FIT-E: An Energy-augmented Input-output Data Update Facility for GTAP-E

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Introduction

This paper forms part of the documentation for a project funded by the United States Department of Energy. The project aims to improve the analytical basis for the development of policies relating to carbon restrictions under the Framework Convention on Climate Change. Cost-effectiveness analysis demands some attention to the question of 'leakage' - how much are the restrictions on Annex I countries likely to be diluted by shifting patterns of trade and production? In addition, questions of international competitiveness have surfaced. Studies of this problem undertaken to date suffer from severe data limitations.

The goal of this project is to construct a publicly available data base which contains the necessary combination of (a) comprehensive input-output data by region, (b) bilateral trade and protection data, and (c) energy price, quantity and tax data. Our approach is to collect consistent data on energy quantity flows, prices and taxes, and incorporate these into the GTAP database. A special purpose data base known as GTAP 4-E has been constructed, which contains information on energy quantities. In addition, energy data in the publicly-released version 5 GTAP data base will be upgraded. These products will allow researchers analyzing the trade, production and welfare consequences of international carbon restrictions to provide more reliable assessments of the national costs and benefits of these policies.

Once energy price and volume data have been collected, these are combined and integrated into the GTAP data base. This documentation describes how this is done. As with other situations in constructing the GTAP data base where it is constructed from multiple data sets not entirely in harmony with each other, the main tool used for this process is the FIT program. This program adjusts each region's IO table so that it is consistent with specified targets. In the standard FIT program used for GTAP version 3, no energy-sector targets were imposed. In the FIT program used to construct GTAP version 4, certain energy targets were imposed (focusing on the value of domestic production of each energy commodity). The GTAP 4 treatment is something of a halfway stage. From the perspective of the energy data, it does not make full use of the detailed information now available. We wish to impose more detailed energy targets, at an industry level rather than an aggregate level. We therefore cease to impose the aggregate energy targets in GTAP version 4, and redesign the FIT program so that we are able to impose detailed energy targets.

The revised program is known as FIT-E. Phonetically, this label turns out to be an apt description of the process of imposing energy targets. In many instances the GTAP database, the energy data, and other targets turn out to be mutually irreconcilable. In such cases, FIT-E is unable to provide the desired output. A variety of measures are developed for overcoming these 'infeasible' situations.

As with other parts of the documentation, no actual data is presented herein. Instead, a file is made available for the user to view as required. This file is named FITEDOCO.HAR. It is a header array file that can be viewed using the publicly-available ViewHAR software. References to data arrays herein are all contained in this file.

Set definitions

Because the level of detail of the volumes data base is not the same as that of GTAP, it is necessary to distinguish a number of different sets: for GTAP commodities, for Volume energy commodities, and for Volume energy-using sectors. Targets are defined at the level of detail of the Volume data, while the GTAP database produced by FIT-E is at the standard GTAP level of detail. In addition, because of the problem of infeasibility that is occasionally struck, it is useful to partition each of these into their feasible and infeasible components. This requires the definition of various subsets.

The volume database separately identifies 22 industry groups. These are listed in array EVCM, and the mapping from GTAP commodities to those is in TTOE. Important energy-using GTAP industries are generally separately identified, while non-energy-intensive industries (e.g. industries in the agricultural and service sectors) are aggregated.

The volume database identifies five energy commodities, coal, oil, gas, petroleum products and electricity. For all of these except gas, there is a one-to-one correspondence between these and the equivalent GTAP commodities. For gas, the IEA volume energy commodity GAS spans two GTAP commodities, gas extraction (GAS) and gas distribution (GDT).

