Environmental Economics

Sol Yates

February 16, 2024

Contents

Lecture 2: Causes of environmental problems

Wed 07 Feb 09:12

1 Market Failure

Environmental economists model market failures using *either* the theory of public goods or the theory of externalities

if the market is defined as 'environmental quality' then the source of the market failure is that environmental quality is a **public good**

if the market is defined as the good whose production or consumption generates environmental damage (benefits) then the market failure is due to negative (positive) externalities

Recall that economists don't simply view any polluting as an environmental problem, environmental problems must reflect an inefficiency whereby the costs of pollution are exceeded by the benefits.

1.1 the theory of public goods

the type of good depends on

1. Excludability : it is possible to prevent people who have not paid for the good from consuming it
2. Rivalness : when the good is consumed by one individual, another perosn is prevented form consuming it at the same time

it is important to note that for a pure public good (non-excludable, non rival) such as clean air or a lighthouse, in practice there is some rivalry or congestion.

why do public goods lead to market failure

- market demand for a private good is found by horizontally summing the demands of individual consumers
- in contrast, once a public good is produced it is available at the same quantity to all consumers (since it is non rival)
  - this implies we have to *vertically sum* each consumer's demand (marginal benefit) to find market demand
  - But how can this be represented graphically?
- however, marginal benefits are not revealed by the private market because public goods are non-excludable (consumers become free riders)
  - this is known as the "non-revelation of preferences" and leads to market failure due to under supply of public goods

How to obtain demand for a public good?

- use valuation methods to calculate willingness to pay (WTP) of consumers:
  1. stated preference methods (eg contingent valuation and choice experiments)
  2. revealed preference methods (eg hedonic pricing methods, travel cost method)
- however, imperfect information can provide an added complication :
  - consumers themselves may not be fully aware of the full benefits of consumptino, and so their WTP may underestimate the true value of the good

1.2 The theory of externalities

- if the production or consumption of a good or service generates environmental damage outside the market transaction, then the market failure is due to a **negative externally**
- the damage that occurs outside the market transaction is not captured by the price of the commodity
- How can we represent a negative (or positive) externally graphically?

what is the relationship between public goods and externalities?

- externalities affect air, water, or land, all of which have public goods characteristics
- if the externality affects a broad segment of society and its effects are non-rival and nonexcludable, the externally is itself a public good
- if external effects are only felt by a narrow range of individuals or firms, then those effects are more appropriately modelled as an externality

how to adress the market failure?

Coase

Starting from the public good idea

Bargaining : the source of the environmental problem in private markets is that property rights are not defined. Ronald Coase (1960) demonstrated that proper assignment of property rights to any good, even in the presence of externalities, will allow *bargaining* between the affected parties that will obtain an efficient solution, no matter which party holds the rights. Thus : Negotiation will overcome market failure! *but how useful is this in practice?*

Pigou

Starting from the control of externalities

Regulation : Taxes, tradable permits, information nudges etc

Coase Theorem

How relevant and useful is the Coase Theorem to pollution problems *in practice*?

- Key assumptions underlying the theorem include
  - No transaction costs
  - Perfect information
- Vittel watter in North-eastern France provides an example of the Coase theorem

> **Example.** In the 80s Vittel initiated a program to reduce agricultural water pollution in locality of the source of its bottled water
>
> Vittel paid 26 local farmers, offered technical assistance and equipment to reduce pollution (ie switch to organic pesticides)
>
> as a result, vittel water benefits from improved water quality

In summ,

- From an economic perspective environmental problems exist because they are market failures
- There are two basic explanations for environmental problems as market failures:
  - environmental quality as a public good
  - environmental externalities from the production or consumption of polluting generating goods
- solution to market failure will typically involve government intervention

2 Government or Regulatory Failure

- government policies can create market inefficiencies
- Further, government policies can lead to unintended environmental consequences
  - Negative externalities are created or intensified
  - common example is a production subsidy to reduce price of market goods with negative environmental effects (fossil fuel)

Example (Case Study : US Ethanol Policy). Ethanol is an oxygenate that is used as an additive to reformulated gasoline

ethanol production has long been supported in the US

- tariffs and subsidies were in place 2004-12
- grants, loan guarantees, cost shares, tax credits, technical fuel standards and ethanol mandates remain in place. Of the petrol sold in the US, 95-95 % is sold within concentrations of E10
- the intended consequences to supporting ethanol production are :
    1. enhance energy security by reducing dependence on imported oil and reduce gasoline prices
    2. reduce net greenhouse emissions
    3. rural development

