An Extension and Application of the Leontief Pollution Model for Waste Generation and Disposal in Scotland *

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1. Introduction

Solid waste generation, treatment and disposal are important policy concerns for the Scottish Parliament. As a result of the Environment Act 1995, a National Waste Strategy for Scotland was introduced with the general aim of reducing the amount of waste produced and dealing with what is produced in more sustainable ways. This implies the need for an empirical framework to inform policymakers regarding the relationship between economic activity and waste generation, treatment and disposal and the likely impacts of any policy actions or other disturbances on all types of sustainability indicators.

In this paper we report on a study to develop an extended input-output (IO) system of the type originally proposed in the seminal paper by Leontief (1970). This involves extending the standard IO accounts to take account of pollution or waste generation as an additional output accompanying production and consumption activities in the economy and of the activity required to clean up (or prevent) these unwanted outputs. The extension of IO tables to take account of pollution/waste generation is relatively widespread in the literature. It is usually achieved through the introduction of physical pollution/waste-output coefficients, and has been previously applied to Scotland for the case of air pollution (see McNicoll & Blackmore, 1993, McGregor *et al*, 2001). Such an approach allows us to examine the impact of the economy on the environment, in terms of the amount of pollution/waste emitted as a result of economic activity. However, it does not allow us to track the feedback from the environment to the economy in terms of the resources used in environmental cleaning. If we are interested in this aspect, we need to identify the input structure of any pollution abatement or waste disposal activities and identify columns in the IO tables representing cleaning activities.

This extension of the environmental IO method is rarely made in empirical applications. This might be explained by the fact that appropriate data are generally not available to separately identify the specific inputs used for pollution abatement from other sectoral input expenditures in standard IO tables, a point highlighted in Leontief & Ford (1972). However, our focus on waste generation and disposal in Scotland partly overcomes this problem because refuse disposal is classified as a distinct activity under the UK 1992 Standard Industrial Classification (SIC) used to construct the Scottish IO tables, although waste generation is not so clearly identified.

Nevertheless, in this paper we argue that the problem revolves around more than simple data availability. There are conceptual issues concerning how pollution/waste generation and cleaning activities are interpreted and related to one another in an IO context. Qayum (1991), Arrous (1994) and Luptacik & Böhm (1999) have previously discussed these conceptual issues and proposed a reformulation of the Leontief (1970) model. We attempt to clarify and summarise these contributions in Section 2.

However, at this point it is instructive to note that all of the contributions cited above are analytical and based on illustrative physical IO systems, which are then converted to a price IO framework. In practice, though, IO tables are generally constructed in terms of quantities rather than prices and in value rather than physical units, while pollution/waste generation data are gathered and reported in physical units. We argue that bringing these components together to construct a fully integrated environmental IO system gives rise to problems where there is anything but a fully enforced 'polluter pays' situation in the delivery of cleaning activities. Therefore, we offer an extension to the environmental IO method that will permit empirical analyses of the environmental impacts of economic activity and of the resource requirement implied by the need to clean up and/or dispose of unwanted outputs.

In Section 3 we apply this method to construct an environmental IO waste framework for Scotland, highlighting data issues relating to the availability of IO and waste generation data that are collected in a compatible format and at a suitable level of industrial disaggregation. This is followed in Section 4 with a presentation and analysis of some preliminary empirical results. Summary and conclusions are provided in Section 5.

2. Development of the Environmental IO Method

2.1 The Leontief (1970) pollution model

Construction of an extended IO framework to examine the problem of pollution or waste generation was first proposed by Leontief (1970) using the example of air pollution. His approach involves extending and partitioning the standard A matrix in two ways. First there are additional rows to take account of each different type of pollution that is generated as an additional output in each production sector, through the introduction of physical pollution-output coefficients. Second, there are additional columns showing the inputs required per unit of pollution elimination/prevention.

In formal terms, where we have i=j=1,…N production sectors/commodities and one pollution elimination sector, k, and one pollutant, e, the output of each standard production sector i is conventionally given by (Miller & Blair, 1985):

[1] $$X_i = a_{i,1}X_1 + \ldots\ldots + a_{i,N}X_N + a_{i,k}X_k + Y_i \qquad \forall\ i=1,\ldots N$$

where $a_{i,j}$ is the input of sector i required per unit of output in sector j. Y_i is final demand for the output of sector i. $a_{i,k}$ is the input of sector i required per unit of output in the pollution elimination sector k. Note that in a real IO system, equation [1] would apply to sector k as well – i.e. the pollution elimination sector would be treated like any other production sector, i. However, as we explain below, in the Leontief (1970) pollution model the interpretation of this sector differs from that of standard production sectors.

Equation (1) is rearranged to state the input-output balance in terms of final demand:

[2] $$[1-a_{i,i}]X_i + \ldots\ldots - a_{i,N}X_N - a_{i,k}X_k = Y_j$$

In Leontief's (1970) environmental IO method, the additional row of the A-matrix gives us the total amount of the pollutant e that is generated by production and consumption activities:

[3] $$X_e = a_{e,1}X_1 + \ldots + a_{e,N}X_N + a_{e,k}X_k + Y_e$$

where $a_{e,j}$ and $a_{e,k}$ are the pollution (or emissions) output coefficients stating how much pollution is emitted per unit of output in each production sector i and the pollution elimination sector k respectively. Y_e is pollution directly generated by final consumption activities (which could also be stated as $a_{e,z}Y_z$, for each z=1,…Z type of final demand).[1] However, the key point is that Leontief (1970) does not interpret the row entries for pollution generation as demands, with the implication that it is not appropriate to rearrange [3] in terms of final demand. First, we must define the output of the pollution elimination sector, X_k, which must be stated in terms of pollution eliminated for the purpose of direct comparability to pollution generation:

[4] $$X_k = X_e - Y_e^*$$

where X_k is the amount of pollution eliminated by the cleaning sector and Y_e^* is the amount of pollution actually tolerated. Leontief (1970) does not explicitly state this relationship. However, it is implied as an identity, which raises two issues. First, is Y_e^* exogenous or endogenous? Second, if it is exogenous, e.g. in the form of an environmental standard set by government (Luptacik & Böhm, 1999), how is it enforced? Another important observation should be made. Equation [4] assumes that all pollution is a function of production and consumption activities. However, there are other sources of pollution, such as natural disasters, that the pollution elimination sector may be involved in cleaning up. This issue is part of a more general one that we return to: how demand for the pollution elimination sector is determined.

By substituting equation [3] for X_e and rearranging, Leontief (1970) then states the equivalent of [2] for pollution generation:

[5] $$a_{e,1}X_1 + \ldots + a_{e,N}X_N + a_{e,k}X_k - X_k = Y_e^* - Y_e$$

However, Leontief (1970, p.267) argues that unlike all other elements of the vector of final deliveries, described in [2], this delivery is not *demanded*; rather Y_e is the amount of pollution directly generated by final demand and Y_e^* is the amount of pollution *tolerated.* If we rearrange [5] to consider Y_e^* as the final delivery of non-eliminated pollution, we have:

[6] $a_{e,1}X_1 + ... + a_{e,N}X_N + a_{e,k}X_k + Y_e - X_k = Y_e^*$

In this way, $Y_e^* = 0$ if all pollution generated is eliminated and $Y_e^* > 0$ if a positive amount of pollution is tolerated.

2.2 Reformulation of the Leontief pollution model – Steenge (1978), Lowe (1979), Qayum (1991), Arrous (1994) and Luptacik & Böhm (1999)

The problem with the Leontief (1970) formulation of the environmental IO framework is that the tolerated amount of pollution Y_e^* appears to be exogenous. First, this raises the question of how the tolerated level is determined. Even if, as suggested by Luptacik & Böhm (1999), this is interpreted in terms of environmental standards that are determined elsewhere (for example, through the political process), a second problem is that Leontief (1970) does not interpret the output of the pollution elimination industry X_k as being determined by demand. In the Leontief (1970) formulation it differs from other industries in that its output is measured in units of pollution eliminated, and its output is determined by the level of pollution generated by production and final consumption, X_e. However, as noted above, Leontief (1970, p.267) does not interpret the pollution generation row, summarised in equation [3], as showing a demand for the output of any sector. This, then, raises the problem of how pollution elimination is demanded and paid for.

Qayum (1991) sums up the problem as being a question of whether the pollution row entries should be regarded as outputs, as in Leontief's (1970) formulation, or inputs. Put another way, in Leontief's formulation, the pollution row entries tell us 'who pollutes' instead of 'who pays' for the output of pollution. Qayum (1991) argues that the problem can be overcome without disrupting Leontief's (1970) numerical illustration by reinterpreting the pollution generation row and pollution elimination column as a single sector that produces clean air instead of a delivering sector of air pollution and a receiving sector of anti pollution activities. That is to say, the row entries will show the effective demand for cleaning activities as a result of each sector's production activity (which equates to the amount of pollution generated in each sector) while the column shows the inputs required to supply these cleaning activities. This reinterpretation also serves to clarify the role of final demand in the pollution row. Leontief (1970) states final demand entries as showing the amount of pollution tolerated in the economy; Qayum (1991) reinterprets these as the change in stocks of air pollution/of clean air.