The terminology used for the sets involved is as follows:

	All	All energy-related	Feasible energy-related	Infeasible energy-related	Non-energy-related
GTAP Commodities	TRAD_COMM (or IND)	ALL-EGY_COMM	EGY_COMM	INF_EGY_COMM	NON_EGY_COMM
Volume energy-using sectors	ALL_EV_COMM	n/a	EV_COMM	INF_EV_COMM	n/a
Volume energy commodities		ALL-EGY_IND	EGY_IND	INF_EGY_IND	n/a

Adjustment of energy volumes

This section describes the steps needed prior to using the energy volume data supplied from the OECD Development Centre in the GTAP framework. Firstly, the data is converted from GAMS format to a GEMPACK HAR file. Next we check that flows for each energy commodity are internally consistent, and we check that all flows are positive (export flows are converted from negative to positive values). We also check that global net exports are zero. The results of these checks can be seen in arrays BAL, CNEG and NETX. It was found that the database contains re-export flows: For some regions, exports exceed domestic production. As this is inconsistent with the GTAP treatment, these are eliminated by setting a maximum export level equal to domestic production (imports are reduced accordingly). All flows are converted from ktoe to mtoe. A procedure was designed to remove flows of a size below a specified tolerance level, but this procedure is not currently implemented.

We next aggregate the country-level data up to the GTAP-region level. Volume data is supplied for 132 countries and 3 composite regions, "Other Africa", "Other Latin America" and "Other Asia”. The 132 countries and the GTAP regions that they belong to are listed in arrays CTY and VTOR respectively. For allocating the volumes of the three composite regions to GTAP regions, GDP shares based on the GDP values for 56 countries within these regions are applied. The shares are shown in array GDP%. Perhaps the most significant country (for energy purposes) within these composite regions is Brunei.

Most flows are allocated directly to their corresponding commodity group. Exceptions are:

- Three separate non-energy flows are identified, for industry, transport, and 'other'. These are allocated to chemical products, trade & transport and agriculture commodity groups respectively.
- Transport energy use is separated into 'road' and 'non-road' use, but not according to household and industry use. All flows to transport are treated as sales to the trade & transport industry except for flows of petroleum products for use in road transport, which we split equally between household consumption and trade & transport industry use. It would be preferable to split this flow across trade & transport use and household final consumption according to actual proportions used, if information on these proportions were available.
- Inter-energy flows are adjusted. Originally, these were identified in a flow category named 'ownuse', which represented energy flows within the energy sector as a whole (this is discussed in more detail in the volumes documentation). In the latest version of the volumes data, OWNUSE values are zero, and these flows have been allocated to intra-industry flows for the coal, oil and gas industries. As it is considered that some portion of own-use is consumed in the processing industries, we arbitrarily attribute the intra-industry use of coal to the electricity industry, the intra-industry use of oil to the petroleum products industry, and half of the intra-industry use of gas to the electricity industry (the remaining half is attributed to the gas industry).
- Energy flows to 'dwellings' include both the industry 'DWE' and final household consumption. All flows to this category are attributed to final household consumption.
- The volume database includes information on heat energy and energy from renewable sources. These are not included in the input-output framework.

Volume flows after making these adjustments can be seen in arrays IVOL, FVOL, XVOL, MVOL and DVOL.

Energy sector targets

FIT-E is a version of the FIT program, revised to incorporate energy targets. This program employs a RAS-like algorithm. It takes as input a single-region input-output table and a set of shocks to various variables, and produces as output a revised input-output table that is consistent with all the targets imposed on it. Care has to be taken in designing this program that contradictory targets are not set, otherwise it is unable to generate a solution.

Before running FIT-E, it is necessary to calculate the shocks which need to be imposed on the model in order to achieve the appropriate values for the variables which are targeted by FIT-E. There are two steps necessary for this stage:

- change the set of inputs into the FITPREP3 program which provides input into FIT, so that the trade shocks it calculates are consistent with the energy trade data.
- construct a new program, 'FITEPREP', to generate shocks for those variables targeted in FIT-E which are not targeted in FIT.

