Lecture 4b
Environmental regulation

Environmental Economics, Politecnico di Milano, Academic Year 2015-2016

Giovanni Marin

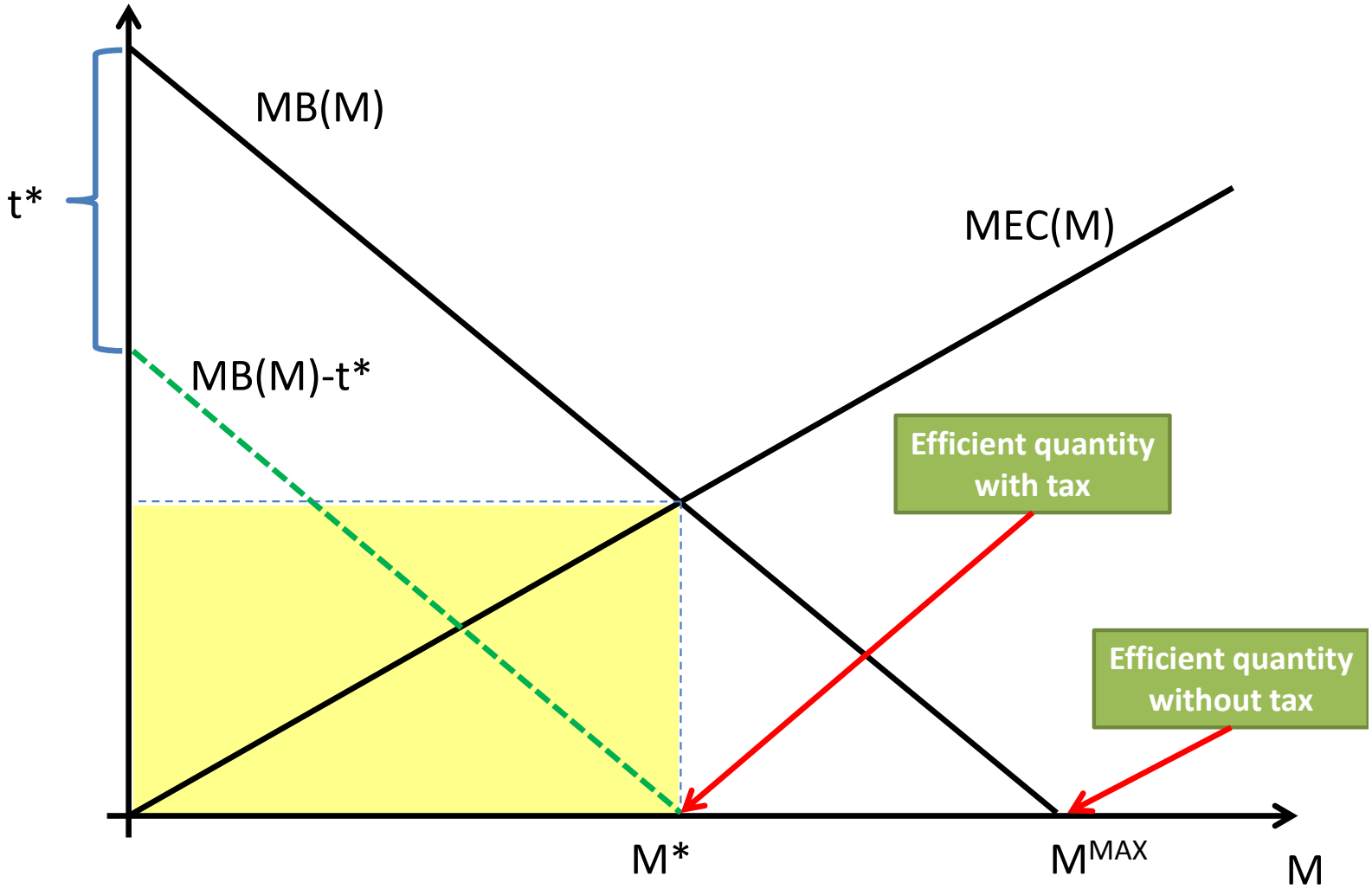
IRCrES-CNR, Milano
e-mail: giovanni.marin@ircres.cnr.it

