Efficiency v. Equity or Fairness
(lexicographic ordering)
3. Shadow Pricing, Direct Price Effects

3.1 Shadow Pricing

[DoF Ch. 3; FP Ch. 1.6, 6; S&W Ch. 8]

The NPV formula can be written as

$$NPV = \sum \frac{b(t) - c(t)}{(1 + r)^t}$$

where $b(t) = \sum b_i p_i = b_1(t) p_1(t) + p_2(t) b_2(t) + b_3(t) p_3(t) + \ldots$

and $c(t) = \sum c_j p_j = c_1 p_1 + c_2 p_2 + c_3 p_3 + \ldots$

Now, we assume here that we have the quantities $b_i$ benefits and $c_j$ costs.

What of the prices $p_i$ and $p_j$?
3.1.2 Example 2: Shadow prices and opportunity costs when prices change

[FP Ch. 2.2.2, 2.3.2; DoF 3.4]

\[ \Delta G \]

Case 2.1

(No price change)

Case 2.2

(Price change)

**Case 2.1: (No price change)**

resource opportunity cost = total social costs for increased factor supply \((2)\)

\[ = P_1 \cdot \Delta G \]
Case 2.2: (Price change)

resource opportunity cost = total social costs

\[ P_1 \cdot \Delta G \] for increased factor supply \((2)\)

+ value of reduced output in the rest of society as a response higher prices \((1)\)

\[ P_1 \cdot \Delta G < \text{Area } [(1) + (2)] < P_2 \cdot \Delta G \]

\[ \therefore P_1 < P_s < P_2 \]

\[ \rightarrow P_s \] is the “effective or shadow price”:

\[ P_s \cdot \Delta G \] is the resource cost = area \((1)\) + area \((2)\)
Prices Change (cont.)

Note: be conservative

if NPV > 0 with $P_2$ - cost
if NPV < 0 with $P_1$ - cost

\[
\begin{cases} 
NPV (P_2) < 0 \\
if \quad NPV (P_1) > 0 \\
NPV (P_s) ? 
\end{cases}
\]

then \text{GO}

then \text{STOP}

then must find $P_s$

Area under Demand Curve

\[
\text{area} = \eta^P Q_D \Delta P \\
(\eta^P : \text{price elasticity of demand})
\]

& $Q_D = \frac{Q_D + Q_1}{2}$
Prices Change (cont.)

Area under Supply Curve

\[
\text{area} = \kappa^p \overline{Q_S} \Delta P
\]

(\(\kappa^p\): price elasticity of supply)

\[
\overline{Q_S} = \frac{Q_1 + Q_S}{2}
\]

**Harberger Analysis**

If \(\Delta P = 0\) and prices competitively determined, then \(P = MC\)

and quantitative effects through the market mechanism should *not* be counted for

\[\therefore P = \text{marginal social cost, and} \]
\[= \text{marginal social benefit} \]
3.1.3 Example 3: Prices change with a tax wedge. [DoF 3.5]

$/$unit

Elastic supply

Tax revenue: a transfer.

Figure 1
Price Change & Tax (cont.)

Figure 3

- Valuation of the increased supply $1 - a$ depends on $S_0$ (after-tax)
- Valuation of the demand shifted to the project $a$ depends on the shaded area under $D_1$
- Figure 3 adds the after-tax supply curve $S_0$ to Figure 2
- So $\Delta D \times \rho_5 = $ the sum of the two areas
Labour (cont.)

Suppose there is a minimum wage $\bar{w}$ for labour set by the Industrial Relations Tribunal. Then the employment level $n_1$ will be less than the competitive level, $n_1^*$.

- The projects shifts out demand for labour from $D_1$ to $D_2$
- If the additional workers who receive jobs value leisure at $w_1^{SP}$, then $w_1^{SP}$ is the shadow wage
- Newly employed workers may have a higher value of leisure $w_2^{SP}$ than $w_1^{SP}$
  \[ \therefore \text{this higher average value } w_2^{SP} \text{ should be used} \]
- The social cost (shadow price) is lower than the market price $\bar{w}$
- Why? Because there is unemployment at minimum wage $\bar{w}$. 

\[ \text{unemployment at } \bar{w} \text{ with } D_1 \text{ for labour} \]
\[ \text{unemployment after with the project } = \bar{w} - n_2 \]
Labour (cont.)

- The change in the wage bill \( = \bar{w} \times (n_2 - n_1) \); in F.A. it was the “rectangle” (brown + green).
- The change in the social cost \( = \frac{w_1^{SP} + w_2^{SP}}{2} (n_2 - n_1) \).
- The opportunity cost of getting a job is less than \( \bar{w} \), which is reflected in the supply curve.

\[ w^{SP} = \left( \frac{w_2^{SP} + w_1^{SP}}{2} \right) \]
Foreign Exchange (cont.)

Project now increases our supply of foreign exchange $\Delta S$ via additional exports. Let $\Delta S = 1$. 

- this situation is similar to the tax example (p.5-12)
- increased exports facilitates increased imports valued at $e_1 + t$ (area base $1 - a$)
- increased new exports displaces traditional exports $a$ valued at net-tax price of $e_1$
- shadow price = $a$ (post-tax price of traded goods) + $(1 - a)$(pre-tax price of traded goods)
- shadow exchange rate will exceed market exchange rate, since exports are under-valued by the market exchange rate. — The Gregory Thesis or Dutch Disease.
A Tax (cont.)