In addition to the normal targets imposed by FIT, the following energy sector targets are calculated for each region (dimensions are shown in parentheses):

- value of intermediate use (ALL_EGY_IND by ALL_EV_COMM)
- value of private final consumption (ALL_EGY_IND)
- government consumption and investment demand (ALL_EGY_IND)
- power of the tax on intermediate use (ALL_EGY_IND by ALL_EV_COMM)
- power of the tax on private final consumption (ALL_EGY_IND)
- unilateral exports and imports (ALL_EGY_IND)

Implicitly, because sales of energy commodities to all destinations (intermediate use, the various final demand categories, and exports) are targeted, and imports are also targeted, domestic output of energy is uniquely determined, although it is not explicitly targeted as it was in generating version 4 of the GTAP database.

Details on calculation of target values and how the targets are imposed are described in turn for each of the categories listed.

Intermediate Demand

Target values are calculated using an average price for the domestic/imported composite energy commodity. (derivation of this price is described in the price documentation):

```
COEFFICIENT (ALL,R,REG)(ALL,I,EGYCOM)(ALL,N,IND)
VFA(R,I,N);! Value of sales of energy commodities to intermediate
users  (at selling agent's prices)
            !
FORMULA (ALL,R,REG)(ALL,I,EGYCOM)(ALL,N,IND)
        VFA(R,I,N) = IIVOL(R,I,N) * AVPRICE(R,I);
```

where IIVOL is the intermediate usage volume, and AVPRICE is the average price.

FIT-E sometimes has difficulty solving when a shock of -100% is required. This is particularly pertinent in the present case because of the fact that the targets are for groups of GTAP commodities. It is very difficult to ensure that the sum of a number of different flows is equal to zero, and simultaneously that each of the flows is non-negative (as FIT-E requires). Therefore we replace all zero target values with an arbitrary small positive number.

```
FORMULA SMALLPOSNUM = .001;
```

The resulting values for VFA are shown in the data file.

Because the standard FIT program does not target any equivalent flows, some adjustment to the structure of the program is necessary. The structure and derivation of the FIT program is outlined in Appendix A of James and McDougall (1993). We introduce a new set of constraints,

$$E_j S_i^j(1) = T_{ij} \qquad \forall\, i \in EGY\_IND, j \in EV\_COMM$$

where Tij are energy use targets.

When this is incorporated into the Lagrangean function, equation A1 in James and McDougall is modified by the addition of the term

$$\ldots - dLIIC_{ij}$$

on the RHS, where LIICij are the Lagrange multipliers associated with this set of constraints. None of the other equations A2-A4 in James and McDougall are affected.

To impose the targets, we define the equivalent of the Tij variable above, which is a composite (domestic and imported) usage variable:

```
variable (all,i,egy_comm)(all,j,ev_comm)                        uimci(i,j)!
value of intermediate usage by set of industries J of energy commodity I !;
equation (linear) INT_DEM_TOT # TOTAL INT DEMAND FOR I BY J   #
(ALL,I,EGY_COMM)(ALL,J,EV_COMM)
        uimci(I,J) =    SUM( L, egy_ind : EItoEC(L)=i, S_E_INT(L,J) *
                  SUM( K, IND : TCTOEV(K)=J, EV_INT(I,K) *
      (S_D_INT(l,K) * (uimdci(L,k) + pbadc(L)) +
        ( 1 - S_D_INT(l,K)) * (uimmci(L,k) + pbamc(L)))));
```

