Introduction to Cost-Benefit Analysis, (Chap.1) and Conceptual Foundations of CBA (Chap.2)

Major Steps in CBA

- Exact Example of Highway in Canada -

1. Specify the set of alternative projects
2. Decide whose benefits and costs count
3. Catalogue the impacts and select measurement indicators
4. Predicts the impacts quantitatively over the life of the projects
5. Monetize all impacts
6. Discount benefits and costs to obtain present values
7. Compute the net present value of each alternative
8. Perform sensitivity analysis
9. Make a recommendation

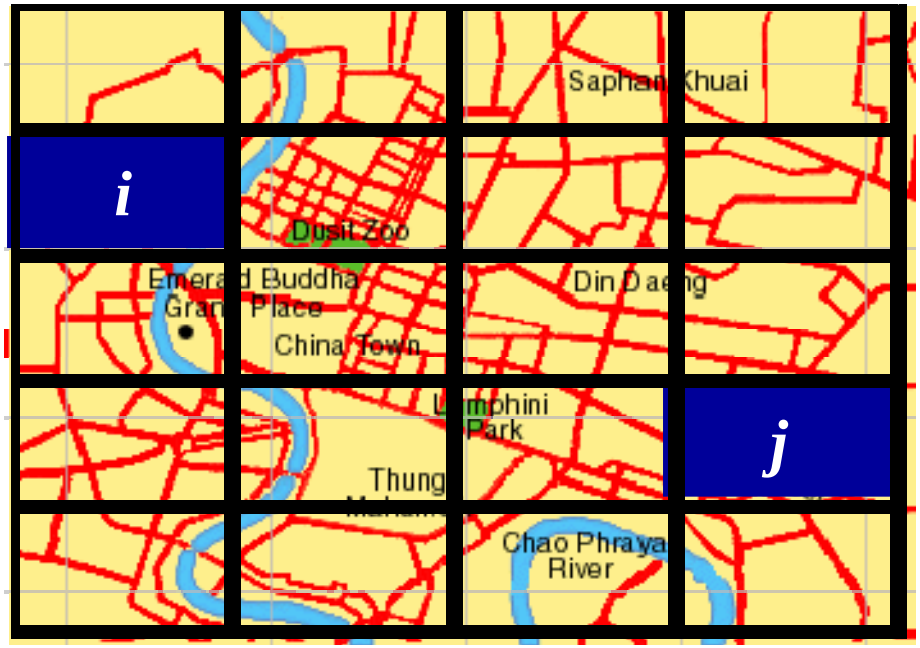
TABLE 1-3 Coquihalla Highway CBA (1986 $ Million)

	No Tolls		*With Tolls*	
	A ***Global Perspective***	***B*** ***Provincial Perspective***	***C*** ***Global Perspective***	***D*** ***Provincial Perspective***
Project Benefits:				
Time and Operating Cost Savings	389.8	292.3	290.4	217.8
Horizon Value of Highway	53.3	53.3	53.3	53.3
Safety Benefits (Lives)	36.0	27.0	25.2	18.9
Alternative Routes Benefits	14.6	10.9	9.4	7.1
Toll Revenues	—	—	—	37.4
New Users	0.8	0.6	0.3	0.2
Total Benefits	494.5	384.1	378.6	334.7
Project Costs:				
Construction	338.1	338.1	338.1	338.1
Maintenance	7.6	7.6	7.6	7.6
Toll Collection	—	—	8.4	8.4
Toll Booth Construction	—	—	0.3	0.3
Total Costs	345.7	345.7	354.4	354.4
Net Social Benefits	148.8	38.4	24.2	−19.7

User Benefit
in Transport Infrastructure Project

Generalized Cost

is an amount of money representing the overall disutility (or inconvenience) of traveling between origin *i* and destination *j* by a particular mode.



Zoning

Origin *i*

Destination *j*

Components of Generalized Cost

Public Transport

Fare, Giving up time, …..