Because of the tax, the demand price $p_1^D$ is greater than the supply price $p_0^S$.

The diagram shows the Tax Revenue and the Dead-Weight Loss as the tax is imposed, pushing up the effective supply, and reducing the quantity demanded, from $q_0$ to $q_1$. 
A Tax (cont.)

e.g. oil at world price plus a local excise

Consumers value the increase in demand ($\Delta D$) at the gross-of-tax price $p_1^D$.

Suppliers' price is unchanged at $p_1^S$.

Shadow price $= p_1^D - t = p_1^S$ = unchanging net-of-tax price, $p_1^S$.

The tax revenue (גיור) is a transfer, and so changes in the tax revenue (changes in a transfer) are not changes in opportunity cost (גיור).

This is only the case if there is no effect on existing purchasers of output, since there is no increase in price with perfectly elastic supply.

\[ \text{Shadow price} = p_1^S, \text{ the price before the tax.} \]

We ignore the transfer payment of the tax.
Net Social Benefits

If workers are indifferent between working or not, then the net social benefit of the program
= the P.V. of before-tax future earnings of successful trainees
  - the operating costs of the program.

The skilled labour market.
  - costs of the program
7.3.2 **Price changes in the skilled market.**

Now relax the assumption that the program will have no effect on competitively determined wages in the skilled labour market.

**Assumption II:** through the increase in skilled workers \((n \rightarrow n')\), the program leads to a fall in skilled-labour wages \((w' \rightarrow w'')\). (The unskilled wage is fixed, and unemployment persists in that market.)

Consider the two groups: employers and workers in the skilled labour market.

- The derived demand for skilled labour is unchanged. (D unshifted.)
- Supply increases from \(n\) to \(n'\), and the wage falls from \(w'\) to \(w''\).
- Skilled labour supply \(S\) is shown as completely price-inelastic (vertical).
3.2.1 Consumer's Surplus

The net willingness to pay that consumers retain after paying for the good or service; for each unit sold, the difference between the maximum which the market would pay for that unit and the price actually paid.

E.g. a higher price of gas from \( p_1 \) to \( p_2 \)

The financial gain to the sellers of gas = the financial loss to the gas buyers, but this is only a transfer payment, not a use of resources, a cost.

If the demand for gas is completely price inelastic, then this is straightforward.

But if the quantity of gas demanded falls, because of the higher price, how are consumers worse off above and beyond the higher price?
total value of new sales
\[ \therefore \text{ net surplus to consumers' } \]
& net surplus of old sales’
\[ \text{DD} = \text{demand curve} \]

\[ P^1 a b P^2 = \text{consumer's surplus associated with the price fall. (a gain)} \]

\[ \text{gain to new consumers or to existing consumers who buy more units} \]
Question.

The price $P$ of a good $X$ increases from $P_{low}$ to $P_{high}$, ceteris paribus, with a budget of $M$.

How much would you pay to have the price of $X$ fall from $P_{high}$ back to $P_{low}$?

A: An amount = the Compensating Variation (CV).
Example: Imposition of a Tax (a price increase)

Consider a tax imposed on the product, which raises the price, from $p$ to $\hat{p}$, and so makes the consumer worse off.

Equivalent Variation: (EV) the maximum amount the consumer would pay to avoid the tax, i.e., to keep the price at $p$ rather than have it change to $\hat{p}$ (at the old price $p$)

Compensating Variation: (CV) how much minimum extra income would the consumer need to have to be as well off after the tax as before (at the new price $\hat{p}$)

With no income effects, $EV = CV = \Delta CS$, willingness to pay = willingness to sell = change in consumer surplus \((in \% )\)

e.g. offshore sewage pipes 
Ex. Sydney Airport noise
e.g. A numerical example:

\[ p_1 = 20\text{¢}/\text{unit} \]

100 units/month → $20/month

If an additional fixed "connect" charge of $16/month is acceptable to the buyer, but any increase would result in the decision to disconnect, then we can conclude that the (net) consumer's surplus associated with a 20¢/unit usage charge is $16/month.

We should expect a higher usage charge to be associated with a lower consumer's surplus: for example, 24¢/unit might result in a fall of consumer's surplus of $3.50 to $12.50/month.
Consider a proposal to supply piped gas to a new rural area.

If the situation is as plotted below, then there exists no level of monthly output at which the average costs of the supplier will be covered by the price (or average revenue). From a purely financial standpoint this is the end: since the seller cannot supply profitably, the supply will not proceed.

\[
\text{Profit} = Q_1 (P_i - AC(Q_1)) < 0 \quad \text{if} \quad P_i < AC(Q_1)
\]
3.2.2 Producers' Surplus

By analogy, the *change in producers' surplus* $PS$ is the strip to the left of the supply curve, bounded by the lower and upper prices.

![Diagram showing producers' surplus](image)

If a firm is buying inputs (labour), using machines (capital) to make output, and selling output (screws), then the difference between its revenue and payments to workers is the producers' surplus to owners of capital (or quasi-rent).

- A higher price for output with no change in the price for inputs will increase the producers' surplus by $\Delta PS$;
- a higher price for inputs with no change in the price for output will reduce producers' surplus, as the supply curve shifts to the left.
Consumer Surplus in Dollar Terms

The price falls from $P_1$ to $P_2$; a budget of $\bar{M}$.