We can than therefore restate equation [3] to show the demand for cleaning activity along the new cleaning sector, k, row of the A-matrix:

[7] $X_k = a_{k,1}X_1 + ... + a_{k,N}X_N + a_{k,k}X_k + [Y_k – Y_k^*]$

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[1] Leontief (1970, pp.270-271) only introduces direct pollution generation by final demand in his

where $a_{k,j}$ is the share of total input/output in sector j accounted for by the intermediate demand for the cleaning activities of sector k. That is to say, $a_{k,j}$ takes the same value as $a_{e,j}$ in [3], it is the interpretation of this coefficient that differs. Similarly $a_{k,k}$ is the input coefficient stating what share of total input to pollution elimination, X_k, is accounted for by the demand generated for cleaning activities as a result of pollution generation that occurs during the process of cleaning up pollution elsewhere in the economy. Final demand for cleaning services is given by $[Y_k – Y_k^*]$, that is the difference between cleaning activity required to eliminate the pollution directly generated in final consumption, Y_k (which, again, could also be stated as $a_{k,z}Y_z$ for each type of final demand, z), and the change in stocks of clean air. Rearranging [6] to state the input-output balance in terms of final demand, we now have:

[8] $- a_{k,1}X_1 + \ldots\ldots - a_{k,N}X_N + (1- a_{k,k})X_k = Y_k – Y_k^*$

If we rearrange [8] to bring all intermediate and final demand for cleaning services together, we are left with the term $-Y_k^*$ describing the change in stock of pollution:

[9] $- a_{k,1}X_1 + \ldots\ldots - a_{k,N}X_N + (1- a_{k,k})X_k - Y_k = -Y_k^*$

This contrasts with equation [6]: basically [6] and [9] have the same elements, but differences in terminology and the signs attached to the variables imply a different interpretation of the change in the stock of pollution, Y_k^*, which becomes a negative variable. If there is a positive change in the stock of pollution, we now have $Y_k^*<0$ because this represents pollution generation for which there is *no demand* for cleaning services (instead of the level of 'tolerated' emissions) and therefore reduces the stock of clean air. On the other hand if there is a negative change in the stock of pollution (i.e. if the cleaning sector eliminates some of the existing stock of pollution, or adds to the stock of clean air), we will have $Y_k^*>0$, with Y_k^* representing a positive demand for cleaning activities.

However, if we have a situation where all pollution is eliminated as it is generated (i.e. there is a demand to clean up all emissions generated in production and consumption), Y_k^* will be equal to zero, with no change in the stock of emissions, so that we have:

[10] $- a_{k,1}X_1 + \ldots\ldots - a_{k,N}X_N + (1- a_{k,k})X_k - Y_k = 0$

The next step in the reformulation of the Leontief (1970) model is to restate the price IO system, taking into account the newly defined cleaning sector. This is described by Arrous (1994), who corrects some errors in Qayum's (1991) reformulation of the physical quantity model. The key difference is that while Leontief's (1970) formulation does not attach prices to pollution generation activity, a set of

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mathematical appendix. It is assumed to be zero in the main text of his paper.

equilibrium prices can now be determined that incorporates the demand for cleaning services generated in each sector and by final demand.

Arrous (1994) defines the price IO system and the financing of the cleaning sector on the basis of each sector eliminating a fixed proportion of the pollution it creates. Luptacik & Böhm (1999) extend this analysis to explore how price determination in the reformulated model can be made consistent with the environmental standards scenario implied by Leontief's (1970) tolerated level of pollution. Another interesting analysis is offered in the earlier paper by Steenge (1978) (which provides the basis for much of the reformulation presented here), who focuses on how the 'polluter pays' principle is operationalised in the price formulation of the IO pollution model. However, we will not explore the price IO component of the reformulated Leontief pollution model in detail here. This is because our interest is empirical, and in practice IO tables are not constructed in physical quantity or price terms. Rather, the convention is to construct IO account reporting quantities in value terms, while pollution and waste generation data - where they are reported in IO format at all - will be reported in physical terms. Under these circumstances, our argument is that further reformulation of the Leontief (1970) system is required if the model is to be used in a practical context.

2.3 An extension of the reformulated Leontief pollution model for empirical applications

To summarise, the crucial limitation with Leontief's (1970) formulation is the absence of effective demand for cleaning activities. Qayum (1991), Arrous (1994) and Luptacik & Böhm (1999) overcome this by redefining the pollution generation row to give demand for cleaning services, which allows the cleaning sector to be made endogenous. However, all of the contributions to this reformulation are analytical in nature and based on an illustrative physical IO system, which is then converted to a price IO framework. In practice, though, IO tables are generally constructed in terms of quantities rather than prices and in monetary rather than physical units so that accounting identities apply. Pollution/waste generation data, on the other hand, are gathered and reported in physical units.[2] In this section we argue that bringing these components together to construct a fully integrated empirical environmental IO system will give rise to problems where there is anything but an enforced 'polluter pays' situation in the delivery of cleaning activities. To overcome this, we offer an extension to the environmental IO method that, dependent on the quality and consistency of the economic and environmental data, will permit an empirical application of the reformulated Leontief pollution model.

The key issue that affects us in attempting an empirical application of the Leontief pollution model is that the analytical development of the model has focussed on IO as a set of relationships. In an empirical context, on the other hand, we begin with IO tables that are a set of accounts describing the structure of the economy in a given year. This raises a problem that has not yet been considered in the

[2] Another issue, that we return to below, is that physical data on emissions may be gathered in terms of gross amounts generated. However, in order to endogenise cleaning activities, the data that are required

analytical reformulation of the model. Leontief (1970, p. 270) explains that identification of the input requirements for the pollution elimination sector column involves stripping these out of the input requirements recorded in other columns in the IO tables (see Tables 7 and 8 on p.268 and p.270 respectively). However, Leontief (1970) does not attempt to identify a corresponding row showing the outputs of the pollution elimination industry. Instead he introduces a row for pollution generation, which in the reformulated model is reinterpreted to give the demand for cleaning services. However, if we begin with a balanced IO table for the target economy, these demands are already incorporated in the inter-industry block of the IO table. That is to say, if it is possible to disaggregate the IO table to identify the column showing the input structure of a cleaning services sector, we should also be able to identify the corresponding row showing the intermediate and final demand for cleaning sector outputs.

However, a second problem arises in an empirical context because we are likely to be starting with a set of IO tables constructed in terms of quantities in value units, as opposed to the physical quantities converted to prices in the analytical formulation. If we are able to identify a cleaning sector, the row entries, the $x_{k,i}$ and $x_{k,z}$ for production sectors and final demand groups respectively, show *payments* to this sector for cleaning services. This is not a problem if all cleaning services are provided directly to each sector and final consumption group via a conventional market transaction and the payment equates to cost of eliminating/treating the pollution generated in that sector/consumption group. That is to say, if an enforced 'polluter pays' situation exists in the delivery of cleaning activities. However, this may not be the case. There may be some institutional (i.e. non-market) arrangement with respect to cleaning services, where government has the responsibility to clean up pollution and make a policy decision on whether all emissions are eliminated as they are generated or whether a change in the stock of pollution/clean air is permitted.

In terms of the cleaning services row in the IO table, this type of situation would imply a government payment that is greater than the demand for cleaning activity that results from government's own activity. As we will see in Section 3, in the Scottish case this manifests itself through a large entry from the Public Administration sector to the Waste Disposal sector, indirectly serving government final consumption.

Where this type of situation exists, there is a need to adjust the entries in the cleaning sector row so that pollution generation and elimination are identified, but ensuring the IO table still balances in value terms so that they can be used in IO accounting (attribution) and modelling work. This involves accounting for the following two factors:

1. What government's commitment is in terms of the provision of cleaning activities. Is all pollution (or waste) eliminated (disposed of) in the same period as it is produced - i.e. does $Y_k^* = 0$ - or is there

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should be in terms of the *net* amount of emissions excluding any emissions that are treated 'in-house' without additional input requirements for cleaning activities.

a constraint implying a positive change in the stock of pollution/waste (a negative change in the stock of clean air) and $Y_k^* < 0$?

2. If cleaning sector services include both public and private elements, with each sector/final consumption group paying for some of the cleaning activities required to eliminate the pollution/waste it generates but with some provided 'free', the existing cleaning sector row entries will not reflect the real cost of provision. Therefore, we need to amend the row to reflect the real input demand implied by the pollution/waste generated by each sector and final consumption group, adjust this through the simultaneous inclusion of an implied subsidy to reflect the public provision of cleaning services.

Once we have endogenised pollution in this way we can either treat the change in stock of pollution/clean air or the absolute output of the cleaning sector as exogenous. Put another way, if there is a combination of public and private sector activity in the provision of cleaning services, we can either treat the private sector activity as endogenous and the public sector final demand as exogenous, or make the public sector wholly endogenous.

Note that what is proposed in the second point above is similar to the treatment in Arrous (1994): in converting the physical IO table to the price IO he adds a parameter for each sector i that reflects how much of its own pollution it pays to eliminate. Arrous (1994) does not specify whether the remaining pollution is eliminated (with the required cleaning activity paid for by government) or added to the existing stock of pollution. However, the point is that with this adjustment the total cost of inputs to production in each sector i remains balanced against the value of output in each sector, i.

Formally, if we have data on the level of pollution/waste generated in each production sector, E^P_i (superscript 'P' denotes physical emissions), the cleaning sector, E^P_k, and each final consumption group, E^P_z, total emissions that are subject to collection/treatment by the cleaning sector, k, are given by[3]:

[11] $$E^P = \sum_i E^P_i + E^P_k + \sum_z E^P_z$$

The next step is to determine the row entries for the cleaning sector that reflect the demand for cleaning activities implied by the level of pollution generation in each sector. For this we need to value sectoral emissions in terms of the average price of eliminating one unit of pollution. Pollution is valued according to the total cost of delivering cleaning services in the economy, or the column total for the cleaning sector (total value of inputs used), X_k. Therefore the average price of disposing of one unit of pollution is given by:

[12] $p_{k(e)} = X_k/\alpha E^P$

where α is the proportion of total emissions (that can be collected/treated sector k) that are in fact eliminated.

