Additional Precision Provided by Region-specific Data: The Identification of Fuel-use and Pollution-generation Coefficients in the Jersey Economy

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TURNER K. (2006) Additional precision provided by region-specific data: the identification of fuel-use and pollution-generation coefficients in the Jersey economy, Regional Studies 40, 347–364. A debate is currently ongoing in the UK regarding the need to collect and report data at the regional level. One specific area of this debate is the extent to which region-specific economic and environmental data are required to carry out analyses of devolved sustainability policy issues. This paper uses the Jersey economy as a case study to assess the added precision from using good-quality region-specific data compared with adjusted national UK data. It is found that, due to differences in polluting technology between Jersey and the UK, estimates based on national emissions intensities produce results that are misleading in terms of both absolute pollution levels and the relative contribution of different activities to total emissions in the economy. While Jersey may be regarded as atypical in many ways relative to other UK regions, it is argued that, the results show that regional environmental accounts must reflect differences in polluting technology in different locations. Moreover, accounting for differences in polluting technology is even more crucial in light of current policy interest in tracing the actual resource use and pollution generation in any one region’s or country’s imports to measure the global impact, or ecological footprint, of economic activity.

Regional accounting
Environmental input–output
National Accounting Matrix including Environmental Accounts (NAMEA)
Ecological footprints

TURNER K. (2006) La précision supplémentaire que fournissent les données spécifiques à une région: l’identification des coefficients de la consommation d’énergie et de la production de pollution dans l’économie de Jersey, Regional Studies 40, 347–364. A l’heure qu’il est, il se déchaîne un débat sur la nécessité de ramasser et de signaler des données au niveau régional. Une question qui se pose est la suivante: dans quelle mesure faut-il des données économiques et environnementales spécifiques à une région, afin d’analyser des questions de politique quant au développement durable régionalisé? A partir d’une étude de cas de l’économie de Jersey, cet article cherche à évaluer la précision supplémentaire que fournissent des données spécifiques à une région et qui sont plus fiables comparées à des données ajustées pour le Royaume-Uni ramassées au niveau national. Il s’avère que des estimations calculées à partir des taux d’émission nationaux laissent voir des résultats trompeurs en termes des niveaux de pollution absolus et de la contribution relative des divers activités aux émissions globales dans l’économie à cause des différences de la technologie polluante en Jersey par rapport au Royaume-Uni. Tanpis que l’on peut considérer Jersey à bien des égards comme atypique par rapport aux autres régions du Royaume-Uni, les résultats de cette étude laissent voir que des comptes régionaux environnementaux devraient refléter les différences de la technologie polluante dans les emplacements différents. En outre, expliquer les différences de la technologie polluante s’avère capital à la lumière de l’intérêt actuel pour la détermination de l’emploi de ressources et de la production de pollution réels dans les importations de toute région ou de tout pays afin de mesurer l’effet global, ou la tracée écologique, de l’activité économique.

Comptes régionaux
Tableaux d’échanges environnementaux
NAMEA
Tracées écologiques

TURNER K. (2006) Zusätzliche Präzision durch regionsspezifische Daten: die Identifizierung von Koeffizienten von Brennstoffverbrauch und Umweltverschmutzungursachen in der Wirtschaft der Insel Jersey, Regional Studies 40, 347–364. Im UK ist z.Zt. eine Debatte über die Notwendigkeit im Gange, Daten auf Regionalebene zu sammeln und darüber Bericht zu erstatten. Ein spezifisches Gebiet dieser Debatte betrifft das Ausmaß, in dem regionsspezifische Daten betreffen Wirtschaft und Umwelt für Analysen der Fragen der den Regionen übertragenen Nachhaltigkeitsbestrebungen erforderlich sind. In diesem Aufsatz wird eine Fallstudie anhand der Wirtschaft der Insel Jersey durchgeführt, um die zusätzliche Genauigkeit zu berechnen, die sich aus regionsspezifischen Daten im Vergleich zu entsprechend angepassten überregionalen Daten des UK ergeben. Die Autorin stellt fest, daß infolge verschmutzungsstechnischer Unterschiede zwischen der Insel Jersey und dem UK, Berechnungen, die auf überregionalen Emmissionsintensitäten beruhen, Ergebnisse zeitigen, die, sowohl in Bezug auf absolute Höhe der Verschmutzung wie auf den relativen Beitrag verschiedener Unternehmen zur Gesamtmenge der Emissionen, irreführend sind. Obwohl die Insel

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Jersey in vieler Hinsicht im Verhältnis zu anderen Regionen des UK als atypisch angesehen werden kann, vertritt die Autorin den Standpunkt, daß die Ergebnisse dieser Studie zeigen, daß regionale Umweltangaben die Unterschiede der Verschmutzungstechnologie an verschiedenen Standorten widerspiegeln müssen. Angesichts des gegenwärtigen politischen Interesses am Aufspüren tatsächlicher Resourcenverwendung und der Verursachung von Verschmutzung in den Importen irgendwelcher Regionen oder Länder ist Rechenschaft über Unterschiede in Verschmutzungstechnologie noch wichtiger für das Messen globaler Auswirkung oder ökologischer Spuren wirtschaftlicher Unternehmen ist.

Karen Turner

**INTRODUCTION AND BACKGROUND**

A significant degree of responsibility for setting and achieving UK sustainability objectives has been devolved to the Scottish Parliament and the National Assembly for Wales and delegated to the English Regional Development Agencies (RDAs) (Department of the Environment, 1996). Thus, given that the success of UK national sustainability programmes depends on policies delivered at the regional level, the region has become the natural spatial focus for the evaluation of policies directed at sustainability. This means that regional policy-makers in the UK need to develop an appropriate database and framework for analysis.

One active debate amongst the English RDAs, Welsh Assembly and the UK Environment Agency, and within the Scottish Executive (in the form of the Scottish Environmental Accounts Working Group) has been the extent to which region-specific environmental and economic data are required to perform this task. Generally, in the absence of existing regional data, and given the costs and survey problems involved in region-specific data collection and reporting, the possibility of adjusting more readily available national data is seen as a tempting option. But what is the likely size of the loss in information if such an option is pursued? Allsopp (2003) identifies the costs involved in data collection at the regional level in terms of diseconomies of scale and sampling issues. However, he fails to consider the potential benefits where tailored regional data collection would allow identification of differences in production technology and consumption behaviour relative to national averages and attention to local preferences in terms of the value associated with environmental quality.

For example, one issue is multisectoral accounting and modelling at the regional level. There have been a number of developments in terms of how national coefficients can be adjusted to reflect the difference in level and composition of activity in the regional economy. Inserman (1980), Round (1983), Richardson (1985), Flegg et al. (1995) and McCann and Dewhurst (1998) discuss how input–output (IO) technical coefficients can be adjusted to apply at the regional level. The most common approaches use location quotients to identify degrees of regional specialization. However, a crucial point is that developments of the methodology for adjusting national IO coefficients typically focus on differences in trade rather than differences in technology. As will be shown below, though, when it comes to economy–environment relationships, the key link between specific industrial outputs and polluting emissions is resource use. That is, while there is no disputing the importance of differences in import requirements at the national and regional levels, and the extent of interregional, as opposed to international, trade, there is a strong a priori case that
when it comes to economy–environment relationships, differences in technology are likely to dominate. For example, at present, Scotland has a greater capacity for electricity generation from renewable sources than the rest of the UK, with the share of Scottish electricity production from renewable sources already meeting the target of 10% by 2010 set for the UK as a whole.