Compensating Variation is thus seen as the max. amount the consumer should pay for the project (of reducing the price from $P_1$ to $P_2$) = $M - M_2$.

Utility = function (quantity $Q$ of good or service, money $M$ spent on all else).

Maximise utility, s.t. budget constraint of $\bar{M}$. 

---

![Diagram of consumer surplus in dollar terms](image-url)
Δ CS in Housing:
e.g. Katoomba
rail: \((P_R, Q_R)\)
housing: \((P_H, Q_H)\)

considering raising the price of railway

\[ P_R \rightarrow P_R' \]
→ reduction in \(D_H\)
→ fall in \(P_H\)
→ \(P_H'\)
fall in \(Q_H\)
→ \(Q_H'\)

fall in \(P_H \rightarrow P_H' \rightarrow \) increase in \(D_R \rightarrow D_R(P_H')\)
→ new quantity of trips \(Q_R'\)

fall in consumers' surplus in railway market
rise in consumers' surplus in housing market

\[ \therefore \text{ net effect on consumers is } (\square) - (\square), \text{ a reduction in consumers' surplus} \]

\[ \therefore \text{ net effect on society (cons. + prod.) } = \Delta \text{ CS in rail-travel market, since housing markets changes cancel.} \]

area \(\square\) is a transfer: from landlords to tenants.
Katoomba Rail and Renting
Δ CS in Housing:

e.g. Katoomba
rail: \((P_R, Q_R)\)
housing: \((P_H, Q_H)\)

considering raising the price of railway

\[ P_R \rightarrow P_R' \]

\rightarrow reduction in \(D_H\)

\rightarrow fall in \(P_H\)

\rightarrow \(P_H'\)

\rightarrow fall in \(Q_H\)

\rightarrow \(Q_H'\)

rail \(\Delta C_R\) negative

house \(\Delta C_H\) positive

social welfare: if\(\Delta C_H = -\Delta P_H\)

only thing is to look at \(\Delta CS_R\)
**Induced Price Changes**

A company hires labour, manufacturers output, and sells to customers.

Company is a price-taker in the labour market.

Then wage increases, $w \rightarrow w'$.

Net loss to firm:
- shaded area (a)
- shaded area (b)

Net loss to consumers:
- shaded area (b)

The social net loss:
- shaded area (a)

If PPIC is sole criterion, then weight consumers = producers (a $ is a $) & need not look at induced price changes in competitive markets for Pecuniary External Benefit.
HEC: "supply AD with hydro @ P₁,"

or "coal @ P₂,"

"additional cost of CXP₁P₂ with coal" ?

\[ t = \text{fall in } \Delta G = \text{new in } PS \]

\[ \text{actual cost} = 2Yxw \]

\[ \text{overstated cost} = xxC \]
1. (i) (a) NPV of A @ 10% = $137.24
   NPV of B @ 10% = $216.94

   (b) IRR of A = 15.24% p.a.
   IRR of B = 14.65% p.a.

   (c) Undertake project B: both projects have the same K0 = $1000, and a + 10% p.a. project B has the larger NPV, even though its IRR is lower.
   Moreover, both projects have the same life and are mutually exclusive.

   (ii) (a) The NPVs of the three projects are $600, $450, and $300, respectively.
   If only one project is chosen, it should be project A, leaving nothing in the budget, with an NPV of $600.

   (b) But if more than one project can be undertaken (not mutually exclusive), then projects B and C should be, also exhausting the budget, but with a combined NPV of $750.
   In general, NPV/K0 gives 0.25, 0.35, 0.27, as is seen below.

   ![Diagram](image.png)

   NPV is the area under the curves, maximised with B & C for K0 = $2400.)
2(a) For the 50 skilled workers diverted from elsewhere, the shadow cost is their value to their previous employer (viz. $500/week). It is a social cost, because their previous employers must now find replacements (either labour or machines, etc.)

For the 150 who have been employed driving cabs (a second-best choice for them) etc., the cost is the value to them (their take-home pay). At the margin, this is $500/1.20 = $416/week but for some workers it's even lower.

The shadow wage is thus a weighted average of the two:
$$\leq 0.25 \times 500 + 0.75 \times 416 \leq 437/\text{week}$$

To be more accurate, we'd need to know the previous (take-home, after-tax) wages of the 150 workers.

(b) From the handout on the solution to the first spreadsheet exercise,
$$NBIR = \frac{\sum (B_t - O_{Ce})}{(1+i)^t} \leq \frac{IC_{Ce}}{(1+i)^t}$$

the ratio of the present value of a project's benefits minus its operating costs $O_{Ce}$ to the present value of its investment cost.

It calculates the net operating benefits per unit of investment. But it is unsuitable for choosing mutually exclusive projects.
but if separates operating costs from investment costs - operating costs might be financed from operating revenues.

NBIR is better than B/C because it ranks projects by return per unit invested, and so can be used with capital budgeting to obtain the mix of (non-exclusive) projects which maximizes NPV.

(c) The table from p. 30 of the DoF Handbook shows how to allow for taxes and subsidies on project inputs and outputs (see Q3946). In particular, there is a distinction between incremental or displaced inputs and outputs.