Book paragraphs for this lecture: 6.4, 6.6

Incentive-based instruments: basic principle

- Incentive-based instruments work by altering the structure of pay-offs that agents face, thereby creating incentives for individuals and firms to voluntarily change their behaviour
- The pay-off structures are altered by changing relative prices
- This can be done in various ways:
  - By the imposition of taxes on polluting emissions or on output of activities deemed to be environmentally harmful
  - By the payment of subsidies for emissions abatement or reductions in activities deemed to be environmentally harmful
  - By the use of tradable emission permit (or allowance) systems in which permits are exchanged on the market and give rise to a market price for pollution. This price is the cost of emitting pollutants
- More generally, any instrument which manipulates relative prices could also be regarded as an incentive-based instrument

Pigouvian tax



Pigouvian tax

- The tax instrument brings about a socially efficient aggregate level of pollution
- It will also achieve the target in an efficient way
  - Cost-efficiency requires that the marginal abatement cost should be equal over all abaters
  - Under the tax regime all firms adjust their firm-specific abatement levels up to the point in which their marginal abatement cost equals the tax rate $\Rightarrow$ when abatement costs are below the tax, it would be profitable to abate rather than to pay the tax, when abatement costs are above the tax, it would be profitable to pay the tax and emit rather than abate
  - As the tax rate is identical for all firms, marginal costs in equilibrium will be identical (to the tax rate) for all firms $\Rightarrow$ efficient outcome

Pigouvian tax: profit maximizing firm

$$Max_{\{X,M\}}\ \pi = P^X X - C(X) - AC(M^{MAX} - M) - tM$$

- AC is the abatement cost function
- t is the pigouvian tax on emissions M
- First order conditions imply that

$$\frac{dAC(M^{MAX} - M^*)}{dM} = t$$

- As t is the same for all firms, marginal costs of abatement will be equalized across all firms