The argument motivating the present paper is that if national coefficients for economy–environment relationships are applied to regions without any adjustment for differences in polluting consumption behaviour and production technology, there is likely to be a significant information loss. Moreover, it precludes the potential to tailor data collection and reporting to reflect local preferences in terms of environmental quality. To assess the nature of the information loss, the example of Jersey, a crown dependency of the UK located in the Channel Islands, is taken. The Jersey economy is atypical in a number of respects. However, the high-quality economy–environment data available for Jersey allow a robust comparison between results using region-specific technical coefficients and UK-adjusted national coefficients, an exercise not presently possible for the other regions of the UK.1

The paper is structured as follows. The second section provides a brief overview of the general method used to report sectoral environmental accounts in this study. The third section considers the current state of economic–environmental accounting at the national and regional levels in the UK. The fourth section outlines three alternative approaches to estimating regional emissions accounts. The fifth section uses Jersey as a case study to compare the results of the two extreme cases: fully region-specific data against the use of adjusted national coefficients. The sixth section assesses the added precision from estimating and using region-specific environmental data for Jersey. The seventh section considers the factors that are likely to explain the variation in results using region-specific and adjusted national data. The eighth section briefly considers the issue of pollution embodied in trade flows, and how the results presented here may inform that debate. Finally, the ninth section has a summary and conclusions.

CONSTRUCTION OF A CONSISTENT SET OF ECONOMIC–ENVIRONMENTAL ACCOUNTS FOR A SMALL REGIONAL ECONOMY

NAMEA approach to economic–environmental accounting

A key issue in economic–environmental accounting is that it is not sufficient to establish regular reporting of both economic and environmental data. If there is a need to determine and monitor the impact of the economy on the environment, it is necessary to ensure that economic and environmental data are gathered and reported in a consistent format. For this reason, the statistical office of the European Union (EU)–Eurostat–has launched a project to promote the construction of what are referred to as the National Accounting Matrix including Environmental Accounts (NAMEA) accounts in all EU Member States (Keuning and Steenge, 1999). A NAMEA database (Keuning et al., 1999; Haan, 2001) provides an integrated set of economic and environmental accounts. The economic accounts are the national accounts in IO or social accounting matrix (SAM) format and are presented in monetary units. The environmental accounts are reported in physical units and present information on material inputs of natural resources (particularly energy resources) used in each activity and outputs of residuals (pollution and waste materials) generated by each activity at a level of sectoral detail consistent with the economic accounts.

More formally, the NAMEA approach involves reporting the total physical amount of emissions, \( P_{ik} \), of pollutant, \( k \), directly generated by each production sector, \( i \), over a period identical to that used in reporting the economic accounts. Where emissions are directly generated in final consumption, this becomes \( P_{ik} \) for each type of final consumption \( z \). For energy/fuel use (or any type of natural resource use), the NAMEA account reports the total physical amounts of energy/fuel used, \( F_{ij} \) and \( F_{ijn} \), for each energy/fuel type \( j \) used by each production sector \( i \) and final consumption type \( z \) during the accounting period.

Estimating emissions generated by economic activity

The economic–environmental accounts should give the total emissions from each individual sector or final demand category, where activity is directly polluting (e.g. the electricity industry burning oil or private households running cars on petrol or diesel). However, in practice, the flows of pollutants from any one activity over a given period (usually 1 year) cannot typically be directly observed. This implies a need to make certain assumptions regarding the relationship between economic activity and pollution generation. The key aspect in determining the flow of emissions that accompanies economic activity will generally be the amount of different types of fuel used and the technology used to combust them, although non-fuel use sources also need to be identified.

The standard assumption is that emissions from any one economic activity are a function of the volume of fuel combusted during that activity plus the levels of output/activity from other polluting processes (e.g. Beauséjour et al., 1994; Vaze, 1997). Thus, for each production sector, \( i \), emissions of each pollutant,
k, are determined as:

$$P_{ik} = \sum_{j} (e_{ij}^k F_{ij}^k) + n_i^k X_i$$

\[ \forall i = 1, \ldots, I; \ k = 1, \ldots, K; \ j = 1, \ldots, J; \ t = 1, \ldots, T \]  

(1)

where $e_{ij}^k$ is an emissions factor, identifying the amount of pollutant $k$ generated when sector $i$ uses (combusts) one unit of fuel $j$ using technology/process $t$; $F_{ij}^k$ is the physical quantity of fuel $j$ used by sector $i$ with technology $t$ during the accounting period; $n_i^k$ is an output-pollution coefficient quantifying the non-fuel combustion-related generation of pollutant $k$ per unit of output in sector $i$; and $X_i$ is the total output produced by sector $i$ in the accounting period.

Emissions are determined in the same way for each type of final demand, $z$:

$$P_{zk} = \sum_{j} (e_{zj} F_{zj}^k) + n_z^k C_z$$

\[ \forall z = 1, \ldots, Z; \ k = 1, \ldots, K; \ j = 1, \ldots, J; \ t = 1, \ldots, T \]  

(2)

where $C_z$ is total expenditure by final demand type $z$ during the accounting period.

The economic IO (or SAM) accounts provide the monetary data on the elements $X_i$ and $C_z$, i.e. levels of economic activity in each production and final consumption sector. They also provide some information on fuel/energy use, in as much as the sales of energy supply sectors to all production and final consumption sectors are shown in industry-by-industry tables and purchases of energy commodities are given in commodity-by-industry use tables. However, note that the elements $F_{ij}^k$ and $F_{zj}^k$ should be reported in physical units (unless the emissions factors $e_{ij}^k$ and $e_{zj}^k$ can be reported in terms of emissions per unit fuel use in value terms) and should relate to total fuel use (including imported fuels). Generally, what useful information can be obtained from economic accounts depends on the nature of the specific IO tables or social accounting matrices available for the economy in question.

**CURRENT APPROACHES TO ECONOMIC–ENVIRONMENTAL ACCOUNTING AT THE REGIONAL LEVEL IN THE UK**

**National NAMEA accounts for the UK**

The UK has already adopted the Eurostat guidelines in reporting 76-sector economic–environmental accounts in the NAMEA format at the national level (VAZE, 1999). The economic IO accounts take the form of an industry-by-commodity use matrix. The environmental component reports pollutants generated and different types of fuels used by 76 production sectors and one type of final consumption, aggregate households. This gives UK national estimates of $P_{ik}^{UK}$, $P_{zk}^{UK}$, $I_{jk}^{UK}$ and $I_{zj}^{UK}$. While staff at the Environmental Accounts Branch of National Statistics confirm that, in principle, the UK method of estimating sectoral emissions is consistent with equations (1) and (2), they acknowledge that in practice a number of adjustments are made. However, these are not specified and a full account of the method used to estimate the sectoral emissions levels reported in the UK NAMEA accounts is not supplied. In particular, while the UK NAMEA accounts do report the total amount of each type of fuel used by each production sector and final demand category, these are not disaggregated by combustion technology to give the $F_{ij}^k$ and $F_{zj}^k$ required for estimating (1) and (2). Moreover, no information is given on the emissions factors $e_{ij}^k$, $e_{zj}^k$, $n_i^k$ and $n_z^k$.

**Economic and environmental accounting at the regional level in the UK**

While National Statistics does produce annual regional economic accounts for the UK, these are not in the form of IO tables, and there has been no attempt by this body to extend the NAMEA programme at the regional level in the UK. As noted in the Introduction, the English RDAs, the Welsh Assembly and the UK Environment Agency have carried out their own consultation on developing economic–environmental accounts, though this is in the absence of region-specific economic IO tables for the English regions. Welsh IO tables are produced by the Welsh Economic Research Unit at Cardiff Business School, but this is independent of and, therefore, not necessarily consistent with the national IO framework used by National Statistics. In the case of Scotland, on the other hand, the Scottish Executive regularly publishes Supply and Use and analytical IO tables at the 128-sector breakdown used in UK IO accounting by National Statistics. The Scottish tables are constructed using the same survey data and other underlying data as used in the UK accounts, using a boosted survey sample for Scotland.

