



Using welfare economics to analyse food waste as a negative externality in a food value chain

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Outline

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- Food waste as a negative externality
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- Defining food waste costs
- Analysing food waste externalities
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- Actions to reduce food waste
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Defining food waste

- FAO (2015) defined food waste as ‘the discarding or alternative (non-food) use of food that was fit for human consumption – by choice or after the food has been left to spoil or expire as a result of negligence’
- Terms such as ‘negligence’ and ‘avoidable’ in definitions of food waste are imprecise
- We prefer to define food waste in terms of creating a negative externality that can be measured in appropriate value terms
- FAO frequently uses the concept of externality related to food waste
- Whether this externality demands action is another matter, which we address below

Food waste as a negative global (national) externality

- A global (national) negative externality is a cost that affects somebody in society throughout the world (in a nation) who is not directly engaged in producing or consuming a good or service
- The person causing the cost does not have to pay for the damage it causes to third parties
- Examples of negative global/national externalities associated with food waste are the various forms of environmental degradation associated with the production of food raw materials that are wasted

Food waste as a negative chain externality

- A chain external cost (chain negative externality) is a cost that adversely affects somebody or some firm in a food value chain not directly engaged in producing, trading in or consuming a good or service
- The party causing the external cost does not have to pay for the damage it causes to third parties in the chain
- A chain externality differs from a global/national externality in that the consequences of the action in creating the externality do not extend beyond the boundary of the value chain
- That is, there are no spillovers

Food waste as a negative chain externality

- Examples of a negative chain externality associated with food waste within a food value chain are demand and supply uncertainty and risk transference
- With demand and supply certainty, chain participants would have perfect knowledge of how much of each type, grade and within-grade quality of food product will be required and available to service the needs of those in the next stage of the chain
- But demand for and supply of each food type, grade and quality are never known with certainty
- This results in food waste when too much product of a particular grade or quality is supplied in the market, given its demand, and prices are ‘stale’

Food waste cost estimates

- FAO (2011, 2014) calculated three annual costs of food waste:
 1. Economic costs - USD 1 trillion
 2. Social costs - USD 700 billion
 3. Environmental costs - USD 900 billion
- Environmental costs of food waste cause negative externalities such as ‘impacts on climate, water, land and biodiversity’ (FAO 2015)
- Global food waste proportions are approximated at 30 per cent according to FAO
- The food sector has been estimated to account for more than 20 per cent of GHG emissions

Defining social cost

- FAO (2014) defined social costs as loss to human welfare or quality of life, which presumably covers all negative externalities caused by food waste other than environmental externalities
- Economists define social costs differently, as private costs plus externalities (public goods could be added to this definition)
- We follow this approach by regarding environmental costs as externalities, which are therefore a form of social cost
- Hence, we think the second category on the previous slide should be ‘Other social costs’

Defining economic cost

- Economic cost from food waste is measured by FAO presumably as the loss of economic surplus it causes
- FAO refers to economic costs as the ‘loss of economic value from wasted food’ in ‘producer prices for production-level wastage [and] gross trade prices for post-production, plus subsidies’

Analysing food waste externalities

- To analyse food waste externalities, we make two strong assumptions to keep diagrams simple
 1. Only two stages exist in the food value chain: food production and retail
 2. Food is treated as a single aggregate product
- More stages in the chain could be easily added and a specific food product or a group of food products could be analysed
- We also introduce the concept of a derived negative externality, which is of particular relevance to an analysis of food waste