Griffin (2013) assesses the three intended benefits, finding

1. Benefits to motorists are insignificant
2. benefits to oil security is small and ill-suited to dealing with supply disruptions
3. minimal reduction in $C0_2$ emissions which could in fact increase due to changing land use

Also finding a negative unintended consequence on world food prices

- Corn is diverted from food to ethanol use, and other crop land is diverted to corn production
- although it is difficult to measure precisely, even conservative estimates suggest mandates lead to a substation al increase in world food prices
- world's poor are particularly impacted due to a lack of substituting possibilities
- the unintended consequence far outweighs any intended benefits

Chen, Huang, Khanna, Onal (2014) consider the welfare effect and GHG emissions of two policies to induce biofuel production in the US

- Renewable Fuel standard (RFS) established in 2007, which sets targets for blending of specigic types of biofuels with fossil fuels
- a low carbon fuel standard (LCFS) aims to reduce the GHG intensity of transportation fuel
- in contrast to these polciies, a **carbon price** policy could be used to directly target a reduction in GHG

In sum,

- Government or regulatory failure refers to the situation where market inefficiencies are created by government policies
- governments use policy tool to reduce prices of market goods, these incentives are justified if there are (net) positive externalities. If this is not the case the right hand of government undoes what the left hand has just accomplished

Exercise 1 (Microecinomics and the environment revision exercise)**.** Application

Case Studies of 18 countries in Central and Eastern Europe

- CIS countries (Belarus, Estonia, Lithuania, Latvia, Moldova, Ukraine)
- CE countries (Poland, czech republic, slovakia, hungaria)

Trade off of ecosystem services showing non convexities. Non convexity in practice does hold up

Z axis agricultural output. So would expect this shape, but we don't see it here at all, we see that if you have.

If want to do research in ecosystem servcies, have to look at shape of PPF. In order to base regulation off of this.

Lecture 3: Designing Environmental Policy

Fri 16 Feb 11:30

2.1 How to set a pollution abatement target

Tradeoff - Stricter abatement targets generates a benefit in the sense of to the environment and human health, but this is at a larger cost. The Tradeoff is optimal at the abatement level where the marginal benefits from further abatement fall to the level equal to the marginal costs of abatement.

Flow Pollutant such as water or air pollution

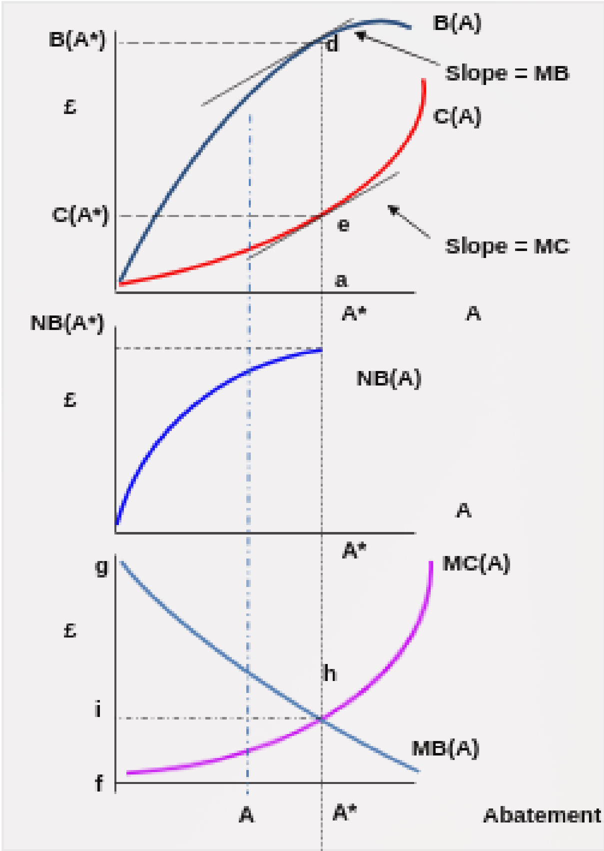

Figure 1: Optimal Level of Pollution Abatement

In the top panel the x axis is level of abatement, y is total benefits and total costs (red). We aim to maximise net benefit from abatement, this is second panel at a star where net benefits are maximised, where total distance from total abatement and total benefits curves are maximised. Similarly marginal benefits and marginal costs are equalised, in top tangent lines indicate marginal benefit and marginal cost equal.

The distance *de* is the cost measure of the optimal level of pollution abatement A* compared to the situation where none is generated.