In terms of regional environmental data, the only semi-official set of accounts to date is a study by SALWAY et al. (2001). It estimates emissions of the three main greenhouse gases—carbon dioxide (CO$_2$), methane (CH$_4$) and nitrous oxide (N$_2$O)—for each of the four constituent countries (England, Scotland, Wales and Northern Ireland) for 1990, 1995, 1998 and 1999. However, emissions are reported for the Intergovernmental Panel on Climate Change (IPCC)-classified sources used in the UK national air emissions inventory rather than the Standard Industrial Classification (SIC) of activities used in UK economic accounting. TURNER (2003) reports on a pilot study instigated by the Scottish Environmental Accounts
Working Group (SEAWG) to develop a basic NAMEA framework for Scotland for the single pollutant CO₂. It was found that there are two main problems with the regional emissions data reported by Salway et al. (2001). The first is that it is not clear how region-specific the data are that Salway et al. reported for Scotland, Wales, England and Northern Ireland. The second is the difficulty in mapping IPCC activities to the SIC classification of activities. Salway et al. did have access to information on source- or site-specific (point) emissions of CO₂ in each region. These are generally large industrial installations, hospitals, etc. that can be easily reclassified under the SIC system. Moreover, these particular emissions data are region-specific and likely to be accurate. However, Salway et al. did not make clear what share of emissions attributed to each of the four regions falls under this category.

For all domestic, agricultural and non-point commercial/industrial/public sector activity emissions, a method called ‘area source mapping’ is used to allocate emissions to regions. This involves using surrogate data sets, such as population and household fuel use data (for domestic activities), land cover and livestock data (for agricultural activities) and employment data (for industrial/commercial/public sector activities). In the case of emissions from road transport, the third ‘road transport mapping’ method is employed, making some (unspecified) use of Department of Transport data such as the UK National Transport Survey. However, no details are given on how these mapping techniques are carried out for each of the UK regions.

The first problem, then, is that without fuller information on the mapping methods used, it is difficult to judge the quality and region-specificity of any results using the latter two methods. The second is how to map emissions inventory data to economic sectors. Even if the quality and region-specificity of Salway et al.’s (2001) emissions estimates for each of the UK regions is judged to be acceptable, there remains the question about whether these can be reported for a sectoral breakdown that is consistent with the SIC classification in the economic accounts. For example, the IPCC classified activity ‘road transportation’ is carried out by most economic sectors. That is, in the SIC accounting system, commercial road transportation services are distinguished from ‘in-house’ transportation activities carried out by individual production sectors and final demand categories; whereas in the IPCC system all road transportation activities are classified together. Similarly, the emissions inventory approach reports energy-related emissions from the commercial/institutional sector, but again this covers a large range of SIC-classified sectors. Even where there is more specific identification of activities, e.g. ‘agriculture/forestry/fishing’, this still covers at least three SIC classified activities.

The key issue is that Salway et al. (2001) appear mainly to use a ‘top-down’ method to allocate UK emissions, reported for IPCC-classified sources, among regions rather than a ‘bottom-up’ approach examining region-specific sources of emissions. The benefit of adopting a top-down approach is that it is relatively cheap and gives regional accounts that are numerically consistent with existing national accounts. Allsopp (2003) is correct in identifying the trade-off between the costs and benefits of collecting and reporting data at the regional level. However, this trade-off is extremely difficult to express explicitly or precisely if region-specific data are not available in the first instance. In the absence of region-specific data to quantify the benefit side of the trade-off, this assessment can only be made based on a priori beliefs on how similar or different regions and nations actually are.

Perhaps the crucial issue, given the current trend towards devolution of responsibility for sustainability policy, is that where decentralization is intended to exploit local policy-makers’ knowledge of regional economic conditions and environmental preferences, the acceptability of any loss of local accuracy is likely to decrease. There are strong arguments in favour of accurate region-specific data. First, if regions have operational responsibility for the environment, regional policy-makers need accurate local information. Second, if regional performance is to be evaluated by central government, region-specific information is required. Third, if policy-makers are to be sensitive to local needs, there must be flexibility in how local data are collected. That is, there may be a need to tailor regional data collection and reporting to address local problems. One issue may be that variation in the level of disaggregation of activities identified is desirable at the regional level. For example, in the case of Jersey, where the consumption activities of visitors to the island are thought to have significant impacts on the local environment, specific attention has been given to developing a tourist survey that elicits information on polluting activities such as fuel use.

**THREE ALTERNATIVE APPROACHES TO ESTIMATING A ‘BOTTOM-UP’ REGIONAL EMISSIONS ACCOUNT**

It is useful to consider three possible categories of emissions estimates within the NAMEA integrated economic–environmental accounting framework that allow one to adopt a more ‘bottom-up’ approach.\(^8\)

**Fully region-specific**

Estimation of (1) and (2) using region-specific data on fuel uses, \(F_{ij} \) and \(F_{ijk} \), and fuel and non-fuel-related emissions factors, \(c_{ij} \), \(c_{ijk} \), \(n_i \) and \(n_k \).
Estimation of (1) and (2) using region-specific data on fuel uses or emissions factors for all or some of the I production sectors and/or Z final consumption groups. Given the resource costs involved in constructing a region-specific set of economic–environmental accounts, it may be appropriate to focus on key sectors/activities where pollution/energy intensities are expected to deviate significantly from the national average.9

**Partially region-specific**

Estimation of (1) and (2) using region-specific data on fuel uses or emissions factors for all or some of the I production sectors and/or Z final consumption groups. Given the resource costs involved in constructing a region-specific set of economic–environmental accounts, it may be appropriate to focus on key sectors/activities where pollution/energy intensities are expected to deviate significantly from the national average.9

\[ m_{ik}^N = \frac{P_{ik}^N}{X_i^N} \quad \forall i = 1, \ldots, I; \quad k = 1, \ldots, K \quad (3) \]

and for final consumption, direct emissions coefficients are defined as:

\[ m_{zR}^N = \frac{P_{zR}^N}{C_z^N} \quad \forall z = 1, \ldots, Z; \quad k = 1, \ldots, K \quad (4) \]

One can then make adjusted-national estimates of sectoral emissions by rearranging (3) and (4) and substituting in region-specific data on X_i and C_z to estimate total emissions generated in each production and final consumption sector.10 For example:

\[ P_{ik}^R = m_{ik}^NX_i^R = \left[ \frac{P_{ik}^N}{X_i^N} \right] X_i^R \quad (5) \]

where superscript ‘R’ denotes the region to which the estimate applies. This would assume that the regional industry has the same fuel use and technology as the nation in generating emissions of pollutant k in sector i. For final consumption:

\[ P_{zR}^R = m_{zR}^NC_z^R = \left[ \frac{P_{zR}^N}{C_z^N} \right] C_z^R \quad (6) \]

**JERSEY AS A CASE STUDY**

Using Jersey as an example, it is possible to make a useful comparison of the alternative methods of estimating regional economic–environmental accounts. This is because Jersey has invested resources in constructing a set of region-specific economic–environmental accounts in which confidence levels are high with respect to accuracy. These accounts are, of course, of interest in themselves. However, their existence also permits a comparison of the results of estimating economic–environmental accounts using the two extremes in the methods identified above, i.e. the first method, with fully region-specific estimates of equations (1) and (2); and the third method, with estimates based on adjusted-national emissions intensities (where the UK is taken as the most appropriate national proxy to estimate unknown Jersey parameters).

