, and the expected output of an entrepreneur is

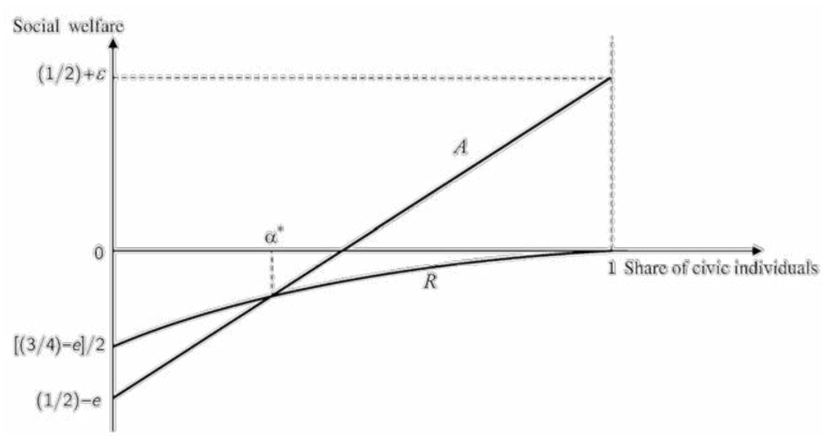
$$A = \frac{1}{2} + \alpha\varepsilon - (1-\alpha)e$$

where $\frac{1}{2}$ is the expected output of entrepreneurs, $y \sim \mathcal{U}[0,1]$.

- With regulation, the expected output of an entrepreneur is

$$R = (1-\alpha) \cdot (1-\alpha) \int_{b^*=\frac{1}{2}}^{1} (y-e)\mathrm{d}y = \frac{(1-\alpha)^2}{2} \cdot (\frac{3}{4} - e)$$

where $(1-\alpha)^2$ is the probability of an uncivic entrepreneur meeting an uncivic official, and the entrepreneurs should have a y greater than $b^* = \frac{1}{2}$. Note that bribes are not included here, since bribes are simply *transfers* between people, no effect on overall social wealth.



$A > R$ if and only if $\alpha > \alpha^*$. The level of public trust is probably positively correlated with α.

Step 1 For your parents, the expected payoff of your child being civic is

$$\begin{cases} \frac{1}{2} + \varepsilon - (1-\alpha)e, & \text{if there is no regulation.} \\ -\frac{1}{2} \cdot (1-\alpha)^2 \cdot e, & \text{if there is regulation.} \end{cases}$$

If there is no regulation, your child will have an expected output of $\frac{1}{2}$, and earn an extra ε of being civic. However, your child will suffer $-(1-\alpha)e$ from the externality imposed by uncivic entrepreneurs. If there is regulation, your child will earn 0 for herself, but suffer from negative externality of uncivic entrepreneurs. Among all entrepreneurs, negative externality can incur only if the entrepreneur's productivity is greater than $\frac{1}{2}$, and an uncivic entrepreneur coincidentially meets an uncivic official.

For your parents, the expected payoff of you being civic is

$$\begin{cases} \frac{1}{2} - (1-\alpha)e, & \text{if there is no regulation.} \\ \frac{1}{8}(1-\alpha) + \frac{1}{4}(1-\alpha) - \frac{1}{2}(1-\alpha)^2 \cdot e, & \text{if there is regulation.} \end{cases}$$

where

- $\frac{1}{8}(1-\alpha) = (1-\alpha) \cdot \frac{1}{2} \cdot (\frac{3}{4} - \frac{1}{2})$
  - $(1-\alpha)$ is the probability of your meeting an uncivic official.
  - $\frac{1}{2}$ is your probability of becoming productive with $y > \frac{1}{2}$.
  - $(\frac{3}{4} - \frac{1}{2})$ is your expected revenue, if you are productive enough and pay the bribe $b^* = \frac{1}{2}$.
- Corruption: $\frac{1}{4}(1-\alpha) = (1-\alpha) \cdot \frac{1}{2} \cdot \frac{1}{2}$
  - $(1-\alpha)$ is the your probability of meeting an uncivic entrepreneur.
  - $\frac{1}{2}$ of the first is the probability of meeting an uncivic entrepreneur with $y > b^* = \frac{1}{2}$.
  - $\frac{1}{2}$ of the second is bribe $b^* = \frac{1}{2}$ you'll receive.
- Negative externality: $-\frac{1}{2}(1-\alpha)^2 \cdot e = (1-\alpha) \cdot (1-\alpha) \cdot \frac{1}{2} \cdot (-e)$.

5.2.3 Equilibrium

Suppose the curves of A and R intersect at α^*. Then, regulation is chosen by the society iff $\alpha < \alpha^*$.