Second panel, beyond a star is not efficient. In top panel distance de is identical to gfh which indicates the total net benefits from abatement activities. From net benefit perspective (alternatively costs).

Area under marginal abatement costs and marginal benefit abatement minimised in bottom panel.

de is equal to *gfh* since the area under a marginal function over some range gives the value of the change in the total function for a move over that range

An efficient allocation maximises total net benefit from generating A*, that is *gfh*

- CS : ghi
- PS : ihf

First Best Solution

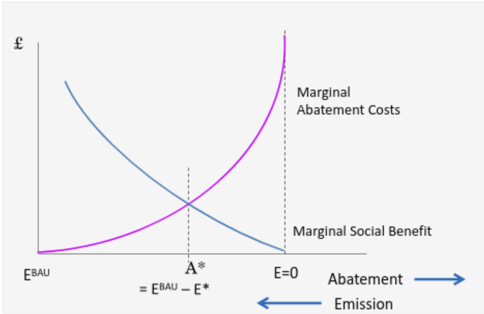

Figure 2: Abatement and Emissions

Abatement from left to right and optimal abatement at A*. Without any abatement there is no regulation at all and marginal abatement costs is 0 but this is business as usual. Moving to the right this is the optimal level of remaining emissions too, abatement goes from left to right and emissions go from right to left. Marginal social benefit 0 where no further abatement where emissions are 0.

The benefit from abatement activities is area between marginal social benefit and marginal abatement costs at A*. Area under marginal social benefit beyond A* is remaining costs from emissions

How clean should the environment be?

First Best solution

- The economically efficient level of pollution is where *marginal social abatement costs* and *marginal social benefits* of abatement are equalised. Thus indicating where the greatest possible net benefits to abatement are achieved
- this gives the first best solution (textbook case) and implies that *each* producer's abatement level consider the benefit to society of the associated abatement

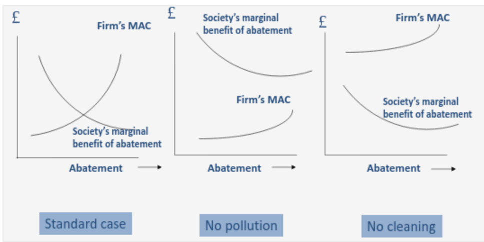

Figure 3

Efficient level may mean no abatement or no pollution LHS - standard case, where pollution refers to harmful residuals, less is prefers to more, it may not be possible to reduce pollution at cost of growth so in practice there is some pollution left in economically efficient situation.

It may also be economically efficient to have no pollution at all, the marginal benefit from abatement is above marginal cost of cleaning up the firm, so here we would suggest no pollution is optimal economic outcome.

Or, if the marginal cost is higher than marginal benefit, then from an economic perspective the suggestion would be no cleaning as the solution.

Summary In the textbook situation we aim for the

1. economically efficient level of abatement and
2. we have full information

This results in the *first best solution* : that each producer must bear the marginal external cost of their emission and should abate upto where marginal benefits and marginal costs from abatement are equalised

In Practice

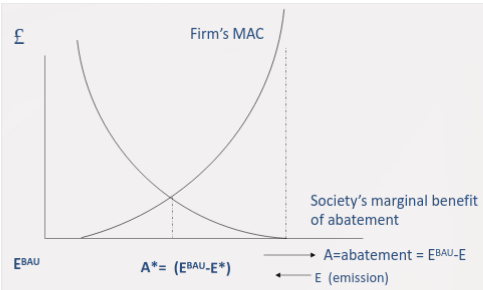

Figure 4

efficient level abatement Where A is the level of abatement and A* is society's optimal level of abatement. For the efficient (first best) it is assumed we have perfect information, so the first best solution assumes the MSB and MSC can be identified, that the government has the marginal abatement cost for each firms to estimate the marginal social costs for each firm. In practice, this is not regelated by the markets due to the non-revelation of preferences.

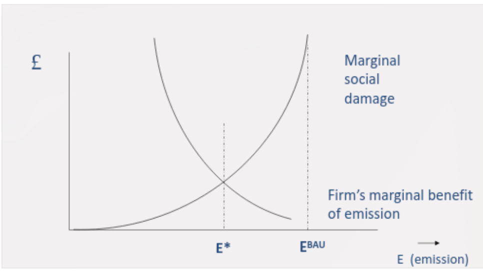

Figure 5

Efficient level of pollution

Environmental Policy in Practice In theory, first best level of pollution abatement A* can be achieved by setting appropriate abatement requirements for each firm

However in practice, this can be very difficult for the government to achieve because of

1. Legislative constraints
2. AND, imperfect information - we do not have this in practice since we do not have full information (about the marginal social benefits of abatement or the marginal abatement costs of each firm)

Thus, the *second best criterion* is to achieve a (likely suboptimal) abatement target using the least amount of resources since this involves setting a minimum level of abatement that is needed and then evaluating the cost of implementing this.