**Policy background**

The States of Jersey have made sustainable development a key policy objective. As an independent, self-governing state, Jersey has full responsibility for achieving the commitment to sustainable development stated in the States of Jersey’s annual policy report in 1995 (States of Jersey, 1995), and the environmental objectives stated in the States’ Environmental Charter, endorsed in 1996 (States of Jersey, 1998). However, Jersey is also a voluntary party to UK international environmental commitments, such as the Kyoto Protocol. Given this emphasis on sustainability policy, the States of Jersey has recognized that credible decision-making on environmental issues requires an appropriate database and empirical framework for analysis. In this context, Jersey’s requirements mirror those of the devolved administrations in the UK.

Jersey initiated the project upon which this paper is based in an attempt to construct a set of economic–environmental accounts in the form suggested by the Eurostat NAMIA programme. This involves augmenting the existing (25×25) industry-by-industry economic IO accounts for 1998 with information on the physical use of different types of energy and the direct pollution generation for each of the 25 production and 12 final demand sectors identified in the IO tables.11

Because the States of Jersey had stated an interest in both economic and environmental issues from the outset, it was possible from the start to gear the accounting process towards construction of an NAMIA framework. Specifically, particular attention was paid to developing a database that would allow identification of economic activities that are likely to be important in terms of environmental questions. Efforts were also made to ensure that adequate and appropriate data were collected to develop a consistent set of environmental accounts for the same sectoral breakdown as in the economic accounts.

**Region-specific estimates of emissions generation for Jersey**

The first element of a basic NAMIA account is resource use. Here, focus is on energy use, as this is
the key source of pollution generation in Jersey. In the Jersey IO accounts, all energy commodities are imported by the two energy supply/distribution sectors, ‘Electricity’ and ‘Gas, Oil & Fuel Distribution’. Sales of these commodities for use as inputs to production/final consumption in different sectors of the economy are recorded in monetary units (£ million) along the ‘Electricity’ and ‘Gas, Oil & Fuel Distribution’ rows of the IO table. However, corresponding data were also collected on the physical use of the eight fuel types supplied by ‘Gas, Oil & Fuel Distribution’ for use by each production sector and final demand category identified in the IO accounts. Table 1 identifies the nine different energy types and the type of activity for which they are used in Jersey.

The second element of the environmental accounts is the physical amount of pollution generated by economic activity in Jersey in 1998. As explained above, this is determined by estimating (1) and (2) for each production sector and final demand category, respectively. The Jersey economy has a very small manufacturing sector, with none of the heavy industries where production processes themselves are often pollution-intensive (independent of energy use). One would therefore expect emissions from fuel use to be the main source of pollution in Jersey. In other words, one would expect the elements \( n^k_i \) and \( n^z_i \) for Jersey in equations (1) and (2) to be equal to zero across most production sectors and final demand categories, respectively, meaning that emissions will depend primarily on the type and amount of fuel used and on the type of vehicle used (combustion technology) and on what type of fuel the vehicle runs. COLEY (1994) identified the Jersey emissions factors, the \( c_{ik} \) and \( c_{ijt} \) in equations (1) and (2), for the motive and non-motive fuel types and technologies. The present study adapts IPCC and Warren Springs Laboratory (WSL) emissions factors to reflect polluting technology in Jersey. The Jersey emissions factors are discussed and reported in detail in TURNER (2002).

There is another type of motive fuel use in Jersey: aviation fuel is used to operate private and commercial aircraft. Data were available on the total amounts of aviation gas and jet fuel imported and supplied in 1998. However, the amount of aircraft fuel supplied in any one economy is unlikely to correspond to the amount of fuel combusted within that economy’s borders. Therefore, as in COLEY (1994) the WSL concept of ‘aircraft movements’ is adopted. An aircraft movement is one landing/takeoff cycle of up to 1000 m and emissions factors are stated in terms of each movement rather than the amount of fuel used. Therefore, in estimating emissions from aviation fuel use, the number of aircraft movements (take-off and landing cycles at Jersey airport) in 1998 is taken as a proxy for the \( F_{ijt} \) and the emissions factors, \( \tilde{c}_{ijt} \), are given for the WSL estimates for a ‘small airport’ (TURNER, 2002). All direct emissions generation from aircraft movements are allocated to the ‘Sea & Air Transport and Transport Support’ sector.

There are several sources of pollution, summarized in Table 2, in Jersey that are not related to the combustion of fuels. Such emissions are calculated by including the additional non-fuel combustion related element, \( n^k_i \) and \( n^z_i \), in the estimation of equations (1) and (2) for the relevant production sectors and final demand groups. The emissions factors, \( n^k_i \) and \( n^z_i \), were identified by COLEY (1994) (and detailed in TURNER, 2002). Adding non-fuel combustion related emissions to total emissions from fuel use for each production sector, \( i \), and final demand category, \( z \), gives

| Sector                        | Process        | Pollutants                  |
|-------------------------------|----------------|-----------------------------|
| Public services               | Waste incineration | Carbon dioxide (CO₂)       |
|                               |                | Methane (CH₄)               |
|                               |                | Nitrous oxides (NO₂)        |
|                               |                | Non-methane volatile organic compounds (NMVOC) |
|                               |                | Carbon monoxide (CO)        |
| Manufacturing                 | Solvent use    | Non-methane volatile organic compounds (NMVOC) |
| Other service activities      |                |                             |
| Agriculture and fishing       | Biological     | Methane (CH₄)               |
| Households                    |                |                             |
| Tourists                      |                |                             |
the total emissions of each pollutant by each sector and final demand category (Turner, 2002).

For purposes of comparison with the UK-adjusted coefficients in the next section, the NAMEA data on emissions-by-sector can then be used to derive a set of direct average emissions intensity coefficients relating the generation of emissions to the total activity in each production and final demand category. Denoting Jersey by the superscript ‘\( \theta \)', these are defined for the \( I = 25 \) production sectors as:

\[
m_{ik}^\theta = \frac{P_{ik}^\theta}{X_i^\theta} \quad \forall i = 1, \ldots, I; \ k = 1, \ldots, K
\]  

(7)

and for final consumption, the direct emissions coefficients are defined as:

\[
m_{zk}^\theta = \frac{P_{zk}^\theta}{C_z^\theta} \quad \forall z = 1, \ldots, Z; \ k = 1, \ldots, K
\]  

(8)

Equations (7) and (8) are analogous to the UK coefficients stated in (3) and (4) above. This gives the \((K \times I = 8 \times 25)\) Jersey-specific matrix \( M_i^\theta \) of direct emissions intensity coefficients for the 25 production sectors and the \((K \times Z = 8 \times 12)\) Jersey-specific matrix \( M_z^\theta \) of direct emissions intensity coefficients for final consumption activities. These matrices are represented (in transpose form) in Table 3. Note that \( M_i^\theta \) is effectively an \( 8 \times 6 \) matrix showing direct emissions of each pollutant by the six final demand categories—five household groups (income quintiles) and tourists—that are responsible for direct emissions generation in Jersey. None of the other five types of final demand has been identified as directly polluting.

UK-adjusted estimates of emissions generation for Jersey

Using equations (3) and (4) and the 1998 UK NAMEA data set and focusing on the \( K = 7 \) pollutants that are common to both the UK and Jersey accounts, we identify a \((K \times I = 7 \times 76)\) UK matrix \( M_i^{UK} \) and a \((K \times Z = 7 \times 1)\) vector \( m_i^{UK} \) of direct emissions intensities. Note that \( Z = 1 \) because aggregate household demand is the only type of final consumption for which direct emissions generation is reported in the UK NAMEA accounts.

The matrix \( M_i^{UK} \) must be aggregated to make it consistent with the sectoral breakdown of the Jersey accounting system. This involves the following steps:

- A weight of zero is attached to the column vector of output-pollution coefficients for all sectors that are present in the UK economy but not in the Jersey economy.
- Remaining sectors present in both economies are aggregated to the sectoral breakdown identified in the Jersey IO tables.
- For each Jersey NAMEA sector, the column vectors from matrix \( M_i^{UK} \) are then weighted according to the contribution of each component activity to the total output of the Jersey sector.