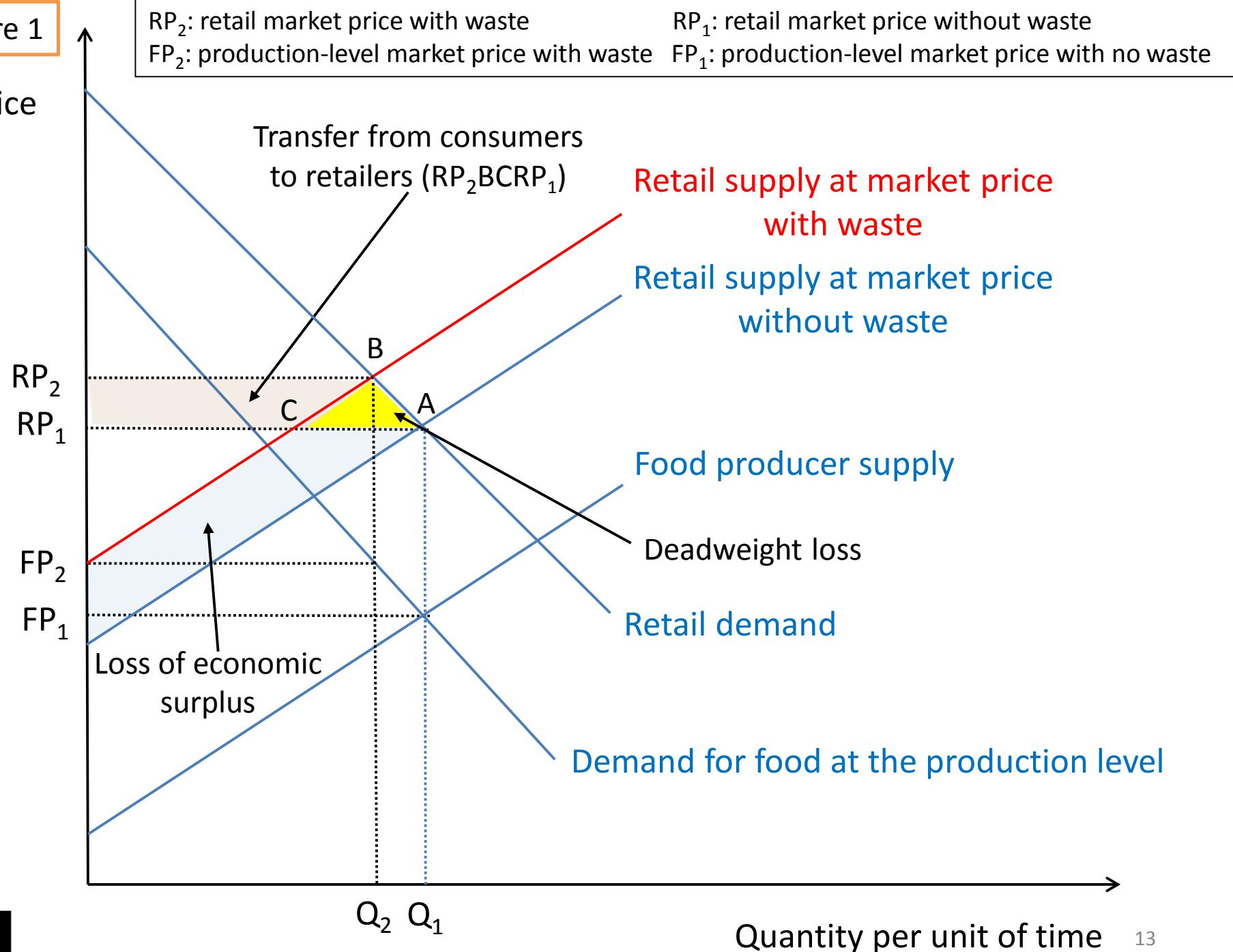
Analysing food waste externalities

- A derived negative externality is generated by the action of a party in the food value chain but is caused by a party further down the value chain towards the final consumer
- In our case it is when food waste occurs at retail, resulting in the production of food raw materials by producers in excess of that required in the absence of food waste
- This ‘excess production’ causes negative externalities through its adverse effects on the environment

Analysing food waste externalities

- Assume for now that there is food waste at retail but no waste in food production
- In Figure 1 on the next slide, market equilibrium is reached at the intersection of the derived supply function with the primary demand function with food waste
- At the production level, market equilibrium is reached at the point of intersection between the derived demand function and the primary supply function
- The economic costs of waste can be measured in the normal way by the change in economic surplus using market prices

Figure 1



Analysing food waste externalities

- The key difference between the waste and no-waste scenarios is a shift to the left of the retail supply function
- Q_1 is the amount of food that must be produced as a result of food waste at retail
- Q_2 is the amount of food that food producers would have produced to meet market demand had there not been waste at retail
- Together with the price elasticities of primary demand and derived supply, the quantity $Q_1 - Q_2$ determines the size of the deadweight loss from food waste (the yellow triangle) and the amount of economic surplus transferred from consumers to retailers ($RP_2 - BC_RP_1$)

Analysing food waste externalities

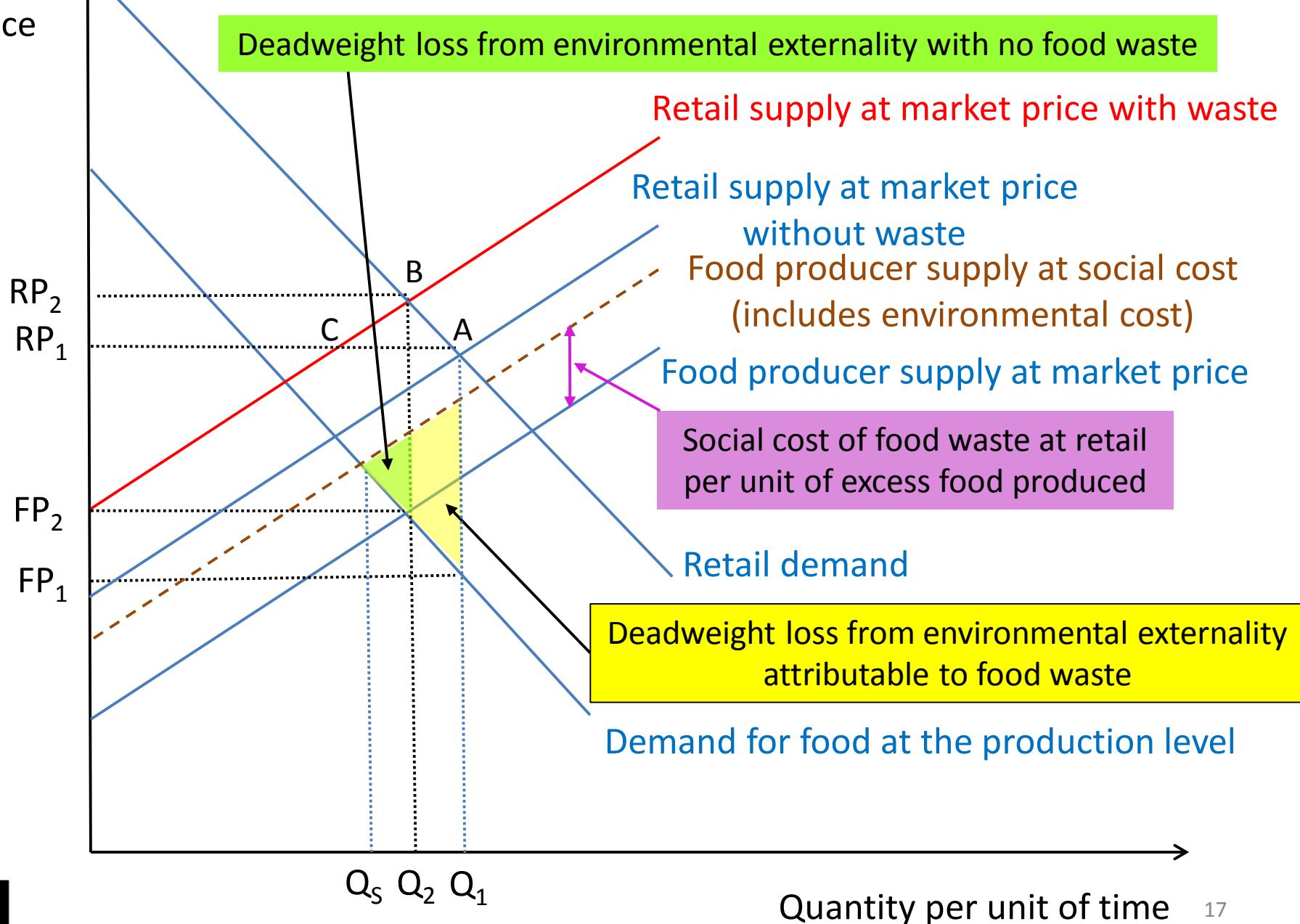
- Proposition 1: Negative externalities are caused by food waste because the loss of consumer surplus it causes disproportionately affects poorer consumers for whom money spent on food purchases is a higher percentage of their disposable income than it is for richer people
- This is consistent with the approach by FAO (2014) identifying food insecurity and nutritional loss as a major form of social cost
- Responsibility for internalising this externality falls to governments and non-government agencies with a welfare goal (e.g. food banks) because of the large spillover effects to society as a whole
- Measuring these externalities is particularly difficult

