Cost-benefit analysis

Quantifying effects in impacted markets

Overview

- Impacted markets
- Efficient versus inefficient markets
- Output market
- Secondary market
- Input market

Impacted markets

- We first deal with tradable goods. Let me start with a simple example —Suppose the city council is deciding whether to build a public park

- Costs include: Land purchase, construction and landscaping, annual maintenance.

- Benefits include: Public health/recreation benefits, tourism, revenue (cafés, events), increased property values nearby.

- Output market—Final goods & services sold to consumers (recreation, events, café services, tourism experience)

- Input market—Labour market (hiring construction workers, landscapers, maintenance staff), capital market (borrowing finance), land market (purchasing land)

- Secondary market—Surrounding housing market

Impacted markets

- Another example—Consider developing a new railway service in an unattended area

- Costs include: Construction cost of tunnels, tracks, bridges, land acquisition, environmental mitigation, maintenance and operations.

- Benefits include: Reduced travel time (time savings valued), increased trade and tourism, lower road congestion and accidents, environmental benefits (less road transport emissions).

- Output market—Passenger and freight transport services (tickets, cargo transport)

- Input market—Labour market (hiring engineers, construction crews, railway staff), capital market (government bonds or private financing), construction materials (steel, concrete, signaling technology)

- Secondary market—Housing and commercial real estate values rise near new railway stations, tourism businesses expand through higher demand.

Measuring impacts in efficient or inefficient market

- Are impacted market operating efficiently or inefficiently?
- In an efficient market, price is informative.
    - It reflects both the opportunity cost of the marginal unit produced and the marginal consumer's willingness to pay.
- Inefficient markets exhibit deadweight loss at the prevailing level of production.
    - Policy impact should be measured not only on marginal benefits and opportunity costs, but also on how deadweight loss changes.

Impact in the output market

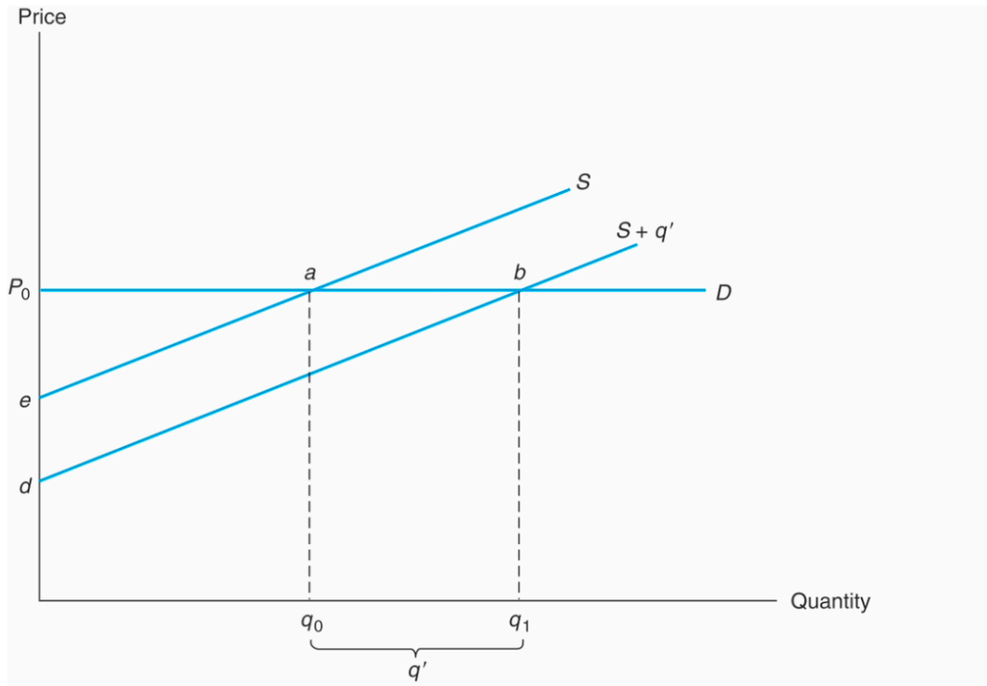
- A project can shift the demand or supply curve in the output market

- Two important considerations:
  - How does the shift affect price? It typically depends on the elasticity of demand and supply.

  - What is the source of the shift? —Is it driven by changes in marginal benefits or marginal costs, or simply by the addition/removal of demand or supply?

Efficient output market

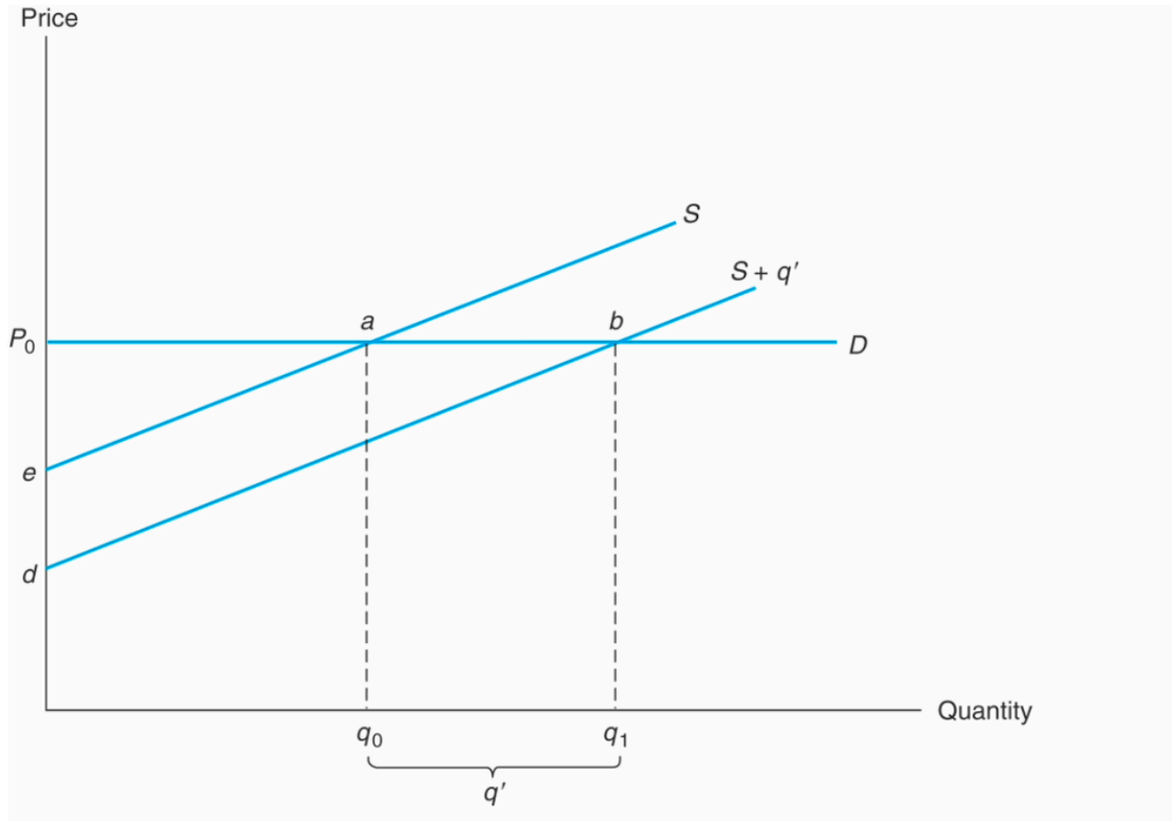
- An example—Unaffected price due to inelastic demand.
- Suppose the government holds excess quantities of a good that it can supply to the market at zero cost.
- If the government sells this additional quantity at the prevailing market price:
- **Change in consumer surplus = 0**, since consumers pay exactly what they are willing to pay.
- **Government's opportunity cost = 0**, as the goods are already available.
- The net change in social surplus is given by area q_0abq_1.
- If the government instead distributes the goods freely —The total surplus is unchanged; The only difference is a transfer between consumer surplus and government revenue.