This allows the derivation of a \( K \times I \ (7 \times 25)\) matrix, \( M_i^{UK(\theta)} \) of UK-adjusted direct emissions coefficients for Jersey production sectors (for 1998). This matrix, in transpose form, and the transposed vector of household direct emissions coefficients are shown in Table 4.

Applying the UK-adjusted emissions coefficients in \( M_i^{UK(\theta)} \) and \( m_i^{UK} \), which are relabelled \( m_i^{UK(\theta)} \) (\( Z = 1 = \) households), to Jersey means making the assumptions that the fuel intensity of production and consumption does not vary between the UK and Jersey economies, and that polluting technology does not vary between the UK and Jersey economies.

ADDED PRECISION FROM ESTIMATING AND USING REGION-SPECIFIC ENVIRONMENTAL DATA FOR JERSEY

The composition of the 25 production sectors is equivalent across both the region-specific coefficients in Table 3 and the UK-adjusted emissions intensity coefficients in Table 4. Therefore, these can be directly compared for the pollutants that are common to both sets. Two crucial observations can be made:

- Jersey-specific and UK-adjusted emissions coefficients for any one sector differ significantly in terms of the absolute pollution intensities of production/consumption (i.e. the level of emissions per unit of output/expenditure).
- Overall, the sets of Jersey-specific and UK-adjusted coefficients differ significantly in terms of the relative pollution intensities of the different activities in the Jersey economy.

Both factors are important. If the absolute intensities are over- or understated, this will lead to errors in estimating total pollution in the Jersey economy. If the relative intensities are incorrect, this will lead to errors in determining the direct (and indirect) contributions of different production sectors and consumption activities to the pollution problem. This could lead to errors in terms of prioritizing activities in determining policy to reduce pollution. As well as affecting the accuracy of the base-year environmental accounts, both factors would impact on the accuracy of any economic-environmental model for Jersey based on these data.

One can determine the magnitude of the first problem (the differences in the absolute level of the pollution intensities across all sectors) by looking at the estimates of total generation for each pollutant, \( k \), from the two methods. First, the Jersey-specific data are used to calculate (1) and (2) for each pollutant, \( k \), summed across all production and final consumption...
activities:

\[ P_k = \sum_{j} P_{ik}^{q} + \sum_{z} P_{iz}^{q} = \sum_{j} k_{ij}^{q} F_{ij}^{q} + \sum_{z} k_{iz}^{q} X_{iz}^{q} \]

\[ + \sum_{j} k_{ij}^{q} F_{ij}^{q} + \sum_{z} k_{iz}^{q} X_{iz}^{q} \]

\[ \forall k = 1, \ldots, K; \ i = 1, \ldots, I; \ z = 1, \ldots, Z; \]

\[ j = 1, \ldots, J; \ t = 1, \ldots, T \]  

(9)

where the superscript ‘\(q\)’ indicates the use of Jersey-specific data and Jersey-specific results. The exercise is then repeated using the UK-adjusted coefficients:

\[ P_k^{UK(q)} = \sum_{j} P_{ik}^{UK(q)} + \sum_{z} P_{iz}^{UK(q)} \]

\[ = \sum_{j} m_{ik}^{UK(q)} X_{ij}^{q} + m_{iz}^{UK(q)} C_{iz}^{q} \]

\[ \forall k = 1, \ldots, K; \ i = 1, \ldots, I; \ z = 1(HH) \]  

(10)

The results for the \(K = 7\) pollutants common to both the Jersey-specific and UK-adjusted data are shown in the first two columns of Table 5.

Note that there are extremely large differences between the estimates using the two methods. In the
case of five of seven of the pollutants, the UK-adjusted coefficients give estimates that are much larger those found using the Jersey-specific data. The largest difference is in the case of N₂O, with the estimate of total emissions using the UK-adjusted coefficients being more than 153 times the size of the estimate based on the Jersey-specific fuel-use figures and emissions factors. This is an extreme result: the next biggest difference is found in the case of CH₄, where the UK-adjusted estimate is over 500% higher than the Jersey-specific one (followed by 35% for sulphur dioxide (SO₂) and 42% for nitrous oxides (NOₓ)). In the case of the three remaining pollutants, CO₂, non-methane volatile organic compounds (NMVOC) and carbon monoxide (CO), the Jersey-specific estimates of total emissions are higher than the UK-adjusted ones (the UK-adjusted estimates being respectively 26, 22 and 36% less than the Jersey-specific ones, respectively).

Second, the relative pollution intensities of sectors differ across the two sets of direct emissions intensities shown in Tables 3 and 4. In accounting terms, the main impact of differing relative pollution intensities will be on the contribution of individual production and final demand sectors to total emissions in the base year. Figs 1 and 2 illustrate this point for the individual pollutant NOₓ. Fig. 1 shows the Jersey-specific and UK-adjusted NOₓ emissions coefficients for each production sector. Fig. 2 shows the (direct) proportionate sectoral contributions to total emissions of NOₓ using the two different methods.

The direct contribution of each production sector, i, and final demand category, z, to total emissions of any one pollutant, k, is determined by the emissions intensity of the activity in question and by the scale of activity. The scale of activity in each production sector, Xᵢ, and final demand sector, Cᵢz, is common to both calculations. Therefore, the differences between the two sets of results shown in Fig. 2 are entirely due to the differences in relative pollution intensities (including the zero intensity for all pollutants

Table 4. UK-adjusted sectoral emission intensities for Jersey (kg/£1 million output/final demand expenditure)

| Sector pollutant | CO₂ as carbon | CH₄ | SO₂ | NOₓ | NMVOC | CO | N₂O |
|------------------|---------------|-----|-----|-----|-------|----|-----|
| Agriculture and fishing | 81 554 | 45 639.38 | 461.23 | 2535.91 | 798.97 | 3633.16 | 4430.08 |
| Quarrying and construction | 17 696 | 10.04 | 45.15 | 577.39 | 661.96 | 2831.31 | 16.26 |
| Manufacturing | 34 122 | 7.95 | 179.10 | 315.55 | 1535.91 | 174.18 | 2.27 |
| Electricity | 1 477 975 | 677.47 | 38 787.26 | 13 239.63 | 277.69 | 2987.62 | 235.55 |
| Water | 38 454 | 10.19 | 46.51 | 611.91 | 710.35 | 2492.16 | 14.72 |
| Gas, oil and fuel distribution | 22 635 | 9896.62 | 7.63 | 263.61 | 2302.70 | 921.68 | 2.98 |
| Jersey telecommunications | 11 231 | 4.21 | 7.87 | 169.20 | 83.28 | 530.92 | 1.89 |
| Wholesale and retail trade | 17 627 | 6.82 | 11.32 | 337.05 | 147.84 | 862.98 | 3.33 |
| Hotels, restaurants and catering | 12 767 | 4.34 | 3.25 | 106.86 | 60.95 | 461.01 | 1.43 |
| Land transport | 247 043 | 69.61 | 206.22 | 6969.05 | 1527.27 | 5310.51 | 33.34 |
| Sea and air transport and transport support | 293 542 | 140.94 | 5142.68 | 10 293.17 | 1719.14 | 4028.01 | 47.13 |
| Post | 11 231 | 4.21 | 7.87 | 169.20 | 83.28 | 530.92 | 1.89 |
| Banks and building societies | 8638 | 3.31 | 5.39 | 93.26 | 62.66 | 492.91 | 1.48 |
| Insurance companies | 8694 | 3.49 | 4.71 | 101.04 | 69.93 | 551.90 | 1.64 |
| Investment trusts and fund managers | 8174 | 3.03 | 5.37 | 83.21 | 54.56 | 428.09 | 1.29 |
| Computer services | 13 079 | 5.96 | 10.79 | 196.87 | 220.67 | 1139.36 | 3.39 |
| Legal activities | 8422 | 2.98 | 7.09 | 81.08 | 51.28 | 398.88 | 1.22 |
| Accountancy | 8422 | 2.98 | 7.09 | 81.08 | 51.28 | 398.88 | 1.22 |
| Other business activities | 9214 | 3.72 | 7.16 | 121.81 | 78.97 | 596.99 | 1.85 |
| Other services activities | 16 856 | 6.43 | 13.84 | 248.56 | 761.15 | 908.26 | 3.09 |
| Recreation, culture and sport | 11 683 | 3.03 | 48.14 | 82.74 | 35.68 | 261.92 | 1.10 |
| Education | 29 057 | 6.62 | 85.31 | 165.14 | 66.32 | 502.90 | 2.04 |
| Health, social work and housing | 13 297 | 2.77 | 116.87 | 65.96 | 31.49 | 93.62 | 0.55 |
| Public services | 30 634 | 110 683.65 | 53.66 | 1250.81 | 1324.95 | 723.43 | 76.85 |
| Public administration and defence | 35 633 | 6.32 | 213.64 | 580.11 | 34.33 | 187.55 | 2.73 |