Analysing food waste externalities

- As noted, additional food production generated at the farm level to compensate for retail waste will incur environmental (and perhaps other) negative externalities
- These externalities are represented in the normal way by the primary supply function at social cost in Figure 2 on the next slide
- This function (the dashed brown line) includes the environmental cost of ‘excess’ food output
- Q_S is the amount of food that would be produced at the socially optimal price after accounting for the environmental cost of producing food to replace retail losses

Figure 2

RP₂: retail market price with waste RP₁: retail market price without waste
 FP₂: production-level market price with waste FP₁: production-level market price with no waste



Analysing food waste externalities

- Proposition 2: A social cost of food waste is incurred by the interaction of food waste at retail with the environmental damage caused by additional food production
- The vertical distance between the primary supply functions at social cost and market price measures this social cost per unit of food produced
- The green triangle represents the deadweight loss generated by producing food in a way that causes environmental damage without food waste
- The yellow trapezoid represents the additional deadweight loss generated by producing food in a way that causes environmental damage with food waste

Analysing food waste externalities

- As noted above, the additional social cost generated by food producers is not caused by their production process
- Nevertheless, improved environmental performance by food producers could indirectly reduce the social cost of food waste
- This improvement would be reflected in a shift downwards of the food producer supply function at social cost in Figure 2

Analysing food waste externalities

- The food producer supply function at social cost in Figure 2 is presented as being parallel to the food producer supply function at market price
- It might be increasing exponentially as more environmental damage is incurred with the intensification of food production
- If so, this would increase the amount of deadweight loss associated with food waste

Analysing food waste externalities

- Retailers typically have a strategy to maximise their market share and avoiding stock-outs is a key element of this strategy
- Figure 2 could be developed further by decomposing food demand by retailers into two components:
 - 1) Food purchased that is estimated to be fully sold at retail
 - 2) Food purchased as ‘inventory insurance’ to avoid stock-outs as part of a market-share maximisation strategy
- In the latter case, it is expected that some food would be wasted due to demand uncertainty
- The expected retail supply function for ‘inventory insurance’ will be a stochastic function of the demand function for inventory insurance at the food production level