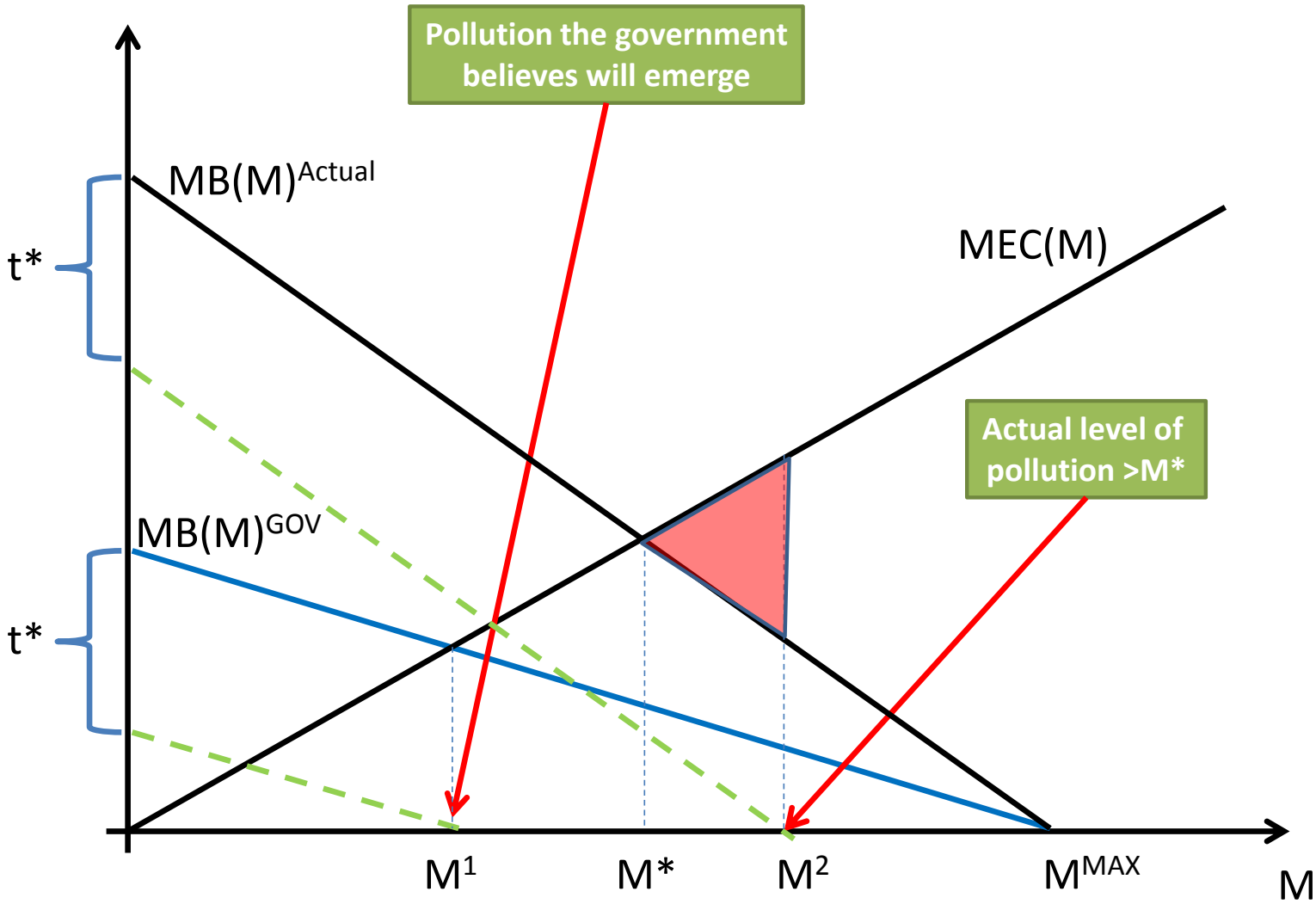
Pigouvian tax

- To set the tax at the socially optimal level the government has to know
  - Aggregate marginal pollution damage function (if the target is based on the criterion of economic efficiency)
  - Aggregate marginal pollution benefit (i.e. abatement) function
- Information on firm-specific abatement functions is not needed as all firms will abate up to the point in which abatement costs equal the tax rate
- With command and control instruments the government had to know the abatement function of all firms to attain the target with the lowest cost for society