Table 5. Environmental accounting: total emissions (kg) of seven air pollutants generated in Jersey, 1998

| Pollutants | Jersey-specific data | UK-adjusted data |
|------------|----------------------|------------------|
| CO₂ as carbon | 291 065 182 | 215 481 253 |
| CH₄ | 961 262 | 5 826 417 |
| SO₂ | 1 024 795 | 2 403 511 |
| NOₓ | 2 205 893 | 1 874 431 |
| NMVOC | 2 403 511 | 1 874 431 |
| CO | 13 277 245 | 8 439 382 |
| N₂O | 1933 | 295 809 |
in the tourist final demand category in the UK-adjusted case).

For example, according to the UK-adjusted coefficients, ‘Land Transport’ is the third most NOx-intensive production sector in the Jersey economy. However, under the Jersey-specific measures, it is only the sixth most NOx-intensive, with an output–NOx coefficient that is much smaller in relative terms. In the
Jersey-specific set of pollution coefficients (Table 3), the ‘Land Transport’ direct NO\textsubscript{x}-intensity coefficient is only 2.3% of the size of the coefficient for the most NO\textsubscript{x}-intensive sector, ‘Electricity’, while this figure is almost 53% in the UK-adjusted case. In terms of contribution to total NO\textsubscript{x} emissions, Fig. 2 shows that ‘Land Transport’ is attributed with the fourth highest contribution of all the production sectors under the UK-adjusted measure, accounting for 4.53% of total emissions. However, under the Jersey-specific measure, this share is smaller both in absolute and relative terms: with a 0.36% share of total NO\textsubscript{x} emissions, it has only the 11th highest contribution of all the production sectors.

Conversely, Fig. 1 reveals that ‘Public Services’ has a higher NO\textsubscript{x}-intensity both in absolute and relative terms under the Jersey-specific measure, being the third most NO\textsubscript{x}-intensive production sector compared with fifth under the UK-adjusted measure. Fig. 2 shows that if one relies on the UK-adjusted coefficients, ‘Public Services’ is attributed with only 1.06% of direct NO\textsubscript{x} generation, the eighth highest contribution of all 25 production sectors; however, the Jersey-specific measure show its contribution to be much higher, 4.03%, which is the fourth highest contribution.

FACTORS UNDERLYING THE VARIATION IN THE REGION-SPECIFIC AND UK-ADJUSTED ESTIMATES OF ECONOMY–ENVIRONMENT RELATIONSHIPS IN JERSEY

Two main factors can be identified that may contribute to the differences in direct emissions intensities shown for equivalent sectors in the Jersey-specific and UK-adjusted sets of coefficients in Tables 3 and 4:

- Accuracy and tailoring of data collection to region-specific priorities in Jersey.
- Regional variation in fuel use (types and intensity) and polluting technology in Jersey and the UK.

Accuracy and region-specificity of data collection in Jersey

Due to the size of the Jersey economy, its island status, the structure of the energy supply industry and the availability of earlier studies, such as by COLEY (1994), it has been possible to construct a highly detailed and accurate database on fuel use and polluting technology. It is unlikely that such a complete database could be constructed for the UK, particularly at the regional level, given the nature of cross-border supply and use of fuels. Moreover, the fact that such detailed studies have been carried out for Jersey reflects the high priority that the population and policy-makers place on the quality of the environment.

In terms of accuracy, note that the reporting of how the 1998 environmental accounts for Jersey have been constructed, here and by TURNER (2002), is characterized by a much greater degree of transparency than the UK NAMEA accounts. For example, as noted in the third section, the UK reporting does not include any information on what is assumed about polluting technology in order to generate sectoral emissions estimates. The Environmental Accounts Branch of the Office of National Statistics (ONS) does acknowledge making adjustments that reflect problems in allocating fuel use and emissions from transport activities. However, these are unspecified. On the other hand, in the Jersey-specific case, it has been possible to identify and state clearly where accounting problems have arisen (TURNER, 2002). This will allow rectification of these problems when and if improved data permit. Conversely, in the case of the UK NAMEA tables, it is not possible to identify the nature of any accounting problems; in particular, what impact these would have on any accounting work for Jersey based on UK-adjusted coefficients.

However, the survey issues raised by ALLSOPP (2003) are important. If it is the case that fuel use and polluting technology did not vary greatly between the UK and Jersey, it may be better to use UK data, which are subject to greater economies of scale in collection and more robust sampling techniques. In general, there is likely to be a trade-off between capturing region-specific characteristics and economies of scale in data collection, with the implication that local data may be of worse quality. However, this is not the case in Jersey, where the preference for good quality environmental data has meant that policy-makers have invested significant resources and effort in local data collection of a very high quality.

Differences in fuel use and polluting technology in Jersey and the UK

The second factor that will contribute to the differences in the UK-adjusted and Jersey-specific estimates is variations in fuel use (types of fuel and amounts used) and polluting technology in Jersey and the UK. The Jersey-specific coefficients in Table 3 reflect the actual average emissions intensities (for each pollutant) of each production and final consumption activity that takes place in the Jersey economy. The adjusted national coefficients reflect the average emissions intensities for equivalent activities in the UK, independent of the location of activity.

Thus, by adopting adjusted national emissions coefficients to apply at the regional level involves adopting the two crucial assumptions identified in the fifth section: that fuel use (type and intensity) and polluting technology at the regional level correspond to the averages observed for the national economy. If this is not the case, i.e. if one or more of the elements on the right-hand side of equations (1) and (2) differ significantly across the national and regional economies, the adjusted national coefficients will
misrepresent absolute and relative pollution intensities in the regional economy. This will in turn lead to errors in estimating total pollution generation at the regional level and the contribution of individual activities to this total (even if the assumptions are not violated for all production and final demand sectors), as well as the contribution of the regional economy to total pollution generation at the national level.

The main motivation for investing resources in constructing a set of Jersey-specific economic—environmental accounts was that important differences are known to exist with respect to the technology used in certain activities in Jersey relative to the UK. For example, all electricity produced in Jersey is generated using oil-powered technology, while in the UK a combination of gas-, hydro-, nuclear- and oil-powered techniques is used to generate the total electricity requirement. Waste disposal is another example: in the UK, there will be emissions from landfill, while in Jersey all waste is disposed of by incineration or composting. Third, the composition of technologies used for commercial and domestic heating activities in Jersey is known to be different to that found in the UK. With no infrastructure for natural gas to be piped to Jersey, it is necessary to import and bottle a combination of propane or butane. As a result, gas-heating systems are expensive relative to other forms of heating and a larger proportion of households and businesses therefore rely on oil-powered heating systems than is the case in the UK.