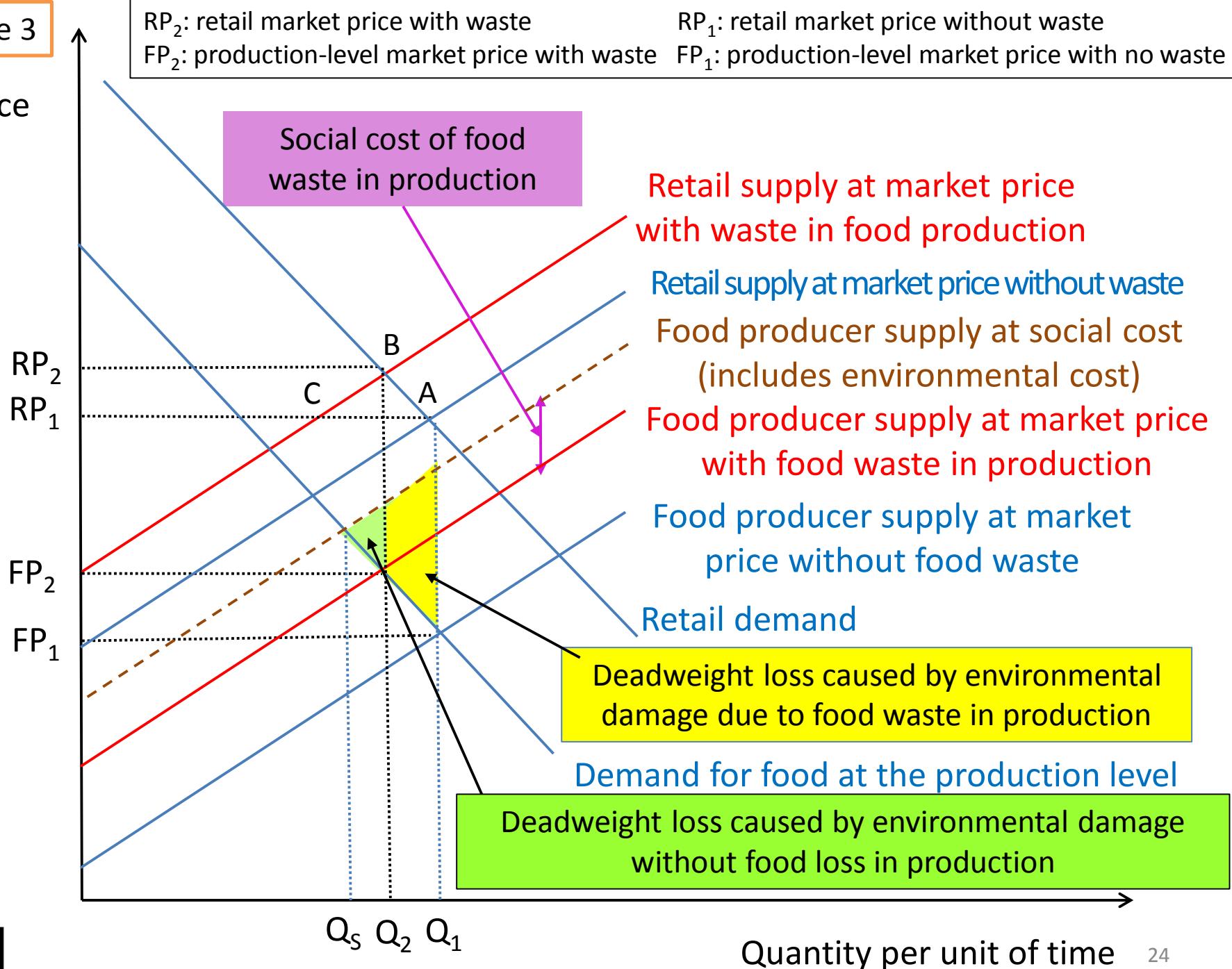
Analysing food waste externalities

- Proposition 3: Retailers with a strategy to avoid stock-outs increase food waste externalities by keeping a stock of food products in reserve to ‘insure’ against running out of stock and losing market share
- This strategy results in a shift outwards of the retailers’ derived demand function (with no change in other functions assuming all such stocks kept in reserve are destroyed)
- Part of the deadweight loss (yellow trapezoid) in Figure 2 will reflect this effect

Analysing food waste externalities

- Now assume that food waste occurs in the production stage, where there is also environmental damage caused in the process of producing food
- Assume no waste now occurs at the retail level
- This is a standard negative externality where the party generating the externality also causes it
- In Figure 3 on the next slide, food producers have a target quantity to supply of Q_2 in the absence of food waste
- Because of food waste in the production process, an additional amount of $Q_1 - Q_2$ needs to be produced

Figure 3



Analysing food waste externalities

- Proposition 4: A social cost of food waste is incurred by the interaction of food waste in production with the environmental damage caused by additional food production
- As before, the vertical distance between the primary supply functions at social cost and market price measures this social cost per unit of food produced
- The green triangle again represents the deadweight loss generated by producing food without food waste in a way that causes environmental damage
- The yellow trapezoid represents the deadweight loss generated by producing food with food waste in production in a way that causes further environmental damage

Analysing food waste externalities

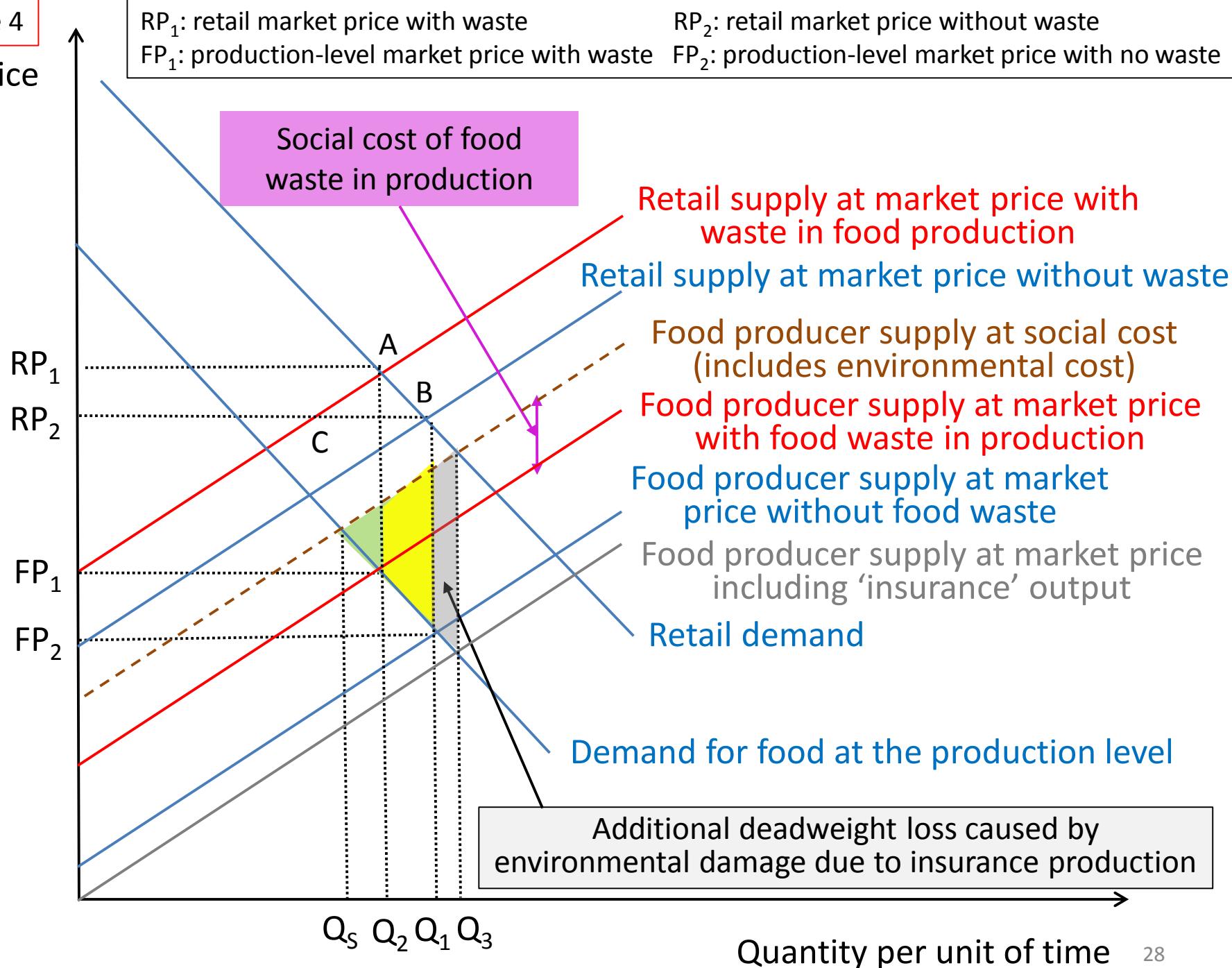
- Risk is commonly encountered in the production and supply of food products
- Production conditions vary substantially over time and the price elasticity of supply is often low, amplifying price volatility in the food value chain
- Supermarkets have been known to shift this sort of risk back along the value chain