- If $\alpha > \alpha^*$, people vote for unrestricted entry.
  - Then, all individuals prefer becoming civic, and indeed $\alpha = 1 > \alpha^*$.
- If $\alpha < \alpha^*$, people vote for regulation.
  - Then, all individuals prefer becoming uncivic, and indeed $\alpha = 0 < \alpha^*$.
    $\Longrightarrow \alpha = 0, \alpha = 1$ are equilibria. From the intuition,
- If everyone is civic with $\alpha = 1$,
  - Individuals do not expect others to impose negative externalities on them, and hence trust each other and see no reason to regulate entry.
  - Output is maximized in the economy as well.
- If everyone is uncivic with $\alpha = 0$,
  - Entrepreneurs in the equilibrium are the most productive, though corrupt.
  - Even though regulators who allow entry are corrupt, they are still needed to prevent less productive entrepreneurs from generating negative externalities.
    * So even with corrupt officials, the society wants more regulation and restrictions on entry.
    * When individuals distrust others, they prefer government officials to regulate, even when they know these officials themselves cannot be trusted.

6 Central & Local Government

6.1 Tiebout Model

Tiebout's insight was that the factors missing from the market for public goods were **shopping and competition**.

The situation would be different when public goods are provided at the local level by cities and towns.

- Competition will naturally arise because individuals can vote with their feet: if they don't like the level or quality of public goods, they can move away.
- The threat of exit can induce efficiency in local public goods production.

6.1.1 Settings

Suppose there are $2N$ families with identical income Y and 2 towns with N homes each. Town 1 and 2 supply level G_1, G_2 of local public schools. And there are 2 types of families:

- N families with kids, with utility $U^K(C, G)$, value both private consumption C and school quality G.
- N elderly families, with utility $U^E(C)$, value only private consumption C.

Allocation of families across towns is a Tiebout Equilibrium iff:

1. In each town, G is decided by median voter and financed equally by town residents with budget constraint $Y = C + \frac{G}{N}$.
    - If majority in town is elderly then $G = 0$.
    - If majority is families with kids, then $G = G^*$ that maximizes $U^K(Y - \frac{G}{N}, G)$.
2. No any pair of families wants to exchange locations across towns.

6.1.2 Tiebout Theorem

Tiebout Theorem Part I

In equilibrium, families will *sort* themselves in towns according to their *taste* for public good.

Tiebout Theorem Part II

In each town, the level of local public good is *efficient*.

Conclusion

1. Local government don't do any redistribution: individuals receive in local public goods exactly what they are paying in taxes (= benefit principle of taxation; Tiebout sorting).
2. Individuals can choose (through their location choice) their preferred mix of public goods and taxes.
3. Competition between local governmenets forces them to provide local public good efficiently.

6.1.3 Issues with Tiebout Model

The Tiebout model is so idealized that some required assumptions may not hold in reality.

1. Individuals can move without any cost across towns.
2. Individuals have perfect information on the benefits and taxes paid in each town.

3. There must be enough towns so that individuals can sort themselves into groups with similar preferences for public goods.
4. No externalities or spillovers of public goods across towns.
   - If with spillover across towns, public goods will be under provided in Tiebout model.
5. Local governments can charge "poll" taxes, i.e., *equal* payments per person. In reality, local taxes depend on property, consumption, income, etc.

6.1.4 Key Consequence of Tiebout Model

It might be hard for a local government to redistribute from rich to poor, since migration is allowed.

If local distribution is high,

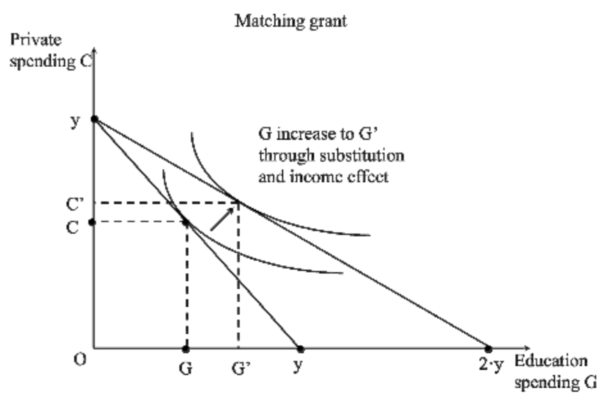
- Poor will flock to the city providing welfare benefits, and
- Rich will flee to other cities to avoid paying for redistribution, then
- $\Longrightarrow$ Local redistribution program will break down.

Therefore, redistribution program works better if implemented at a higher level, since migration is then more costly. At local level, tax-benefit linkage to avoid migration is needed. Tax-benefit linkage refers to the relationship between the taxes people pay and the government goods and services they get in return.