We use the price determined in [12] to adjust the entries in the cleaning sector row for the two factors identified above. First, there is the issue of whether all emissions that can be collected/treated by sector k are in fact eliminated. If α=1 in [12], all treatable emissions are eliminated, i.e. $Y_k^* = 0$. However, if α<1, only a proportion of these emissions are eliminated, i.e. $Y_k^* < 0$. This is accounted for by including a negative entry for the value of change in stocks (of clean air) in the cleaning sector row, $-E^V{}_z{}^*$ (where the superscript 'V' denotes the value, or cost of eliminating emissions), equal to the amount of emissions not eliminated, $-Y_k^*$, valued at the price $p_{k(e)}$, where

[13] $E^V{}_z{}^* = (p_{k(e)}.(1-\alpha)E^P)$

Next, to find the value of treatable waste generated by each production sector i, $E^V{}_i$, and each final consumption group (excluding changes in stocks, distinguished above with an asterix), $E^P{}_z$ – i.e. the new row entries for the cleaning sector k – we apply the price of disposing of one unit of waste, $p_{k(e)}$, to the physical amount of emissions generated in each production sector, i, the cleaning sector, k, and each final consumption group, z:

[14] $E^V{}_j = p_{k(e)}.E^P{}_j \qquad \forall\ j = i = 1,\ldots,N; k; z = 1,\ldots,Z$

These row entries reflect the effective demands for cleaning services that are implied by the (net) pollution/waste generated by each sector and final demand group (and not treated 'in-house'). However, if there is some public provision of cleaning services these are not the actual costs paid to the cleaning sector: these are given by the original cleaning sector entries when we disaggregate the row and column in the IO table. In point (2) above, we explain that a further adjustment will be required to reflect public provision of cleaning services. This will take the form of a subsidy (which enters the IO table as a negative value) reported in an additional row in the primary inputs/value added block (the bottom two quadrants of the IO table). We determine the value of the implied subsidy, $S_{i(e)}$ for production sectors, $S_{k(e)}$ for the cleaning sector, and $S_{z(e)}$ for final consumption groups as the difference between payments to the waste disposal sector from the original IO table, $x_{k,i}$, $x_{k,k}$ and $x_{k,z}$ respectively, and the value of emissions generated by each production sector and final demand group. Therefore, we have:

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[3] For simplicity of exposition here we assume one type of pollution/waste and one cleaning sector; however it is straightforward to expand to more pollutants if it is possible to identify a cleaning sector

[15] $S_{j(e)} = x_{k,j} - E^{V}_{j} \quad \forall\ j = i = 1,\ldots,N;\ k;\ z = 1,\ldots,Z$

As noted above, the implied subsidy takes a negative value. That is, an implied subsidy of £50million is entered in the IO table as -£50million. Therefore, where $S_{i(e)}<0$ this means that the value of waste generated in sector i is greater than the payment made to the cleaning sector to eliminate emissions in sector i. Where $S_{i(e)}>0$ an implied tax is paid – we would expect this to occur in the government sector through which the subsidy is transmitted. For example, in the next section, where we apply this extended methodology to the case of waste generation and disposal in Scotland, we discuss how the public provision of cleaning services in Scotland appears to be delivered through the Public Administration sector. This is because Public Administration shows a large payment to our Waste Disposal sector relative to the estimated value of waste generated by Public Administration's own production activity.

3. Application of the extended Leontief pollution model for the case of waste generation and disposal in Scotland

3.1 Identification of a cleaning sector in the Scottish IO tables

We use the industry-by-industry Scottish IO tables, for the year 1999 (Scottish Executive, 2002), aggregated to the 19-sector breakdown detailed in Table 1.[4] The Scottish IO tables are presented in analytical/symmetric form with quantities valued at purchaser (basic) current prices for 128 input-output categories (IOC) which map to the 1992 UK Standard Industrial Classification (SIC). In previous analysis we have applied and developed environmental IO techniques to Scotland for the case of air pollution (see McGregor *et al*, 2001, 2003, and Ferguson *et al* 2003, 2004) using pollution output coefficients, as have McNicoll & Blackmore (1993), for a wider range of pollutants, including solid waste generation. However, to date there have been no attempts to apply the full environmental IO method detailed in Section 2 by identifying a cleaning sector(s) in order to examine the resource requirements implied by pollution generation.

As we have noted in the introduction to this paper, practical attempts to apply the full Leontief pollution model are rare. The difficulty in separating pollution abatement and other cleaning services from other transactions reported in IO tables might explain this. For example, the Scottish IO tables do not identify activities such as environmental protection services related to air, water or land pollution. Schäfer & Stahmer (1989) is a counter example. Their analysis used very detailed satellite accounting data on environmental protection expenditure collected and collated by the (then) Federal Republic of Germany.

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for each.

[4] The 19-sector breakdown shown in Table 1 has been chosen for the purpose of consistency with UK data on sectoral waste intensities.

However, their analysis focuses entirely on the economic implications of environmental protection activities, and does not relate these to physical pollution or waste generation at the aggregate or sectoral level.

Generally, the problem of separating pollution abatement and other cleaning services from other transactions reported in IO tables is an important one. One issue, identified above, is that such activities may in fact be carried out 'in-house' by the polluting firm – i.e. not involving any inter- (or intra-) sectoral transaction. If no additional input requirements can be identified for such in-house activities, any waste/pollution generation that is treated in this way should be excluded from the model (i.e. *net* rather than *gross* sectoral emissions data are required). A second issue is that, even if cleaning activities are carried out externally, the SIC classification of activities used in IO accounting may not be sufficiently detailed to allow the identification of cleaning activities. For example, as noted above, at the level of SIC breakdown of activities used in the Scottish IO tables, activities such as environmental protection services related to air, water or land pollution are not identified. In terms of waste treatment and disposal, on the other hand, four types of cleaning services *are* identified among the SIC activities incorporated in the Scottish IO tables (though these still preclude activities carried out 'in-house'):

1. SIC 84 'recycling'
2. SIC 90001 'collection and treatment of sewage'
3. SIC 90002 'collection and treatment of other [non-sewage] waste'
4. SIC 90003 'sanitation, remediation and similar activities'

However, in order to endogenise these cleaning activities, by relating them to the effective demand implied by waste generation, we need to be able to do two things:

(i) First, we need to identify each cleaning activity as a separate sector in the IO tables (i.e. with a column showing the input requirements from each production sector and primary input category and a row showing the destination of output in terms of intermediate and final demands).

(ii) Second, we need to identify the net amount of waste generated in each sector that is treated by each cleaning sector (i.e. not treated in-house).

The identification of a 'recycling' sector is precluded on both of these points. SIC 84 is part of IOC 84 in the Scottish IO tables, with the other sector being SIC 36.6 'miscellaneous manufacturing, not elsewhere identified'. At this time we do not have data to disaggregate IOC 84 to separate these activities. Moreover, in terms of point (ii), we do not have information to estimate the share of physical waste generated in each sector that is recycled (using external services).

In the case of the other three SIC-classified cleaning activities listed above, the situation is somewhat different. The Scottish IO tables identify an input-output sector that maps directly and exclusively to these three activities: IOC 119 'Sewage and refuse disposal, sanitation and similar activities', which maps to the aggregate activity SIC 90 (identified as Sector 19 in Table 1). However, in order to endogenise IOC119 as the cleaning sector, we need data on sectoral emissions/generation of all types of waste treated by these three sub-sectors of SIC 90 (the IOC 119 row only tells us about payments for these services, including public provision). However, at this time we have only been able to gather data on the type of waste that relates to activity in SIC 90002 'collection and treatment of other [non-sewage] waste'. Therefore we need to split sector IOC 119 in order to treat the activity covered under SIC 90002 as being endogenously determined by waste generation activity, but continue to treat the other, sewage/sanitation related cleaning activities as exogenous. That is to say, we attempt to split the 'Sewage and refuse disposal, sanitation and similar activities' sector into two sub-sectors, identified in Table 1 as the new sector (19) named Sewage, Sanitation etc (SIC 90001 and 90003) and an additional sector (20) named Waste Disposal (SIC 90002).

The Scottish Executive Input-Output branch estimate that in the 1999 tables 36.7% of sectoral gross output, X_i, in IOC 119, our original i=19, is directly accounted for by SIC 90002 (collection and treatment of non-sewage waste).[5] Thus, we can estimate gross sectoral output/input in our new sectors (19) and (20):

[16] $X_{(19)} = 0.643{*}X_{19}$

[17] $X_{(20)} = 0.367{*}X_{19}$

where, in line with the notation used in Section 2, we now have i=1,….,19 production sectors and k=20 as the cleaning (Waste Disposal) sector. Note that we actually have two cleaning/waste disposal sectors: the new sector (19), Sewage, Sanitation etc, is also a cleaning sector. Ideally, we would treat both new sectors (19) and (20) in the same way. However, as explained above, because there are no data on the physical outputs of waste that are cleaned by the latter, here we treat it as a standard production sector.

Equations [16] and [17] give us gross input/output in the new sectors (19) and (20). However, no data are available to make adjustments to the row and column coefficients underlying the 1999 Scottish IO table when we disaggregate IOC 119 to identify the collection and treatment of non-sewage waste as a separate sector. Therefore we assume that the average input shares implied by the column coefficients and the destination of output shares implied by the row coefficients for IOC 119 apply to all 3 sub-

[5] We are grateful to Lynn Graham, Office of the Chief Economic Adviser, Scottish Executive, for providing this estimate. We acknowledge her concerns over the reliability of this estimate and note that any inaccuracy embodied in the consequent calculations are entirely the responsibility of the authors.

sectors (SICs 90001, 90002 and 90003). That is to say, – i.e. $a_{i19} = a_{i(19)} = a_{i(20)}$ for all i, and $a_{(29)j} = 0.643a_{19j}$, $a_{(20)j} = 0.367a_{19j}$ for all j. By multiplying these by the gross sectoral input/outputs for the new sectors, $X_{(19)}$ and $X_{(20)}$, we generate the row and column entries for the Sewage, Sanitation etc (SCI 90001, 90003) and Waste Disposal (SIC 90002) sectors in the 27-sector IO table presented in Table 2. At this point we should note that, given the lack of information available, this is the simplest and most transparent assumption for separating these two sectors. However, as we explain in Section 4, some of the results indicate that this assumption may not be valid (particularly with respect to the payments implied by the row entries).

The Waste Disposal row gives us the payments made for cleaning services delivered by this sector. However, as we have argued in Section 2.3, if there is any commitment by government with respect to the provision of waste collection and treatment services, this would imply a government payment that is greater than the demand for cleaning activity that results from government's own activity. Note from Table 2 that 27% of payments along the Waste Disposal row are made by the Public Administration sector, which in turn serves a large proportion of government final consumption. Therefore, there is a need to adjust the entries in the Waste Disposal row to take account of the two factors identified in Section 3.2. First we must determine what the Scottish government's commitment to waste disposal is – i.e. whether all waste generated in the economy is collected and disposed of or whether government allows a change in the stock of waste. Second, we need to adjust the row entries to reflect the real cost of providing waste disposal services to each sector. That is to say, we need to compute equations [11] to [15] for the Scottish case. To proceed with this process the first thing we need is data on total physical waste generation in each production sector, E^P_i (where i=1,….19 in Table 2), the cleaning sector, E^P_k (k=20) and each final consumption group, E^P_z (z=1,….7). We explain the estimation of these variables for Scotland in 1999 in Section 3.2, before going on to apply our proposed extension to the reformulated Leontief pollution model (by calculating equations [12] to [15] in Section 2.3 for the Scottish case).