Car

Giving up time, toll(charge),

VOC (Vehicle Operating Costs)

Other components?

Market in Transport Service

Price = Generalized Cost

WTP is the maximum amount of money that a user would be willing to pay to make a trip. (can be interpreted as a maximum generalized cost that they are prepared to accept a trip)

The economic characteristics of transport

Derived nature of the demand

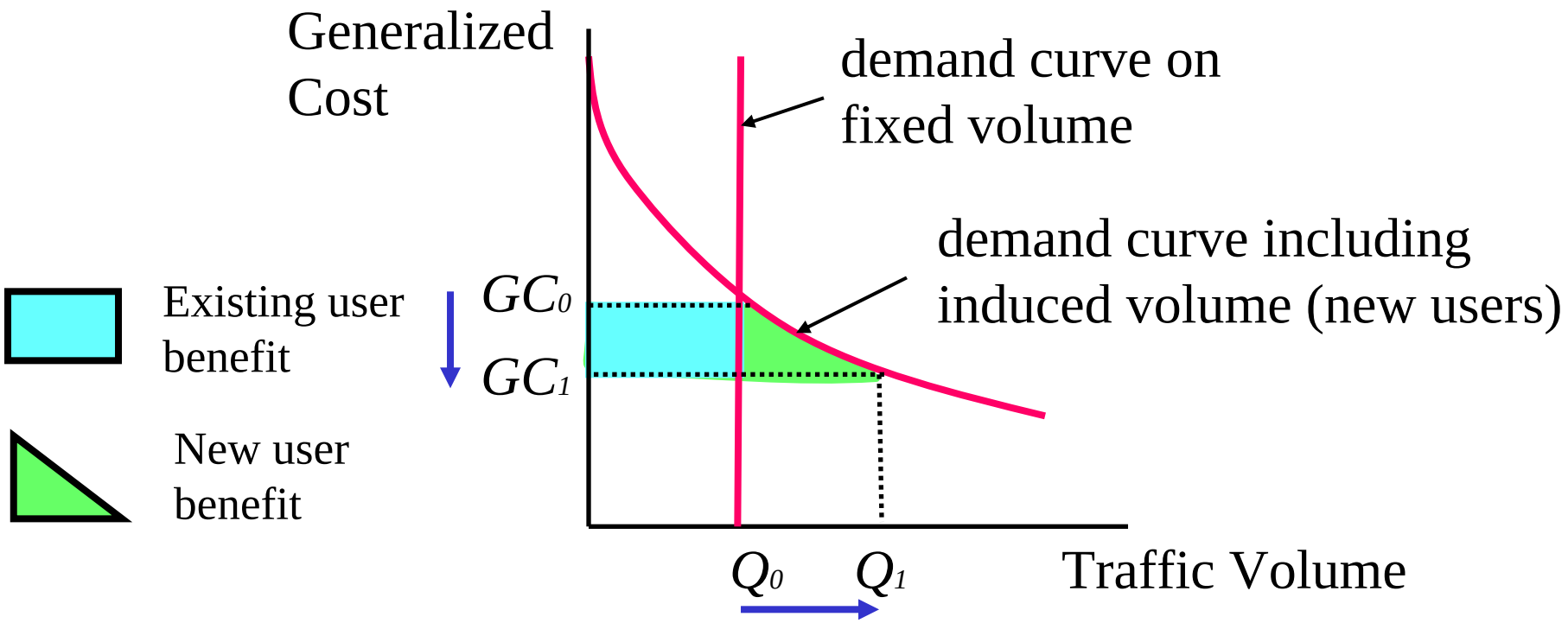
- benefit to travel as short as possible
- "joy riders", "tourists" to be in the minority

