Landfill Tax Model

Conceptual Framework

The theoretical framework for the Landfill Tax Model is illustrated in Figure 1, which shows - in the form of marginal cost curves – the cost of disposing waste at landfill and the cost of alternative disposal (e.g. recycling, composting, incinerating, etc.). By convention, it is assumed that in any given year the unit (marginal) cost of each waste management option increases as more of it is provided, as increasingly scarce, and thus more valuable, resources are consumed. In Figure 1:

- the line marked MC_{A1} shows the quanities of waste that can be management by means other than landfill at any given marginal (financial) cost;
- the line marked MC_{L1} shows the quanities of waste that can be disposed at landfill at any given marginal financial cost, inclusive of landfill tax (assumed equal to LFT_1); and
- the line marked MPC_{W1} shows the quanities of waste that can be recycled, composted, incinerated, etc. and disposed at landfill at any given marginal financial cost. MPC_{W1} is the horizontal sum of MC_{A1} and MC_{L1}.

Faced with the costs of managing a given amount of waste arisings, Q^*, the waste sector should seek to identify the minimum marginal cost, P_1, where all this waste can be managed. At this point, the marginal costs of all management options are equalised, and in turn the total cost of managing Q^* is minimised. The cost-minimising quantities of waste that should be recycled, composted, incinerated etc., A_1, and disposed to landfill, L_1, are found by identifying the point where P_1 intersects each respective cost curve, and reading the corresponding quantity of the x-axis.

If the landfill tax is to increase from LFT_1 to LFT_2 the landfill cost curve will shift upwards, from MC_{L1} to MC_{L2}. In turn, the cost curve for all waste services, which is the horizontal sum of the underlying cost curves for each individual waste management method, will also shift upwards, from MC_{W1} to MC_{W2}. Now, faced with MC_{W2}, the marginal cost of all management options are equalised at P_2, where the total cost of managing Q^* is minimised. As before, the cost-minimising quantities of waste that should be recycled, composted, incinerated etc., A_2, and disposed to landfill, L_2, are found by identifying the point where P_2 intersects each respective cost curve, and reading the corresponding quantity of the x-axis. Note: that $L_2 < L_1$ and $A_2 > A_1$.

If the landfill tax is to further increase from LFT_2 to LFT_3 the landfill cost curve will again shift upwards, from MC_{L2} to MC_{L3}. The new cost-minimising quantities of waste that should be recycled, composted, incinerated etc., A_3, and

disposed at landfill, L_3, are similarly found by identifying the point where P_3 intersects each respective cost curve, and reading the corresponding quantity of the x-axis. Note: that $L_3 < L_2$ and $A_3 > A_2$.

Figure 1 also shows the demand curve for landfill, which can be derived from the landfill cost curve, as total waste management costs are minimised at different levels of landfill tax. The (own price) elasticity of demand for landfill, which characterises the relationship between changes in the price (cost) of landfill and demand for landfill, is captured by the demand curve.

Previous studies commissioned by DEFRA (e.g. Aspinwall (1999) Enviros (2001 and 2002)) constructed preliminary cost curves for a restricted range of options for managing MSW and C & I, from which some estimates of the (own price) elasticity of demand for landfill were derived. The data underlying the cost curves were updated as part of the programme of work in support of the COSU Waste Report and the elasticity estimates also updated accordingly. The cost curves were essentially static however, in that they referred to a specific point in time; the elasticities derived from them are therefore only applicable to the short-run. Based on expert judgment, the authors of the above studies did provide an estimate of how much the short-run elasticities were likely to increase in the long-run (10 years).

Behavioural responses within the Landfill Tax Model are driven by elasticity matrices, which are based on the 'derived' short-run and long-run elasticities of demand for landfill.

Structure of the Model

The model consists of two modules: (1) Waste Arisings and Disposal, and (2) Tax Model, each contained on separate, but linked Excel spreadsheets. For the purpose of this exercise forecast C & I arisings and disposal data for England were provided by DEFRA ('central case' output from the REEIO Model). This data was directly input into the Tax Model, the structure of which is shown in Figure 2; there was no need to use the Arisings and Disposal module.