Social surplus change (ignoring costs of project inputs to the government):
Project (a): Direct increase in supply of q'—gain of project revenue equal to area of rectangle q_0abq_1

Efficient output market

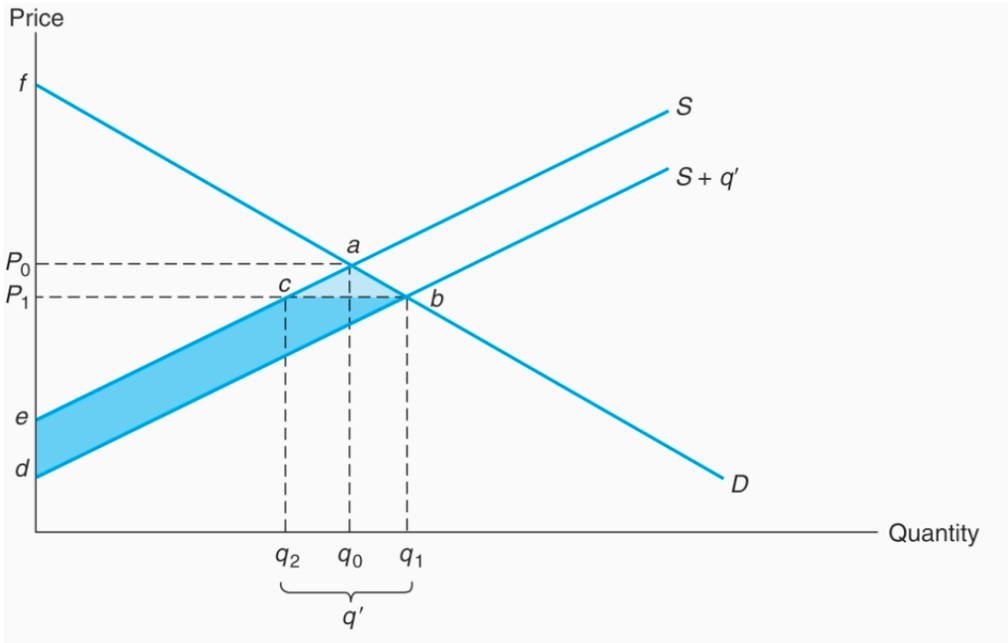
- Suppose the supply curve shifts outward due to a decrease in marginal production costs.
- This results in a gain in producer surplus.
- There is no change in consumer surplus (price remains unchanged).
- The net change in social surplus is represented by area *abde*.



Social surplus change (ignoring costs of project inputs to the government):
Project (b): Supply schedule shift through cost reduction for producers—gain of trapezoid *abde*

Efficient output market

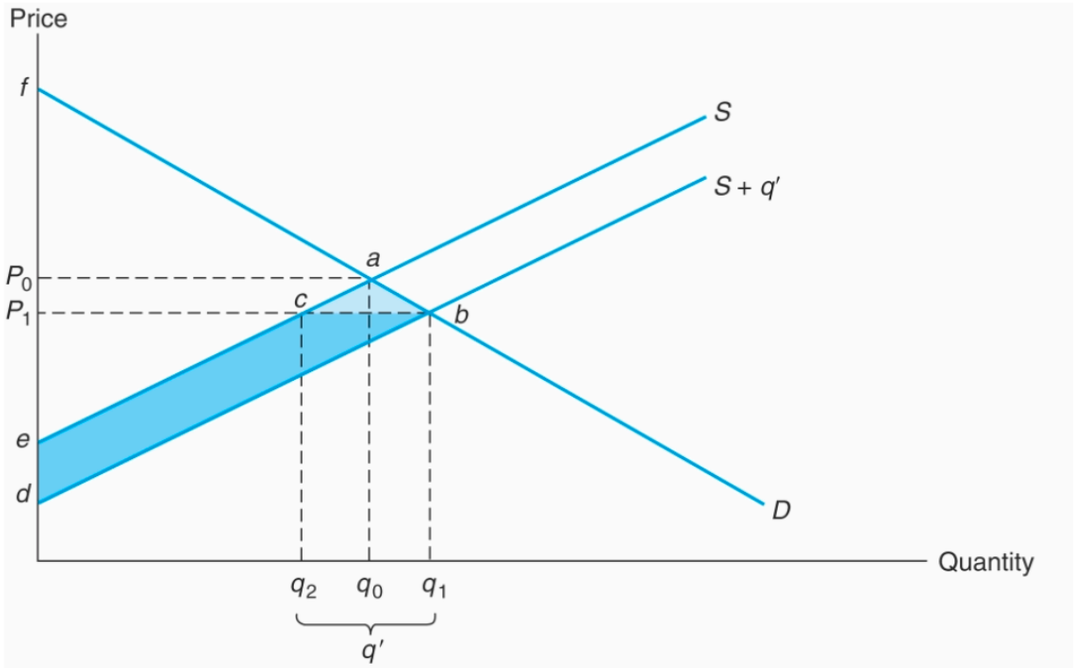
- Consider a drop in price due to elastic demand.
- Assume the government holds excess quantities of the good, which it can supply at zero cost.
- **Producers' surplus decreases**, but this loss is simply transferred to consumers through lower prices.
- **Consumers gain additional surplus** on the excess supply, represented by the triangle **abc**.
- There is an **additional source of surplus**: the difference between consumers' willingness to pay and the (zero) opportunity cost of supplying these additional goods
- The **total change in surplus** is represented by area q_2cabq_1.



Social surplus change (ignoring costs of project inputs to the government):
Project (a): Direct increase in supply of q'—gain of triangle *abc* plus project revenue equal to area of rectangle q_2cbq_1

Efficient output market

- Suppose the supply curve shifts outward due to a decrease in marginal production costs
- This leads to a **gain in consumer surplus** (from the price reduction)
- Part of the **existing producer surplus is transferred to consumers** (lower prices reduce producers' price-based surplus)
- However, producers also gain from **reduced production costs**, creating an additional source of surplus.
- The net change in social surplus is represented by area *abde*.



Social surplus change (ignoring costs of project inputs to the government):
Project (b): Supply schedule shift through cost reductions for producers—gain of trapezoid *abde*

Inefficient output market

- Market failure or inefficient policy intervention can distort the output market. Measuring the change in surplus from a new public project can therefore be complex.

- Common types of market failures include:

- **Monopoly** – firms restrict output and charge prices above marginal cost. *Example:* A regional electricity company with no competitors charging high prices

- **Information asymmetry** – one party in a transaction has more or better information than the other. *Example:* Sellers of used cars knowing more about the car's condition than buyers

- **Externalities** – costs or benefits spill over to third parties not directly involved in the transaction. *Example*: Air pollution from factories harming nearby residents

- **Public goods** – non-excludable and non-rival goods lead to under-provision in private markets. *Example*: National defense or street lighting.

- **Addictive goods** – consumers may undervalue long-term costs, leading to overconsumption. *Example*: Tobacco or alcohol consumption despite health risks.

Inefficient output market

- Market failure or inefficient policy intervention can distort the output market. Measuring the change in surplus from a new public project can therefore be complex.

- **Monopoly** – firms restrict output and charge prices above marginal cost.
  Example: Evaluating the welfare effects of introducing a new railway line in a region dominated by one bus company charging high fares.

- **Information asymmetry** – consumers lack full information when buying a good or service.
  Example: A health screening program's CBA must account for the fact that patients may not know their true health risks without it.

- **Externalities** – output of a project creates spillover costs or benefits not reflected in prices.
  Example: A hydropower project's CBA must include environmental damages (negative externality) or reduced CO_2 emissions (positive externality).

- **Public goods** – output is non-excludable and non-rival, so private provision is insufficient.
  Example: A CBA of building a public park or lighthouse must capture non-market benefits to all residents.

- **Addictive goods** – consumers' willingness to pay may not reflect true long-term welfare.
  Example: A CBA of restricting tobacco or alcohol sales must adjust demand-side benefits to reflect overconsumption biases.