The **Second best criterion** can be achieved by an environmental policy instrument that leads to **cost effective abatement**. That is, allocation of abatement across pollution sources such that MACS are equalised across firms, and as such environmental objectives are met at minimum costs.

Essentially, we drop the idea of efficient level of pollution and turn to minimum cost abatement.

Cost of pollution abatement

- polluting firms will select the least cost method of polluting abatement
- This is reflected by the firm level marginal abatement cost function
- Each polluter may face a unique MAC curve
- Each firm's total abatement costs will typically increase at an increasing rate with abatement, e, marginal abatement costs rise
- This general pattern is ubiquitous for emission control

As abatement continues and environment becomes cleaner, the costs to added abatement rise at an increasing rate

Deriving market level marginal abatement cost

- MAC_{mrkt} represent the least cost methods of pollution abatement and so at each point on the aggregate MAC_{mrkt}, the MAC of individual firms are equalised
- Aggregation of all individual firms' MACs represents the market-level marginal abatement cost (e, $MAC_{MRKT} = \sum MAC_i$ for all I firms)
- MAC_{mrkt} is defined by horizontal summation
- if there are no costs to monitoring and enforcing pollution regulation, then MAC_{mrkt} = marginal social cost of pollution abatement (MSC)

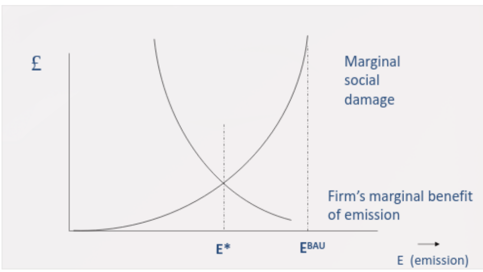

Figure 6

Policy instrument to minimise total abatement costs, here 2 firms with information on market level MAC and target of abatement at 150 Tans of this specific pollutant. Natural approach would be to split abatement equally, reduce by 75 with total abatement costs would be area under marginal abatement cost of respective firm upto 75.

Starting from uniform allocation, we can shrink total abatement by assigning more abatement to firm with lower marginal cost. That is marginal abatement costs equalised, abate upto here, the intersection with horizontal brown line

Thus the cost effective allocation is achieved when the asst unit of pollution control is the same, other wise there is a way to reallocate and reduce total abatement costs. Now we need to find policy instrument to enforce this, but without knowing each individuals firms marginal abatement cost.

What environmental policy instruments should be used most environmental policies fall into two broad categories

- Direct regulation - 'command and control' : use technology or performance standard to prescribe how emission reduction take places
- Market based (Economic) instruments : use incentives to motivate abatement through market forces

Other approaches include voluntary agreements and the dissemination of information

Direct Regulation Technology Standards

- Designate the equipment or method used to achieve some abatement level - preventing from being least cost method (some operate above marginal abatement cost curves, thus not very suitable from economic perspective)
- **Advantage** being that it has low monitoring costs
- **Disadvantage** being that it is no cost-effective, there is no incentive to develop new technologies

Performance Standards

But does not say how to achieve, each polluter would follow its self interest and choose the least cost abatement method. But still isn't cost effective since abatement costs differ among polluters

- Uniform (emission or ambient standard) is not cost effective
- Non-uniform standard can be CE (cost effective) in theory but in practice, imperfect information and legislative constraints make this difficult to achieve

In second case regulator would need to know firm's MAC, but this again runs into the problem of imperfect information, there is no incentive to provide this

Market Based Instruments Pigouvian Tax

- A unit charge on a market good whose production generates a negative externality. The tax should equal the marginal external cost at efficient output level
- This can be an attractive option when it is difficult to monitor emissions directly
- Internalises negative externalities, which can be difficult to measure in the real world, it differs on the suitability however, say whole range of consumer goods
- regressive tax - burdens lower income population disproportionately more

Emission Tax

- A fee placed directly on every unit of pollution emitted (removed below baseline)
- A **Price Instrument** establishing the price of emissions
- *Firms need to decide how much emission to abate and then pay the tax on their remaining emission*
- Firm chooses cost minimising response - firm has incentive to reduce all or part of emissions