Take labour as an input (Q46): when there is no displacement from existing employees (no change in price, because the supply elasticity of labour is infinite and the labour supply curve horizontal), then the shadow wage should be $\text{market wage} - \text{tax (tax exclusive)}$ because this take-home pay is what the workers receive = their value of other opportunities forgone, at the margin.

When there is displacement (the project bids up the wage rate, since labour supply is not perfectly elastic or horizontal) then the cost is the value of these displaced workers to their previous employer = the unit cost = the wage paid (including the tax).
1) The $500k is clearly a cost: the value of the increased resources of the police etc. Since it cannot be used elsewhere now, it is an opportunity cost.

What of the $1m of stolen goods? This is a transfer (yes, an involuntary, illegal transfer, but still something for nothing). Who loses with the increased policy? (The owner of the goods win, since their goods are not stolen.)

Well, after selling to the fences, the thieves would have received $600k, so they lose. And the fences, nearly bought ‘hot’ goods, have a net value of $400k, which they lose with the increased policy.

Ignore these transfers.

So far: one cost = $500k.

Need to consider other benefits of the increased policy: lower private security payments, lower levels of anxiety, less/less loss of sentimental goods (of no value to the thieves, but often irreplaceable for their owners). These benefits are not captured in the $1m book value.
3. 

**Effective cost per trip**

$\begin{align*}
\text{Save} & \left\{ 6 \text{ min } @ 4/\text{hr} \right\} \downarrow \\
\text{2 L } @ 2/\text{L} \quad \text{(including 80¢/L tax)} \\
\end{align*}$

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>100k</td>
<td></td>
<td></td>
</tr>
<tr>
<td>150k</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) Including fuel taxes:

Savings to existing drivers (case A)

\[ \text{time} = \frac{1}{2} \times 50,000 \times \frac{1}{2} \times 4 = 10,000 \text{ /year} \]

\[ \text{fuel} = \frac{1}{2} \times 50,000 \times 2 = 50,000 \text{ /year} \]

Best for existing drivers, 80% of the fuel savings is a transfer: Subtract \$160,000 /year.

Annual savings = \$140,000 /year = \$\Delta CS$

At 10% p.a. \rightarrow capital value of \$1.4 m

Cost of construction = \$1.2 m \quad \Rightarrow \text{NPV > 0 GO!}$

(b) What is the lifetime of the road?

What are the maintenance and operating costs?

What is the level of unemployment among truckers?

What is the tax level for truckers? (payroll)

What is the reduction in accidents?

What is the level of externalities - drivers?

- construction?

etc.
4. (a) IRR = discount rate $\rightarrow$ NPV = 0
NPV is scale-dependent, i.e., additive
unique used for capital budgeting
simple to calculate
IRR is scale-independent, non-unique
required - we are not cash flows

(b) When K (the supply elasticity of labour) is infinite
then the supply curve S
is horizontal, and no
diverted labour, only
incremental
\[ \text{Sh. w} = \text{market wage} - \text{tax} \]
social cost as shown:

When K is less than infinite,
the S curve is upwards sloping,
and there is diverted labour as
the market wage rises
\[ \begin{align*}
\text{incr: Sh. w} &= \text{m. w.} - \text{tax} \\
\text{div: Sh. w} &= \text{m. w.}
\end{align*} \]
(including tax)
The lower the price elasticity of labour supply,
the greater the proportion of displaced workers
& so the greater the opportunity cost of labour.

(c) For involuntarily unemployed workers, the
(wage - tax) overstates the value of leisure:
they would work, but can't find jobs:
The shadow wage < market wage - tax.
(d) Beware double country (multipliers, P.E.E.).

The purpose of Interlingua is to become profitable for its shareholders (see FA). From a social point of view (CRA), we are concerned with increased efficiency especially from the uses to which its graduates put their new language skills to increase Australia's value added.

To the extent that these benefits accrue to the graduates via higher salaries, Interlingua could raise its fees. If the (positive) externalities are beyond Interlingua and its graduates look at the activity and profitability of the firms who employ the graduates and the levels of inbound tourism from the countries whose languages are taught (see later).

(e) If FA < 0 but NPV > 0, then from PIC Interlingua is a good thing, but it won't operate at a loss.

The government could assist (through subsidies or tax breaks), but any such taxes will distort the markets in missing money \( \rightarrow \) a Dead Weight Loss or inefficiency OK, so long as DWL < NPV.
Chapter 3
Exercise 1

Table 1 Parameters Table

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Project life (years)</td>
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<tr>
<td>Project output volume (tons)</td>
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<tr>
<td>Output price ($/ton)</td>
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<td>Inflation (% pa)</td>
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<td>Raw materials (% pa)</td>
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<td>Investment cost ($L million)</td>
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<tr>
<td>Labour costs (% pa)</td>
<td>4</td>
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<tr>
<td>Overheads (% pa)</td>
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</table>

all nominal

Table 2 Financial Analysis

<table>
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<tr>
<th>Years</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>...</th>
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<td>($) L million</td>
<td>66.67</td>
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</tbody>
</table>

1. Expenditures

Investment costs

Operating costs

Raw materials

Labour

Overheads

Total expenditures

2. Receipts

Net benefits (2-1)

Net present value ($ million)

Nominal discount rate

Internal rate of return

Benefit cost ratio

Net benefit investment ratio

V.O.C.