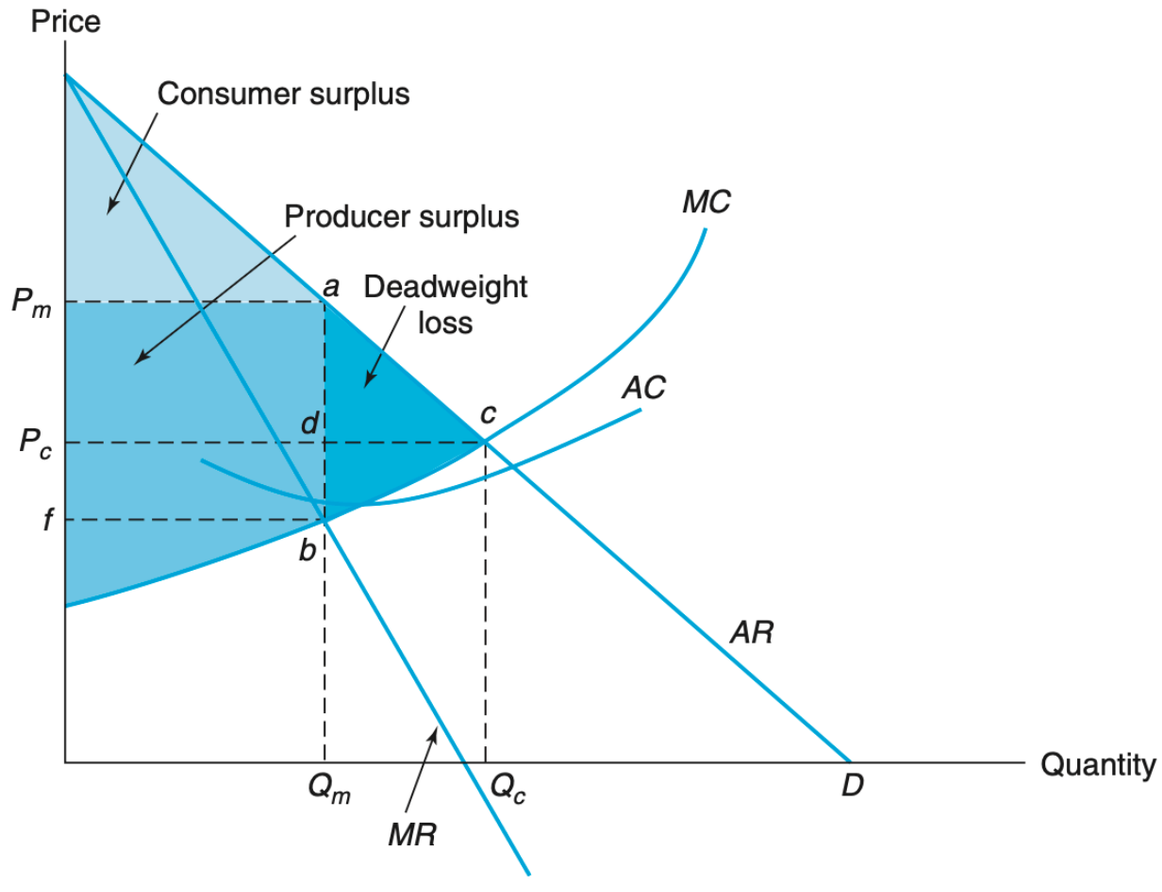
Inefficient output market

- Monopoly—Unlike the perfectly competitive case, social surplus is not maximized if the monopolist is left to its own devices.

- This is because the monopolist maximizes profits, not net social benefits.

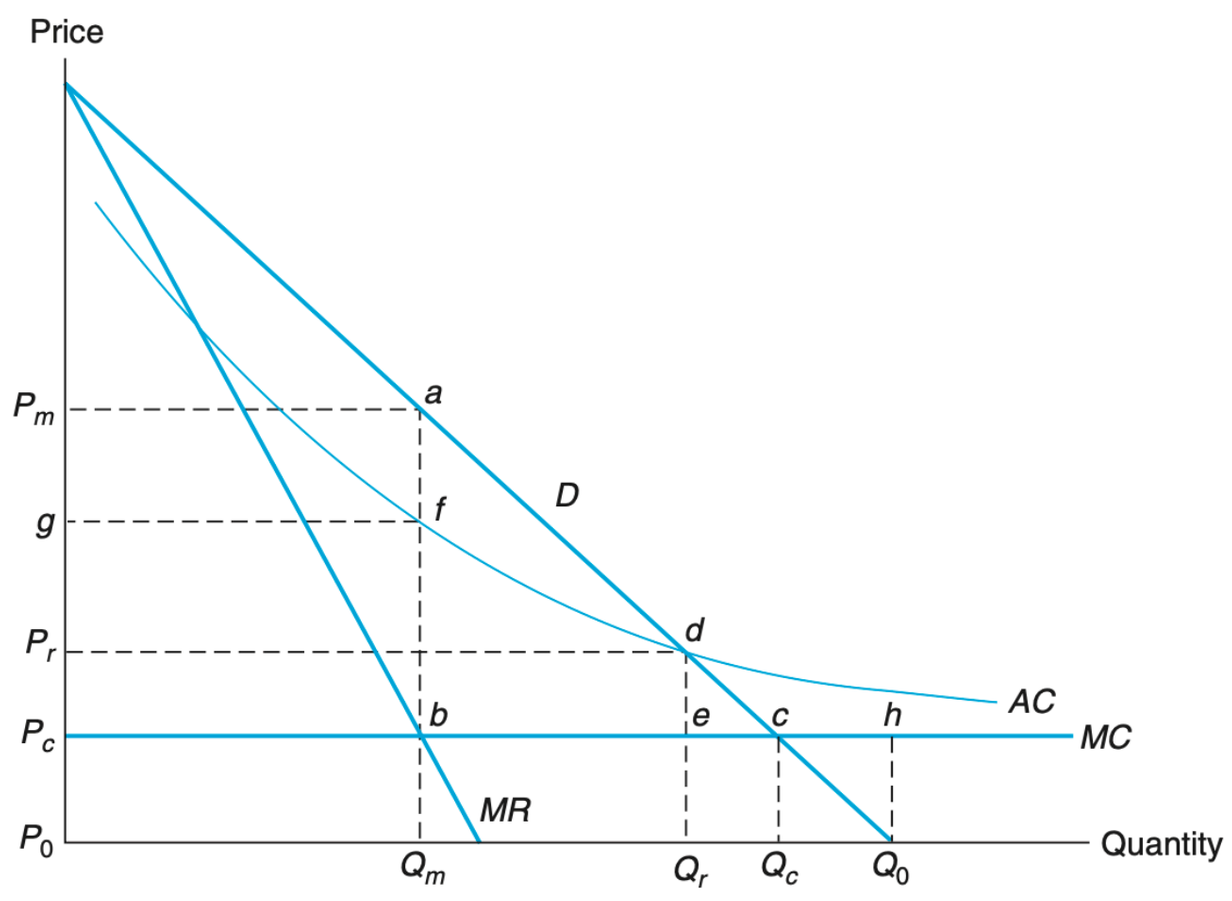
- Net social benefits are maximized at point c, where as the monopolist stops production at Q_m.

- The "lost" social surplus, which is the deadweight loss resulting from monopoly is the triangular area *abc*.



Inefficient output market

- A **natural monopoly** arises when economies of scale are so strong that one firm can supply the entire market at lower average cost than multiple firms.
  - Common examples include utilities, roads, and bridges.
- Over the relevant range of output, long-run average costs exceed long-run marginal costs, so average costs fall as output expands.



Inefficient output market

- What can be done?

- No intervention—Allowing profit maximization: allow the monopolist to set price P_m and output Q_m.
  This yields monopoly profits but creates deadweight loss (area abc) and restricts output below the competitive level Q_c.

- Average cost pricing: set price at P_r, where demand intersects the average cost curve.
  This eliminates monopoly profits, expands output, and reduces deadweight loss, but some inefficiency remains.

- Marginal cost pricing: set price at P_c, where demand intersects marginal cost.
  This maximizes social surplus and eliminates deadweight loss, but requires subsidies since revenues fall below average costs.