Analysing food waste externalities

- Proposition 5: A fifth cause of food waste externality can arise where retailers use their market power to transfer market risk back to the producer
- If producers face large penalties and potential loss of contract for supply shortages, they may engage in ‘insurance production’: producing an extra quantity to avoid a supply shortage
- Figure 4 on the next slide shows that this would have the same effect as food waste in production in situations where the extra output cannot be disposed of in other markets and is destroyed or left to rot in the field

Figure 4

Price



Analysing food waste externalities

- The negative externality is initially within the food value chain as the retailers are forcing food producers to meet the costs associated with risk management
- But there are also spillovers to the rest of society because the insurance production comes at a social cost caused by the environmental damage generated by this additional production
- Remedyng this situation is likely to require some form of intervention by government, which leads into ...

Internalising a food waste negative externality

- There is a justifiable role for local, regional and national governments to play in food value chains that internalises food waste externalities where these externalities spill over beyond chain borders
- Governments may focus on a wide range of issues within particular food value chains, or preferably on common issues across a range of food value chains, in internalising global and national externalities, and perhaps also in helping to internalise negative chain externalities
- Incentives for private, chain and government action vary according to the marginal benefits and costs of each action

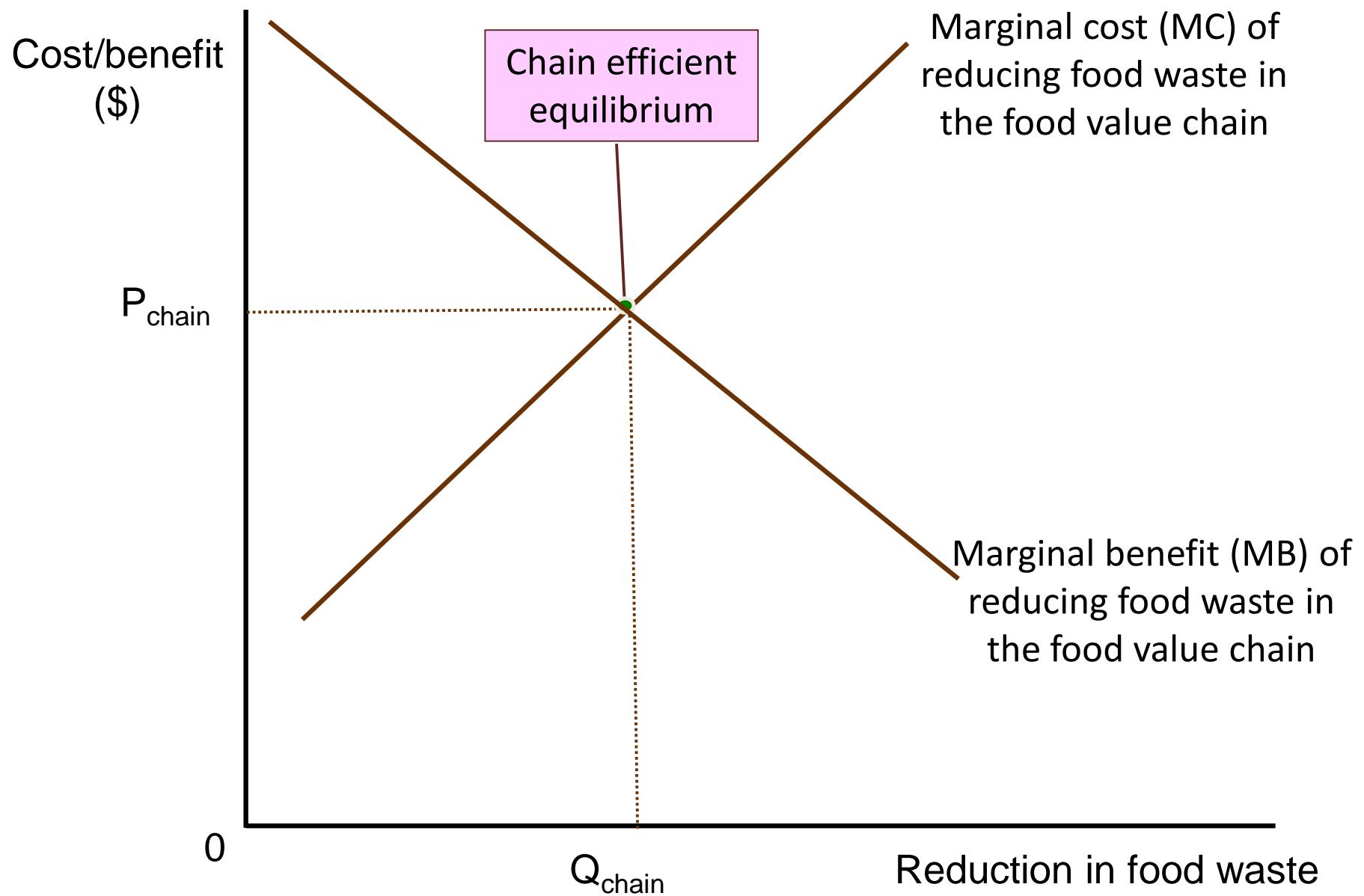
Internalising a food waste negative externality