As explained above, information is not available on the precise mix of polluting technologies used in the UK; in particular, the UK NAMEA tables do not include emissions factors for comparison with the ones used for Jersey. However, the UK NAMEA table accounts do include fuel use by sector that allows a direct comparison of the physical fuel-use intensities of equivalent activities in the UK and Jersey (but only for some of the fuel types used in Jersey). If fuel-use in equivalent sectors differs sufficiently between Jersey and the UK, this alone would cast serious doubt on the validity of using UK-adjusted pollution coefficients to estimate and model pollution generation in the Jersey economy.

First, look at the heating fuel, gas oil.\[1\] Given what has been explained above about the lack of infrastructure for piping natural gas to Jersey and the consequent reliance on oil-powered heating systems, one would expect to find higher heating oil-use intensities in Jersey than in the UK. Fig. 3 reveals that this is indeed the case across most production sectors for gas oil use. Note that Fig. 3 also reflects another peculiarity of fuel consumption and supply patterns in Jersey: while oil-powered heating systems are generally more prevalent in Jersey than any other type of heating system, gas oil is only used in the commercial sector. Domestic heating systems in Jersey run exclusively on kerosene (and the private household sector is the sole user of kerosene as a heating fuel). Therefore, while the aggregate UK household sector shows a positive, but relatively low, use of gas oil, the Jersey household sector has zero intensity for this fuel. This distinction between different types of fuel (e.g. kerosene or gas oil) used for the same purpose (e.g. running oil-powered domestic heating systems) is crucially important because the pollution properties of different types of fuel can vary significantly. In the current example, the combustion of 1 kg kerosene using the type of technology identified for heating systems in Jersey generates significantly smaller amounts of \( \text{SO}_2 \), \( \text{NO}_x \) and CO than would result from the combustion of 1 kg gas oil (Turner, 2002).

Therefore, if one were to assume that gas oil intensities are the same across equivalent sectors in the UK and Jersey, the result would be significant errors in estimating the amount of gas oil used at both the aggregate and sectoral levels. In terms of total fuel use in the economy, actual total gas oil use in Jersey in 1998 was almost twice as high as would be estimated using the 1998 UK-adjusted gas oil intensities. This is consistent with the greater reliance in Jersey on oil-powered heating systems noted above. However, more important in the present context is fuel use at the sectoral level. The fuel-intensities shown in Fig. 3 demonstrate that assuming identical gas oil use for equivalent sectors in Jersey and the UK would lead to drastically misleading results, both in terms of the amount of gas oil used and the amount of emissions generated from this type of fuel use. This would be the case even if the technology used to combust this type of fuel were identical in the UK and Jersey.

However, it is also the case that automotive fuel use intensities differ across equivalent sectors in Jersey and the UK, even though there are not the same restrictions on combustion technology, i.e. there is no restriction on the type of vehicles that can be used on the island. Fig. 4 shows that 20 of the 25 production sectors are significantly less automotive fuel-intensive than would be equivalent sectors in the UK. In particular, ‘Land Transport’ is far less fuel-intensive than its UK counterpart, the value of its petrol/derv-output intensity being only 6.2% of the value of the UK-adjusted intensity. The other five production sectors (Quarrying and Construction; Total Manufacturing; Electricity; Gas and Oil & Fuel Distribution; Telecommunications) are significantly more automotive fuel-intensive than would be equivalent sectors operating in the UK.

In terms of final demand categories, note again that the UK figures do not separately identify fuel use by tourists, so it is not possible to determine the extent of any variation in automotive fuel use by visitors to Jersey compared with destinations in the UK. However, total final consumption by Jersey households is significantly less automotive fuel intensive, despite the high level of private car ownership on the island (of
course, this may be expected given the limited road space available on which to drive).

Therefore, just as is found in the case of stationary fuel use, it is clearly the case that automotive fuel-use patterns in Jersey are quite distinct from those that underlie the combustion-related element of the UK-adjusted pollution coefficients. Some of the differences in emissions intensities can be related to differences in the types of fuel use associated with their generation. For example, in Turner (2002), I find that the main source of SO2 combustion-related emissions from production activities that take place in the Jersey economy is stationary fuel use (automotive fuel use, other than aircraft movements, does not generate SO2 emissions).

![Fig. 3. Direct gas oil intensity of production/final consumption: comparison of Jersey-specific and UK-adjusted fuel use intensities](image1)

![Fig. 4. Direct petrol/derv intensity of production/final consumption: comparison of Jersey-specific and UK-adjusted fuel use intensities](image2)
Here, it has been explained that the main type of fuel involved in stationary combustion in the production sector of the Jersey economy is gas oil. Examination of the output-SO$_2$ coefficients in Tables 3 and 4 and the gas oil intensities in Fig. 3 show that it is the case that the Jersey-specific output-SO$_2$ coefficients do tend to be higher (lower) than the UK-adjusted ones where gas oil intensities are higher (lower).

However, in general, the observed differences in the Jersey-specific and UK-adjusted pollution coefficients, and in the estimates of total emissions in Table 5, cannot be explained simply by looking at the differences in fuel intensities. As noted above, no information is available about the emissions factors used to estimate the sectoral pollution levels reported in the UK trial NAMEA accounts. Without this, it is difficult to determine whether violation of one or both of the assumptions required for adoption of the UK-adjusted coefficients alone can explain all the observed variation in results. It may be the case that the other potential explanatory factor suggested above, accuracy of data collection, is also important. Nonetheless, the crucial point is that, independent of all other possible explanations, the observed differences in fuel intensities across the board in Jersey (1998) from what would be expected in their UK counterparts are sufficient to render use of pollution coefficients based on UK technical relationships inappropriate.

Again, it would be incorrect to generalize the results reported here to other regional economies. Jersey is a very small and quite idiosyncratic economy. However, what the results show is that if it is expected that fuel intensities and/or combustion technology are likely to deviate from the national average, e.g. in domestic fuel use or electricity generation across space in the UK, the case for even partially region-specific data collection should be explored (see the second method outlined in the fourth section).

**POLLUTION CONTENT OF TRADE FLOWS**

One factor that has not been addressed herein is any pollution embodied in trade flows. The focus is on accounting for pollution generated within the local economy. The issue of trade has only risen with regard to imported fuels, which are then combusted within the local economy. However, the problem of pollution embodied in trade flows is the source of a significant level of political and academic debate. One of the main contributions has been the concept of ecological footprints (Wackernagel and Rees, 1996, 1997; Van den Bergh and Verbruggen, 1999). More generally, the concern in this debate is that (final) consumption is the ultimate driving force behind resource use and pollution generation. Of central importance is the recognition that a significant proportion of the resource use and pollution generation indirectly embodied in final consumption in any one region will occur outwith the boundaries of that region.

This issue is explored in more depth elsewhere in several co-authored papers that focus on adapting IO and SAM accounting techniques to address the problem of resource use and pollution embodied in final consumption in Jersey (McGregor et al., 2004d) and in Scotland and the rest of the UK (Ferguson et al., 2004, McGregor et al., 2004a–c). Here, attention is drawn to the implications of the results reported here to this debate.