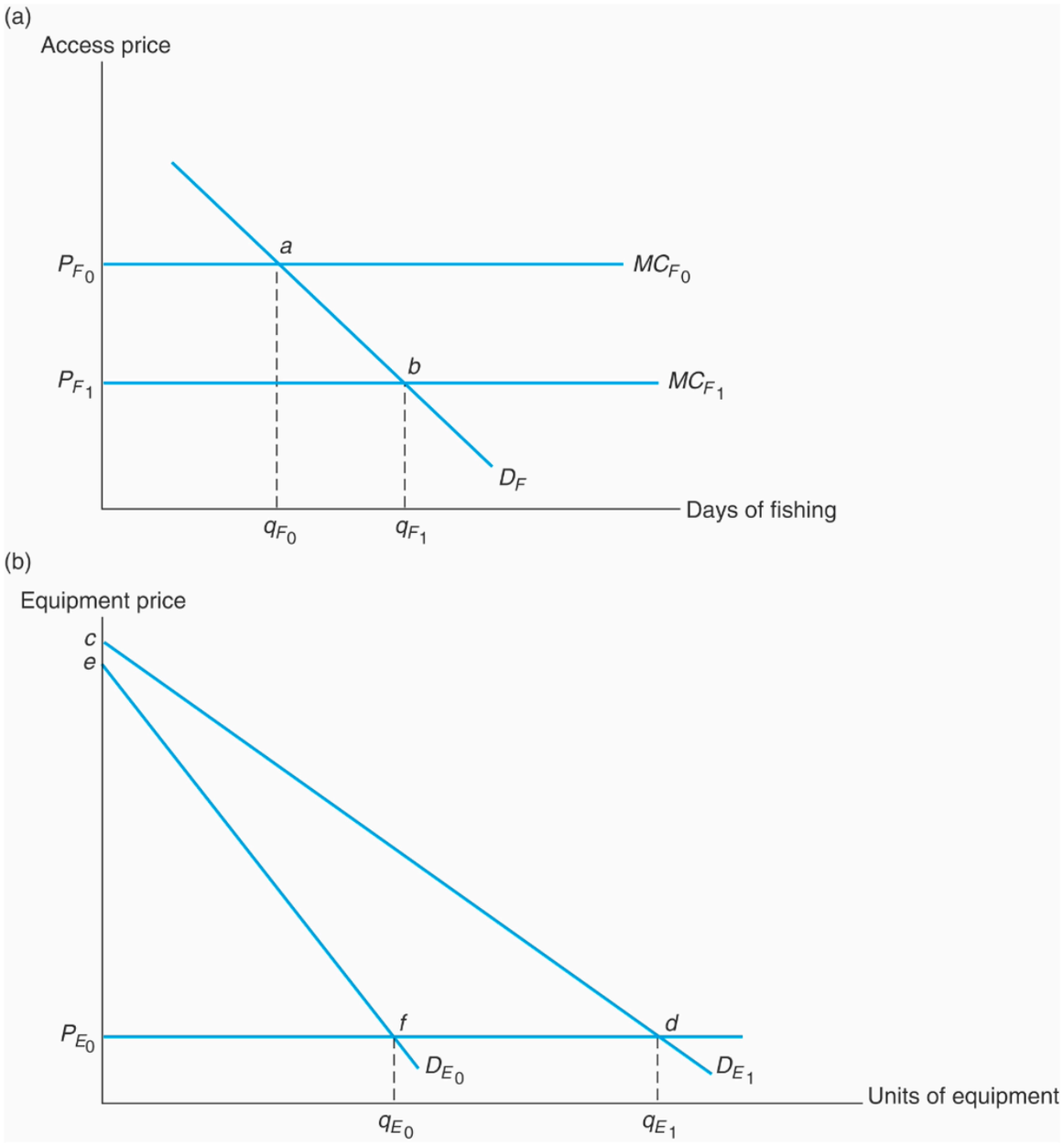
- Free access (zero price): expand output to Q_0, where demand hits the horizontal axis.
  This overshoots the efficient level, creates new deadweight loss (area chQ_0), and requires full cost coverage through taxation.

Secondary market

- **Simple rule**: If the **secondary market** is efficient, we may ignore its effects in a CBA.
- **Why?** Any project impact in the secondary market gets fully reflected in the **primary output market's surplus measures**.
- Example: Suppose a project lowers the price of a good.
  - The demand for its **complement** increases.
    If the complementary good is in **perfectly elastic supply**, its price stays unchanged.
    Still, the demand curve for the complement shifts outward, so consumer surplus in that market appears to increase.
- Should this be counted separately?
  - 'No — because the gain in surplus for the complement market is already captured by the original project's surplus effects.
    Counting it again would be **double-counting**.
- **Rule of thumb**: If secondary markets are competitive and efficient, changes in them need not be measured separately in CBA.

Efficient secondary market

- Consider stocking a city lake with fish lowers fishing costs and increases the number of fishing days.
- This generates a gain in **consumer surplus** in the primary market (fishing).
- The secondary market for fishing equipment, which has a perfectly elastic supply curve, sees higher demand but unchanged price.
- If we also count surplus gains in this secondary market, we risk **double-counting**.



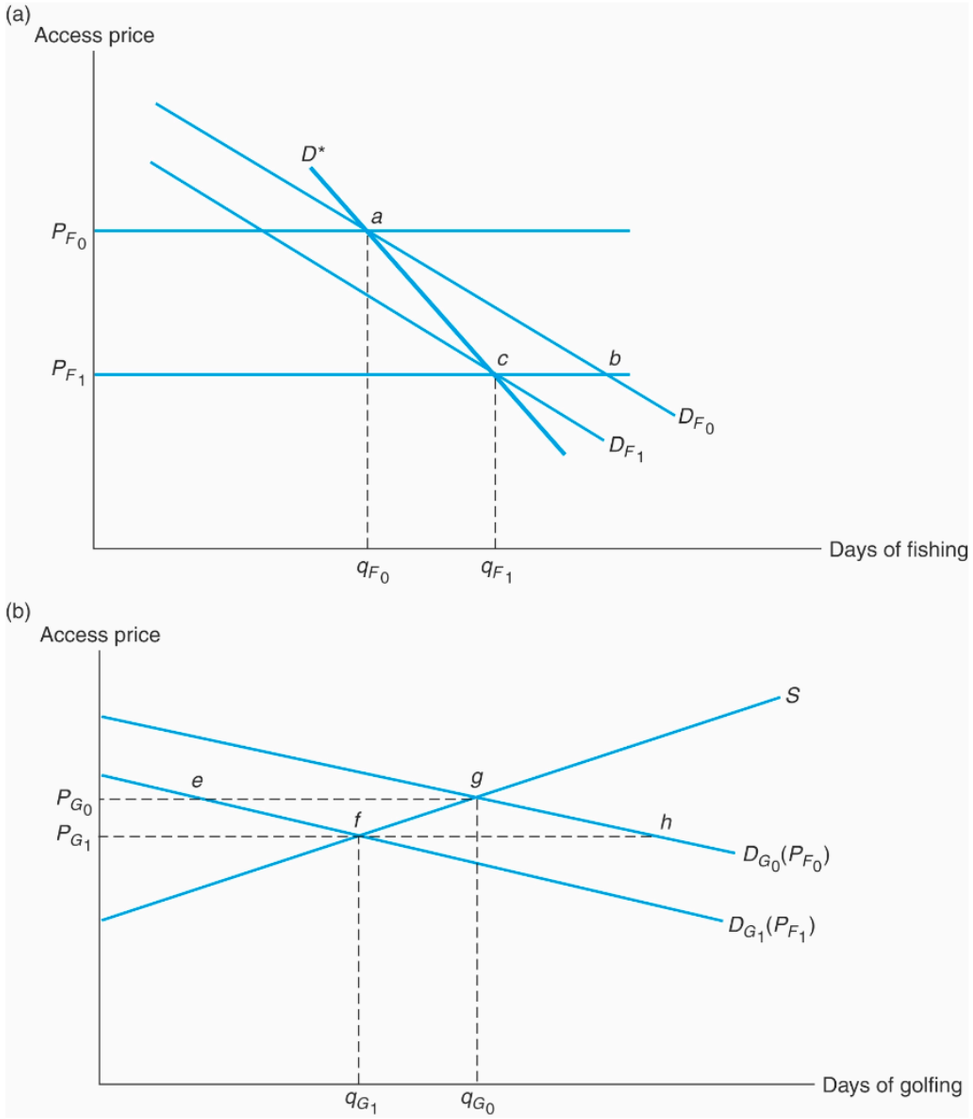
Efficient secondary market with no price effect

Efficient secondary market

- When the lake is stocked, more people want to go fishing (primary market effect). Among these additional fishers, there are **two groups**:
    - **Existing equipment owners** – they already have rods, reels, boats, etc. They don't need to buy more equipment; their gain is purely the extra enjoyment (consumer surplus) from more fishing days.
    - **New equipment buyers** – they didn't fish before because costs (including equipment) outweighed benefits. Now, because fishing is cheaper and more attractive, they decide to buy equipment and go fishing.
- For the second group, their decision to start fishing includes weighing both: The benefit of extra fishing days, and the cost of buying equipment in the secondary market.
- Their **willingness to pay for fishing days already reflects this trade-off**: they only enter if the value of fishing days exceeds the combined cost of trips **plus** equipment.
- Therefore, when we measure the gain in consumer surplus in the fishing market (primary market), we have already captured their net benefit. If we also add surplus from the equipment market, we'd be **double-counting** the same gain.