3.2 Estimation of physical waste generation by Scottish production sectors and final consumption groups

At this time there is no national waste survey, or any other statistical vehicle by which data are gathered on physical waste generated by SIC-classified economic activities in Scotland. Therefore we have had to estimate the amount of waste that is generated in each sector and treated by the Waste Disposal sector. This is problematic because any inaccuracy in this component of the waste IO data will impact on the validity of the results, particularly in combination with any errors resulting from the assumptions made in Section 3.1 to separately identify the Waste Disposal sector.

Where region-specific data on a given variable are not available, data from a comparable regional economy or the nation as a whole may be substituted as a proxy. In the case of sectoral waste generation for Scotland, a possible course of action, therefore, is to use information on the average waste intensity of production and final consumption estimated for UK sectors. Data on sectoral waste generation is limited at the UK level. However a dataset is available that reports 7 types of solid waste arising in 19 SIC-classified activities (see Table 1) and households in the UK during the period 1998/99[6]. Our first step, therefore, is to use these data along with information on sectoral gross input/output in each of the 19 sectors and household final expenditure from (the column totals of) the UK 1999 Supply-Use Tables SUT[7] to estimate UK average (total) waste intensities or waste-output coefficients.[8] These coefficients are shown in the first column of Table 3 and can be applied to the Scottish IO tables, aggregated to the same 19-sector breakdown to estimate sectoral waste generation, to give a Scottish waste IO framework for 1999. In the case of our additional Sewage, Sanitation etc and Waste Disposal sectors, we have taken the waste estimate for the aggregate 'Sewage and refuse disposal, sanitation and similar activities' and split this between the two sub-sectors on the basis of the output shares in equations [16] and [17].

However, using UK waste-output coefficients in this way means making the assumption that the waste intensity of economic activity in each of the 19 SIC-classified activities and by households in Scotland does not vary from the UK average. In general this assumption is unlikely to be satisfied due to differences in technology across regions (Turner 2003a,b). In this specific case, however, we are especially concerned because the weighted composition of many of the 19 SIC-classified sectors identified here varies significantly between Scotland and the UK. That is to say, while each of the 19 sectors are classified in the same way, the contribution of different activities to total sectoral output differs, often dramatically between Scotland and the rest of the UK.

Therefore we have attempted to introduce Scottish-specific information where it is possible to do so. As noted above, there is no waste survey in Scotland that gathers information on physical waste generation at the sectoral level in a format that is consistent with the SIC-classifications used to construct the economic accounts. However, Scottish-specific data are available for waste generation from agriculture and mining and quarrying activities that correspond to the first two IO sectors identified in Table 1. In the case of Sector 1, Agriculture, data from the Scottish Agricultural Census (Scottish Executive, 2001) provides information on waste generation from farming and fishing activities in 1999. Data on waste generation from the other activity included in Sector 1, forestry, is taken from the Remade Scotland (2002) report. These sources give a revised estimate of gross waste generation in

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[6] The UK dataset on sectoral waste arisings is part of the UK Environmental Accounts and can be downloaded from http://www.nationalstatistics.gov.uk/STATBASE/ssdataset.asp?vlnk=5329. We are grateful to staff at ONS for confirming the SIC-classifications of the production sectors identified in this dataset.

[7] We use a version of the UK 1999 SUT that is compatible with the Blue Book 2001 for the purpose of consistency with the Scottish 1999 IO tables (however, this version of the UK 1999 SUT is no longer available via the National Statistics web-site).

[8] We use the UK coefficients to estimate total Scottish waste, rather than Scottish production of each of the 7 types of waste identified in the UK dataset because we are unable to identify different cleaning activities for individual types of waste. However, a limited environmental IO analysis of waste generation may be carried out using the UK waste output coefficients for each waste type.

the Scottish Agricultural sector that, at just over 16million tonnes (see Table 4) is 1.1% bigger than what is estimated using the UK coefficient for this sector (see Table 3). In the case of Sector 2, Mining & Quarrying, data on the production of different types of minerals in Scotland is published by the British Geological Society (2002). We augment this with information on the average waste output from each type of minerals published by the UK Department for Environment, Food and Rural Affairs (DEFRA, 2003). These sources give a revised estimate of gross waste generation in the Scottish Mining and Quarrying sector that, at just over 14 million tonnes (see Table 4) is 6.2% bigger than what is estimated using the UK waste-output coefficient.

The other activity for which we have attempted to estimate Scottish-specific data is waste generation by households. The Scottish Environmental Protection Agency (SEPA, 2001) report that 2,888,937 tonnes of household waste went to landfill in 1999. SEPA (undated) also report that 45,116 tonnes were incinerated (with energy recovery) and 42,716 were composted in 2000. On the latter two types of treatment, we assume that these figures also apply to our base year of 1999. This gives us a figure for total household waste of 2,976, 769 (see Table 4), 35% higher than what is estimated using the UK household expenditure waste coefficient in Table 3. Note, however, that in contrast to the production sector estimates, these household estimates are of what we term *net* waste – i.e. waste that is collected and treated by the Waste Disposal sector. Since this is higher than the gross waste estimate calculated using the UK coefficient, we take our Scottish-specific estimate as total waste generated, with the implication that 100% of household waste is collected and treated by the Waste Disposal sector (see Table 4).

However, in order to endogenise the cleaning activities of the Waste Disposal sector, we must estimate how much of the gross waste generated in of the 20 production sectors is collected and treated by the Waste Disposal sector, what we refer to here as *net* waste generation. The SEPA (2001, undated) sources identified above for the estimation of net household waste also provide figures for the amount of waste that is collected and sent to landfill, incinerated and composted for four aggregate groups. These are 'commercial', 'construction and demolition', 'industrial' and 'other'. First, we assume that all the construction and demolition waste is generated in our Construction sector and allocate the 4,277,051 tonnes of waste collected from this sector to net waste generation by Sector 13 in the second column of Table 3. We designate our Sectors 3-12 (the manufacturing and utilities industries) as 'industrial' and allocate the total amount of waste treated in 1999/2000 under this category (1,674,374 tonnes) across these sectors according to the distribution of gross waste generation. (That is to say, we assume that a fixed proportion, 39%, of waste generated in these sectors is treated by the Waste Disposal sector.) Similarly, we allocate the net waste reported for the 'commercial' sources (2,003,018 tonnes) across our Sectors 14-19 (the service sectors). The remaining category, 'other', which only accounts for 58,922 tonnes, is allocated to our Sectors 1 and 2 (Agriculture and Mining & Quarrying) according to the distribution of gross waste generation across these two sectors.

The resulting estimates of net waste generation in each sector (i.e. waste that is subject to collection and disposal by the Waste Disposal sector) are shown in the second column of Table 4, and the implied net waste output coefficients are shown in the third column of Table 3. Note that the difference between gross and net waste is very large in the case of the Agriculture and Mining & Quarrying sectors. This is because in both these sectors waste is commonly treated 'in-house' (e.g. through re-use, composting etc).

3.3 Application of the proposed extension to the reformulated Leontief pollution model for the case of Scotland

The net waste generation estimates reported in Table 4 for the production sectors i=1,…..,18, (19), the cleaning sector k=(20) and for households (we have z=1,….,7 types of final demand, but the data imply that waste is only directly generated during household final consumption) allow us to calculate equation [11] for total emissions of physical waste E^P that are subject to treatment by the Waste Disposal sector. This result is given in the bottom row of Table 4: we estimate that 10,990,134 tonnes of waste that are subject to collection and treatment by the Waste Disposal sector were generated by production and final consumption activities in the Scottish economy in 1999.

The 20-sector Scottish IO table for 1999 and the sectoral waste data in Tables 2, 3 and 4 provide the basis for the type of limited environmental IO analysis previously conducted for Scotland in McNicoll & Blackmore (1993) and McGregor *et al* (2001). This would allow us to analyse the impact of different activities on the environment in terms of the physical amount of waste generated. However, in order to examine the resource requirement implied by the sectoral waste generation reported in Table 4, we have to endogenise the cleaning sector on the basis of the effective demand for waste collection and treatment services implied by physical waste generation in each sector. We do this by applying our proposed extension to the reformulated Leontief pollution model, i.e. calculating equations [12] to [15] for Scotland in 1999.

The first step is to value the sectoral waste generation in Table 4 at the average cost of disposing of one unit of waste, using equation [12]. That is, the total value of inputs used in the Waste Disposal sector, i.e. the column total for this sector in Table 2 (£347.93million), divided by the total amount of waste disposed of/treated by the Waste Disposal sector. The latter is determined by multiplying the total amount of net waste generated from Table 4 (10,990,134 tonnes) by the parameter α, representing the proportion of total waste disposed of/treated.

Therefore, before we adjust the row entries we must determine what the Scottish government's commitment is in terms of the provision of this cleaning activity in our base year of 1999. This is the first of the two factors identified in our extension of the reformulated model in Section 3.2: is all waste treated/disposed, i.e. is $Y_k^* = 0$, do we have $Y_k^* < 0$ implying that a positive change in the stock of waste allowed, or even $Y_k^* > 0$ for treatment of existing waste or waste generated through non-economic sources (e.g. cleaning up the effects of natural disasters)? Note from Table 2 that there is a small (relative to the value of total output) negative entry for the change in stocks in the Waste Disposal row (-£0.39million). A negative entry for the change in stocks implies that the sector is producing less output than is demanded so that stocks are being run down. In the Scottish IO table, this may be a balancing entry, or suggest a change in internal stocks (e.g. cleaning equipment). However, in the context of the current environmental/waste IO application developed here, this implies that the Waste Disposal sector is collecting and/or treating less waste than the total amount generated in production and consumption that is subject to the treatment by this sector. In the case of 'collection and treatment of non-sewage waste' activity carried out by this sector (SIC 90002), this could be interpreted as a positive change in the amount of landfill created (i.e. waste that is collected but not treated). On the other hand, it could be interpreted as a constraint on the amount of waste collection and treatment that the government is prepared to provide (i.e. no more landfill is available/permitted and no other treatment option is considered economically viable).