- Economists generally favour the use of market-based policies to deal with negative externalities caused within a value chain
- An example of such a policy to reduce waste in the food value chain is improving the flow of market information throughout the chain
- Another is vertical integration, or an improvement in the processes of vertical coordination among participants within the chain
- The key questions are: How can decisions be made that identify the best method of intervention and by whom, and how much food waste should be avoided?

Internalising a food waste negative externality

- Figures 5 to 7 show (first for all the food value chain and then separately for the chain and the rest of the society) that the efficient level of food waste is not zero
- This is neither possible nor desirable
- Reducing food waste will have benefits and costs
- As waste is reduced, the additional benefits become smaller and the additional costs of waste reduction become greater
- The optimal decision for the chain is to keep taking measures to reduce food waste until the marginal cost of doing so is equal to its marginal benefit

Figure 5



Internalising a food waste negative externality

- In Figure 6 on the next slide, social costs beyond the food value chain are introduced into Figure 5 by splitting externalities into those that exist within the food value chain and those spilling over outside it
- Adding the cost of food waste spilling over to society to the chain cost of food waste provides the equilibrium social price and quantity of food production as P_{social} and Q_{social} , respectively
- Figure 7 is similar to Figure 6 but has different shapes and locations of curves to show the relative potential for chain and government (social) action