The Tax Model provides output on, among other things: (a) total and incremental revenue effects, and (b) total and incremental environmental effects (defined narrowly, in terms of reduced levels of landfill)[1]. For the purpose of this exercise, incremental effects are measured as: (1) the difference between a **Reference Case** and a **Base Case** and (2) the difference between the **Base Case** and a **Policy Case**. The Reference Case defines the profile of standard landfill tax rates prevailing prior the announcement in Budget 2003 (i.e. that the standard rate of landfill tax would rise by £3 per tonne per year in 2005-06, and by at least £3 per tonne per year thereafter until a rate of £35 per tonne is reached in the medium-term). The Base Case defines the profile of standard landfill tax rates announced in Budget 2003, where the tax rate reaches £35 per tonne in 2011-12 and remains at this rate thereafter. Under the Policy Case the

[1] The current model was constructed with the primary purpose of predicting, as reliably as possible, levels of landfill under various tax rate scenarios and, directly related to this, levels of tax receipts. The model also predicts the amount of waste **diverted from landfill** when the landfill tax increases, but it does not identify where that waste ultimately goes. The latter can only be derived from a full cost curve-based model.

standard landfill tax rate rises from £35 per tonne in 2011-12 to £40, £45 and £50 per tonne in 2012-13, 2013-14 and 2014-15, respectively.

The model works on a financial year basis, since new rates of landfill tax are typically introduced in April, following the Budget.

As mentioned above, changes in demand for landfill within the model are predicted using matrices of elasticities[2], which measure the responsiveness of 'waste operators' to changes in the total cost of collecting, transferring, transporting and disposing waste at landfill (the landfill tax is one element of this total disposal cost).

The matrices operate along two dimensions – in general: (a) the larger the increase in the tax rate in any given year, the greater the reduction in demand for landfill and (b) the further we move away from the date when changes in the tax rate are announced, the larger the reduction in demand. This is consistent with expectations from economic theory.

The Tax Model contains low, medium and high estimates of total landfill cost (before tax). For any increase in the standard tax rate, the reduction in demand for landfill will be less when the high cost estimates are used in contrast to the low cost estimates, ceteris paribus. In the latter case, the increase in the tax rate will represent a larger proportion of the total landfill cost, thereby generating a larger reaction.

Estimates of total landfill costs are not held within the model for England as a whole, but rather for individual regions (e.g. South West, North East, etc.). A weighted average cost was thus used, where the weights are based on each regions share of total disposal of C & I at landfill in the 2002 survey.

For each year over the forecast period the (weighted) total landfill cost including tax (for the Reference Case, Base Case and Policy Case) is calculated. The difference in total costs between, for example, the Base Case and Reference Case provides a measure of 'price change', which is subsequently used in conjunction with the elasticity matrix and Reference Case level of landfill disposal to determine the new, Base Case, level of disposal. The difference between the Base Case and Reference Case level of disposal represents the amount of C & I waste, originally destined for landfill, which is now diverted to an alternative disposal route, as a result of the increase in the standard rate of landfill tax. Likewise, the difference between the Policy Case and the Base Case level of disposal represents the amount of C & I waste, originally destined for landfill, which is now diverted to an alternative disposal route, as a result of the standard landfill tax rate rising from £35 per tonne in 2011-12 to £40, £45 and £50 per tonne in 2012-13, 2013-14 and 2014-15, respectively.

The results of the tax modelling exercise are summarised in Table 1 and Table 2. These are based on the 'best guess' long-run price elasticity, which over a period of ten years was assumed to be 1.25 times higher than the short-run elasticity. Under the Reference Case, disposal at landfill, as predicted by REEIO, is 29,450 kt in 2005-06, rising to 33,690 kt in 2014-15. Under the Base Case with medium total landfill costs, disposal at landfill is 29,200 kt in 2005-