Definition of User Benefit Change in Consumer Surplus

$UB = CS_1 - CS_0$

CS_1: do-something = with-project

CS_0: do-minimum = without-project



Improved transport condition by the transport project

Reduction of Generalized Cost e.g. time saving

accidents reductions

Rule of a Half

$$UB = \int_{GC1}^{GC0} D(GC)dGC = \frac{1}{2}(GC_0 - GC_1)(Q_0 + Q_1)$$

Generalized Cost Function

$$GC = \alpha T + \beta L$$

GC: generalized cost by day and by vehicle type [yen/ vehicle]
α : value of time by day and by vehicle type [yen/ vehicle*minute]
β : VOC by vehicle type [yen/ vehicle*km]
T : average travel time by vehicle type [minute]
L : travel distance by vehicle type [km]

User benefit (per day) m: vehicle type. i,j: origin and destination.

weekday $$BU_n = \sum_{m,i,j} \frac{1}{2}(GC_0 - GC_1)(Q_0 + Q_1)$$

holiday $$BU_s = (h\,\text{factor}) \cdot \sum_{m,i,j} \frac{1}{2}(GC_0 - GC_1)(Q_0 + Q_1)$$

annual user benefit $$BU_n \times 243 + BU_s \times 122$$

Values of Time (VOT) (α)

Saving travel time: Large proportion of total project benefits

-- Values for working time

Average gross wage rate [per hour] in the country

to consider a travel mode

* walking, waiting and interchanging 1.6 times

-- saving in non-working time

30% of the average new wage rate in the country

*new wage: to deduct taxes, social security, other overheads

-- saving in freight time

Measurement of User Benefit

Benefit of travel time saving: to convert **monetary value**

Value of Time

- Resource value is the marginal productivity of time: Weekday
- Behavioral value is WTP to spend other activity: Holiday

Who is users?

vehicle drivers and fellow-passengers

Vehicle Occupancy Rate (VOR) * Unit of Demand is *vehicle*

$$\underset{\text{VOT}}{1.10} * \underset{\text{VOR}}{1.35} = 1.485 \text{ US\$ / veh-hr}$$

Measurement of Value of Time

1) **Resource value**, based on Opportunity Cost

a) Average (expected) gross wage rate (per hour)

b) National annual income data (instead of gross wage rate)

ex. VOT = GDP / number of employment / working time

2) **Behavioral value**, based on Generalized Cost Function

$Utility = GC = -0.147TW - 0.0411TT - 2.24C$

(estimated by mode choice model)

VOT = 0.0411 / 2.24

= 1.10 US$/ hr / person

Unit Time Value

[Unit: yen per vehicle•minute]

Vehicle Type	Weekday	Holiday
Passenger Car	56	84
Bus	496	744
Small Truck	90	90
Heavy Truck	101	101

[Japanese 1999 price]

VOC (Vehicle Operation Costs) (β)

Elements:

Fuel, Oil, Tire & Tube, Maintenance and Depreciation

to estimate by road type, by travel speed and vehicle type

Toll road

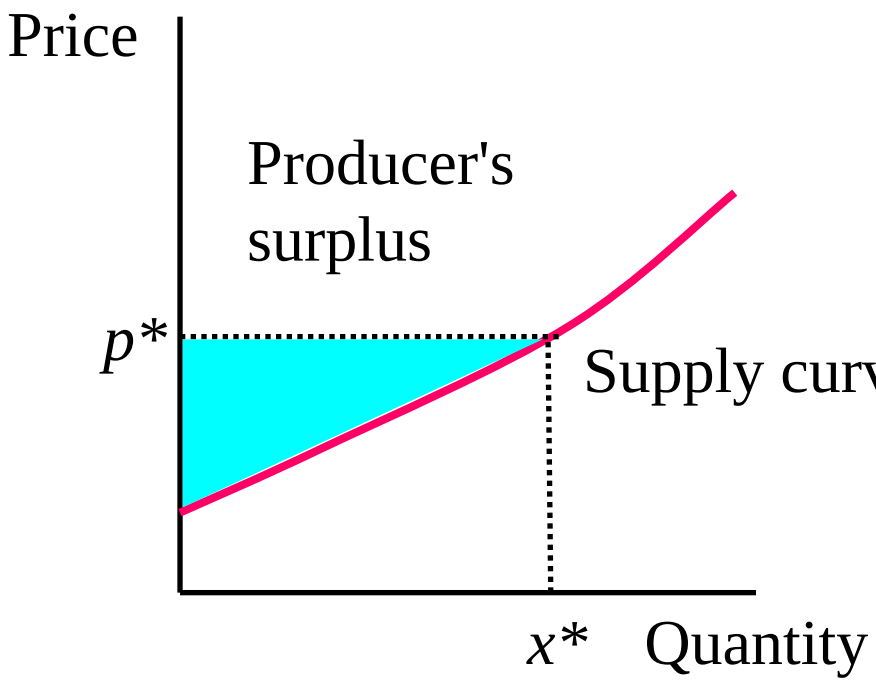
Toll must be included in generalized cost in demand forecast,