Efficient secondary market

- Stocking the lake reduces fishing costs → demand for fishing rises (primary market effect).
- Since fishing and golfing are substitutes, higher fishing demand reduces demand for golf.
- In the golf market (secondary):
  - Demand shifts left, price falls.
  - Consumers gain some surplus (they pay less).
  - Producers lose surplus (they earn less, sell less).
  - Net effect = a **loss of surplus** in the golf market due to fewer participants and lower price.
- Question: Should this net loss in the secondary market be added to our CBA?



Efficient secondary market with price effect

Efficient secondary market

- Price changes in the secondary market create **feedback effects** in the primary market (fishing).
    - Lower golf prices reduce fishing demand somewhat. This shifts the fishing demand curve slightly downward/left.
- The **observed demand curve** for fishing already reflects these interactions.
- If we use the observed demand schedule to measure consumer surplus:
    - The surplus gain looks smaller than if other markets' prices were held constant. This **underestimation in the primary market** corresponds roughly to the surplus loss in the secondary market.
- Guiding principle:
    - Whether or not secondary market prices change;
      Measure surplus change in the primary market only;
      Ignore efficient secondary markets to avoid double counting and because empirically identifying all substitutes/complements is impractical.

Inefficient secondary market

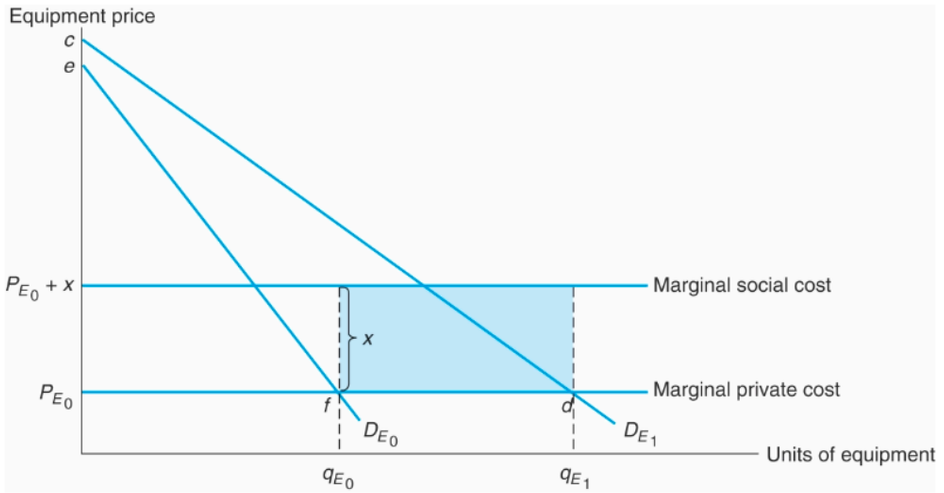
- In If the secondary market is **distorted or inefficient** (price ≠ social marginal cost), measuring surplus only in the primary market may miss important effects.

- Example: Fishing equipment market with a **negative externality** in production.

  - Private marginal cost < social marginal cost.

  - Even before the project, there is excessive equipment production.

  - Stocking the lake increases fishing demand → higher demand for equipment → **additional deadweight loss** in the secondary market.



- Other distortions in secondary markets may arise from:

  - Taxes, subsidies, quotas or other regulations.

Inefficient secondary market

- In principle, we should measure changes in deadweight loss in distorted secondary markets.
- In practice, this is **difficult and complex** because it requires:
  - Estimating the precise demand shift in secondary markets.
  - Measuring the size of distortions (externalities, tax wedges, etc.).
- If expected **price changes in secondary markets are small**, then demand shifts (and thus extra distortions) are also small.
- **Rule of thumb**: Even when distortions exist, ignoring secondary markets in CBA usually introduces only **minimal bias**—especially when secondary effects are modest.

Inefficient secondary markets

- Indirect effects can arise not only from **complements/substitutes** but also from **input markets** where the primary good is used.

- A policy lowering input costs in a secondary market may raise producer surplus, but:

  - In competitive markets, most gains are passed on to consumers.

  - In less competitive markets, producers retain more of the gains.

- Rule of thumb for CBA:

  - If secondary markets are **efficient**, these indirect effects are already reflected in the primary market's surplus → **ignore them**.

  - If secondary markets are **distorted**, deadweight loss may change, but ignoring them typically introduces only **minimal bias** unless price shifts are large.

Input market

- **Shadow price**:
  In inefficient markets, observed prices do **not reflect true social opportunity costs**.

  - Example: Student fees for non-EEA students in public universities are not set by market clearing → unlikely to equal the true incremental cost or benefit of education. In some cases, no market price exists (e.g., valuing a worker's accident).

- **Solution:** Assign explicit or adjusted values called **shadow prices**, which better capture social value.

- Common shadow prices in CBA:

  - Value of a statistical life

  - Social cost of pollution

- Shadow prices are especially important when analyzing **input costs in distorted markets**.

Input market

- **Opportunity Cost of a Project**:
  A project requires resources → these resources cannot be used elsewhere.

- Opportunity cost = value of the most valuable alternative use of resources.

- Key considerations:

  - If resources are already committed ("sunk"), their opportunity cost = best alternative disposal (e.g., resale in secondhand market minus scrapping costs). This can even yield a **negative value** if scrapping costs exceed resale value.

- In practice, we often observe **budget expenditures** (price × volume).

- Question: Do these expenditures accurately measure opportunity cost?

  - **Yes** if markets are efficient;
    No if markets are distorted → shadow prices must be used instead.

Efficient input market with no price effect

- **Perfectly Elastic Input Supply and Opportunity Cost**

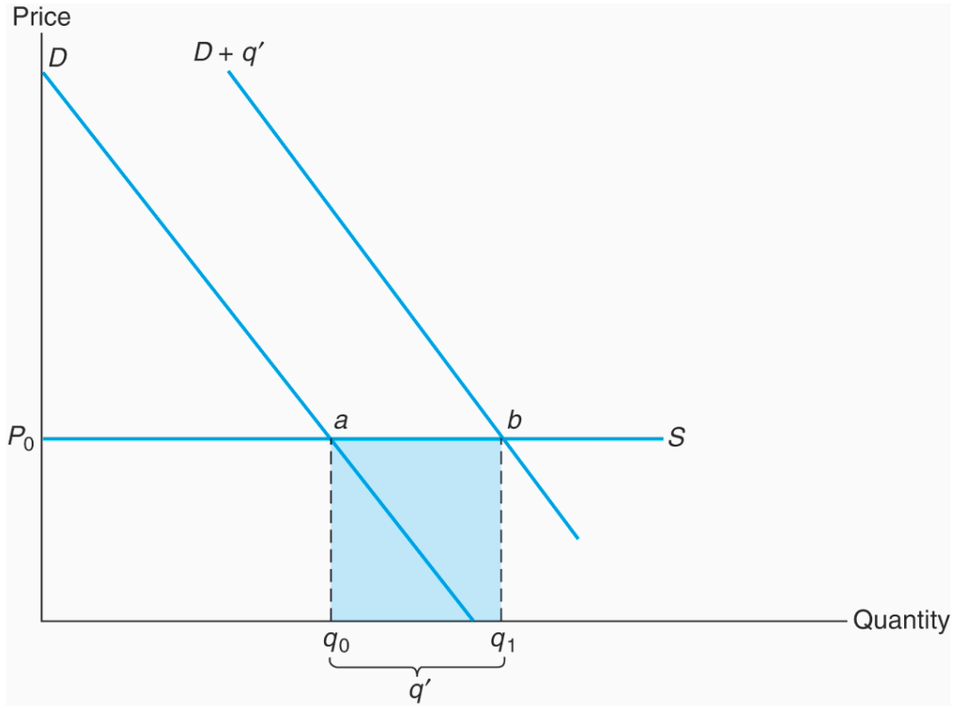
- When a project raises input demand but supply is **perfectly elastic**, the input price remains unchanged.

- This is likely if the project's demand is small relative to total national demand for the input.

- Effect: Demand curve shifts right (from D to D+q′), but price stays fixed at P_0.

- The **opportunity cost** of the additional input use = P_0 *times* q′ (budget expenditure).

- In this case, budgetary expenditure = true opportunity cost (no adjustment needed).



Efficient input market with perfectly elastic supply curve

Efficient input market with no price effect

- **Perfectly Inelastic Input Supply and Opportunity Cost**

- If the project's input has a **perfectly inelastic supply** (e.g., land), the situation differs.

- Example: Government acquires land that could otherwise be sold to private buyers for housing.