where uimdci and uimmci are rates of change of quantities of intermediate use of domestic and imported inputs, pbadc and pbamc are rates of change of prices of intermediate use of domestic and imported intermediate inputs, and S_E_INT and S_D_INT are share variables defined as follows:

```
coefficient (all,i,egy_ind)(all,j,ind)      S_D_INT(i,j)
! Share of purchases of domestically-produced goods in total
  intermediate purchases of i by j
  The targets are valued at basic prices.  Therefore commodity taxes are
   excluded (we use S_D_INT instead of S_UIMCI_D, and pbadc instead of
ppuimdci!;
formula (all,i,egy_ind)(all,j,ind)
                S_D_INT(I,J) = DINT(i,J) / (DINT(i,J) + IINT(i,J));

coefficient (all,i,EGY_IND)(all,j,EV_COMM)      S_E_INT(i,j)
! Share of total int demand for egy_ind i in total int demand by ev_comm J
for corresponding egy_com. (this should be 1 for all except GAS and GDT).!;
formula (all,i,egy_ind)(all,j,ev_comm)
```

```
S_E_INT(i,j) = sum(k,ind:TCtoEV(k)=j, DINT(i,k) + IINT(i,k)) /
sum(l,EGY_IND:EItoEC(l) = EItoEC(i), sum(k,ind:TCtoEV(k) = j,
      DINT(l,k) + IINT(l,k)));
```

S_E_INT is introduced to account for the non-unique mapping between the five energy commodities and (a subset of) the GTAP commodities. TCtoEV is a mapping from tradable commodities to ALL_EV_COMM, and EItoEC is a mapping from ALL_EGY_COMM to ALL_EGY_IND. DINT and IINT are levels of intermediate use of domestic and imported commodities respectively.

Once the usage variable is defined, it is declared to be exogenous, and an appropriate shock calculated. It is important to note that these targets are only imposed for the 22 industry groups for which volumes are available. For large energy-using industries, these have a 1:1 correspondence with the equivalent GTAP industry, but for less energy-intensive industries group (example of such groups are Agriculture, Food processing, and Services), they do not. For the latter, FIT-E ensures that the total usage by the group is consistent with the target, but does not place any restrictions beyond this on the usage of particular GTAP industries. In similar fashion, because the target is specified at composite level, no restrictions are placed on the balance between domestic and imported energy (except insofar as total sales must conform with the import targets).

Private Consumption

Private consumption is treated in a similar way to intermediate demand. Calculation of target values, modification of the theoretical structure of FIT, and implementation are all similar, although one less dimension is involved.

Government Consumption, Investment Demand

Government consumption and investment demand are not separately identified in the volumes database, and so we assume that both of these are zero. It is still necessary to modify the structure of FIT as was done for private consumption, but shocks to the usage variable are simply defined as –99.9% rather than being calculated from a comparison of the IO data and the target values. The shock value is specified to be –99.9% rather than –100% for computational convenience.

Energy taxes

Data on taxes have been collected for households, utilities, and industry. These are applied respectively to private consumption, intermediate use of energy by utilities, and intermediate use of energy by industries other than utilities. In many cases, no information on taxes has been collected. One possibility in these cases is to preserve the tax rates already in the IO tables. However, this is not currently done: Where no tax information is available a zero tax rate is assumed.

Like energy use, taxes are also calculated using the average composite price:

```
COEFFICIENT (all,i,EGYCOM)(all,r,REG)                        TP(i,r)
! Power of commodity tax on final consumption of energy commodities
  Note: no distinction between domestic and imported commodities.      !;
FORMULA (all,i,EGYCOM)(all,r,REG)
        TP(i,r) = (AVPRICE(r,i) + REGUTAX(r,i,"h")) / AVPRICE(r,i);
```

```
COEFFICIENT (all,i,EGYCOM)(all,j,TRAD_COMM)(all,r,REG)      TF(i,j,r)
! Power of commodity tax on intermediate usage of energy commodities!;
FORMULA (all,i,EGYCOM)(all,j,TRAD_COMM)(all,r,REG)
        TF(i,j,r) = (AVPRICE(r,i) + REGUTAX(r,i,"i")) / AVPRICE(r,i);
FORMULA (all,i,EGYCOM)(all,r,REG)
        TF(i,"ELY",r) = (AVPRICE(r,i) + REGUTAX(r,i,"u")) / AVPRICE(r,i);
```

Because the standard FIT program targets tax rates, implementation of these targets is straight-forward, and requires no adjustment to the structure of the program. The same tax rate is applied to both domestic and imported commodities, and, for non-utility industries, the same rate is applied uniformly to each GTAP commodity.