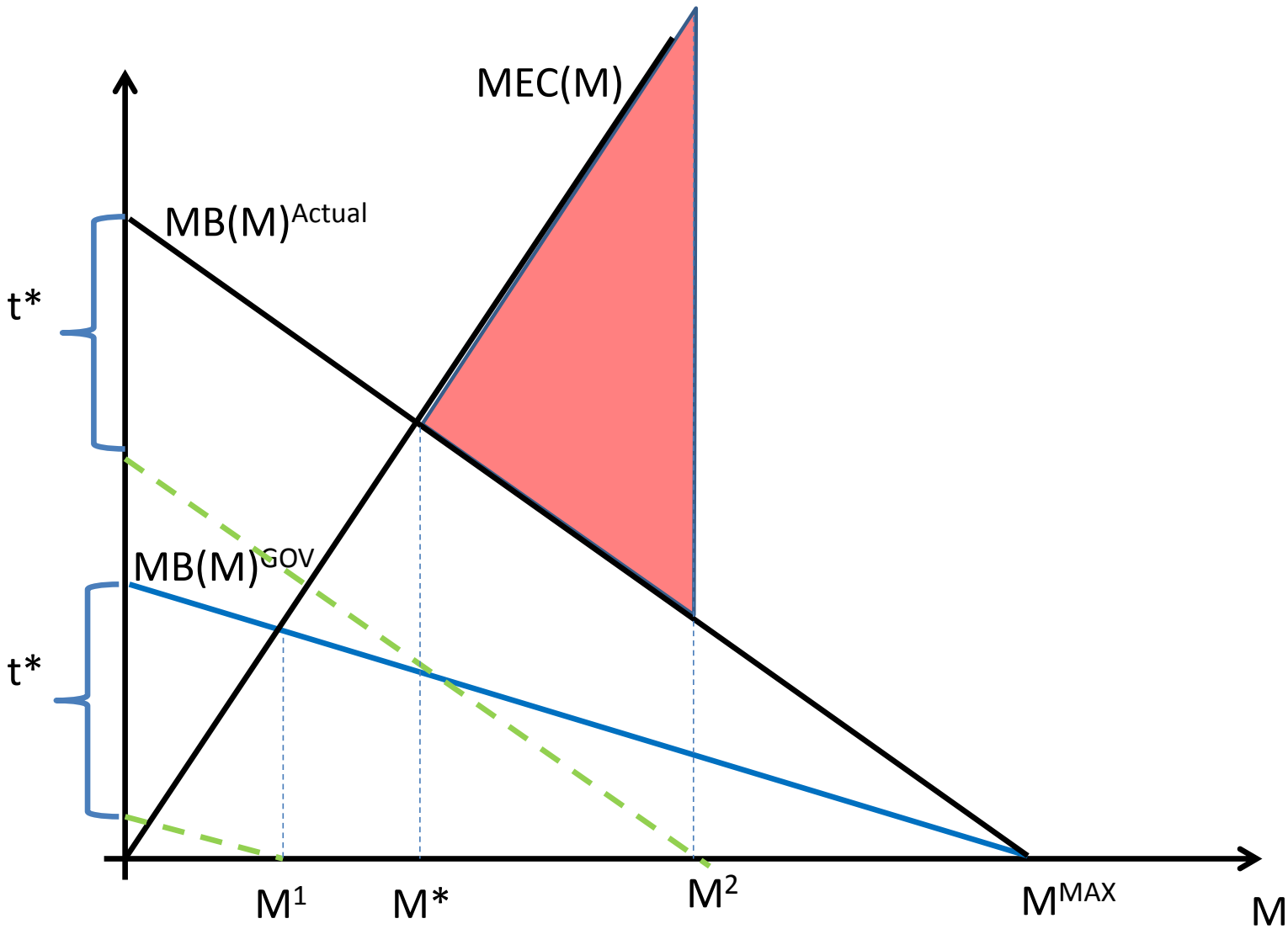
Pigouvian tax and uncertainty

- Suppose the government has only imperfect knowledge of the aggregate abatement cost function
- The equilibrium level of marginal abatement cost is still certain (i.e. equal to the tax rate)
- The amount of emissions in equilibrium is uncertain
- If the marginal pollution damage function is particularly steep, that uncertainty may entail very large social losses

Pigouvian tax and uncertainty



Pigouvian tax and uncertainty



Marketable emissions permits

- Marketable permit systems are based on the principle that any increase in emissions by one firm must be offset by an equivalent decrease elsewhere
- A limit is set on the total quantity of emissions allowed (cap) but the regulator does not attempt to determine how that total allowed quantity is allocated among individual sources

Marketable emissions permits

- The externality (e.g. emissions) can be generated only upon owning a permit (or allowance or licence)
- Permits are distributed ex ante up to a certain quantity (cap)
- These systems are also defined as "cap-and-trade"

Phases of a cap-and-trade system

1. The regulator sets the overall emissions target (cap) $\Rightarrow$ ideally the cap should be set such that total marginal abatement costs equal marginal benefits from abatement
2. The total amount of emissions is partitioned in units (e.g. tons)
3. For each unit, a permit is created
4. A market for permits is created
5. Permits are allocated to polluting units (either trough auctions or for free - grandfathering)
6. Trading of permits begins
7. Firms have to return an amount of permits that is sufficient to cover the amount of verified emissions

Allocation of permits

- Free allocation to the participants (grandfathering)
  - Based on historical emissions
  - Uniform allocation to all participants
  - Sometimes some permits are reserved to new participants to the scheme
- Auctioning of permits