In short, in the context of the current waste IO application, the negative stock entry in the Waste Disposal row of Table 2 implies the existence of some constraint that means not all waste generated is collected and/or treated. Taking the value of the reduction in stocks as a share of the value of total output, this implies that the parameter α takes a value of 0.999, i.e. 99.9% of waste generated is collected and/or treated. In terms of equation [12] this means that the denominator, αE^P takes the value of 10,978,723, and the average cost/price of disposing of/treating one tonne of waste, $p_{k(e)}$, is £34.15.

Next we use $p_{k(e)}$ in equation [13] to compute the value of the waste that is not eliminated: £0.39million (11,412 tonnes valued at £34.15 per tonne). This enters our adjusted Waste Disposal row in Table 5 as a negative value (and is identical to the one recorded in Table 2).

However, the values of all the other entries in the Waste Disposal row are expected to change because we are adjusting them to reflect the effective demand implied by sectoral waste *generation*. We use equation [14] to determine the Waste Disposal row entries for each production sector, i, the Waste Disposal sector, k, and households respectively, by multiplying the physical waste generation figures in Table 4 by the average price of Waste Disposal, $p_{k(e)}$ = £34.15, determined in [12]. The new row entries reflecting the effective demand for the cleaning services of the Waste Disposal sector are highlighted in Table 5.

In the presence of a fully enforced 'polluter pays' situation the effective demands in the Waste Disposal row of Table 5 should be equal to the value of payments to the Waste Disposal sector in Table 2. However, because there is public provision of waste disposal and treatment services in Scotland the row entries in Table 5 are not the actual costs paid to the cleaning sector: these are given by the original cleaning sector entries in Table 2. Therefore a further adjustment is required to reflect public provision of waste collection and treatment services (made through the Public Administration, Health and Education sector). This takes the form of an implied subsidy that enters the adjusted IO table in Table 5 as a negative value reported in an additional row in the primary inputs/value added block. We determine the value of the subsidy, $S_{i(e)}$ for production sectors, $S_{k(e)}$ for the Waste Disposal sector, and $S_{z(e)}$ for final consumption groups using equation [15] – i.e. the difference between payments to the waste disposal sector in Table 2 and the value of emissions generated by each production sector and final demand group from [14].

3.4 Data problems

However, while we argue that this is the correct method of adjusting the IO table in order to endogenise the cleaning sector in the absence of a fully enforced 'polluter pays' situation in the delivery of cleaning services, the results in Table 5 suggest data problems in the Scottish case. Note the entries in this row for a number of production sectors and final demand groups take positive values. We would only expect this to be the case for the Public Administration, Health and Education sector, i.e. the sector through which the public provision of cleaning services is made. For all other sectors and final demand groups we would expect to observe negative entries in this row. A positive entry in this row is effectively a tax, implying that some sectors are subsidising others by paying more for Waste Disposal services than the value of their waste generation. This violates the IO assumption of constant average prices.

We think that this problem is an empirical one resulting from one or both of the two main data problems we have encountered in constructed the waste IO system for Scotland. First, in Section 3.1 we explain that, in the absence of better information, we assume that the row coefficients for the aggregate 'Sewage and refuse disposal, sanitation and similar activities' sector are applied with a fixed constant ratio to both of the sub-sectors, Waste Disposal and Sewage, Sanitation etc. This may not be a valid assumption, and any inaccuracy in the row entries for the Waste Disposal sector will affect the computation of equation [15]. We have made attempts to adjust the composition of the Waste Disposal and Sewage, Sanitation etc sectors to overcome this problem. However, so far these have been unsuccessful, and we are concerned about introducing additional assumptions that are more *ad hoc* than the very simple one we have made in assuming that the row coefficients are constant across the two sectors.

The second problem is outlined in Section 3.2, where we explain that we have had to estimate net physical waste generation for each production and final demand sector for the Scottish case. There are really two problems here. First, we have had to make the assumption that the average *gross* waste intensity of activity in each of the 19 (20) SIC-classified production sectors is the same in Scotland as in the equivalent UK sector (and similarly for households). Second, we have had to estimate the *net* waste generation (i.e. subject to collection/treatment by the Waste Disposal sector) for each Scottish sector according to shares in total waste that are treated in different ways. It is not possible to assess the accuracy of our results at the sectoral level. However, any inaccuracy will affect the computation of all the equations, [11] to [15] in our extension of the Leontief pollution model.

A third possibility may arise from the fact that the IO data for Waste Disposal and other cleaning activities encompass both private and public sector activities. However, if there is a division of private and public sector provision of these services that differs across sectors, this may in fact cause prices to vary from the average that we assume in the IO framework.

4. Illustrative results from the Scottish (1999) Waste IO System

Given the problems outlined above, the results of any analysis based on the actual accounts constructed here will be subject to inaccuracies. However, we can use the Scottish (1999) waste IO system to carry out some basic multiplier and impact analyses that illustrate the importance of how the cleaning services sector is treated within the IO framework.

The crucial thing that we have done is to endogenise the public provision of Waste Disposal activities. If we were to take the payments to Waste Disposal as the demand for waste collection and treatment services, a large share of total demand (27.5%) would be accounted for by the Public Administration, Health and Education sector. This sector directly accounts for 97% of gross government final consumption and 70% of its output goes directly to government consumption. Therefore, if government final demand were to increase, demand for waste disposal would also increase, without being tied to waste generation activity in the economy. For example in Table 6 we show the results of a 10% increase in exogenous government expenditure (in line with the initial distribution of government final consumption). The Type II results of the demand shock (i.e. including direct, indirect and induced effects) using the unadjusted IO table (Table 2) are reported as Case A. Note that while net waste generation rises by only 2.18% at the aggregate level, activity in the Waste Disposal sector increases by 4.29%. This implies that government is running down any existing stocks of waste.

This result arises from the fact that in this first simulation based on Table 2 we are treating all government expenditure as exogenous. However, if we repeat this simulation using the adjusted IO table (Table 5), government expenditure on waste disposal services is made endogenous (while all other government expenditures are held exogenous). This is because the row coefficients in the **A**-matrix for the Waste Disposal sector reflect the effective demand for cleaning services implied by sectoral waste generation activity rather than payments to this sector. This adjustment means that government expenditure on waste disposal responds to the change in waste generation activity in the economy as a result of the exogenous demand shock, rather than to the change in government expenditure itself. For example, if we repeat the simulation above - reported as Case B in Table 6 –the increase in activity in the Waste Disposal sector of only 2.17%. (The change in X_k is slightly greater than the increase in waste generation, X_e, because not all waste generation is collected and/or treated by the Waste Disposal sector, i.e. $Y^*_e<0$.) This is because we have now linked output in the Waste Disposal sector directly to physical waste generation in each sector and final consumption group.

The results in Table 6 are explained by examining the output-multipliers in the Leontief inverses for Tables 2 and 5, specifically the row of the inverse that shows the output generated in the Waste Disposal sector per £1million of final demand for the outputs of each of the other sectors. Table 7 shows this row (transposed) for Type I and II cases, for the standard IO (Table 2) and our adjusted IO (Table 5). For clarity we have converted the multiplier values from units of £1million to units of £1 of Waste Disposal services required per £1million final demand in each of the 20 sectors of the IO table. Note that, in moving from the unadjusted to the adjusted IO table in both the Type I and II cases, the amount of Waste Disposal output required rises in the case of the more waste intensive sectors. The opposite is true in the case of sectors with a relatively low waste intensity (the direct net waste intensity of each sector is shown in the last column of Table 3). However, the key thing to note is the dramatic reduction in the size of the Waste Disposal output multiplier in the case of the Public Administration, Health and Education sector when we adjust to take account of the public provision of waste treatment and disposal services.

5. Summary and conclusions

In this paper we have proposed an extension to the reformulated Leontief pollution model for empirical applications where IO tables are constructed in terms of quantities rather than prices and in values rather than physical units, and where there is some public element in the provision of cleaning services. We then apply this extension to the case of waste generation in Scotland (for the year 1999) and carry out some impact and multiplier analyses to demonstrate the importance of how cleaning services are treated in an empirical IO framework.

However, our results suggest that, if there is a need for this type of framework to examine the resource requirements implied by pollution/waste generation in different sectors of the Scottish economy, two important data issues must be addressed.

First, more detailed IO data are required to identify cleaning sectors. In the case of waste generation, this is more straightforward than the air pollution case that is more commonly the focus of environmental IO analysis, due to the fact that solid waste collection and treatment is defined as a distinct activity under the Standard Industrial Classification (SIC) system. However, in the UK and Scottish IO classification of activities (IOC), this is incorporated with other waste collection and treatment activities (sewage and sanitation) in the aggregate IOC 119 sector. Either physical waste data need to be made available to endogenise this aggregate cleaning sector, or IO construction should focus on separating solid waste/refuse collection and treatment from the other cleaning activities.

In terms of physical waste data, a second problem exists. This is that information on gross waste generation by production and final consumption activities, and, more importantly, on net waste generation/waste collection and treatment is not currently gathered or reported in a format that is consistent with the SIC system used in IO accounting. This second problem also applies to the construction of the more widespread limited environmental IO method, where the environmental component of the framework is limited to a set of pollution (or waste) output coefficients in order to examine the impact of the economy on the environment. Our motivation for extending this approach to also endogenise cleaning activities is that this allows us to track the feedback from the environment to the economy, in terms of the resource use implied by pollution/waste generation in different sectors of the economy. The implications of this for policy issues such as green accounting are explored in Allan *et al* (2004).