There are huge information problems in tracing through the actual resource use and pollution generation in any one region or country’s imports. To do this accurately implies the need for a set of interregional world IO tables (McGregor et al., 2004d). In practice, short-cut methods are generally employed, often involving the assumption that the resource and/or polluting characteristics of economies from which imports are drawn are identical to those for the local economy (e.g. Bicknell et al., 1998). Of particular relevance to the present findings, the UK National Statistics agency recently carried out a study (National Statistics, 2002) examining alternative approaches to accounting for pollution embodied in imports to UK consumption. One option it considered is applying UK emissions intensities to goods and services imported from other countries. This is an approach that is commonly adopted in computing ecological footprints and has been applied to several recent ecological footprint calculations for UK regions (e.g. Best Foot Forward, 2004).

However, the results reported herein suggest that this may lead to extremely misleading results. The application of UK average emissions intensities implies that Jersey is like the UK. While this is true, in terms of sharing broad similarities such as culture and climate, it has been shown here that the use of UK pollution coefficients leads to inaccurate results. This, then, raises the question of the impact of assuming that UK technology applies more widely to regions and nations that are much less similar to the UK than is Jersey.

**SUMMARY AND CONCLUSIONS**

The present paper has identified three alternative approaches to estimating a sectoral emissions account at the regional level: using fully region-specific data, partially region-specific data or adjusted national data. Jersey is used as a case study to assess the added precision gained by using region-specific data compared with the other extreme of using entirely adjusted national data. This is possible because of the availability of very detailed regional data, in which there is a high degree of confidence in terms of accuracy. It is found that the degree of information loss when adjusted national data are used, both in terms of the absolute values of
The Jersey case study should be of interest in its own right, particularly to those interested in economy–environment relationships in this type of small, open island economy. However, the findings are of more general interest. First, this is an example of using fully region-specific data to construct an economic–environmental account. While adopting this approach permits one to focus on issues that are of particular interest at the regional level, the resource costs of investing in such a database are significant, and will be higher the larger the economy, and the more complex transactions and trade flows become. However, the argument is that these costs should be considered against the benefits of using region-specific data where technical relationships in polluting activities are expected to deviate significantly from the national average. The fact that Jersey is a particularly small and idiosyncratic economy was highlighted: for other UK regions that are not quite so atypical, a partially region-specific approach that focuses on key areas where polluting technology is expected to deviate significantly from the UK average may be more appropriate.

However, if one considers the findings reported here in a wider context, it is argued that the focus on differences in polluting technologies in different regions has important implications for the debate on how to measure the environmental impact of consumption in any one economy. Due to the information problems in tracing through the actual resource use and pollution generation embodied in any one region or country’s imports, a short-cut method of assuming that the resource and/or polluting characteristics of economies from which imports are drawn are identical to the local economy is commonly adopted. However, the findings reported here suggest that making this type of assumption is likely to give misleading results.

More generally, the finding that the key difference between Jersey and the UK is in terms of technology rather than trade has implications for specific applications such as multisectoral modelling of economy–environment interactions at the regional level. It is commonly the case that, as in the generation of regional IO tables using national data, nationally estimated parameters are taken to apply at the regional level. Again, the findings reported here suggest that this type of assumption is likely to give misleading results.

All this brings one back to the ongoing debate in the UK regarding the extent to which region-specific environmental and economic data are required to carry out devolved sustainability policy analysis. ALLSOPP (2003) highlights the trade-off between the desire for region-specific data and the costs and sampling issues involved in collecting and reporting good-quality data. However, so far, a key issue appears to have been neglected in this debate: what are the implications if the regions actually are different from the national economy? The present paper has argued that the benefits of region-specific data cannot be properly assessed in the absence of some degree of region-specific data collection in the first place.

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NOTES

1. Jersey is not strictly a region of the UK (or any other larger nation). It is an independent self-governing state. However, the Jersey economy is very closely integrated with that of the UK, sharing its language, currency, exchange and interest rates. Moreover, the majority of Jersey’s trade flows are with the UK. Therefore, in the absence of Jersey-specific data, the UK would seem to be the natural choice of a proxy national economy from which to draw estimates of parameter values (where appropriate UK data exist).

2. Indirect pollution generation embodied in final consumption can also be accounted for in an economic–environmental IO or SAM framework. The paper will return to this issue below.

3. It may be preferable to relate non-fuel-related emissions to some variable other than total activity, as defined by the value of output or total expenditure, where more appropriate data are available.

4. For the UK NAMEA accounts, see http://www.nationalstatistics.gov.uk

5. The 76-sector NAMEA breakdown of activities maps to the 128-sector classification of the UK IO accounts, with some IO sectors aggregated and some disaggregated in the NAMEA to focus on key polluting sectors and/or energy users.
6. Despite this, inconsistencies and incompatibilities remain between the Scottish and UK IO accounts (Ferguson et al., 2004).

7. The study by Salway et al. (2001) is not in the public domain. It was carried out by AEA Technology, a commercial body that constructs the UK National Air Emissions Inventory, and was co-funded by Defra, the National Assembly for Wales, the Scottish Executive and the Department of the Environment, Northern Ireland. However, the Scottish Executive kindly made the report available to the author for use in another study to construct a partial NAMEA framework for Scotland with CO2 emissions reported at the sectoral level (Turner, 2003).

8. The following assumes that region-specific data on sectoral activity levels, \( X_i \), and final demands, \( C_i \), or other appropriate economic data, are available in all cases. However, it is commonly the case in the UK that the regional economic data required under the NAMEA approach, i.e., in the form of region-specific IO tables, will not be available on sectoral activity levels.

9. For example, in a recent study where an interregional environmental IO and SAM framework for Scotland and the rest of the UK are constructed, focus is on incorporating region-specific data for the Scottish electricity sector (McGregor et al., 2004c).

10. Here, emissions intensities are stated in terms of gross sectoral output and total final consumption expenditure. However, emissions intensities could be stated in terms of other variables that can be measured for both economies (although this would not strictly be consistent with standard NAMEA accounting conventions).

11. For a detailed description of the construction of the 1998 economic and environmental accounts for Jersey, see Turner (2002).

12. Another type of motive fuel combustion that is not covered in the present study, but which leads to the generation of emissions, is shipping activities. Coley (1994) does not make any attempt to identify fuel used in shipping activities due to problems of data availability. A previous study of energy supply and use in Jersey (Burek, 1988) had found that shipping represents a relatively small proportion of fuel use in the economy. Moreover, as with the case of air transport, there are problems in determining how much of the fuel supplied to marine users can actually be classified as being combusted within the economy's borders. However, when appropriate data do become available, emissions from shipping and marine fuel use should be separately identified and accounted for in Jersey.

13. This allocation may not be entirely satisfactory: Jersey Aero Club (part of the ‘Total Recreation, Culture & Sport’ (TRCS) sector) and private flyers (both local and non-local) also purchase aviation gas and fly in and out of Jersey Airport. Therefore, some aircraft movements should really be allocated to TRCS, Jersey households and tourists. However, no information is available on how many aircraft movements these groups account for, and, due to the problem discussed above, it is not possible to make an allocation based on shares in fuel purchases. This is a problem that should be rectified if and when better data become available.

14. Details on the composition of each production sector identified here (according to 1992 SIC classification) are available on request from the author.

15. For attribution analyses for pollution generation in Jersey, see McGregor et al. (2004d).

16. In terms of modelling, note that, unlike the UK-adjusted coefficients, the Jersey-specific data do not limit one to the application of fixed IO-type Leontief output-pollution coefficients. Where region-specific, or partially region-specific, data are available to estimate pollution generation using equations (1) and (2), it is possible to model changes in pollution generation due to technology and input substitution effects. However, if one relies on equations (3) and (4), or on (7) and (8), only changes in pollution due to changes in the scale and composition of economic activity can be captured. Learnmonth et al. (2002) apply the latter to the case of Jersey.

17. Gas oil is technically the same fuel as the diesel used for automotive purposes; however, it is standard practice to define and record the supply of gas oil used for automotive purposes separately as ‘diesel’ or ‘derv’.

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