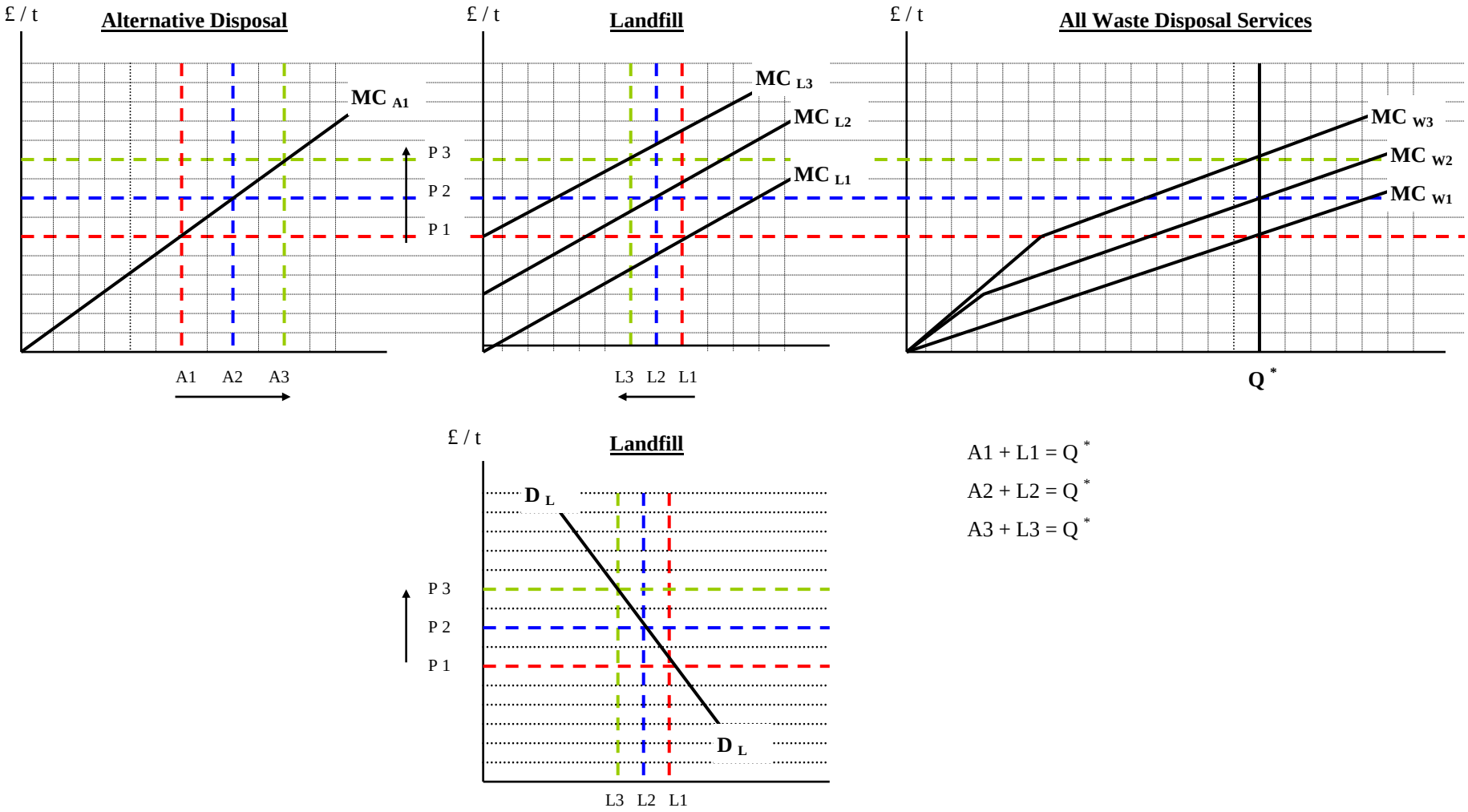
[2] A separate elasticity matrix has been constructed for each major waste stream – i.e. MSW, C & I, and C & D.

06, rising to 30,810 kt in 2014-15. Relative to the Reference Case, the standard landfill tax profile announced in Budget 2003 is predicted to reduce the landfill of C & I waste in England by 250 kt per year in 2005-06, 1,810 kt per year in 2009-10 and 2,880 kt per year in 2014-15. Relative to the Base Case, the tax rates under the Policy Case will reduce the landfill of C & I waste in England by an additional 1,500 kt in 2014-15, or 2.7 million tonnes in total over the period 2012-13 to 2014-15. The results are also displayed in Figure 3, Figure 4 and Figure 5.

A sensitivity test of the long-run elasticity is shown in Table 3 and Table 4, where the long-run price elasticity is assumed to be 1.50 times higher than the short-run elasticity after 10 years. As expected, diversion towards the end of the forecast period is higher than under the lower long-run price elasticity.