Figure 6

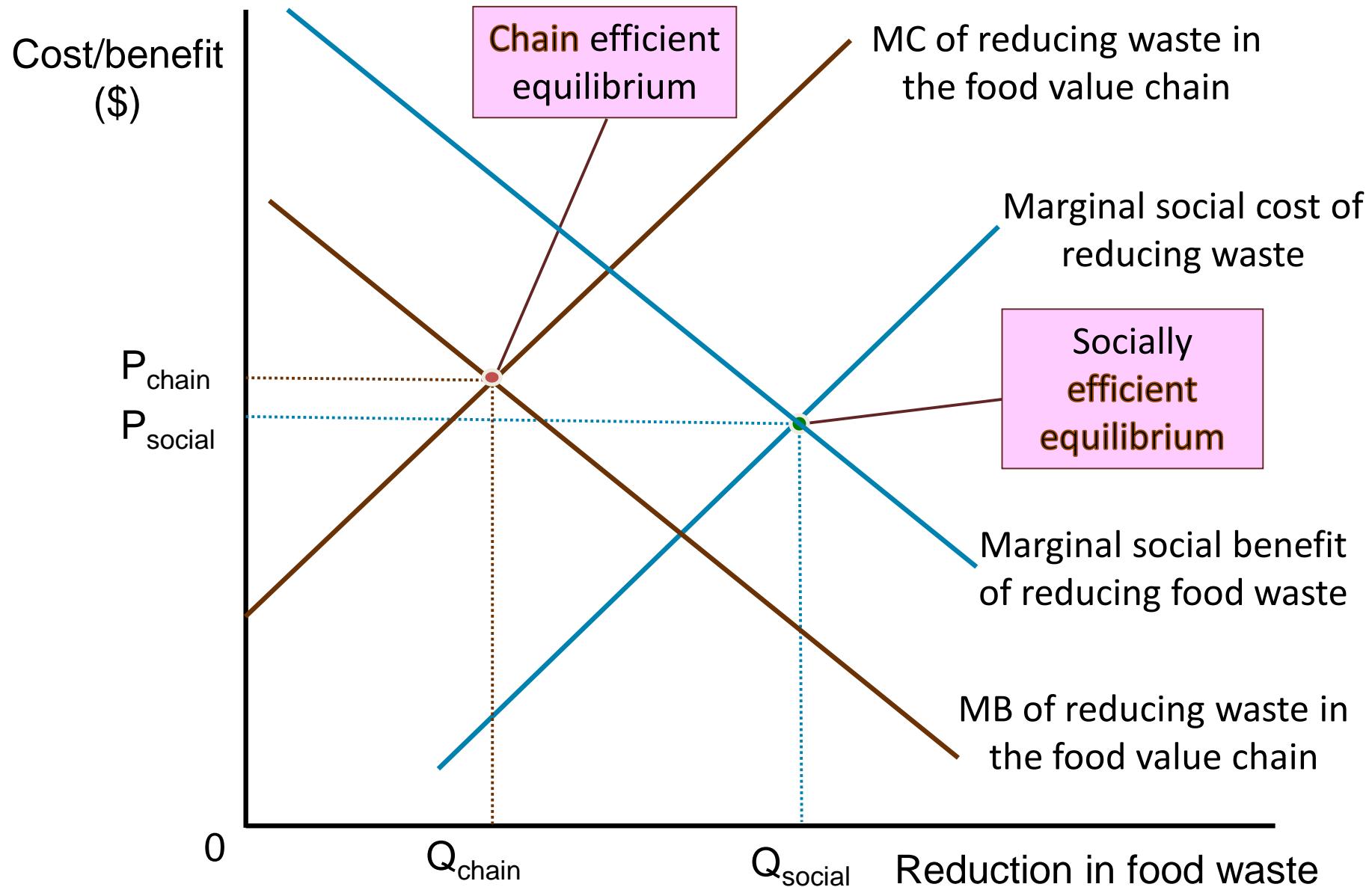
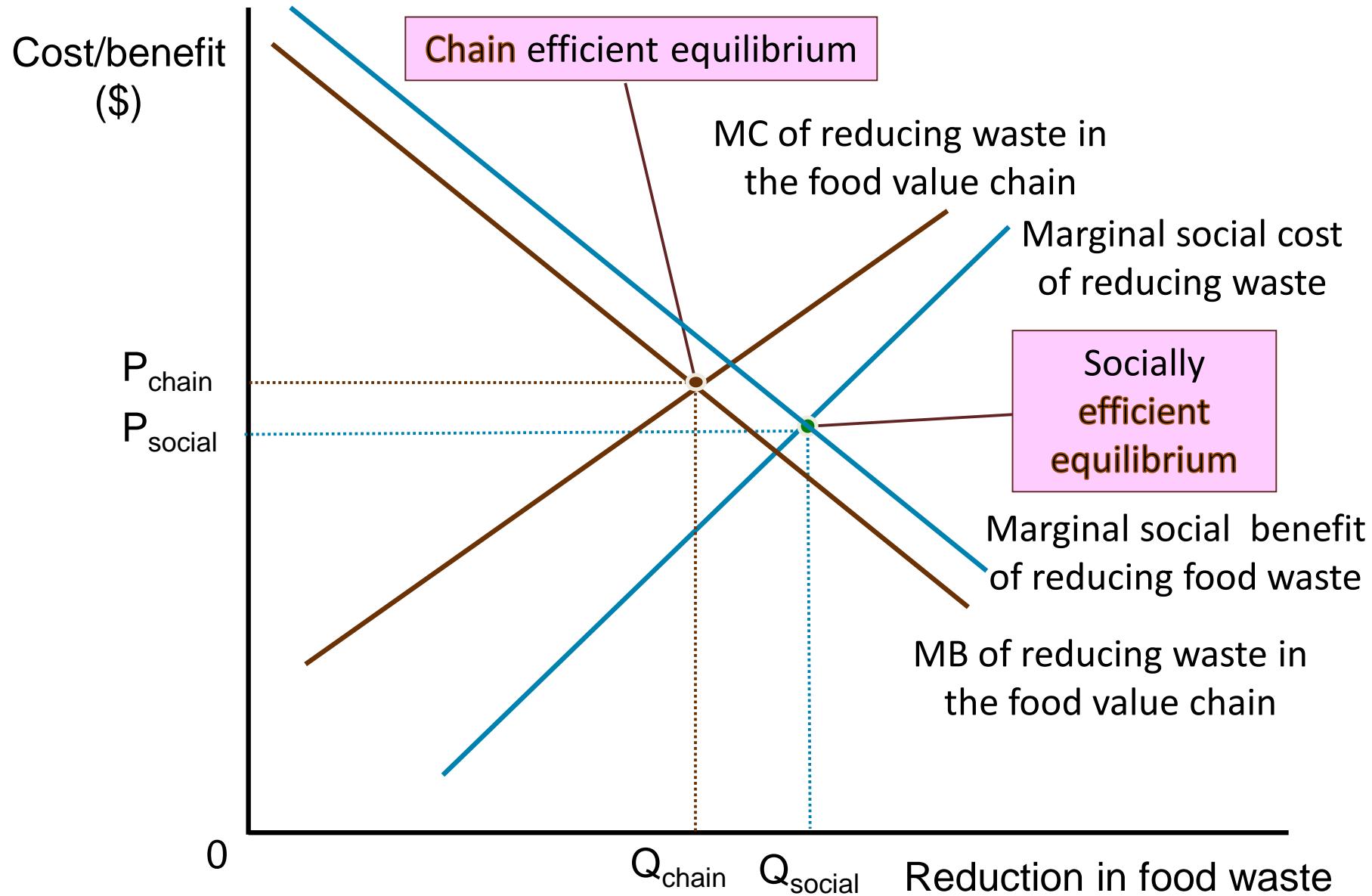


Figure 7



Internalising a food waste negative externality

- The optimal decision is to continue reducing food waste until the marginal cost to the society/chain of doing so is equal to its marginal benefit to society/chain members
- The efficient level of food waste reduction is where the marginal benefit from food waste reduction is equal to the marginal cost of food waste reduction: $MB = MC$

If $MB > MC$	Further reduction of food waste will make society/value chain better off
If $MB < MC$	Further reduction of food waste will make society/value chain worse off
If $MB = MC$	Efficient level of food waste reduction has been achieved

Classifying actions to reduce food waste

- Actions to reduce food waste take four main forms:
 1. Government action at the global, regional, national, state or local level
 2. Collective action by food value chain participants
 3. Collaboration between the government and food value chain
 4. Joint action by food value chain participants taken privately
- Analysts have talked up the merits of the second and third forms, but there is little evidence of action
- We consider the first and fourth actions first before commenting on a lack of second and third initiatives