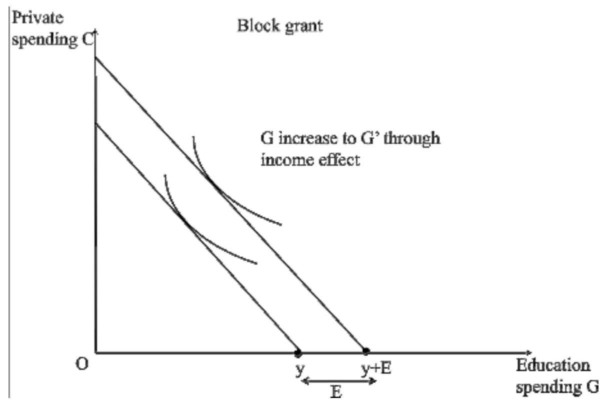
6.2 Intergovernmental Grants

Higher-level government can redistribute across lower levels of government through intergovernmental grants, and lower levels of governemnt provide grants to redistribute across communities and incentivize communities to spend on public goods. Three main forms of grants are:

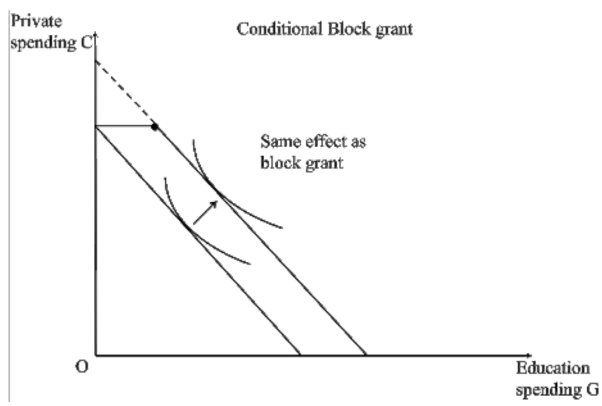
1. Matching grant: the amount of which is tied to the amount of public good spending by the community.



1. Block grant: A grant of some fixed amount with no mandate on how it is to be spent.



1. Conditional block grant: A grant of some fixed amount with a mandate that the money be spent in a particular way
   - In some cases, the outcome is the same as unconditional one.
   - In other cases, corner solution may be obtained.



6.3 Policy Experimentation

6.3.1 Basics

Primary form of experimentation is *experimentation points* ( ). Before deciding whether a new policy should be implemented nationwide, the central government first tries out the policy regionally in a limited number of sites, possibly repeating the experiment in several waves. ( )

The central government generally announces and introduces policy experiments by publishing general guidelines. Such documents are issued by the ministries and commissions that lead the experiments, sometimes co-signed by others.The local government of each experimentation site typically responds to the central government documents by publishing a local experimentation action plan, laying out logistical and implementation details for the experiment.

The central government usually directly assigns certain regions as sites for experiments, but sometimes also solicits local governments that would be willing to participate. Typically, the central government chooses experimentation sites at the province level. And then the provincial governments further delegate the experimentation to specific prefectural cities or counties within their jurisdictions.

A subset of the policy experiments is clustered in "experimental zones" ( ). These are regions selected by the central government and given broad discretionary powers to try out various new policy bundles. Once a policy experiment is determined to be successful, certain experimentation points are set as ”demonstrational zones” ( ). Their experience in implementing the new policy will be actively promoted by the central government to the rest of the country ( ). Effective policies based on the experiments eventually are formalized by the central government and become national policies. In contrast, if a policy experiment fails to generate desirable, for various reasons, the policy experimentation quietly stops expanding beyond the initial implementation stage. And few failed policy experiments are explicitly revoked.

6.3.2 Representativeness

From the central government's perspective, a key criterion for experimentation site selection is its representativeness, which will determine the quality of knowledge one could extract from a policy experiment.

However, there is no clear evidence on the exact mechanisms behind the observed deviation from representativeness. Potential reasons are (more of correlation):

- Local officials have greater political incentives.
- Central and local officials have closer connections.
- A location is more stable economically, socially and politically.

Policy experiments are with high visibility, high political reward, and explicit monitoring by the central government. They may induce additional efforts by local government officials, who are incentivized to make the policies appear successful at the experimentation stage.

6.3.3 Cautions: Alternative Experimentation Objectives

- More complex learning-related objectives

  The central government has other objectives in addition to learning about the true underlying treatment effects, such as persuading other agents who might hold different priors.

- Experimentation sites' own welfare and stability

  Especially when the direction of the experimentation outcome is unclear. Thus, the central government tend to select synthetically.

- Political connection objectives

  Higher trust and higher cooperation; better knowledge of local officials' ability.

- Lastly and importantly: policy learning is by nature extremely difficult.