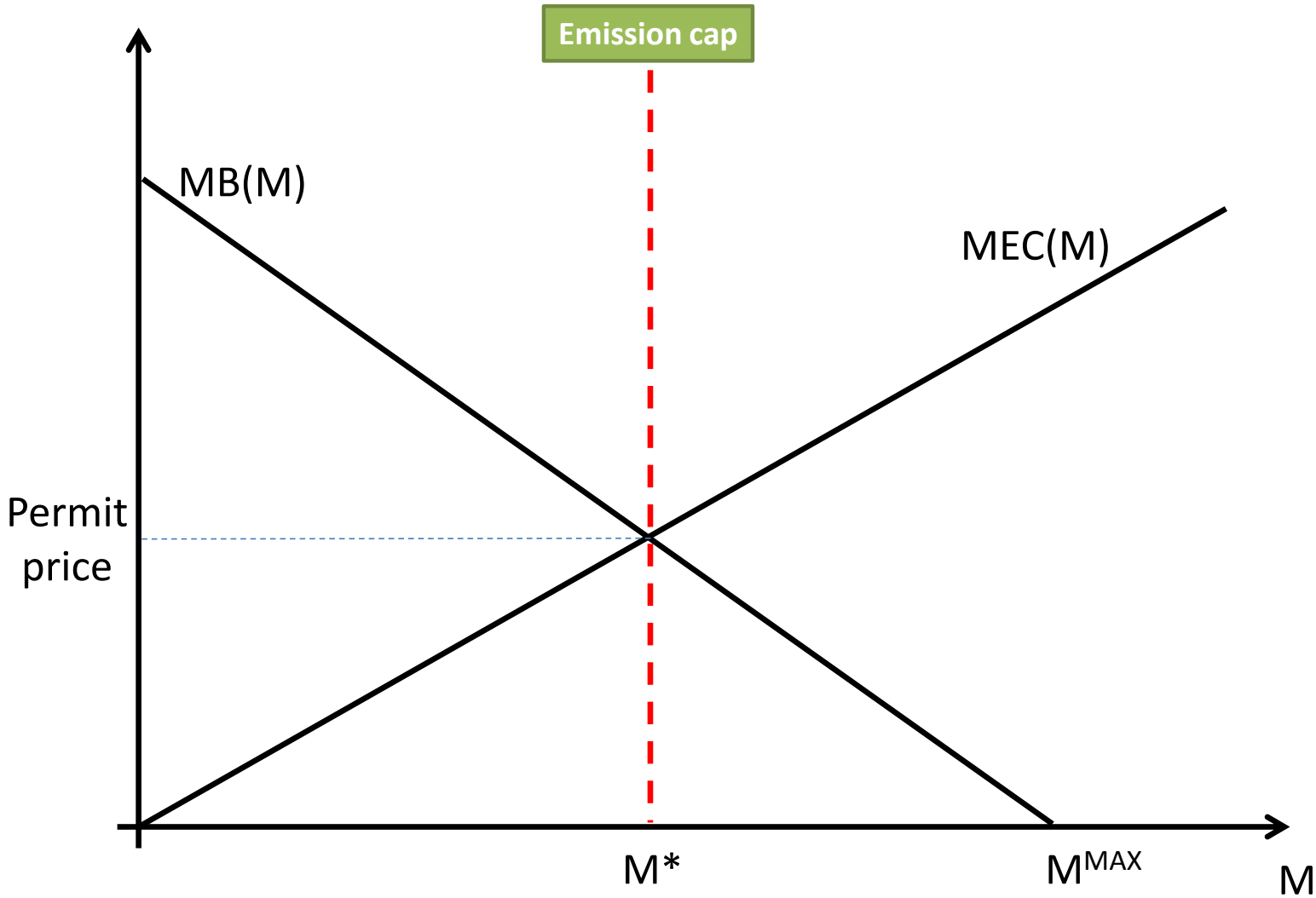
Grandfathering

- The regulator distributes permits at no charge, and allows them to be subsequently traded in the free market for permits
- The initial allocation is unlikely to correspond to the desired, welfare-maximizing (i.e. uniform marginal abatement costs), distribution of permits
- Once the initial allocation has taken place, firms will evaluate the marginal worth of permits to themselves $\Rightarrow$ that will depend on the abatement cost functions
- If these marginal private valuations differ across firms there will be room for mutually beneficial trade of permits