Government solutions to global/regional/national externalities

- Government solutions to global/regional/national externalities are the source of most initiatives to date because of the large spillover effects of food waste
- A range of initiatives have been implemented
- FAO (2015) provides an overview of recent global, regional and national initiatives
- Advocacy and exhortation are prominent among actions taken but to limited or patchy effect
- Insufficient focus has been on the origin, nature and extent of externalities for these actions to be effective

Government solutions to global/regional/national externalities: taxes and subsidies

- Taxes and subsidies are intended to bring about an efficient level of food output in the presence of externalities
- A tax on food production and marketing equal to the cost of the externality internalises a negative externality (e.g. a tax on supermarkets in France not supplying still-edible food waste to charities)
- So does a subsidy equal to the value of the negative externality provided to food value chain participants to counter it
- Examples abound of the use of taxes and subsidies

Government solutions to global/regional/national externalities: regulation

- Regulation is another potentially important tool for governments to use to reduce food waste
- Vittuari (2016) reported that ‘53 EU legislative acts impacting on food waste have been identified’
- But implementation and oversight can be costly and ineffective
- Easing regulations is an effective option in some circumstances, such as revising ‘regulations and standards on aesthetic requirements for fruit and vegetables’ (FAO 2016)

Government solutions to global/regional/national externalities: facilitation

- Facilitation is likely to be more effective and well suited to deal with specific problems creating food waste
- Examples abound of facilitation measures adopted by local and national governments
- They include building infrastructure, which has been particularly important in developing countries
- Governments increasingly are supporting joint private actions to solve food waste problems through their facilitation role

Joint private solutions to chain externalities: applying a generalised Coase theorem

- The more limited the extent of food waste externalities, the more likely it is that a solution can be found without the need for government or whole-of-chain intervention
- Applying a generalisation of the Coase theorem, reports can be found of many private solutions to the problem of food waste externalities through negotiation between parties in the food value chain
- These solutions have been put into effect through (horizontal, vertical or matrix) strategic alliances

Private parties find efficient solutions to
externalities without government intervention

Joint private solutions to chain externalities: applying a generalised Coase theorem

- Examples of joint private action include:
 - restaurant negotiating to use supermarket produce past its use-by date but still edible
 - food in excess of needs redirected by chain participants to welfare agencies such as food banks
 - waste reused in other food production processes
 - supermarket buyer located in food supplier to reduce demand uncertainty and gain early intelligence on supply uncertainty
 - emergence of outlets to dispose of non-standard fruits and vegetables

Joint private solutions to chain externalities: applying a generalised Coase theorem

- ‘Spill-ins’ are a common form of joint private actions
- A negative externality caused by food waste prompts a party outside the food value chain to respond to the externality by joining the chain to internalise the externality
- The first two examples on the previous slide are of this nature: restaurants set up to use supermarket produce past its use-by date and welfare agencies establishing links with chain participants to supply food banks

Joint private solutions to chain externalities: applying the generalised Coase theorem

- Solutions to food waste in a food value chain obtained by joint private action are likely to be more feasible and effective among a few chain members than in the whole chain or society at large
- This is because of the shared interest of members in making a particular part of the chain work better
- There needs to be an economically efficient level of adjustment of an activity causing an externality that these members of the value chain can agree to

Joint private solutions to chain externalities: applying the generalised Coase theorem

- Three limitations of joint private solutions are:
 1. A large number of chain members involved in bargaining makes the process unwieldy and consensus more difficult to achieve
 2. Unreasonable demands may be made by chain members, especially those with market power
 3. All chain members may not have full information about the costs and benefits of taking action to internalise the food waste externality
- Their presence usually means a whole-of-chain solution is needed

Especially constraining

Whole-of-chain solutions

- Many analysts have recommended whole-of-chain solutions to food waste
- These solutions require the establishment of a chain governor
- Despite some good analytical work (e.g. product life cycle analysis), participants do not appear to have engaged in collective action across the whole food value chain:
 - high transaction costs
 - absence of a suitable governing agency
 - market structure impediments
 - ‘somebody else’s problem’

Whole-of-chain solutions

- Many in food value chains see the internalisation of externalities to reduce social costs as a government responsibility
- They are also happy to leave it to small chain participants to operate around the edges of the problem of food waste
- If serious whole-of-chain action is to occur, the role of supermarkets is likely to be central to most actions
- Can government support help in getting whole-of-chain initiatives under way?
- FAO thinks so ...

Collaboration between the government and food value chain

- Collaboration between the government and food value chain is consistent with the FAO (2015) initiative aimed at food value chain members (consumers included) but requiring public support to facilitate changes in the chain
- In some situations, benefits can be gained by actors in a food value chain internalising food waste externalities, but they are insufficient to match the costs of these actions
- Government support may help tip the balance in favour of action

Collaboration between the government and food value chain

- There are promising signs, particularly in terms of public-private partnerships into alleviating food waste in Europe
- The FUSIONS and REFRESH projects are good examples (Timmermans 2017):
 - FUSIONS aims ‘to contribute significantly to the harmonisation of food waste monitoring, feasibility of social innovative measures for optimised food use in the food chain and the development of a Common Food Waste Policy for EU28’
 - REFRESH ‘is based on strategic agreements across all stages of the supply chain (backed by Governments), delivered through collaborative working and supported by evidence-based tools to allow targeted, cost effective interventions’

Conclusions

- A case is made for greater focus on the origin, nature and extent of the negative externalities of food waste when designing actions to reduce it, estimating the net benefits, and deciding on who should undertake the actions
- Analysts in the literature have pushed the merits of whole-of-chain action and chain and government collaboration to reduce food waste, but there is little evidence that such initiatives are taking place
- A better understanding of net benefits to chain participants of internalising food waste externalities and the values of spillovers and spill-ins should improve government collaboration with food value chain members

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