Exports and imports

For exports and imports, the unilateral totals are not directly imposed as targets. The normal FIT procedure targets bilateral trade flows (at both fob and cif values). For the most part, we wish to maintain these original targets. Only for the energy commodities do we wish to change the targets. However, the energy volume data does not provide us with full bilateral trade data, but only total exports and imports from and to each country. A RAS procedure is used to reconcile the original bilateral targets with these totals.

This is done by means of the following steps:

- Obtain bilateral volume flows by dividing fob values from the original trade matrix through by export prices (we assume a region's exports all have a similar price)
- ‘Smear’ these flows so that zero values are assigned small positive values
- RAS this to total export and import volume targets as given by the energy volume data
- Calculate cif/fob margins for energy commodities from original trade data
- Apply source-wise fob prices to find the fob values of trade in each energy commodity
- Apply these margins to find cif values.
- Insert fob and cif values into the original trade matrix
- Use this revised trade matrix as a target for FIT

Thus, the FIT structure itself does not require modification once these steps have been carried out. Only the targets that are imposed are changed.

Infeasibility

As alluded to above, care has to be taken in implementing FIT that contradictory targets are not set, as FIT is unable to resolve any such contradictions. After adjusting the program structure, and introducing new targets, it was found that such contradictions, or ‘infeasibilities’, arose for a number of regions. In this section, the causes of infeasibility are first discussed, and then the steps taken to overcome the problem.

Unprofitable energy processors

The energy targets that are introduced include values of sales to each user of each energy commodity. This means that, for each energy commodity, sales are targeted and also their purchases of energy inputs are targeted. For certain sets of prices, the sum of energy commodity purchases of an industry will exceed the sum of all sales of that energy industry. This violates the zero-profit condition that the data base is required to meet.

For example, if the petroleum industry in a particular region purchases 100mtoe of crude oil and sells a total of 100 mtoe of petroleum products then any set of prices in which the purchase price of crude oil is higher than the seller price of petroleum products will be infeasible. Because of their reliance on inputs of primary energy commodities, this problem occurs predominantly but not exclusively in the processed energy industries.

Array COST shows the total value of sales of each energy commodity in each region less the value of purchases of energy commodities. A negative total indicates an infeasible situation.

Even when energy input costs do not exceed sales, an infeasible situation may still arise. This is because of non-commodity taxes, i.e. production taxes. Non-commodity taxes are modeled as changing in accordance with the value of an industry's output, and in accordance with any change in the tax rate. Thus, while endogenous, this tax is effectively constrained by the (implicitly targeted) value of domestic production. Where this tax exceeds the surplus of sales over energy input costs, an infeasibility occurs. In array DROP, a value of –1 indicates the commodities/regions for which this is the case.

As a first step in overcoming this problem, we considered placing restrictions upon the allowable range of relative basic prices between each primary energy commodity and the corresponding secondary commodity into which each is transformed. It was found that:

- there is a fair degree of variation in the relative prices of primary energy commodities and their processed equivalents across countries. These relative basic prices of primary/secondary energy pairs are shown in array PSRB.
- prices of coal and gas are low relative to electricity, while prices of crude oil are much closer to prices of petroleum products.
- without fairly strong restrictions on relative prices, the frequency of infeasibility is little reduced.

We also found that limiting relative prices in this way would be insufficient to avoid all of the infeasible situations. Some examples of cases where price restrictions would not be helpful include:

- The South African crude oil sector uses 13.8 mtoe of coal and 1.7 mtoe of gas to produce 7.7 mtoe of oil. In value terms this is almost but not quite feasible. Restriction of relative prices isn't useful here because oil, coal and gas are all primary energy industries.
- The Japanese gas sector uses 3.4 mtoe of petroleum products and 0.3 mtoe of coal to produce 6.1 mtoe of natural gas. There is no restriction on the basic price of natural gas relative to the price of petroleum products.