P.V. of benefits = P.V. of Investment costs + P.V. of oper. costs

P.V. of (benefits - oper. costs) = P.V. of Investment costs

Discounted benefits net of oper. costs per dollar (p.u.) of investment

N.B.I.R.
Exercises
1. In a middle-income developing country a private consortium is considering investing in an integrated steel mill project and wishes to undertake a financial analysis of the project. Draw up a cash flow of the expected receipts and expenditures on a spreadsheet program like Lotus 123.

The project will last 25 years and produce 100,000 tonnes of steel products per annum, starting from year 4. Each tonne of output will sell for $L1,400 in current-day local dollars, but the sales price is expected to rise with the general rate of inflation, which is projected to be 6 per cent p.a. over the life of the project.

Total investment will be $L200 million, spread evenly over the first 3 years of the project. There will be no inflation in construction costs once the contract for construction is let.

In the fourth year of the project, when production starts, annual operating costs are expected to be:

- raw materials  $L8 million
- labour        $L4 million
- overheads     $L1 million.

In each year following, raw material prices are expected to rise by 6 per cent, labour costs by 8 per cent, and overheads by 5 per cent.

Draw up a parameters table, as shown below, which lays out clearly all the basic information, or parameters, provided on the project. All quantitative data should be placed in a separate cell so that it can be referenced by formula in the

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Parameter table (Separate cell entries)</th>
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<tbody>
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<td>Project life (years)</td>
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<tr>
<td>Project output volume (tonnes)</td>
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<td>Output price ($/tonne)</td>
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<td>Investment cost ($L million)</td>
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<td>Investment period (years)</td>
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<td>Raw materials cost p.a. ($L million)</td>
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<td>Labour cost p.a. ($L million)</td>
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<td>Overheads cost p.a. ($L million)</td>
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<td>Inflation (r p.a.):</td>
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<td>Output price (r p.a.)</td>
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<tr>
<td>Raw materials (r p.a.)</td>
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<td>Labour costs (r p.a.)</td>
<td>8</td>
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<tr>
<td>Overheads (r p.a.)</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 2 | Financial analysis

Divide the cash flow into headings, and estimate the net benefit cash flow of the proposed project.

<table>
<thead>
<tr>
<th>Years</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>25</th>
</tr>
</thead>
</table>

1. Expenditures
   - Investment costs
   - Operating costs
   - Raw materials
   - Labour
   - Overheads

2. Receipts

Net benefits (2 - 1)
Chapter 7
Exercise 1

The total economic benefits of the new coal fired electricity generation project are represented in the diagram above by the sum of the areas (1) and (2).

Area (1): Part of the project's output (100,000 MWh) has substituted for existing sources of supply. The economic benefit of this part of the project's output will be the cost of resources used by these decommissioned units which can now be released for other purposes in the economy. This is represented by the shaded area (1) under the producer's supply curve, $S_P$.

Area (2): The remainder of the project's output constitutes an increase in the availability of electricity (500,000 MWh) which is expected to cause the price of electricity to fall. The economic benefit of this increased production will be measured by the amount that people are willing to pay for this electricity, the area (2) under the consumers' demand curve, $D_N$.

Mathematically, the project's total economic benefits are given by:

Total economic benefits = $AvP_s \times Q_s + AvP_d \times Q_d$

= $(95 \times 100,000) + (95 \times 500,000)$

= $57$ million

Benefits per unit of output = $\frac{AvP_s \times Q_s + AvP_d \times Q_d}{Q_S + Q_D}$

= $\frac{(95 \times 100,000) + (95 \times 500,000)}{(100,000 + 500,000)}$

= $95$ per MWh

Using the Harberger equation:

$\varepsilon_{ip} = \frac{dQ_S}{dP \times P_S / Q_S}$

= $(-0.1 + -10) \times (100 + 3)$

= $0.333$

$\eta_{ip} = \frac{dQ_d}{dP \times P_d / Q_d}$

= $(0.5 + -10) \times (100 + 3)$

= $-1.667$

$\frac{Q_s}{Q_d} = 1$
Benefits per unit of output

$$\frac{e_{ip} P_{is} - \eta_{ip} P_{id} (Q_{id} / Q_{is})}{e_{ip} - \eta_{ip} (Q_{is} / Q_{id})} = \frac{(0.333 \times 95) + (1.667 \times 95)}{(0.333 + 1.667)} = \$95 \text{ per MWh}$$

Uncompensated gain in consumer surplus

The uncompensated gain in consumer surplus is the difference between the gain in consumer surplus and the loss of producer surplus as a result of the project. When price and quantity move from point A to point B on the above diagram, consumer surplus increases by the shaded area due to the lower price and higher quantity. Producer surplus lost to decommissioned generators is the hatched area. The uncompensated gain in consumer surplus is therefore the triangular area ABC.

Increase in consumer surplus

$$= (100-90) \times 3 + (100-90) \times (3.5-3) / 2$$
$$= \$32.5 \text{ million}$$

Decrease in producer surplus

$$= (100-90) \times 2.9 + (100-90) \times (3-2.9) / 2$$
$$= \$29.5 \text{ million}$$

Uncompensated gain in consumer surplus

$$= 32.5 - 29.5$$
$$= \$3 \text{ million}$$
Some of the skilled technicians required for the project will be bid away from existing employers (30 technicians), the remainder (70 technicians) will be induced by higher wages to return to this occupation from other occupations. The economic cost of 100 skilled technicians to the project is made up of these two components and is shown on the diagram above as the sum of areas (1) and (2). Area (1) represents the utility (value of output) lost by the displaced employers of technicians, measured by what they were willing to pay for those technicians - the area under the demand curve, $D_D$. Area (2) represents the real cost of the services of the newly employed technicians, measured by the amount expended on them for their work on the project, the area under the supply curve, $S$.