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Table 1. Production Sectors/Activities Identified in the Scottish Waste IO Tables, 1999

Sector	SIC (1992) codes	Scottish IO categories
1 Agriculture	1-5.02	1-3.2
2 Mining and quarrying	10-14	4-7
3 Food, drink and tobacco	15.1-16	8-20
4 Textiles and clothing etc	17.1-19.3	21-30
5 Paper and printing	21.2-22	32-34
6 Chemicals	24.11-24.6	36-45
7 Non-metallic mineral products	24.7-26.8	46-53
8 Metal Products	27.1-28.7	54-61
9 Machinery and equipment	29.1-33	62-76
10 Transport equipment	34-35.3	77-80
11 Other manufacturing	36.1-37, 20	81-84, 31
12 Electricity, gas and water supply, coke and petrol products	40.1-41, 23	85-87, 35
13 Construction	45	88
14 Wholesale and retail	50-52	89-91
15 Hotels, catering, pubs etc	55	92
16 Transport and communications	60.1-64.2	93-99
17 Finance and other services	65.11-74.8, 91-93, 95	100.1-114, 120-123
18 Public administration, health & education	75, 80, 85.1-85.3	115-118
19 Sewage, sanitation and refuse disposal	90	119
(19) Sewage, sanitation etc	90001, 90003	part of 119
(20) Waste disposal	90002	part of 119

Table 2. The Scottish Industry-by-Industry (20x20) IO Table for 1999, £ million (part 1)

	1. Agriculture	2. Mining and Quarrying	3. Food, drink and tobacco	4. Textiles and clothing	5. Paper and printing	6. Chemicals	7. Non-metallic mineral products	8. Metal products	9. Machinery and equipment	10. Transport equipment	11. Other manufacturing	12. Electricity, Gas and water supply, coke and petrol product	13. Construction	14. Wholesale and retail	15. Hotels, catering, pubs, etc	16. Transport and communications	17. Finance and other services
1. Agriculture	411.58	2.75	980.53	0.32	6.03	2.32	1.11	1.01	1.82	0.57	21.89	2.47	34.22	80.91	150.30	6.93	36.95
2. Mining and Quarrying	1.88	58.18	6.35	1.19	7.44	6.91	14.40	4.98	5.51	2.47	1.41	379.96	176.01	16.41	1.22	14.58	41.58
3. Food, drink and tobacco	170.91	0.09	290.92	0.40	4.38	1.12	0.28	0.31	0.77	0.04	0.30	5.13	54.72	216.01	213.45	12.86	200.13
4. Textiles and clothing	23.19	0.00	0.19	23.77	1.10	0.01	2.66	0.00	0.09	0.26	0.20	1.02	11.60	23.08	10.20	1.83	81.09
5. Paper and printing	4.17	0.20	115.10	1.83	98.87	1.90	3.00	2.55	9.85	0.75	3.89	18.35	19.88	56.97	7.94	41.31	509.09
6. Chemicals	35.26	10.48	7.61	2.37	10.62	115.09	7.54	4.03	15.85	2.51	6.20	36.65	80.06	11.55	1.24	5.74	61.49
7. Non-metallic mineral products	24.70	1.63	152.19	0.72	3.49	0.83	14.05	1.67	14.12	16.78	9.24	2.21	197.51	39.66	2.18	49.63	84.49
8. Metal products	3.66	26.35	40.57	0.19	2.45	2.68	5.87	121.15	235.91	57.62	15.02	21.93	205.05	19.32	0.74	7.67	14.57
9. Machinery and equipment	29.17	10.72	33.22	1.68	10.40	9.41	6.33	19.09	326.15	62.66	6.62	59.31	182.70	24.17	0.34	44.16	65.49
10. Transport equipment	37.65	2.89	3.42	0.12	0.97	0.58	0.50	0.95	4.79	291.17	4.01	2.19	76.19	3.86	0.46	67.92	37.81
11. Other manufacturing	13.25	0.10	2.57	0.34	51.82	0.35	2.58	2.70	1.64	0.83	74.51	1.92	203.89	9.02	4.80	3.96	39.57
12. Electricity, Gas and water supply, coke and petrol product	75.21	21.85	89.98	14.26	38.48	83.30	41.80	37.59	85.25	10.01	17.59	1033.20	43.95	252.54	105.66	142.17	470.17
13. Construction	83.62	113.55	13.71	2.14	2.33	10.03	2.31	19.48	15.04	1.69	3.59	218.04	1574.10	185.50	75.45	110.52	1403.80
14. Wholesale and retail	137.97	55.33	191.51	26.78	53.75	73.55	35.47	64.97	456.07	47.88	30.23	172.54	185.30	177.67	62.91	299.97	242.96
15. Hotels, catering, pubs, etc	5.13	5.90	5.47	2.64	2.77	4.49	1.86	6.82	15.83	2.44	2.42	32.22	0.00	4.92	0.00	6.88	25.39
16. Transport and communications	132.97	298.58	128.73	15.00	48.79	84.70	21.49	33.01	115.55	22.22	28.00	141.17	94.61	307.86	17.25	2381.95	1613.65
17. Finance and other services	227.89	785.53	473.99	56.35	114.28	159.27	45.53	153.80	329.41	178.13	76.73	612.94	2401.05	725.34	112.16	1517.25	4932.01
18. Public administration, health, education	29.38	3.28	7.51	2.53	3.45	8.32	1.73	4.73	15.34	6.23	1.94	44.44	13.97	6.91	1.45	50.59	150.10
19 Sewage, sanitation etc	1.17	4.33	30.53	5.04	12.86	18.15	2.86	6.90	9.32	3.94	6.61	50.42	1.32	12.50	2.75	30.91	36.19
20. Waste disposal	0.68	2.51	17.70	2.92	7.45	10.52	1.66	4.00	5.41	2.29	3.83	29.23	0.77	7.25	1.59	17.92	20.98
Total Intermediate Inputs	1449.45	1404.29	2591.78	160.57	481.73	593.53	213.02	489.75	1663.71	710.49	314.24	2865.35	5556.90	2181.44	772.11	4814.76	10067.48
Imports from Rest of UK	524.73	86.92	1133.22	430.90	582.54	700.40	462.19	716.67	3143.23	408.46	165.41	1069.92	1025.68	1405.76	309.83	1159.53	3093.57
Imports from Rest of World	294.42	39.35	359.07	149.17	349.28	427.83	284.59	207.85	5187.71	191.08	186.23	104.32	205.62	294.94	148.16	234.60	231.85
Net production and commodity taxes	120.10	75.92	55.53	44.86	87.05	107.33	66.70	94.39	550.52	54.74	37.36	317.02	332.18	601.97	151.76	532.52	927.74
Income from employment	566.41	702.08	1050.51	444.52	729.03	549.01	509.80	852.56	2184.23	617.10	321.25	632.88	2462.55	4330.03	1241.90	3493.99	7695.65
Other value added	618.78	596.29	850.15	116.22	308.42	590.05	243.02	158.85	1495.10	324.76	101.29	1093.29	523.85	3337.30	564.41	1220.79	8662.25
Total Primary Inputs	2124.44	1500.57	3448.47	1185.68	2056.32	2374.62	1566.30	2030.32	12560.78	1596.15	811.54	3217.43	4549.87	9970.00	2416.06	6641.43	20611.06
Total Gross Inputs	3573.89	2904.86	6040.25	1346.25	2538.05	2968.15	1779.32	2520.07	14224.49	2306.64	1125.77	6082.78	10106.78	12151.44	3188.17	11456.19	30678.54

Source: Scottish Executive (2002), FAI calculations

	18. Public administration, health, education	19 Sewage, sanitation etc	20. Waste disposal	Total Intermediate Demand	Households	Tourist Exp	GGFC	GDFCF	Change in inventories	RUK	RoW	Total Final Demand	Total Demand for Products
1. Agriculture	10.95	0.09	0.05	1752.79	109.56	10.77	1.27	87.02	29.94	856.01	726.55	1821.10	3573.89
2. Mining and Quarrying	16.08	0.60	0.35	757.53	16.01	4.82	0.00	22.94	-38.50	802.42	1339.64	2147.32	2904.86
3. Food, drink and tobacco	34.05	0.40	0.23	1206.50	554.24	63.37	0.00	0.04	-9.40	1883.84	2341.66	4833.75	6040.25
4. Textiles and clothing	35.40	0.37	0.22	216.29	50.51	34.83	0.00	0.00	46.56	504.84	493.22	1129.96	1346.25
5. Paper and printing	188.74	2.95	1.71	1089.03	85.36	8.45	0.00	13.95	14.82	862.34	464.10	1449.03	2538.05
6. Chemicals	140.70	3.47	2.01	560.47	12.63	16.54	0.00	0.05	-38.02	1012.70	1403.77	2407.68	2968.15
7. Non-metallic mineral products	40.90	2.33	1.35	659.68	10.03	27.79	0.00	24.97	0.53	550.28	506.04	1119.65	1779.32
8. Metal products	6.20	0.37	0.21	787.53	7.03	0.86	0.00	53.97	25.39	1045.54	599.75	1732.53	2520.07
9. Machinery and equipment	128.71	0.97	0.56	1021.88	48.04	10.17	0.00	179.58	5.50	2811.01	10148.31	13202.62	14224.49
10. Transport equipment	10.30	0.35	0.20	546.33	72.62	1.69	0.00	27.73	-92.67	1095.16	655.79	1760.32	2306.64
11. Other manufacturing	20.15	0.13	0.07	434.20	42.04	14.56	0.00	45.14	17.64	276.85	295.34	691.57	1125.77
12. Electricity, Gas and water supply, coke and petrol product	251.26	32.15	18.64	2865.05	1392.32	19.15	0.00	0.00	-3.71	1809.43	0.54	3217.73	6082.78
13. Construction	583.90	43.95	25.48	4488.24	280.44	10.78	0.00	5032.75	118.74	160.31	15.53	5618.54	10106.78
14. Wholesale and retail	268.49	1.29	0.75	2585.42	8114.50	118.69	2.96	297.86	-2.52	510.68	523.84	9566.02	12151.44
15. Hotels, catering, pubs, etc	71.08	0.00	0.00	196.26	1552.64	1165.61	0.00	1.48	-0.49	272.67	0.00	2991.91	3188.17
16. Transport and communications	354.83	10.54	6.11	5857.02	1321.82	207.25	0.28	53.15	0.83	3213.17	802.68	5599.17	11456.19
17. Finance and other services	1817.04	105.45	61.14	14885.30	7816.77	241.79	418.61	567.81	88.21	4935.15	1724.89	15793.24	30678.54
18. Public administration, health, education	4256.99	0.46	0.27	4609.62	2316.15	53.53	17556.33	54.73	1.11	447.41	188.49	20617.75	25227.36
19 Sewage, sanitation etc	177.63	0.04	0.02	413.50	226.28	2.87	0.00	4.03	-0.67	0.21	0.47	233.18	646.68
20. Waste disposal	102.99	0.02	0.01	239.74	131.19	1.66	0.00	2.34	-0.39	0.12	0.27	135.19	374.93
Total Intermediate Inputs	8516.39	205.96	119.41	45172.37	24160.19	2015.18	17979.46	6469.53	162.89	23050.13	22230.88	96068.26	141240.63
Imports from Rest of UK	2430.64	9.29	5.39	18864.28	9784.07	908.79	0.00	2662.58	54.87	0.00	0.00	13410.30	32274.58
Imports from Rest of World	833.32	1.16	0.67	9731.23	7227.11	249.00	0.00	1488.04	13.02	0.00	0.00	8977.16	18708.39
Net production and commodity taxes	592.48	62.45	36.21	4848.83	2941.21	225.34	83.04	572.25	5.29	1098.40	295.51	5221.03	10069.87
Income from employment	11760.35	171.64	99.51	40415.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40415.00
Other value added	1094.18	196.19	113.75	22208.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22208.93
Total Primary Inputs	16710.97	440.73	255.53	96068.26	19952.39	1383.12	83.04	4722.87	73.17	1098.40	295.51	27608.50	123676.76
Total Gross Inputs	25227.36	646.68	374.93	141240.63	44112.58	3398.30	18062.50	11192.40	236.06	24148.53	22526.39	123676.76	264917.39