and might be also included in estimating user benefit, but be excluded in estimating social benefit

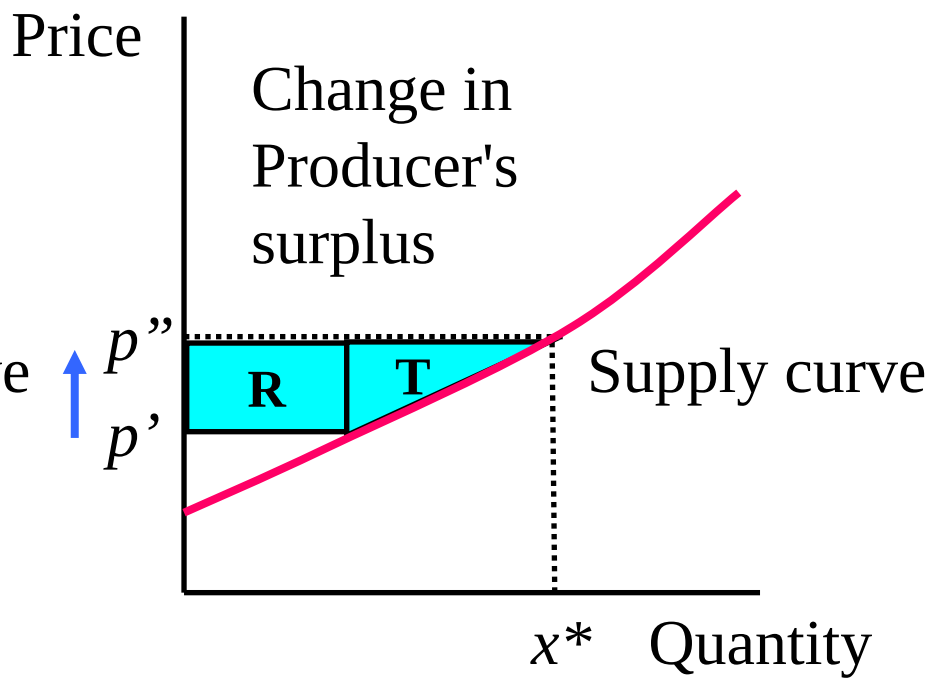
$$GC = \alpha T + \beta L + Toll$$

Transfer

Producer’s Surplus



Net producer's surplus



R: Gain (revenue) to sell the higher price

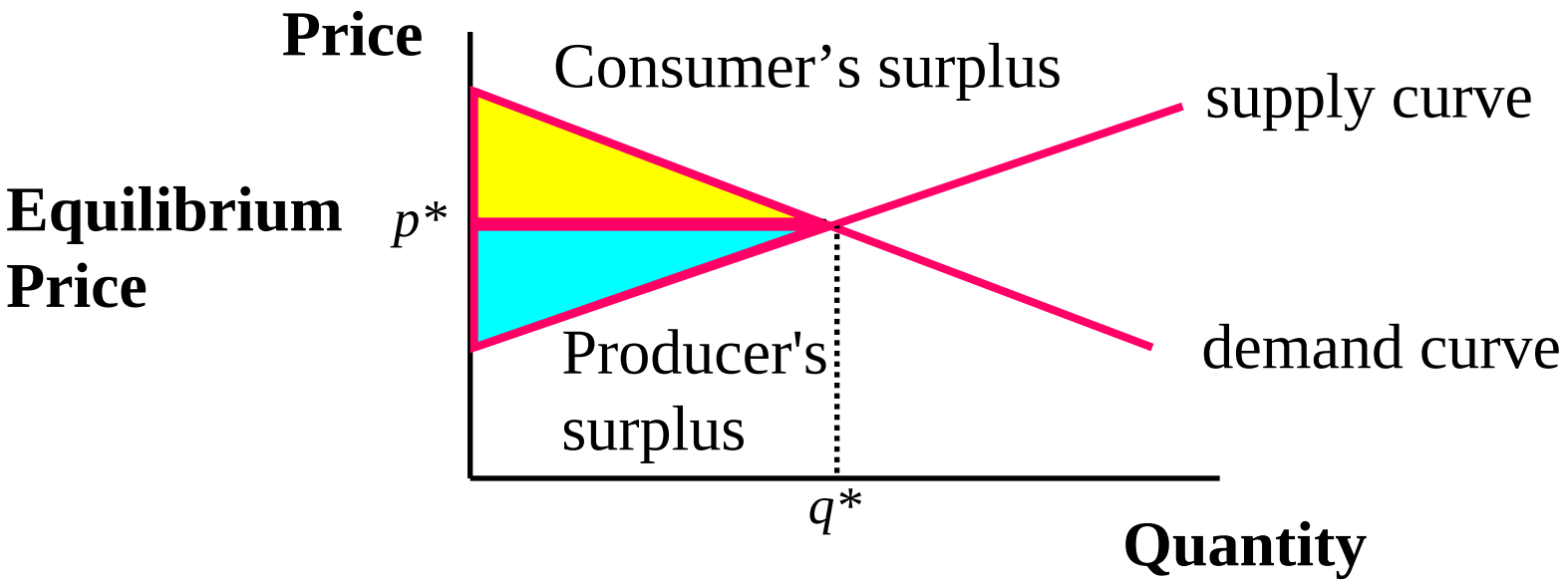