Mathematically, the economic costs of the project's inputs is given by:

$\text{Total economic costs} = \text{AvP}_s \times Q_s + \text{AvP}_D \times Q_D$

$= (525 \times 30) + (525 \times 70)$

$= \$52,500 \text{ per month}$

$\text{Costs per unit of input} = \frac{\text{AvP}_s \times Q_s + \text{AvP}_D \times Q_D}{Q_s + Q_D}$

$= \frac{(525 \times 30) + (525 \times 70)}{(30 + 70)}$

$= \$525 \text{ per worker per month}$

Using the Harberger equation:

$\epsilon_{js} = \frac{dQ_s}{dP} \times P_s / Q_s$

$\eta_{js} = \frac{dQ_d}{dP} \times P_d / Q_d$

$= (70 + 50) \times (500 + 700)$

$= 1$

$= -0.429$

$Q_s / Q_{jd} = 1$

$\text{Cost per unit of input} = \frac{\epsilon_{js} P_s - \eta_{js} P_d (Q_{jd} / Q_{js})}{\epsilon_{js} - \eta_{js} (Q_{js} / Q_{jd})}$

$= \frac{(1 \times 525) + (0.429 \times 525)}{(1 + 0.429)}$

$= \$525 \text{ per worker per month}$
Chapter 7
Exercise 3

Price ($/MWh)

Area (1): The economic benefits of that part of the project’s output which substitutes for existing supply are measured by the saving in the real resources no longer required by decommissioned generators. This is measured by the shaded area (1) under the supply curve, $S_0$.

Area (2): The economic benefits of electricity which meets new demand is the area under the total demand curve, $D$. This measures the total amount that consumers are willing to pay for this increased production. The part of area (2) between the two demand curves, $D$ and $D_{ST}$, is actually paid to the government as sales tax but is still included in the project’s benefits as consumers are willing to pay the full amount, including tax, for this quantity of electricity.

Total economic benefits

\[ \text{Total economic benefits} = A v P_s \times Q_s + A v P_d (1 + t_{ST}) \times Q_d \]
\[ = (9.5 \times 100,000) + (9.5 \times 1.1 \times 500,000) \]
\[ = $61.75 \text{ million} \]

Benefits per unit of output

\[ \text{Benefits per unit of output} = \frac{A v P_s \times Q_s + A v P_d (1 + t_{ST}) \times Q_d}{Q_s + Q_d} \]
\[ = \frac{(95 \times 100,000) + (95 \times 1.1 \times 500,000)}{(100,000 + 500,000)} \]
\[ = $102.92 \text{ per MWh} \]

Using the Harberger equation:

From exercise 1: \( \varepsilon_{ip} = 0.333 \)
\( \eta_{ip} = -1.667 \)
\( Q_{it}/Q_{id} = 1 \)

Benefits per unit of output

\[ = \frac{\varepsilon_{ip} P_{it} - \eta_{ip} P_{id} (Q_{id}/Q_{it})}{\varepsilon_{ip} - \eta_{ip} (Q_{it}/Q_{id})} \]
\[ = \frac{\varepsilon_{ip} P_{im} - \eta_{ip} P_{id} (1 + t_{ST})(Q_{id}/Q_{it})}{\varepsilon_{ip} - \eta_{ip} (Q_{it}/Q_{id})} \]
\[ = \frac{(0.333 \times 95) + (1.667 \times 95 \times 1.1)}{(0.333 + 1.667)} \]
\[ = $102.92 \text{ per MWh} \]

Note: Exercises 1 and 3 should be considered as separate projects. They cannot be represented as before and after sales tax situations. If a sales tax were introduced into exercise 1, not only would supply and demand prices diverge but quantities transacted would also change.
1. (a) (i) Definition 
   (ii) No - "potential" only... no vetos allowed. Efficiency means, not equity or fairness. 
   (iii) "economic efficiency"

(b) (i) P.E.E. occurs when, via the market mechanism, the price in a related market (substitute or complement) changes in response to a supply or demand change (including price) in the primary market. Note: the transmission mechanism has to be via the market mechanism. So long as the related market is competitive, there will be transfers that cancel in that market i.e. ignore any P.E.E. so long as the related market is competitive.

(ii) Avoid double counting etc., no transfers.

(c) The $500k is a cost: increased resources of police etc => an opportunity cost of $500k/year. The loss of $1m is a transfer to the thieves of $600k and the buyers of $400k. Ignore transfers. Consider other cost savings. Are they worth $500k/year? (Lower private security, less concern, less loss of sentimental value, not captured in the $1m book value)
(a) (i) Definition.

(ii) DPLC an efficiency measure. But if equity (or fairness) matters or if political considerations matter, then compensation may be desirable.

(b) Reject all with \( \text{NPV} < 0 \). Rank by \( B/C \). Choose until capital exhausted \( \rightarrow \) the maximum \( \text{NPV} \) for the investment.