- The Russian electricity sector uses 61.1 mtoe of coal, 0.4 mtoe of oil, 177.4 mtoe of gas and 45.2 mtoe of petroleum products to produce 73.9 mtoe of electricity.

All of these sectors appear to be somewhat inefficient energy producers. It is not evident that these contradictions can be resolved by any sensible restrictions on relative basic prices. We might expect to see government subsidies on production of these sectors, but in the GTAP database at any rate, we do not. One approach to solving this problem is to impute subsidies by some method (as is done by Rutherford and Babiker, 1998), but we do not have sufficient evidence (because our price estimates are not sufficiently robust) to allow us to do this here.

As a result, the only relative price restriction imposed is on petroleum products vis-à-vis crude oil:

```
!  The relative price of petroleum products is required to be 10% more than
  the composite price of crude oil. !
Formula (all,r,reg: AVPRICE(r,"oil") / REGBP(r,"p_c") > 0.9)
        REGBP(r,"p_c") = AVPRICE(r,"oil") / 0.9;
```

where REGBP is the basic price of the domestic commodity, and AVPRICE is the composite price (as described in the prices documentation).

The approach currently taken to address this problem is simply to relax some of the energy targets for those commodities/regions where infeasibilities occur. Various other means of addressing this problem are possible, and it is hoped that this issue will be examined in more depth in future work.

There are various sets of targets that can be relaxed. These include targets for:

- energy input costs of the infeasible industry
- sales of the infeasible industry
- both of the above

The first of these is the preferred option, as it preserves the consistency of the energy database to the greatest extent possible. However, it was found that for several regions, relaxation of the cost targets only was insufficient to allow a solution (the exact reasons for this have not yet been determined). Consequently, for these regions targets for both costs and sales were relaxed. Where possible, cost targets only were relaxed. The countries falling into both categories are listed in Appendix I.

To implement this target relaxation, we utilise GEMPACK's data-dependent set definition feature. This allows us to first specify a set containing all energy commodities (ALL_EGY_COMM). We then specify a subset of this set whose members are those for which an infeasibility is identified (INF_EGY_COMM). A similar process is done for energy-using industry groups. These sets are potentially different for each region. FIT-E then imposes targets only for members of the set EGY_COMM (which is the complement of INF_EGY_COMM).

Zero-value initial flows
In some cases, the initial input-output table contains values of exactly zero, when achievement of the targets requires that these be changed to positive values. The standard approach (of applying a percentage shock to the original value) is ineffective in this case.

An example of this situation arises in New Zealand, which has a synthetic fuel plant which converts locally-produced natural gas to crude oil. This flow is correctly identified in the volume data, but not in the I/O table, where the flow of domestic gas to the oil industry is exactly zero, and the flow of imported gas is very small. The target for the sum of these is $124m. However the total import target for gas is only $0.04m. As a result the usage and import targets cannot both be achieved, as the flow of domestic gas will remain at zero regardless of the size of the shock applied to it.

In order to circumvent this problem, the matrix of domestic intermediate use values is 'smeared', which has the effect of turning zero values into small positive values. Targets can thus be met, even though the shocks required will in some cases be very large.

Unidentified problems
Considerable effort was devoted to attempting to understand why infeasible situations arose, and a number of different causes were identified. However, at present FIT-E is unable to generate solutions for several regions, despite the fact that these regions have not been identified as presenting any infeasibilities. Fortunately, none of these regions are globally-significant energy users. It is to be hoped that in future the reasons why solutions for these regions cannot be obtained will be identified.

In order to expedite the process of producing a final product, the current treatment for these regions is to relax energy targets, in a similar way to that described above. For these regions, we relax both cost and sales targets for all energy commodities.