It is not possible to provide the total or incremental revenue effects, since tax receipts are affected by the LTCS, and it is not possible to disaggregate the impact of the LTCS by waste stream; the LTCS is normally applied to total tax liability across all waste streams.

Figure 1: Conceptual Framework for Landfill Tax Model

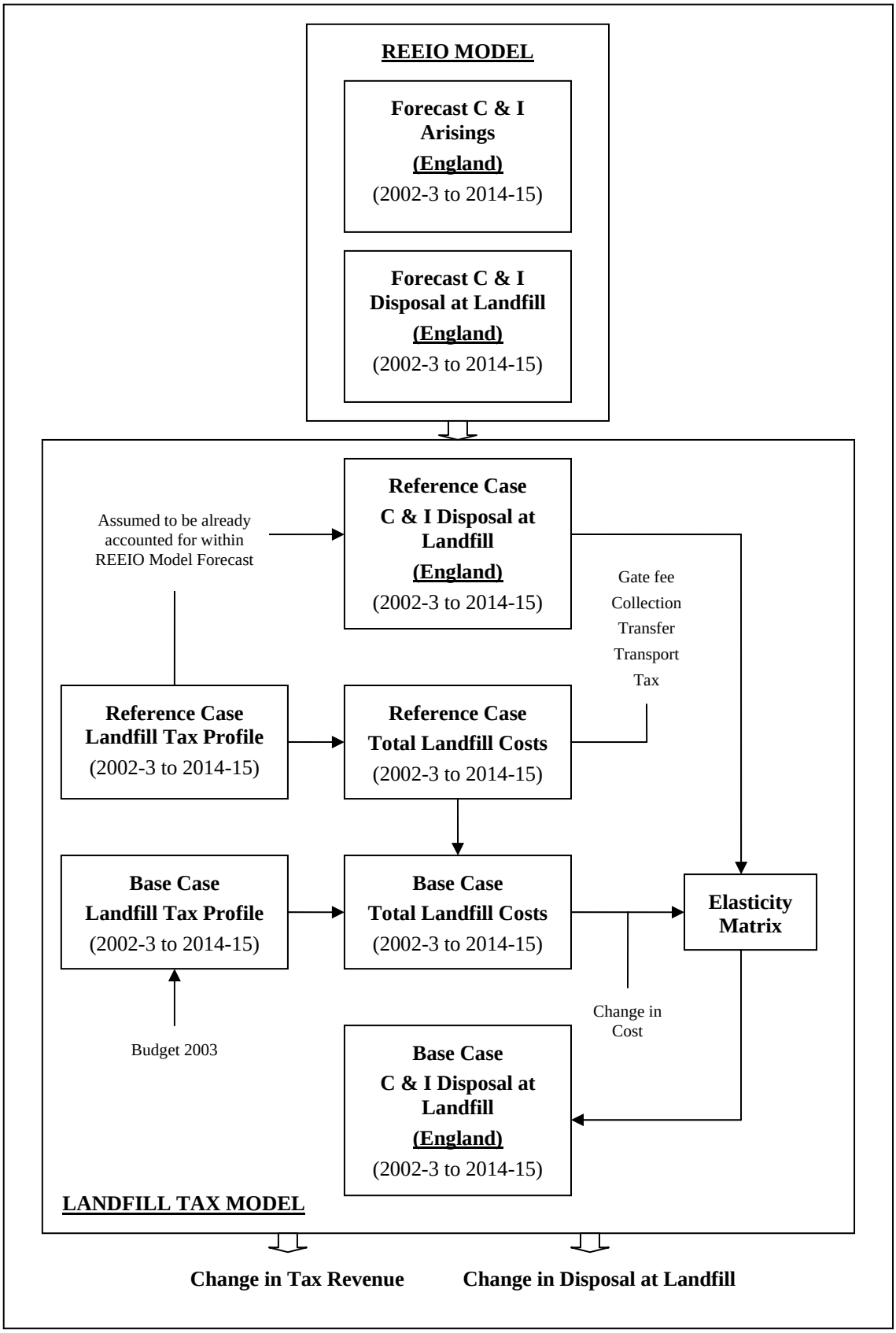


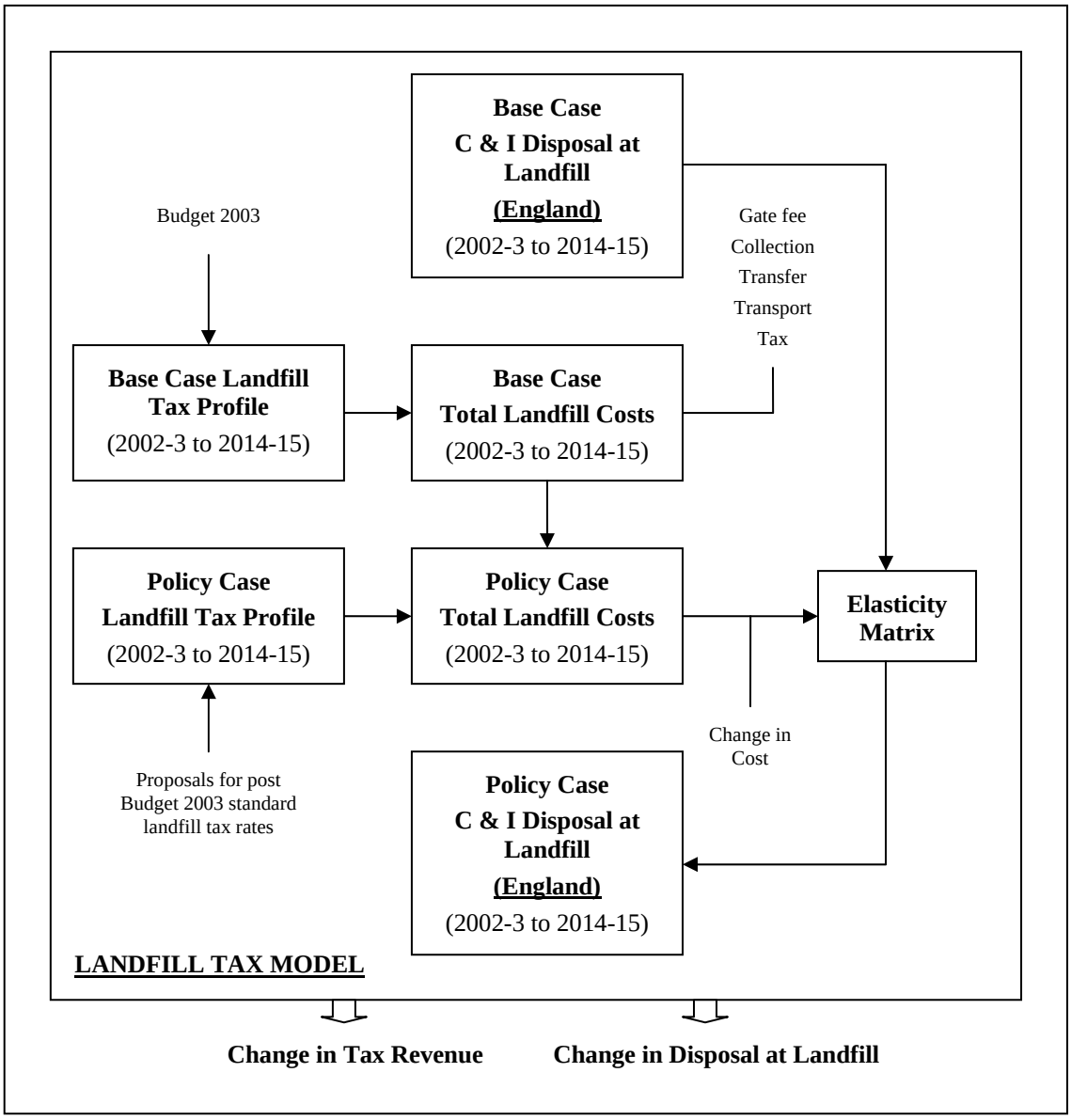
$A1 + L1 = Q^{*}$

$A2 + L2 = Q^{*}$

$A3 + L3 = Q^{*}$

Figure 2: Structure of Landfill Tax Model




Base Case
C & I Disposal at Landfill
(England)
(2002-3 to 2014-15)
Budget 2003
Gate fee
Collection
Transfer
Transport
Tax
Base Case Landfill Tax Profile
(2002-3 to 2014-15)
Base Case
Total Landfill Costs
(2002-3 to 2014-15)
Policy Case
Landfill Tax Profile
(2002-3 to 2014-15)
Policy Case
Total Landfill Costs
(2002-3 to 2014-15)
Elasticity Matrix
Change in Cost
Proposals for post Budget 2003 standard landfill tax rates
Policy Case
C & I Disposal at Landfill
(England)
(2002-3 to 2014-15)
LANDFILL TAX MODEL
Change in Tax Revenue
Change in Disposal at Landfill