(c) Consider the impacts on the related market if this market is not competitive, or if there are distributional concerns.

(d) Consider the potential benefits (productivity, leisure, happiness, etc.) and the potential costs (dark mornings, more accidents, etc.). Try to quantify \( \text{WTP} \) to see whether \( B/C > 0 \).

2 (a) \( \text{DWL} = $500 \) per week.

(Transfer of $4000/week.)

(b) Because the impact on the concrete market is not via the market mechanism — the government decreases the toll and also decides to cut back on concrete purchases, the concrete market is not a P.E.E. $25,000 overstates the saving, but $24,500 understates it. Use a shadow price of $24.75 → $24,750 saving.
4. (a) Save both:

\[ \{ \begin{align*}
6 \text{ minutes} & \times \$4/\text{hr} \\
2 \text{ litres} & \times \$1/\text{L}
\end{align*} \]

Incl. 80c/L tax

- Time saved: \[100,000 \times \frac{1}{10} \times 4 + \frac{1}{2} \times 50,000 \times \frac{1}{10} \times 4\]
  \[= \$50,000 \text{ (125,000 minutes)}\]

- Fuel saved:
  \[= 100,000 \times 2 + \frac{1}{2} \times 50,000 \times 2\]
  \[= \$250,000 \text{ (250,000 litres)}\]

But the 80c/L tax is a transfer: subtract it from the existing drivers (even A)

\[= \$160,000\]

\[\therefore \text{without tax transfer: } \Delta CS = \$140,000/\text{year}\]

or \[\$1.4 \text{m} @ 10\% \ p.a.\]

(b) Go ahead

\[NPV = \$1.4 \text{m} - \$1.2 \text{m} = \$200,000 > 0\]

(b) Other externalities etc.
<table>
<thead>
<tr>
<th>Minimum price to sell</th>
<th>Maximum to pay for P.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2.50</td>
<td>$4.00</td>
</tr>
<tr>
<td>2.00</td>
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<tr>
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<td>1.10</td>
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</tr>
<tr>
<td>2.50</td>
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</table>

Walk away. Consistency?
Chapter 6

Exercise 1

Table 1 Parameters Table

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Project life (years)</td>
<td>20</td>
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<tr>
<td>Treatment volume (tons per day)</td>
<td>1,000</td>
</tr>
<tr>
<td>Construction costs</td>
<td></td>
</tr>
<tr>
<td>Total construction cost ($L million over two years)</td>
<td>2.5</td>
</tr>
<tr>
<td>Financial labour cost</td>
<td>0.8</td>
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<tr>
<td>Free market labour cost</td>
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<tr>
<td>Taxes and tariffs on imported construction materials</td>
<td>0.5</td>
</tr>
<tr>
<td>Income tax on skilled technicians and engineers</td>
<td>0.2</td>
</tr>
<tr>
<td>Imported equipment ($L million - cif value)</td>
<td>1</td>
</tr>
<tr>
<td>Tariff on imported equipment</td>
<td>20%</td>
</tr>
</tbody>
</table>

Operating costs ($L million per annum) 0.8
Included in operating costs...
Income taxes 0.1
Taxes on fuel and raw materials 0.5
Sale of clean water ($ per ton) 2.5
Environmental benefits of clean water ($ per ton) 3.5
Financial discount rate 10%
Social discount rate 11%

Table 2 Financial Analysis

($L '000)

<table>
<thead>
<tr>
<th>Years</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
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<tr>
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<td>2,450</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Sale of clean water</td>
<td>912.5</td>
<td>912.5</td>
<td>912.5</td>
<td>912.5</td>
<td>912.5</td>
<td>912.5</td>
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<td>912.5</td>
</tr>
</tbody>
</table>

Net benefits
-1,250 -2,450 112.5 112.5 112.5 112.5 112.5 112.5 112.5 112.5 112.5

Net Preset Value (FDR 10%) -2,399
Financial internal rate of return -5.53%

Table 3 Economic Analysis

($L '000)

<table>
<thead>
<tr>
<th>Years</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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</tbody>
</table>

<table>
<thead>
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<th>1</th>
<th>2</th>
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<th>4</th>
<th>5</th>
<th>6</th>
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<td>912.5</td>
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<td>912.5</td>
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<tr>
<td>Environmental benefits</td>
<td>1277.5</td>
<td>1277.5</td>
<td>1277.5</td>
<td>1277.5</td>
<td>1277.5</td>
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<td>1277.5</td>
<td>1277.5</td>
<td>1277.5</td>
<td>1277.5</td>
</tr>
</tbody>
</table>

Total benefits
2190 2190 2190 2190 2190 2190 2190 2190 2190 2190 2190

Net benefits

Net Present Value (SDR 11%) 10,429
Economic internal rate of return 69.02%

(a) If the operator is private and only concerned with its profitability, the project should not be undertaken. This is because the financial costs outweigh the financial benefits after the financial cost of borrowing is accounted for using discounting. The net present value is negative.

(b) If the project operator is a government, concerned with the welfare of the whole country the economic analysis should be used to determine whether the project is worth undertaking. Using a social discount rate we find the economic net present value to be positive, so the project should be undertaken.