Source: Scottish Executive (2002), FAI calculations

Table 3. Direct waste intensity of production and final consumption activities, Scotland 1999

Sector/Activity	**Tonnes gross waste per £1million output/expenditure** (UK waste-output coefficients)	**Tonnes gross waste per £1million output/expenditure** (Partly Scottish-specific waste-output coefficients)	**Tonnes net waste (treated by the Waste Disposal sector) per £1million output/expenditure** (Partly Scottish-specific waste-output coefficients)
1 Agriculture*	4,429.74	4,479.51	8.77
2 Mining and quarrying*	4,568.02	4,853.14	9.50
3 Food, drink and tobacco	145.11	145.11	56.33
4 Textiles and clothing etc	72.91	72.91	28.30
5 Paper and printing	116.33	116.33	45.16
6 Chemicals	132.93	132.93	51.60
7 Non-metallic mineral products	141.37	141.37	54.88
8 Metal Products	318.82	318.82	123.77
9 Machinery and equipment	36.20	36.20	14.05
10 Transport equipment	47.40	47.40	18.40
11 Other manufacturing	138.13	138.13	53.62
12 Electricity, gas and water supply, coke and petrol products	133.80	133.80	51.94
13 Construction	711.40	711.40	423.19
14 Wholesale and retail	55.05	55.05	25.95
15 Hotels, catering, pubs etc	98.02	98.02	46.21
16 Transport and communications	181.16	181.16	85.40
17 Finance and other services	20.38	20.38	9.61
18 Public administration, health & education	18.29	18.29	8.62
19 Sewage, sanitation and refuse disposal	103.20	103.20	48.65
(19) Sewage, sanitation etc	103.20	103.20	48.65
(20) Waste disposal	103.20	103.20	48.65
Houshold final consumption expenditure*	49.99	67.48	67.48

Sources: See Section 3.2

Table 4. Estimated sectoral waste generation (tonnes) in Scotland, 1999

Sector/Activity		Gross waste generation (tonnes)	Net waste generation (tonnes)
1	Agriculture*	16,009,266	31,332
2	Mining and quarrying*	14,097,667	27,590
3	Food, drink and tobacco	876,495	340,258
4	Textiles and clothing etc	98,157	38,105
5	Paper and printing	295,262	114,621
6	Chemicals	394,560	153,169
7	Non-metallic mineral products	251,534	97,646
8	Metal Products	803,446	311,900
9	Machinery and equipment	514,953	199,906
10	Transport equipment	109,345	42,448
11	Other manufacturing	155,505	60,367
12	Electricity, gas and water supply, coke and petrol products	813,890	315,954
13	Construction	7,189,934	4,277,051
14	Wholesale and retail	668,888	315,327
15	Hotels, catering, pubs etc	312,512	147,324
16	Transport and communications	2,075,385	978,377
17	Finance and other services	625,269	294,764
18	Public administration, health & education	461,422	217,523
19	Sewage, sanitation and refuse disposal	105,430	49,702
(19)	Sewage, sanitation etc	66,737	31,461
(20)	Waste disposal	38,693	18,241
	Houshold final consumption expenditure*	2,976,769	2,976,769
	TOTAL WASTE GENERATION	48,835,690	10,990,134

Sources: See Section 3.2

Table 5. The Scottish Industry-by-Industry (20x20) Waste IO Table for 1999, £ million (part 1)

	1. Agriculture	2. Mining and Quarrying	3. Food, drink and tobacco	4. Textiles and clothing	5. Paper and printing	6. Chemicals	7. Non-metallic mineral products	8. Metal products	9. Machinery and equipment	10. Transport equipment	11. Other manufacturing	12. Electricity, Gas and water supply, coke and petrol product	13. Construction	14. Wholesale and retail	15. Hotels, catering, pubs, etc	16. Transport and communications	17. Finance and other services
1. Agriculture	411.58	2.75	980.53	0.32	6.03	2.32	1.11	1.01	1.82	0.57	21.89	2.47	34.22	80.91	150.30	6.93	36.95
2. Mining and Quarrying	1.88	58.18	6.35	1.19	7.44	6.91	14.40	4.98	5.51	2.47	1.41	379.96	176.01	16.41	1.22	14.58	41.58
3. Food, drink and tobacco	170.91	0.09	290.92	0.40	4.38	1.12	0.28	0.31	0.77	0.04	0.30	5.13	54.72	216.01	213.45	12.86	200.13
4. Textiles and clothing	23.19	0.00	0.19	23.77	1.10	0.01	2.66	0.00	0.09	0.26	0.20	1.02	11.60	23.08	10.20	1.83	81.09
5. Paper and printing	4.17	0.20	115.10	1.83	98.87	1.90	3.00	2.55	9.85	0.75	3.89	18.35	19.88	56.97	7.94	41.31	509.09
6. Chemicals	35.26	10.48	7.61	2.37	10.62	115.09	7.54	4.03	15.85	2.51	6.20	36.65	80.06	11.55	1.24	5.74	61.49
7. Non-metallic mineral products	24.70	1.63	152.19	0.72	3.49	0.83	14.05	1.67	14.12	16.78	9.24	2.21	197.51	39.66	2.18	49.63	84.49
8. Metal products	3.66	26.35	40.57	0.19	2.45	2.68	5.87	121.15	235.91	57.62	15.02	21.93	205.05	19.32	0.74	7.67	14.57
9. Machinery and equipment	29.17	10.72	33.22	1.68	10.40	9.41	6.33	19.09	326.15	62.66	6.62	59.31	182.70	24.17	0.34	44.16	65.49
10. Transport equipment	37.65	2.89	3.42	0.12	0.97	0.58	0.50	0.95	4.79	291.17	4.01	2.19	76.19	3.86	0.46	67.92	37.81
11. Other manufacturing	13.25	0.10	2.57	0.34	51.82	0.35	2.58	2.70	1.64	0.83	74.51	1.92	203.89	9.02	4.80	3.96	39.57
12. Electricity, Gas and water supply, coke and petrol product	75.21	21.85	89.98	14.26	38.48	83.30	41.80	37.59	85.25	10.01	17.59	1033.20	43.95	252.54	105.66	142.17	470.17
13. Construction	83.62	113.55	13.71	2.14	2.33	10.03	2.31	19.48	15.04	1.69	3.59	218.04	1574.10	185.50	75.45	110.52	1403.80
14. Wholesale and retail	137.97	55.33	191.51	26.78	53.75	73.55	35.47	64.97	456.07	47.88	30.23	172.54	185.30	177.67	62.91	299.97	242.96
15. Hotels, catering, pubs, etc	5.13	5.90	5.47	2.64	2.77	4.49	1.86	6.82	15.83	2.44	2.42	32.22	0.00	4.92	0.00	6.88	25.39
16. Transport and communications	132.97	298.58	128.73	15.00	48.79	84.70	21.49	33.01	115.55	22.22	28.00	141.17	94.61	307.86	17.25	2381.95	1613.65
17. Finance and other services	227.89	785.53	473.99	56.35	114.28	159.27	45.53	153.80	329.41	178.13	76.73	612.94	2401.05	725.34	112.16	1517.25	4932.01
18. Public administration, health, education	29.38	3.28	7.51	2.53	3.45	8.32	1.73	4.73	15.34	6.23	1.94	44.44	13.97	6.91	1.45	50.59	150.10
19 Sewage, sanitation etc	1.17	4.33	30.53	5.04	12.86	18.15	2.86	6.90	9.32	3.94	6.61	50.42	1.32	12.50	2.75	30.91	36.19
20. Waste disposal	1.07	0.94	11.62	1.30	3.91	5.23	3.33	10.65	6.83	1.45	2.06	10.79	146.07	10.77	5.03	33.41	10.07
Total Intermediate Inputs	1449.85	1402.72	2585.70	158.95	478.19	588.24	214.70	496.40	1665.13	709.66	312.46	2846.91	5702.20	2184.96	775.54	4830.25	10056.56
Imports from Rest of UK	524.73	86.92	1133.22	430.90	582.54	700.40	462.19	716.67	3143.23	408.46	165.41	1069.92	1025.68	1405.76	309.83	1159.53	3093.57
Imports from Rest of World	294.42	39.35	359.07	149.17	349.28	427.83	284.59	207.85	5187.71	191.08	186.23	104.32	205.62	294.94	148.16	234.60	231.85
Net production and commodity taxes	120.10	75.92	55.53	44.86	87.05	107.33	66.70	94.39	550.52	54.74	37.36	317.02	332.18	601.97	151.76	532.52	927.74
Additional payment for waste collection, treatment and disposal	-0.39	1.57	6.08	1.62	3.54	5.29	-1.68	-6.65	-1.42	0.84	1.77	18.44	-145.30	-3.52	-3.44	-15.49	10.92
Income from employment	566.41	702.08	1050.51	444.52	729.03	549.01	509.80	852.56	2184.23	617.10	321.25	632.88	2462.55	4330.03	1241.90	3493.99	7695.65
Other value added	618.78	596.29	850.15	116.22	308.42	590.05	243.02	158.85	1495.10	324.76	101.29	1093.29	523.85	3337.30	564.41	1220.79	8662.25
Total Primary Inputs	2124.04	1502.14	3454.55	1187.30	2059.86	2379.91	1564.62	2023.67	12559.36	1596.98	813.31	3235.87	4404.57	9966.48	2412.63	6625.94	20621.97
Total Gross Inputs	3573.89	2904.86	6040.25	1346.25	2538.05	2968.15	1779.32	2520.07	14224.49	2306.64	1125.77	6082.78	10106.78	12151.44	3188.17	11456.19	30678.54