Impact of Landfill Tax on Commercial and Industrial Waste Disposal at Landfill

Table 1: Disposal of Commercial and Industrial Waste at Landfill in England (Long-run Elasticity 25% Higher than Short-run Elasticity)

Year	REFERENCE CASE		BASE CASE				POLICY CASE			
	Standard Landfill Tax Rate	Disposal at Landfill	Standard Landfill Tax Rate	Disposal at Landfill			Standard Landfill Tax Rate	Disposal at Landfill		
				Low Total Landfill Costs	Medium Total Landfill Costs	High Total Landfill Costs		Low Total Landfill Costs	Medium Total Landfill Costs	High Total Landfill Costs
	(£ per t)	('000 t)	(£ per t)	('000 t)	('000 t)	('000 t)	(£ per t)	('000 t)	('000 t)	('000 t)
2002-2003	13	28,500	13	28,500	28,500	28,500	13	28,500	28,500	28,500
2003-2004	14	28,760	14	28,760	28,760	28,760	14	28,760	28,760	28,760
2004-2005	15	29,130	15	29,130	29,130	29,130	15	29,130	29,130	29,130
2005-2006	15	29,450	18	29,120	29,200	29,260	18	29,120	29,200	29,260
2006-2007	15	29,690	21	28,940	29,140	29,250	21	28,940	29,140	29,250
2007-2008	15	29,910	24	28,680	29,010	29,190	24	28,680	29,010	29,190
2008-2009	15	30,260	27	28,470	28,940	29,210	27	28,470	28,940	29,210
2009-2010	15	30,780	30	28,320	28,970	29,340	30	28,320	28,970	29,340
2010-2011	15	31,280	33	28,120	28,960	29,440	33	28,120	28,960	29,440
2011-2012	15	31,780	35	28,090	29,070	29,640	35	28,090	29,070	29,640
2012-2013	15	32,360	35	28,590	29,600	30,180	40	28,140	29,230	29,870
2013-2014	15	33,000	35	29,150	30,180	30,780	45	28,080	29,320	30,060
2014-2015	15	33,690	35	29,750	30,810	31,420	50	27,890	29,310	30,170

Table 2: Diversion of Commercial and Industrial Waste from Landfill in England (Long-run Elasticity 25% Higher than Short-run Elasticity)

Year	BASE CASE vs REFERENCE CASE				POLICY CASE vs BASE CASE			
	Standard Landfill Tax Rate	Diversion from Landfill			Standard Landfill Tax Rate	Diversion from Landfill		
		Low Total Landfill Costs	Medium Total Landfill Costs	High Total Landfill Costs		Low Total Landfill Costs	Medium Total Landfill Costs	High Total Landfill Costs
	(£ per t)	('000 t)	('000 t)	('000 t)	(£ per t)	('000 t)	('000 t)	('000 t)
2002-2003	13	-	-	-	13	-	-	-
2003-2004	14	-	-	-	14	-	-	-
2004-2005	15	-	-	-	15	-	-	-
2005-2006	18	340	250	200	18	-	-	-
2006-2007	21	750	550	440	21	-	-	-
2007-2008	24	1,230	910	720	24	-	-	-
2008-2009	27	1,800	1,330	1,050	27	-	-	-
2009-2010	30	2,460	1,810	1,430	30	-	-	-
2010-2011	33	3,160	2,320	1,840	33	-	-	-
2011-2012	35	3,690	2,710	2,140	35	-	-	-
2012-2013	35	3,770	2,760	2,180	40	450	370	310
2013-2014	35	3,850	2,820	2,230	45	1,070	860	720
2014-2015	35	3,940	2,880	2,270	50	1,860	1,500	1,250

Table 3: Disposal of Commercial and Industrial Waste at Landfill in England (Long-run Elasticity 50% Higher than Short-run Elasticity)