Emission trading scheme (permit / cap and trade)

- Establishes a market for rights to pollute by issuing traceable permits to polluters
- *Quantity instrument* : placing a limit on total quantity of emissions (determined by number of permits issued)
- Within this overall limit, companies can boy and sell emission allowances as needed
- The regulator either grandfathers the permits (distributes for free) or sells them at auction, with a combination also possible

Direct Controls vs Market Based Instruments

- Economic theory suggests that market instruments are the least costly way of achieving a given environmental objective
  1. firms can decide whether they would prefer to control their output of emissions or change their inputs or change production techniques
  2. Firms with the lowest abatement costs will be the ones to abate more
- In contrast, direct controls force all polluters to meet the standards regardless of their opportunity costs
- Other Advantages
  1. Economic instruments provide dynamic incentives to develop new and cleaner technologies
  2. Economic instruments can generate revenue, which can be used for environmental or other purposes
- However, the cost advantage of market based instruments decreases if marginal abatement costs are similar across firms
- if there is a narrow range of technology options available to achieve the environmental target (for ie)

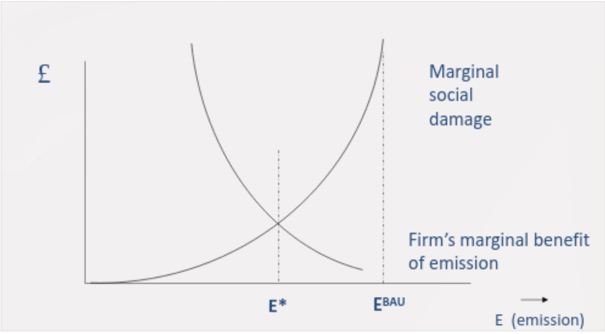

Figure 7

Price vs Quantity Instrument 1 : emission tax (price insturment) set tax at P*, resulting in abatement A* 2 : Emission trading scheme (quality) set abatement at A*, resulting in price P*

Shows why price instrument gives same result as quantity instrument Fi there is no uncertainty, marginal social cost and marginal abatement costs across all firm s are important. P* $\rightarrow$ A* abatement (price) and vice versa with quantity, allow E* emissions