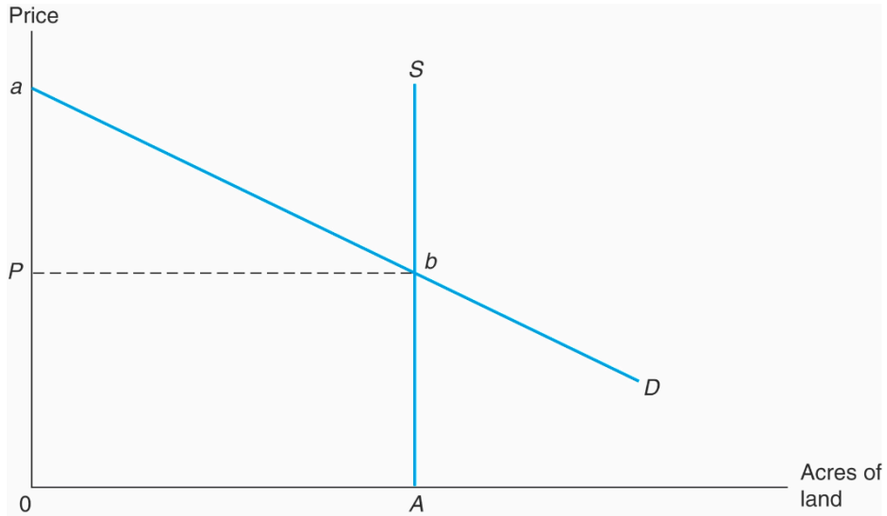
- Government pays a fair market-based price (expenditure = area PbAO).

- But this understates true social opportunity cost:

  - Private buyers lose potential **consumer surplus** (triangle aPb).

  - This foregone surplus is not reflected in the government's purchase price.

- **Conclusion:** With perfectly inelastic inputs, budgetary expenditure **< true opportunity cost**.



Efficient input market with perfectly inelastic supply curve

Efficient input market with significant price effect

- When a project purchases a **large quantity of an input**, even in an efficient market, input prices may rise (upward-sloping supply).

- Impact:

- Existing buyers purchase less → they lose some surplus. New units supplied involve real production costs.

- Budgetary expenditure (P1 *times* q′) covers both:

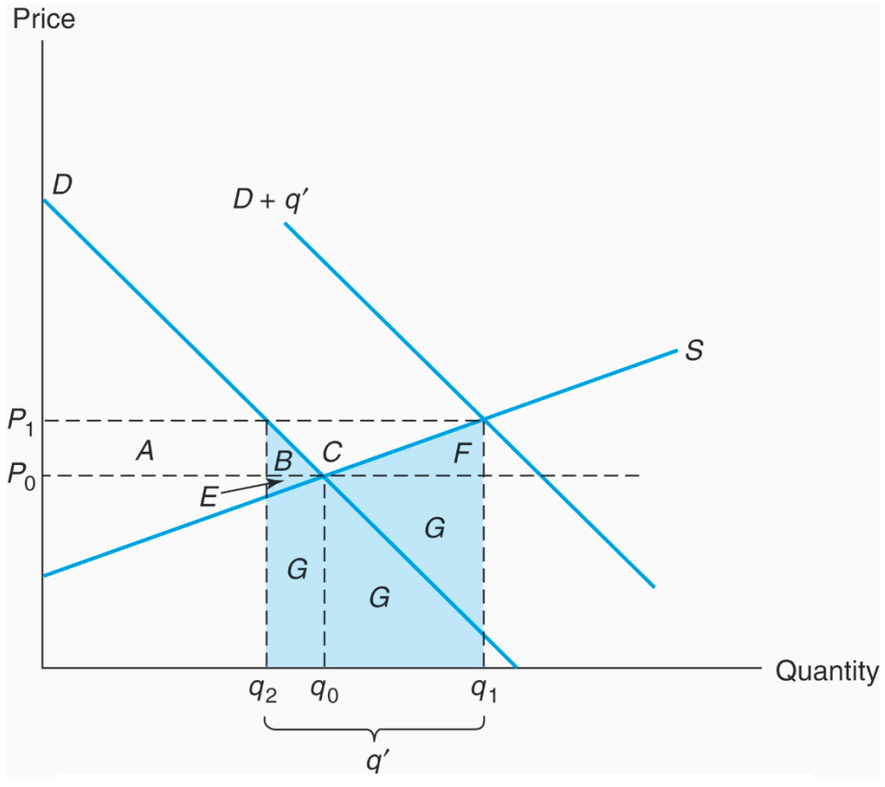
  - **Transfers** to producers (extra producer surplus).

  - **True costs** of supplying additional units.

- Therefore, budgetary expenditure ≠ true opportunity cost.

  - It usually **overestimates** social costs by including transfers.

  - True opportunity cost = real supply cost + lost surplus from displaced buyers.



Change of price in an efficient input market

Efficient input market with significant price effect

- Practical adjustment:
  Sometimes governments buy inputs at **aggregate supply cost** (e.g., G+F), avoiding overpayment at marginal price.

- But even then, budgetary expenditure may **understate** opportunity cost, because it ignores the **surplus loss of displaced buyers**.

- **Key principle**:
  When prices change, **budget ≠ social cost**.
  If price changes are small → budget is a good approximation.
  If price changes are large → budget must be adjusted.

- **Practical method**:
  Approximate opportunity cost by: **$0.5(P_0+P_1)$ *times* q′**

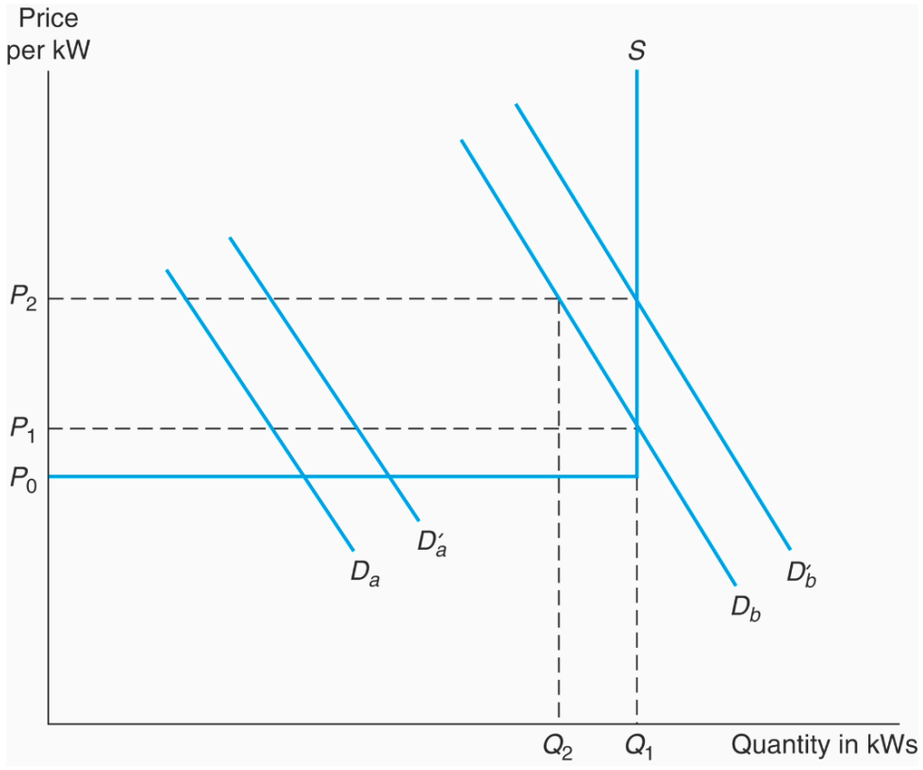
- This "average price" serves as a **shadow price**, better reflecting the social cost.