Year	REFERENCE CASE		BASE CASE				POLICY CASE			
	Standard Landfill Tax Rate	Disposal at Landfill	Standard Landfill Tax Rate	Disposal at Landfill			Standard Landfill Tax Rate	Disposal at Landfill		
				Low Total Landfill Costs	Medium Total Landfill Costs	High Total Landfill Costs		Low Total Landfill Costs	Medium Total Landfill Costs	High Total Landfill Costs
	(£ per t)	('000 t)	(£ per t)	('000 t)	('000 t)	('000 t)	(£ per t)	('000 t)	('000 t)	('000 t)
2002-2003	13	28,500	13	28,500	28,500	28,500	13	28,500	28,500	28,500
2003-2004	14	28,760	14	28,760	28,760	28,760	14	28,760	28,760	28,760
2004-2005	15	29,130	15	29,130	29,130	29,130	15	29,130	29,130	29,130
2005-2006	15	29,450	18	29,120	29,200	29,260	18	29,120	29,200	29,260
2006-2007	15	29,690	21	28,930	29,120	29,240	21	28,930	29,120	29,240
2007-2008	15	29,910	24	28,630	28,960	29,160	24	28,630	28,960	29,160
2008-2009	15	30,260	27	28,340	28,850	29,140	27	28,340	28,850	29,140
2009-2010	15	30,780	30	28,090	28,800	29,210	30	28,090	28,800	29,210
2010-2011	15	31,280	33	27,770	28,700	29,240	33	27,770	28,700	29,240
2011-2012	15	31,780	35	27,610	28,720	29,360	35	27,610	28,720	29,360
2012-2013	15	32,360	35	28,030	29,190	29,850	40	27,520	28,770	29,500
2013-2014	15	33,000	35	28,510	29,710	30,410	45	27,290	28,720	29,570
2014-2015	15	33,690	35	29,020	30,280	31,000	50	26,880	28,540	29,540

Table 4: Diversion of Commercial and Industrial Waste from Landfill in England (Long-run Elasticity 50% Higher than Short-run Elasticity)

Year	BASE CASE vs REFERENCE CASE				POLICY CASE vs BASE CASE			
	Standard Landfill Tax Rate	Diversion from Landfill			Standard Landfill Tax Rate	Diversion from Landfill		
		Low Total Landfill Costs	Medium Total Landfill Costs	High Total Landfill Costs		Low Total Landfill Costs	Medium Total Landfill Costs	High Total Landfill Costs
	(£ per t)	('000 t)	('000 t)	('000 t)	(£ per t)	('000 t)	('000 t)	('000 t)
2002-2003	13	-	-	-	13	-	-	-
2003-2004	14	-	-	-	14	-	-	-
2004-2005	15	-	-	-	15	-	-	-
2005-2006	18	340	250	200	18	-	-	-
2006-2007	21	760	570	450	21	-	-	-
2007-2008	24	1,290	950	760	24	-	-	-
2008-2009	27	1,920	1,420	1,120	27	-	-	-
2009-2010	30	2,680	1,970	1,560	30	-	-	-
2010-2011	33	3,510	2,580	2,040	33	-	-	-
2011-2012	35	4,180	3,060	2,420	35	-	-	-
2012-2013	35	4,330	3,170	2,510	40	510	420	350
2013-2014	35	4,500	3,290	2,600	45	1,220	990	830
2014-2015	35	4,660	3,410	2,690	50	2,150	1,740	1,460

Figure 3: Disposal of Commercial and Industrial Waste at Landfill in England (Long-run Elasticity 25% Higher than Short-run Elasticity; Medium Total Landfill Costs)