Array DROP shows those commodities/regions which were able to be successfully targeted (indicated with a '0'), those were identified as infeasible (identified with a '-1'), and which were not identified as infeasible, but nevertheless were not targeted because FIT-E was unable to generate a solution for these regions (identified with a '1').

Generation of volume adjunct data

In addition to improving the quality of the value data in GTAP, another aim of this project is to provide researchers with consistent information on energy volume flows which can be used to examine emission levels, etc. This is based on the IEA energy volumes, but requires some adjustment so that the level of aggregation is compatible with the standard GTAP database. The energy volume information required (with dimensions in parentheses) is:

- Intermediate use of domestic and imported energy commodities (EGY_COMM by TRAD_COMM by REG)
- Final consumption of domestic and imported energy commodities (EGY_COMM by REG)
- Exports of energy (EGY_COMM by REG by REG)

As the set EGY_COMM is not defined in the standard GTAP model, it is also contained in the file, ENERGY.VOL.

As described in the preceding section, it has been necessary in some cases to abandon the targets generated by combining the volume and price data. For these cases, value flows in the GTAP 4E database will be based on (although not necessarily remain equal to) the original values given by the IO table. This means that, in these cases, we are obliged to abandon either the price data or the volume data. We can supply a volume figure which is either consistent with the original volume data but gives an implicit price (when combined with the value shown in the main database) different from that observed, or we can supply a figure which is not consistent with the original volume data, but whose implicit price is the same as that observed.

Overall, we have more confidence in the volume database, and it is more complete. For this reason, we choose to supply volume information consistent with the original volume information. Users should be aware that this treatment results in some implausible implicit prices for those commodities/regions where targets were relaxed. Consider for example the Japanese gas sector. Targets for use of oil and electricity by this sector are zero, and the energy volume figures given in ENERGY.VOL are consistent with these. However, this is an infeasible sector, and cost targets for energy inputs into GAS and GDT industries are not imposed. As a result, in the fitted IO table, we find that the values of purchases of oil and electricity by GAS are both non-zero (although small). This prevents us from calculating an implicit price. Currently, a value of zero is assigned to the implicit price in such cases (in fact, this arises in all cases where a zero target exists, not only those where the targets are infeasible, because of the replacement of zero value targets with small positive targets).

The initial volume data is given at a more aggregate level than that used in GTAP. Energy users are grouped into 22 industries, and energy commodities are grouped into 5 commodities (GAS and GDT are combined). To disaggregate these volumes to the GTAP level, we assume that the price of each energy commodity to each industry group is the same for all subsets of that flow. This assumption is probably least defensible in the case of GAS and GDT. We therefore use value shares to disaggregate the volume totals for each flow. To split the aggregate volume total into domestic and imported components, we calculate a non-use-specific domestic share from total domestic production net of exports compared to imports, for each energy commodity. This share is then applied uniformly to all usages.

References

James, M. and R. McDougall (1993), ‘FIT: An input-output data update facility for SALTER’, SALTER working paper 17, Industry Commission, Canberra.

Rutherford, T.F. and M. Babiker (1998), “GTAP-E: A global energy-economy dataset”, University of Colorado, mimeo.

Appendix I: Regions Expriencing Infeasibility

Regions without infeasibilities	Regions with identified infeasibilities for which cost targets are relaxed for infeasible commodity(s)	Regions with identified infeasibilities for which cost and sales targets are relaxed for infeasible commodity(s)	Regions with unidentified infeasibilities for which cost and sales targets are relaxed for all EGY_COMM
AUS	JPN	PHL	MYS
NZL	KOR	SGP	VNM
MYS	IND	HKG	LKA
THA*	IND	DEU	COL
CHN	RAS	REU	URY
TWN	MEX	TUR	SAF
CAN	RAP	ROW	
USA	GRB		
VEN	SWE		
BRA	EFT		
CHL	FSU		
RSM			
DNK			
FIN			
CEA			
RME			
MAR			
RNF			
RSA			
RSS			