T: Gain (revenue) to sell more units

Equilibrium and Social Surplus

Competitive Market

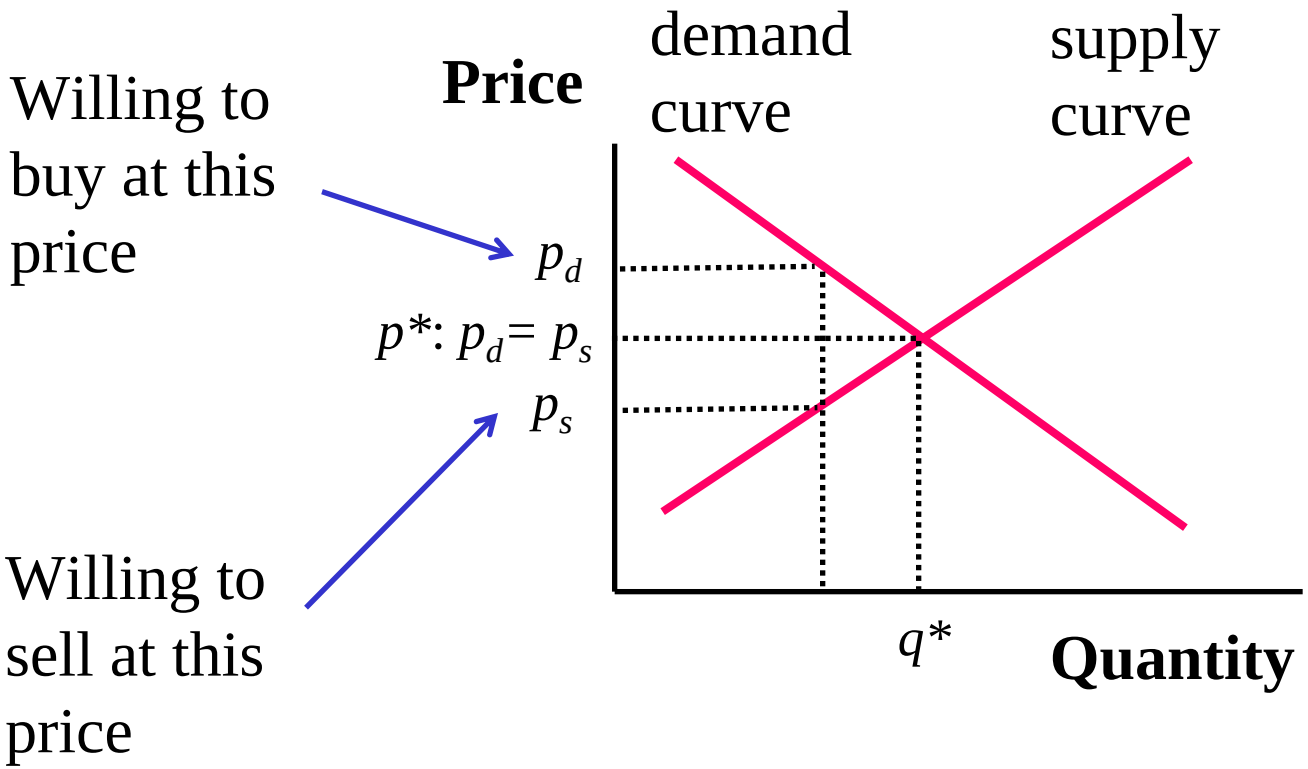
Consumers and Suppliers are *Price Takers*

Market price is independent of any agent's behavior



Social surplus = Consumer's surplus + Producer's surplus

Pareto Efficiency (1)