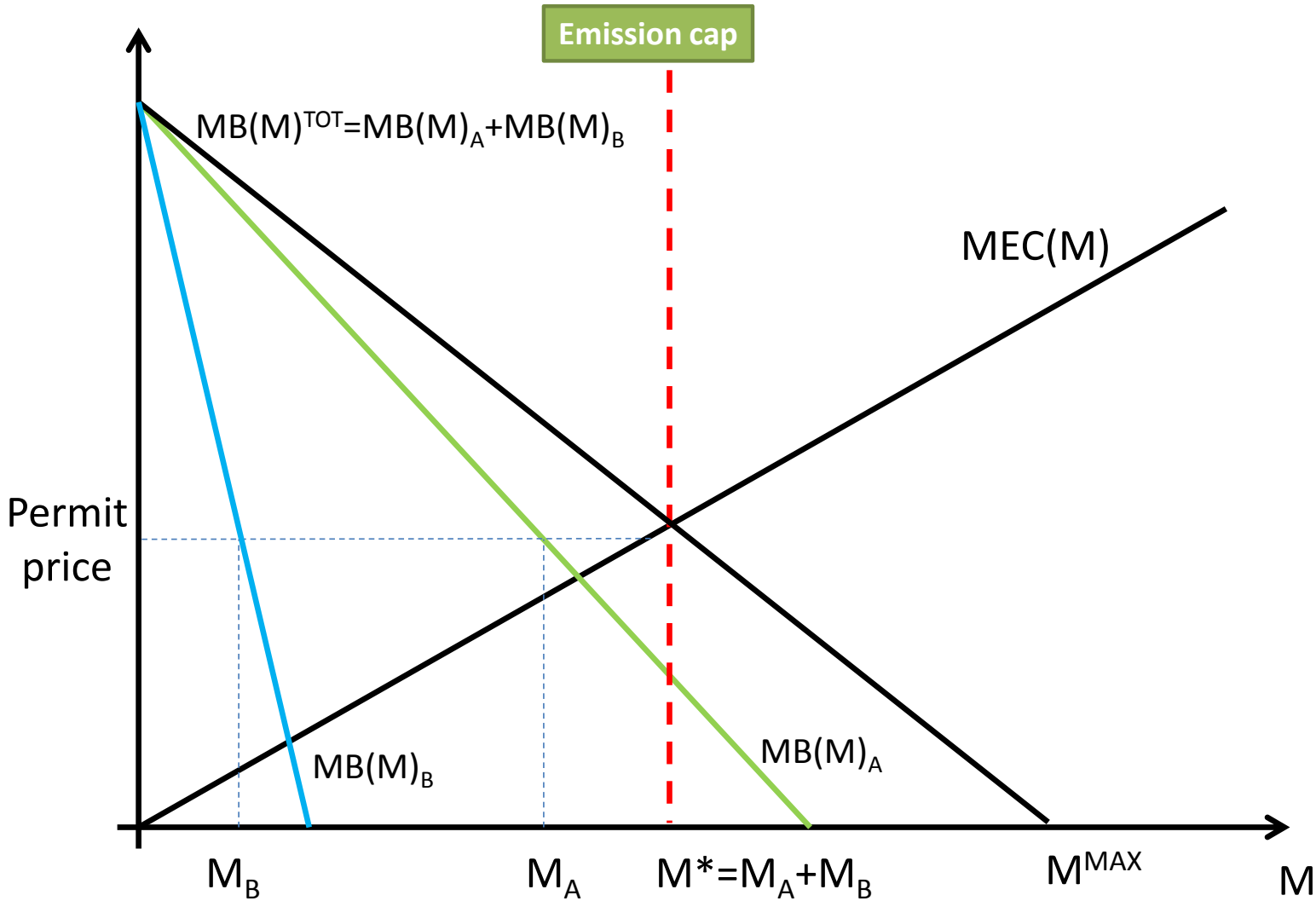
Marginal evaluation

- Some firms will have high marginal abatement costs and are willing to buy permits as long as the price is below their marginal abatement costs
- Other firms may abate emissions at lower costs and are willing to sell permits as long as the price is above their marginal abatement costs

Equilibrium in cap-and-trade



Equilibrium in cap-and-trade



Allocation through auctions

- Each firm submits a bid for buying permits
- Bids are ranked in descending order with respect to their price
- The resulting schedule can be interpreted as a market demand curve for permits
- Assuming no strategic behaviours, this demand curve will be the sum of the marginal benefits coming from emissions or, symmetrically, the sum of marginal costs of abatement
- The market demand for permits describes the aggregate marginal cost of abatement

Allocation through auctions

- A firm will bid to purchase an additional emissions permit whenever the marginal cost of abating emissions exceeds the permit price
- The market equilibrium permit price is determined by the value of the aggregate marginal abatement cost at the level of abatement implied by the total number of issued permits (cap)

Marketable permit systems and the distribution of income and wealth

- In a perfectly functioning marketable permit system the method of initial allocation of permits has no effect on the short run distribution of emissions between firms
- The choice of the allocation mechanism has significant effects on the distribution of income/wealth across firms
- If the permits are sold by competitive auction, each permit that is purchased involves a payment by the acquiring firm to the government that is equal to the equilibrium permit price
- If permits are distributed at no charge (grandfathering), there is no transfer of income from business to government $\Rightarrow$ there will be transfers between firms
- Grandfathering may give rise to windfall profits $\Rightarrow$ with non-competitive markets for the final output and inelastic demand (e.g. electricity), firms may pass-through the price for CO2 permits on final consumers almost entirely

Comments on marketable permit systems

- Under marketable permit schemes, in equilibrium marginal abatement costs will be equal over all firms
- Marketable permits, like taxes, achieve the environmental target at the lowest cost for society
- If the total quantity of permit issued is the same that would emerge from a pigouvian tax on emissions (or pigouvian subsidy on abatement), then the marketable permit scheme will generate an equilibrium price that is equal to the pigouvian tax and to the shadow price of pollution