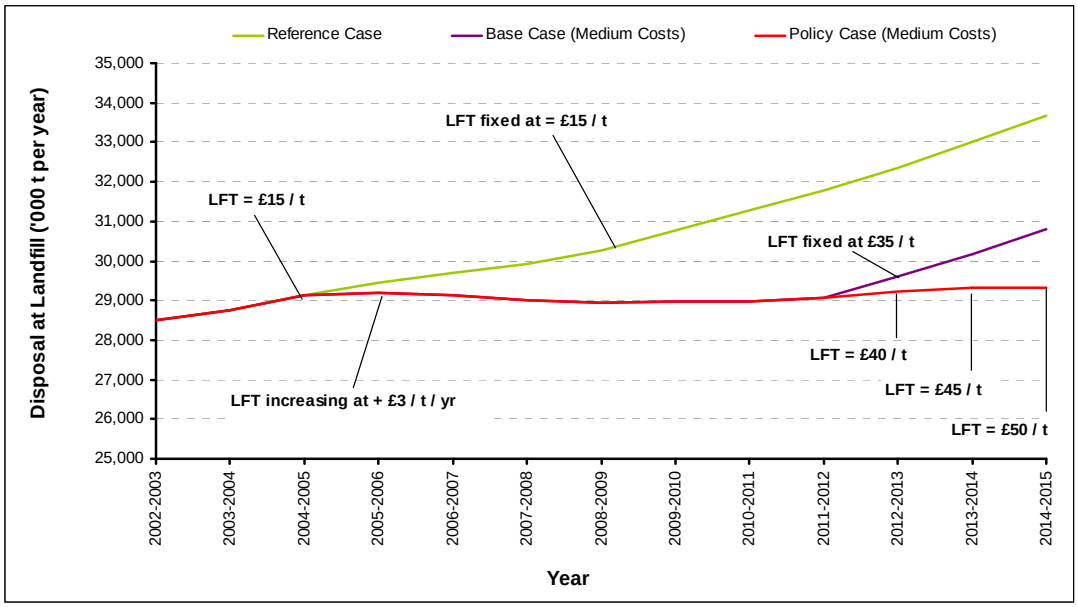


Figure 4: Diversion of Commercial and Industrial Waste from Landfill in England (Policy Case Relative to Reference Case) (Long-run Elasticity 25% Higher than Short-run Elasticity)

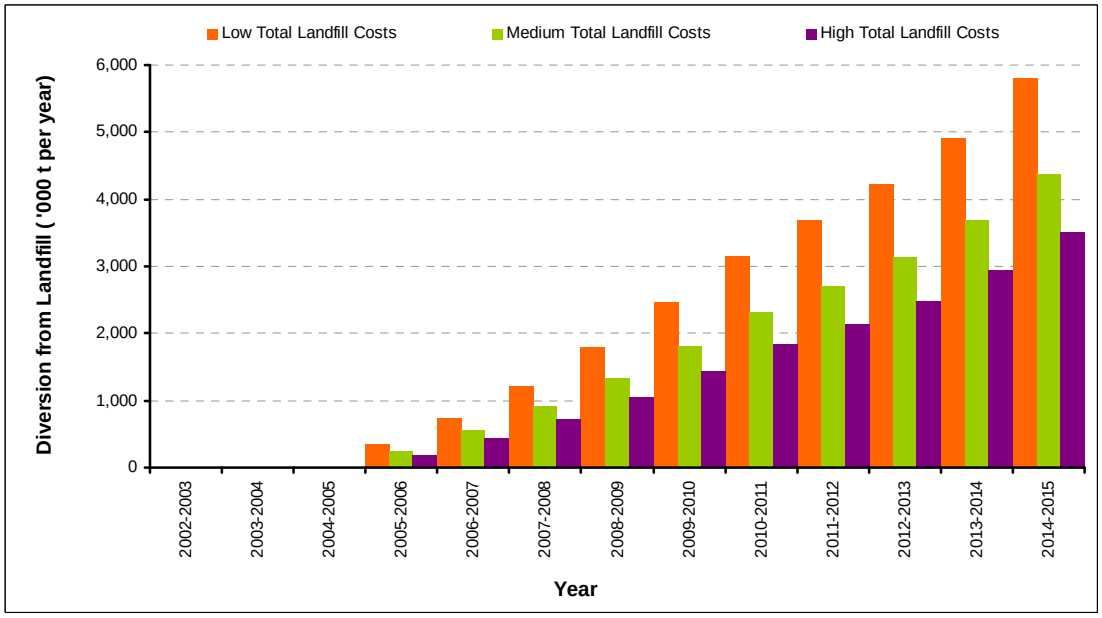


Figure 5: Diversion of Commercial and Industrial Waste from Landfill in England (Relative Contribution of Base Case and Policy Case Tax Rate Profiles) (Long-run Elasticity 25% Higher than Short-run Elasticity; Medium Total Landfill Costs)