Measuring input costs in distorted markets

- Inefficiencies in factor markets can arise from:
  - Absence of a functioning market;
    Market failures (public goods, externalities, monopoly, information asymmetry);
    Government interventions (taxes, subsidies, regulations, price controls)
- These distortions make it harder to measure **true opportunity cost**.
- **Solution:** Use **shadow pricing** to adjust observed prices.
- Key scenarios:
  - Government purchases an input in **fixed supply**
  - Government hires labor in a market with **unemployment**
  - Government buys inputs from a **monopolist**

Fixed input supply and opportunity cost

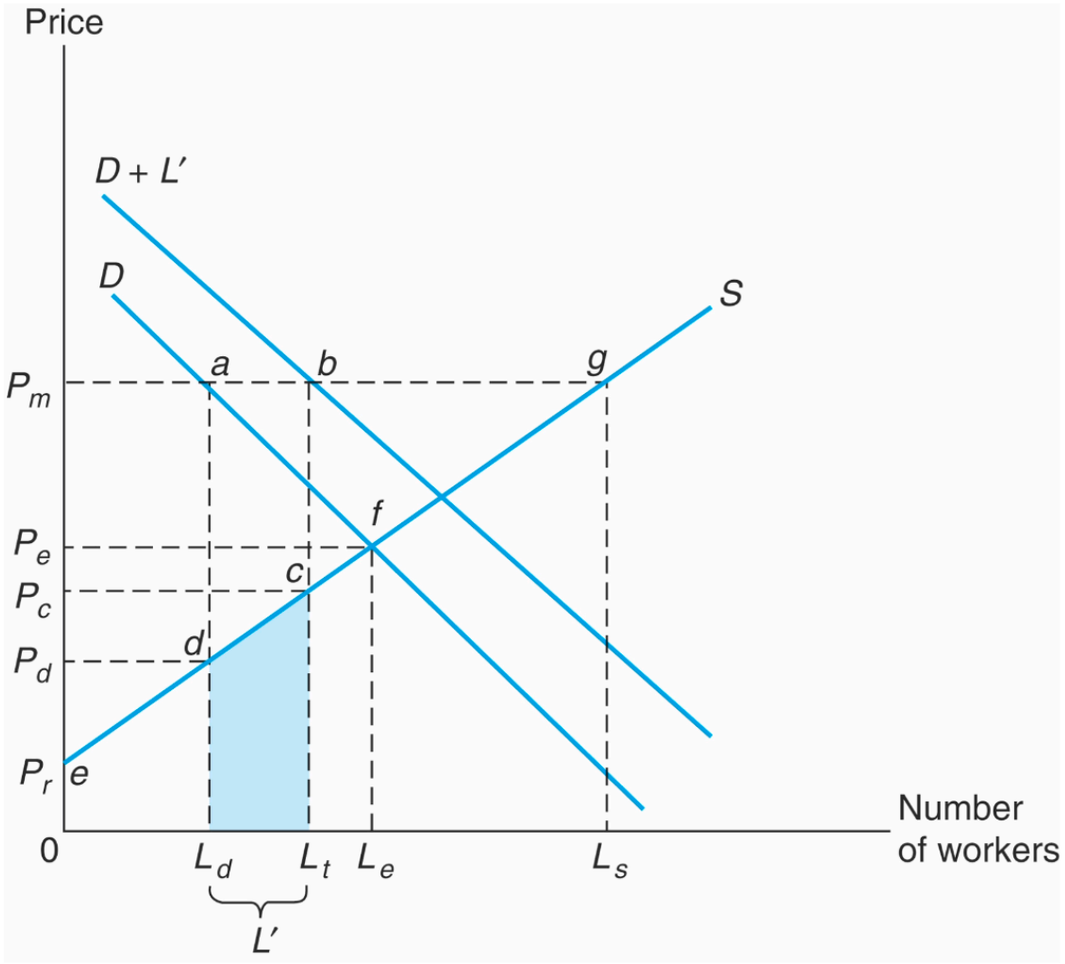
- If input supply is **fixed** (e.g., due to an import quota), a project raises input demand → price increases.
- Government expenditure = $P_2 \cdot (Q_1 - Q_2)$.
- But this **overstates opportunity cost** because part of the expenditure is a **transfer** (producer surplus).
  - Existing consumers lose surplus, but producers gain it → net effect is just redistribution.
  - Outgoing consumers (no longer buying the input) lose surplus, which reflects a real cost.
- True opportunity cost = government expenditure minus the transfer to producers.
- Practical method: Use the average of old and new prices $0.5(P_1+P_2)$ as a **shadow price** for project inputs.



Input in fixed supply

Opportunity cost of labour with unemployment

- With high unemployment, projects often hire workers who would otherwise remain unemployed.
- Budgetary expenditure = $P_m \cdot (L_t - L_d)$, but this does not equal true opportunity cost.
- Why not?
  - Unemployed workers still engage in **valuable activities** (job search, childcare, home work).
  - Even pure leisure has intrinsic value.
- Better measure: workers' **reservation wage** (willingness to accept a job).

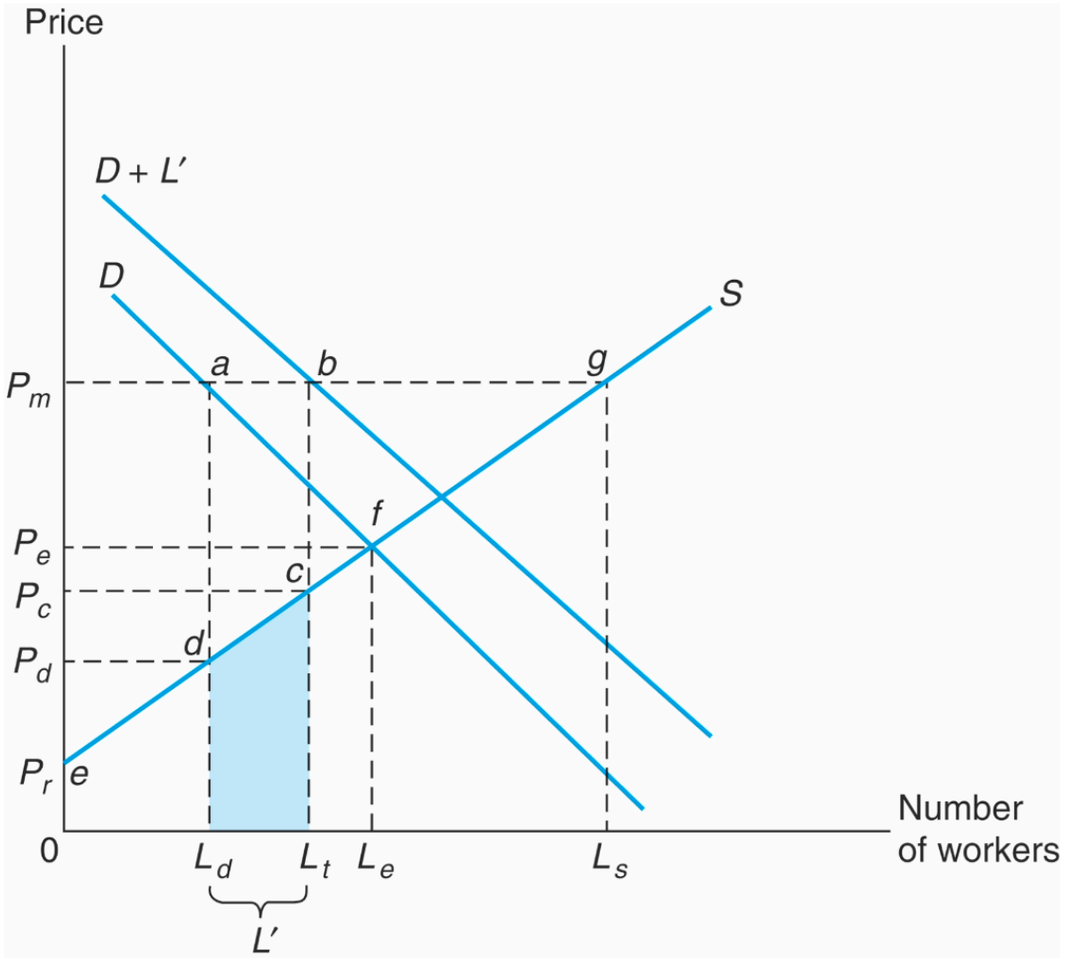


Labour supply with unemployment

Opportunity cost of labour with unemployment

- **Challenges**:
  - Recruitment may not follow the order of the supply curve.
  - Reservation wages vary across workers and jobs.
- **Practical approach:**
  Use a **shadow wage**, often approximated by