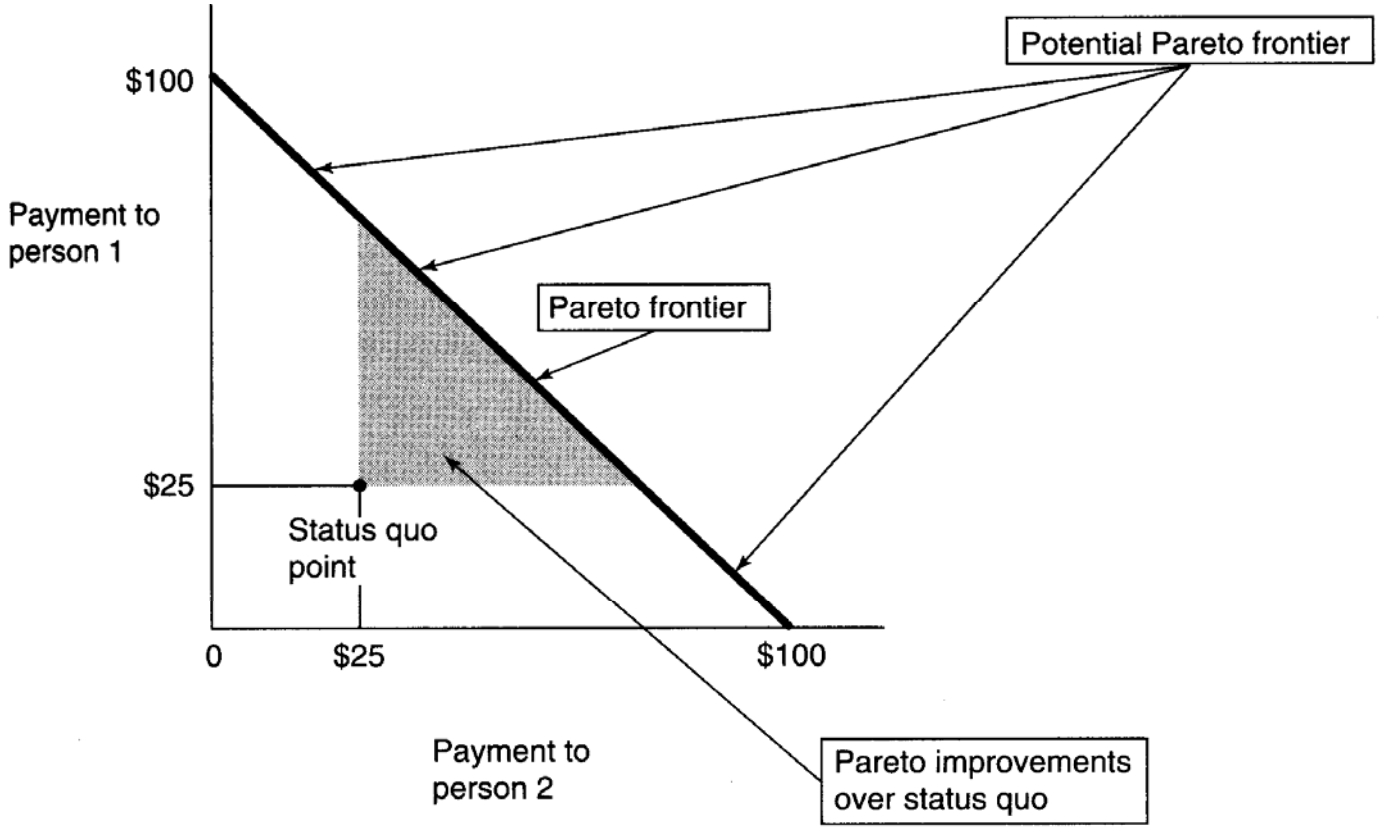


Competitive market produce **Pareto efficient** amount of output

Pareto Efficiency (2)

Pareto Efficiency

We cannot find a way to make some people better off without making anybody else worse off



Net (Social) Benefits and Pareto Efficiency

If a policy (or project, measure) has positive net social benefits (= present social benefit – present social cost), then it is possible to find a set of transfer that makes at least one person better off without making anyone else worse off.

Willingness-to-Pay (WTP)

Person 1: $100
Person 2: $200
Person 3: - $250 (Willingness-to-Accept, WTA)

} Net Benefit +$50

(Not Pareto Efficiency)

↓

Compensation

1 to 3: $75
2 to 3: $175

} 1: $25 (=100-75)
2: $25 (=200-175)
3: $ 0 (=75+175-250)

Potential Pareto Efficiency

Kaldor-Hicks Criterion

Basis for the Potential Pareto Efficiency rule = Net Benefit Criterion

Positive Net Benefit

A policy should be adopted if and only if those who will gain could fully compensate those who will lose and still be better off.

Justification of Potential Pareto Efficiency

- Society maximizes aggregate wealth
- Different policies will have different sets of winners and losers
- Contrast to the incentives in representative political systems
- Equity of wealth or income will be addressed after adopting efficient policies

Pareto Efficiency

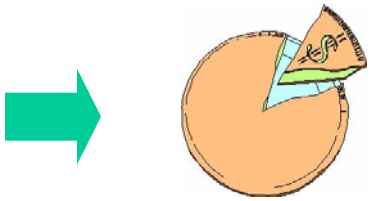
Criterion for comparing the outcomes of different situation

Definition

If there is no way to make any person better off without hurting anybody else.

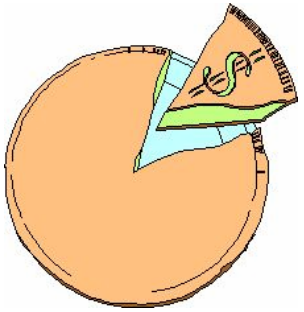
Social net benefit express <u>efficiency</u>, but do not consider <u>equity.</u>

Raw Material



Pareto inefficient

or



Pareto efficient

How to distribute? = Equity