Source: Scottish Executive (2002), FAI calculations

Table 5. The Scottish Industry-by-Industry (20x20) Waste IO Table for 1999, £ million

	18. Public administration, health, education	19 Sewage, sanitation etc	20. Waste disposal	Total Intermediate Demand	Households	Tourist Exp	GGFC	GDFCF	Change in inventories	RUK	RoW	Total Final Demand	Total Demand for Products
1. Agriculture	10.95	0.09	0.05	1752.79	109.56	10.77	1.27	87.02	29.94	856.01	726.55	1821.10	3573.89
2. Mining and Quarrying	16.08	0.60	0.35	757.53	16.01	4.82	0.00	22.94	-38.50	802.42	1339.64	2147.32	2904.86
3. Food, drink and tobacco	34.05	0.40	0.23	1206.50	554.24	63.37	0.00	0.04	-9.40	1883.84	2341.66	4833.75	6040.25
4. Textiles and clothing	35.40	0.37	0.22	216.29	50.51	34.83	0.00	0.00	46.56	504.84	493.22	1129.96	1346.25
5. Paper and printing	188.74	2.95	1.71	1089.03	85.36	8.45	0.00	13.95	14.82	862.34	464.10	1449.03	2538.05
6. Chemicals	140.70	3.47	2.01	560.47	12.63	16.54	0.00	0.05	-38.02	1012.70	1403.77	2407.68	2968.15
7. Non-metallic mineral products	40.90	2.33	1.35	659.68	10.03	27.79	0.00	24.97	0.53	550.28	506.04	1119.65	1779.32
8. Metal products	6.20	0.37	0.21	787.53	7.03	0.86	0.00	53.97	25.39	1045.54	599.75	1732.53	2520.07
9. Machinery and equipment	128.71	0.97	0.56	1021.88	48.04	10.17	0.00	179.58	5.50	2811.01	10148.31	13202.62	14224.49
10. Transport equipment	10.30	0.35	0.20	546.33	72.62	1.69	0.00	27.73	-92.67	1095.16	655.79	1760.32	2306.64
11. Other manufacturing	20.15	0.13	0.07	434.20	42.04	14.56	0.00	45.14	17.64	276.85	295.34	691.57	1125.77
12. Electricity, Gas and water supply, coke and petrol product	251.26	32.15	18.64	2865.05	1392.32	19.15	0.00	0.00	-3.71	1809.43	0.54	3217.73	6082.78
13. Construction	583.90	43.95	25.48	4488.24	280.44	10.78	0.00	5032.75	118.74	160.31	15.53	5618.54	10106.78
14. Wholesale and retail	268.49	1.29	0.75	2585.42	8114.50	118.69	2.96	297.86	-2.52	510.68	523.84	9566.02	12151.44
15. Hotels, catering, pubs, etc	71.08	0.00	0.00	196.26	1552.64	1165.61	0.00	1.48	-0.49	272.67	0.00	2991.91	3188.17
16. Transport and communications	354.83	10.54	6.11	5857.02	1321.82	207.25	0.28	53.15	0.83	3213.17	802.68	5599.17	11456.19
17. Finance and other services	1817.04	105.45	61.14	14885.30	7816.77	241.79	418.61	567.81	88.21	4935.15	1724.89	15793.24	30678.54
18. Public administration, health, education	4256.99	0.46	0.27	4609.62	2316.15	53.53	17556.33	54.73	1.11	447.41	188.49	20617.75	25227.36
19 Sewage, sanitation etc	177.63	0.04	0.02	413.50	226.28	2.87	0.00	4.03	-0.67	0.21	0.47	233.18	646.68
20. Waste disposal	7.43	1.07	0.62	273.66	101.66	0.00	0.00	0.00	-0.39	0.00	0.00	101.27	374.93
Total Intermediate Inputs	8420.83	207.01	120.02	45206.29	24130.65	2013.52	17979.46	6467.19	162.89	23050.01	22230.61	96034.34	141240.63
Imports from Rest of UK	2430.64	9.29	5.39	18864.28	9784.07	908.79	0.00	2662.58	54.87	0.00	0.00	13410.30	32274.58
Imports from Rest of World	833.32	1.16	0.67	9731.23	7227.11	249.00	0.00	1488.04	13.02	0.00	0.00	8977.16	18708.39
Net production and commodity taxes	592.48	62.45	36.21	4848.83	2941.21	225.34	83.04	572.25	5.29	1098.40	295.51	5221.03	10069.87
Additional payment for waste collection, treatment and disposal	95.56	-1.05	-0.61	-33.92	29.53	1.66	0.00	2.34	0.00	0.12	0.27	33.92	0.00
Income from employment	11760.35	171.64	99.51	40415.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40415.00
Other value added	1094.18	196.19	113.75	22208.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22208.93
Total Primary Inputs	16806.53	439.68	254.92	96034.34	19981.93	1384.78	83.04	4725.21	73.17	1098.52	295.78	27642.43	123676.76
Total Gross Inputs	25227.36	646.68	374.93	141240.63	44112.58	3398.30	18062.50	11192.40	236.06	24148.53	22526.39	123676.76	264917.39

Source: Scottish Executive (2002), FAI calculations

Table 6. Impact of a 10% increase in gross government final consumption (GGFC) in Scotland, 1999

	Case A: Unadjusted IO table				Case B: Adjusted IO table			
Sector	Output effect £million	Employment effect FTEs	GDP effect £million	Waste effect Tonnes	Output effect £million	Employment effect FTEs	GDP effect £million	Waste effect Tonnes
Agriculture	22.29	207	7.39	195	22.23	206	7.37	195
Mining and quarrying	14.58	119	6.52	139	14.50	118	6.48	138
Food, drink and tobacco	43.93	383	13.82	2475	43.81	382	13.78	2468
Textiles and clothing etc	8.42	175	3.51	238	8.39	175	3.50	238
Paper and printing	37.72	435	15.42	1704	37.61	434	15.37	1698
Chemicals	18.20	93	6.99	939	18.13	93	6.96	936
Non-metallic mineral products	12.38	149	5.24	680	12.31	148	5.21	676
Metal Products	6.60	84	2.65	817	6.56	84	2.63	812
Machinery and equipment	21.39	123	5.53	301	21.33	123	5.52	300
Transport equipment	8.17	74	3.34	150	8.14	74	3.32	150
Other manufacturing	8.99	135	3.37	482	8.95	134	3.36	480
Electricity, gas and water supply, coke and petrol products	125.02	332	35.48	6494	124.25	330	35.26	6454
Construction	133.97	1672	39.58	56692	133.04	1661	39.31	56301
Wholesale and retail	359.79	8044	227.02	9337	358.83	8023	226.41	9312
Hotels, catering, pubs etc	66.86	2227	37.88	3089	66.69	2222	37.78	3082
Transport and communications	175.93	1693	72.40	15025	175.29	1686	72.14	14970
Finance and other services	728.23	9187	388.29	6997	725.10	9148	386.62	6967
Public administration, health & education	2224.96	39044	1133.72	19185	2224.64	39038	1133.56	19182
Sewage, sanitation etc	27.76	444	15.79	1350	27.72	444	15.77	1348
Waste disposal	16.09	444	9.15	783	8.15	225	4.63	396
Households	0.00	0.00	0.00	112736	0.00	0.00	0.00	112431
ABSOLUTE VALUE OF TOTAL CHANGE	4061.30	65065	2033.11	239807	4045.67	64746	2025.00	238532
PERCENTAGE CHANGE	2.88%	3.55%	3.25%	2.18%	2.86%	3.53%	3.23%	2.17%

Table 7. Multiplier effects in the waste disposal sector of £1million final demand for sectoral outputs

		Demand for Waste Disposal services (£) per £1million final demand for sector output			
		Type I effects (households exogenous)		Type II effects (households endogenous)	
		Unadjusted IO (Table 2)	Adjusted IO (Table 4)	Unadjusted IO (Table 2)	Adjusted IO (Table 4)
Sector/Activity					
1	Agriculture	£998	£1,560	£2,822	£3,143
2	Mining and quarrying	£1,648	£2,161	£4,278	£4,442
3	Food, drink and tobacco	£3,688	£2,866	£5,610	£4,531
4	Textiles and clothing etc	£2,417	£1,251	£4,660	£3,194
5	Paper and printing	£3,429	£2,011	£5,569	£3,863
6	Chemicals	£4,084	£2,331	£5,622	£3,662
7	Non-metallic mineral products	£1,238	£2,205	£3,209	£3,917
8	Metal Products	£1,961	£4,924	£4,431	£7,071
9	Machinery and equipment	£565	£766	£1,733	£1,780
10	Transport equipment	£1,447	£1,209	£3,727	£3,186
11	Other manufacturing	£4,074	£2,575	£6,410	£4,598
12	Electricity, gas and water supply, coke and petrol products	£6,341	£3,616	£7,987	£5,038
13	Construction	£857	£18,159	£3,622	£20,591
14	Wholesale and retail	£1,011	£1,589	£3,542	£3,785
15	Hotels, catering, pubs etc	£1,133	£2,540	£3,955	£4,990
16	Transport and communications	£2,422	£4,405	£5,330	£6,931
17	Finance and other services	£1,305	£1,849	£3,593	£3,834
18	Public administration, health & education	£5,273	£1,254	£9,080	£4,548
(19)	Sewage, sanitation etc	£719	£3,498	£3,031	£5,509
(20)	Waste disposal	£1,000,719	£1,003,498	£1,003,031	£1,005,509