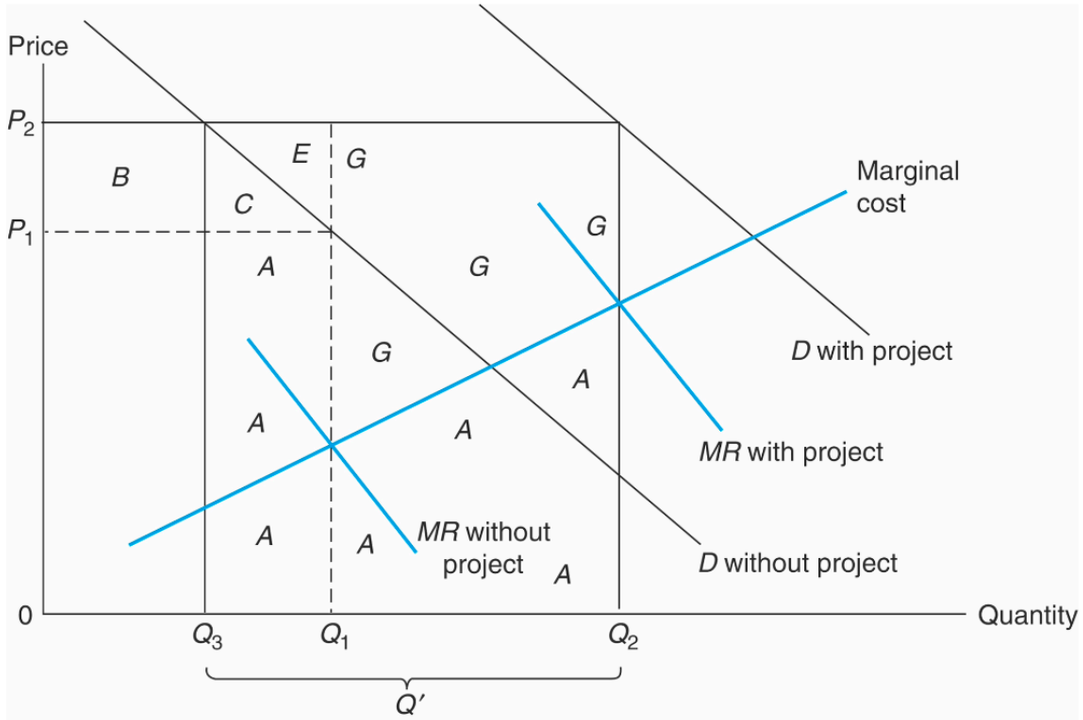
  $1/2(P_m+P_r)$ or simply $1/2P_m$
- Shadow wages give a more realistic estimate of labour's opportunity cost in CBAs under unemployment.



Labour supply with unemployment

Input market with a monopoly supplier

- Project increases input demand → monopolist raises **price** ($P_1 \rightarrow P_2$) and **quantity** ($Q_1 \rightarrow Q_2$).
- Government expenditure = $P \cdot (Q_2 - Q_3)$
- Does this reflect true opportunity cost?
  No – it overestimates.
- Why?
  - Some existing consumers exit → real loss (
    surplus (deadweight loss).
  - Remaining consumers pay higher prices, b
    this is mainly a **transfer** to the monopolist.
  - Monopolist gains **extra producer surplus**
    (beyond covering costs), enabled only by the
    project.



Input with a monopoly supplier

Input market with a monopoly supplier

- True cost = Government expenditure – monopolist's extra producer surplus.

- Net effect of project:

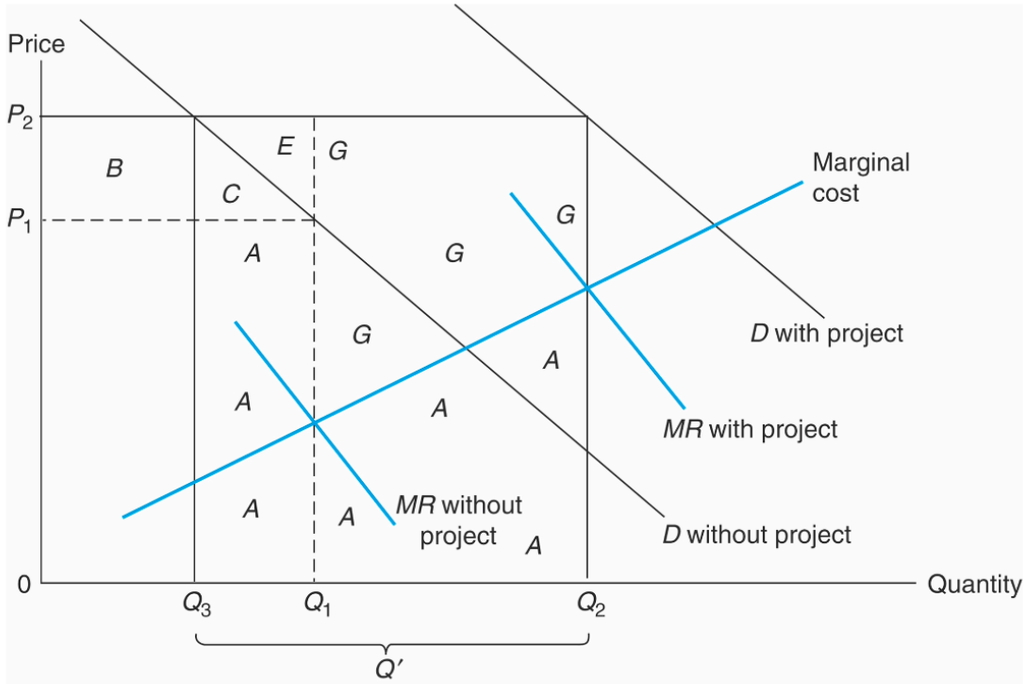
  —Existing consumers lose surplus.
  —Monopolist gains extra surplus.
  —True opportunity cost = real resource cost + surplus lost by consumers who exit.

- Correction method:

  - Use a **shadow price** lower than monopoly price.

  - No fixed formula, but adjustment depends on:
    —Demand and supply elasticities
    —Extent of monopoly power (price vs. marginal cost gap)

- If monopoly power is weak (P close to MC), budgetary expenditure is a good approximation.



Input with a monopoly supplier

Other distortions in input markets

- Input markets may also be distorted by **taxes, subsidies, or externalities**.
  - **Tax on input** → expenditures *overestimate* opportunity cost.
  - **Subsidy on input** → expenditures *underestimate* opportunity cost.
  - **Positive externalities** → expenditures *overestimate* opportunity cost.
  - **Negative externalities** → expenditures *underestimate* opportunity cost.
- Key task in CBA: assess whether budgetary expenditure reflects true opportunity cost.
- Shadow prices are used to correct mismeasurement — but estimating them accurately is **empirically complex**.

Rules for measuring social benefits and costs

Type of intervention	Efficient markets	Inefficient markets
Changes in output markets (Concept: value benefits as WTP for the change and costs as WTP to avoid the change.)	Value change as net change in social (i.e., consumer and producer) surplus plus (less) any increase (decrease) in government revenues. (Example: government provision of goods and services to consumers or producers.)	Value change as net change in social (i.e., consumer, producer, and third party) surplus plus (less) any increase (decrease) in government revenues. (Example: tax or subsidy in market with externality.)

Rules for measuring social benefits and costs

Type of intervention	Efficient markets	Inefficient markets
Change in input markets (Concept: value costs as the opportunity cost of the purchased resources.)	If supply schedule is flat, value cost as direct budgetary expenditure. (Example: purchase of materials from a competitive national market.) If supply schedule is not flat, value cost as direct budgetary expenditure less (plus) any increase (decrease) in social surplus in market. (Example: purchases of materials from a competitive local market.)	Value costs as direct budgetary expenditure less (plus) any increase (decrease) in social surplus in market. (Examples: hiring unemployed labor; purchases of materials from a monopoly.)

Rules for measuring social benefits and costs

Type of intervention	Efficient markets	Inefficient markets
Changes in quantities exchanged in secondary markets as a result of government intervention in input or output markets (Concept: commodities exchanged in secondary markets are typically complements of or substitutes for commodities exchanged in primary markets; most impacts in secondary markets can be valued in primary markets.)	If prices do not change in secondary market, ignore secondary market impacts. If prices do change, but benefits in primary market are measured using a demand schedule with other market prices held constant, then social surplus changes in the secondary market will always represent reductions in social surplus that should be subtracted from changes in the primary market. However, if benefits in the primary market are measured using a demand schedule that does not hold other prices constant, ignore secondary market impacts. (Example: price changes in primary market cause demand schedule shifts in competitive secondary market.)	Costs or benefits resulting directly from increases in the size of the distortion should, in principle, be measured. Other impacts in secondary market should be ignored if prices do not change. (Example: price change in primary market causes the demand schedule to shift in a secondary market with an externality.)

Reading materials

- Boardman et al. Chapters 5, 6, and 7.
- Veileder i samfunnsøkonomiske analyser, section 3 and 4.