(c) If the project is privately operated, the government should consider subsidising it in order to make it financially viable for the private operator. A subsidy given to the private operator would increase the financial net present value without changing the economic net present value.
Area (1) represents the utility lost by the displaced employers of technicians, measured by what they were willing to pay for those technicians - the area under the demand curve, $D_P$. Area (2) represents the real value of the services of the newly employed technicians, measured by the amount required to induce them to work on the project, the area under the supply curve, $S$. This includes the area between the two supply curves, $S$ and $S_{sub}$, which is the amount of the subsidy paid by government for training. This area is included in the economic cost of newly employed technicians because the training cost must be added to the real cost of the services of these technicians.

Mathematically, the economic costs of the project's inputs is given by:

**Total economic costs**

$$= AvP_s \times Q_s + AvP_d \times (1 - S) \times Q_d$$

$$= (525 \times 30) + (525 \times 0.96 \times 70)$$

$$= \$54,031.25 \text{ per month}$$

**Costs per unit of input**

$$= \frac{AvP_s \times Q_s + AvP_d \times (1 + S) \times Q_d}{Q_s + Q_d}$$

$$= \frac{(525 \times 30) + (525 \times 0.96 \times 70)}{(30 + 70)}$$

$$= \$540.31 \text{ per worker per month}$$

OR, using the Harberger equation:

**From exercise 2**

$$\varepsilon_{jp} = 1$$

$$\eta_{jp} = -0.429$$

$$Q_{jp}/Q_{jd} = 1$$

**Costs per unit of input**

$$= \frac{\varepsilon_{jp} P_{jm} - \eta_{jp} P_{jd} (Q_{jd}/Q_{jm})}{\varepsilon_{jp} - \eta_{jp} (Q_{js}/Q_{jd})}$$

$$= \frac{\varepsilon_{js} P_{jm} (1 - S) - \eta_{jp} P_{jm} (Q_{jd}/Q_{jm})}{\varepsilon_{jp} - \eta_{jp} (Q_{js}/Q_{jd})}$$

$$= \frac{(1 \times 525 + 0.96) + (0.429 \times 525)}{(1 + 0.429)}$$

$$= \$540.31 \text{ per worker per month}$$
Chapter 7
Exercise 5

The diagram above shows a situation where the domestic price of coal is fixed at $60 per ton. At this price consumers will demand 20 million tons but producers are only willing to supply 12 million tons. The additional million tons produced by the project should not be valued at the fixed price but the amount consumers would be willing to pay for this output. If the black market price is an accurate approximation to the demand price of an additional unit of coal then these black market prices before and after the project can be used to estimate the economic benefit of the additional production of 1 million tons of coal, the area under the demand curve. As the price received by producers has not fallen as a result of the project there are no displaced producers and the supply price is irrelevant to measuring the benefits.

Total economic benefits = \( ApD \times Q_D \)
= \((97.5 \times 1,000,000)\)
= $97.5 million

Benefits per unit of output = \( \frac{ApD \times Q_D}{Q_D} \)
= \( \frac{(97.5 \times 1,000,000)}{1,000,000} \)
= $97.5 per ton

OR, Using the Harberger equation:

Benefits per unit of output = \( P_s W_s + P_d W_d \)

All the outputs of the project meet excess demand and there is no substitution of project outputs for existing supply. In this case the weight on the supply price is zero \( (W_s = 0) \), the weight on the demand price is one \( (W_d = 1) \).

Using the definition of \( W_s \): \( W_s = \frac{\varepsilon_{ip}}{\varepsilon_{ip} - \eta_{ip}} \quad \left( \frac{Q_d}{Q_s} \right) \)
the price elasticity of demand, \( \varepsilon_{ip} \), must be zero as the denominator cannot be zero. Calculating price elasticity of supply:

\( \eta_{ip} = \frac{dQ_d}{dP} \times \frac{P_d}{Q_d} \)
= \((1 + 5) \times (100 + 12)\)
= \(-1.667\)

\( Q_s / Q_d = 1 \)

Benefits per unit of output = \( \frac{\varepsilon_{ip} P_s - \eta_{ip} P_d \left( Q_d / Q_s \right)}{\varepsilon_{ip} - \eta_{ip} \left( Q_s / Q_d \right)} \)
= \( \frac{(0) + (1.667 \times 97.5)}{0 + 1.667} \)
= $97.5 per MWh
The complete demand curve: Clawson.

travel costs ~ individuals different costs
e.g. consumers’ surplus lost if a theatre closes
the opportunity cost of going to the theatre

opportunity cost = price of the
ticket + travel time

Observe only 1 point on each group’s demand curve: assume a single curve, or estimate each separately.
- National Parks
- method used to estimate value of visiting NPs
Sydney Harbour Travel

Q: “how do you travel?”, “what’s the next best alternative?”

e.g. Manly Jet Cat v. ferry
     $8.00 & 15 min. $2.50 & 35 min.

Then the slope of green line → $?? per minute saved i.e. price, value of time saved.
Assumption: individual rationality.
5.4.1 Why the Environment Will Always Matter

1. technical change, inventions: more Manufactured Goods from the same Environmental Amenity reduction  
   \[ A \rightarrow B \]

2. increasing scarcity $\rightarrow$ greater value of the environment in the future. (with no change in preferences)

   The lower slope at point B (new price ratio)  
   \[ \frac{a}{b} > \frac{b}{a} \]

   $\Rightarrow$ a higher value of environmental amenity in terms of manufactured goods.

Against this: expectations of a higher level per generation.