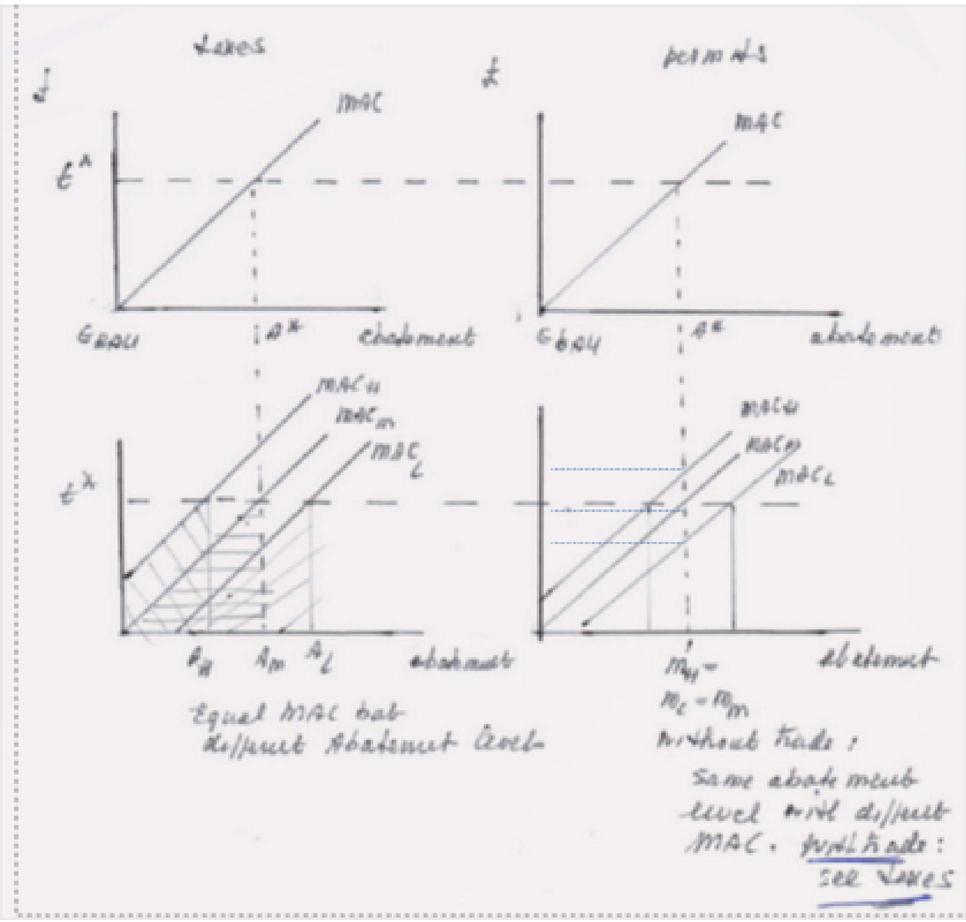

Figure 8

Cap and trade and carbon tax are both CE Four panels, if we are interested in certain level of abatement we could use either instrument to shift and get at same cost. To achieve A* set tax at t* or introduce permit to allocate firms allowances and to abate upto A*. In bottom panel 3 firms, different abatement costs, each 3 firms abate upto level where abatement costs meets tax, shaded area indicates total abatement costs for each of 3 firms, techy have equal marginal abatement costs but different levels of abatement. For remaining emissions, the firms pay the tax.

Initially M allowances, they have same abatement level but with different marginal abatement costs, if allow trade, the high cost producer buts more permits to avoid marginal abatement costs.

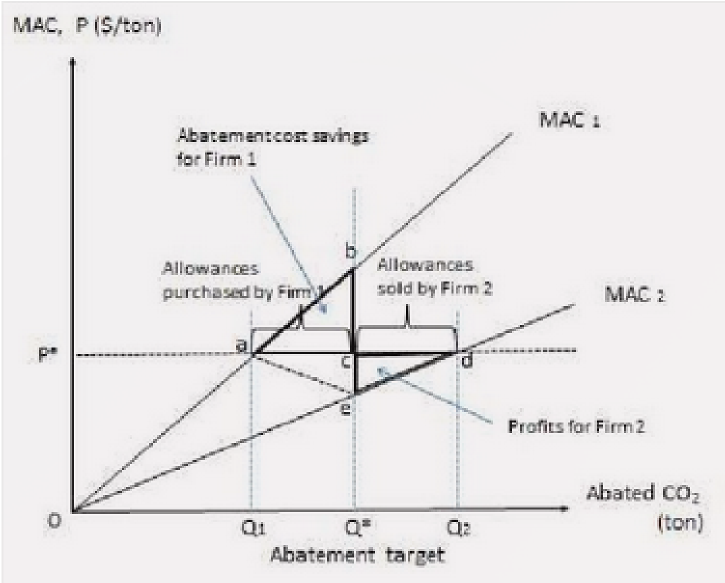

Figure 9

Why price and quantity are both CE and give same result. For Co2 abatement, 2 polluters,

1 high cost, introduce tax, firms abate upto marginal abatement cost s meet tax, q1, q2. Total abatement is sum of these, marginal cost per last unit of abatement is equalised for 2 firms, without needing to know marginal abatement costs (market instrument system - market takes care of that)

cap and trade - set an abatement target, q*. tell each firms to abate upto q* and we see high cost polluter has significant abatement costs to get to same level of abatement, if tradeable then firm 1 will buy permits from firm 2so that it would not need to abate q1 - q* and thus cost saving for firm 1 of ABC. Firm 2 interested in selling permits, marginal abatement cost are below price of permits,

In equilibrium, firm 1 abate upto q1 and firm 2 to q2 - the same as the tax

Emissions taxes and trading schemes are both cost-effective

- both equalise MACs across firms
- which holds regardless of whether permits are distributed through auction or by free allocation
- If we know where the aggregate MSC and aggregate MSB are with **certainty**, then two policies will lead to the same (optimal) outcome

However, there are differences between these instruments in practice

- in practice, we are usually uncertain about the MSC of abatement ($\sum MAC$) and about the MSB of abatement
- Trade in permits is needed for the tradeable permit system to be cost effective but there might be transaction costs that prevent this
- tradeable permits don't have to be adjusted for inflation or economic growth

summary Economic theory suggests that market instruments (carbon tax and cap and trade) are the least costly way of achieving a given environmental objective :

- firms can decide whether they would prefer to control their output of emissions, change their inputs, or change production techniques
- Firms with the lowest abatement costs will be the ones to abate more

In contrast, direct controls force all polluters to meet the standards regardless of their opportunity costs